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Nuclear May Be Down But Not Out

The article “End of an Illusion” Front Line April 12 by Praful Bidwai makes an interesting reading in connection with embracing renewable energy options for meeting the basic energy needs of the people as if electricity is needed only for lighting fans etc. Today only about fourth of electricity is used for domestic whereas remaining three fourth for the industry, agriculture, transportation and commercial requirements are also as much basic. We can not run and stop a chemical process industry or railways depending on the wind if it is blowing or not. This is where the base load generation comes into play. While the life time emissions on nuclear power at about 66 gm/kWh as comparable to renewable options, it is much lower as compared to 900 gm/kWh for coal power and 450 gm/kWh of gas which we don have anyway. The nuclear option is thus a base load generator like thermal and environmentally clean like renewable. The fact that the potential itself is limited is of course another constraint but we can remain in an illusion that the renewable is answer to all our needs.

In the process of supporting renewable energy Praful has given tons of information collected from the net; devoid of not only any research but also analysis of the reports.

<u>I give only two examples.</u>

The table below gives the reactors in operation and under construction since 2007.

Year	Operation Number (GW)	Under construction Number (GW)
2007	435 (369)	28(23)
2008	439 (372)	35 (29)
2009	436 (372)	43 (38)
2010	436 (373)	53 (51)
2011	443 (378)	62 (64)
2012	435 (372)	61 (62)

With number of nuclear power reactors under construction doubling in last five years, the nuclear power is here to stay and this is called “renaissance”.

The second example relates to the California Energy Commission projection of the cost of nuclear power at 34 cents/ kWh and stated to be highest amongst all other sources of power generation. The study has calculated levelized cost of electricity generation for three types of plants namely; utility owned plants (UOP), Investor owned plants (IOP) and Merchant plants. The institute has calculated the levelized cost of generation in the year 2018 from different technologies. The 34 US cents per kWh refers to the levelized cost of generation referred by Mr. Praful is for merchant plants. Nuclear plants being the base load generators are never built as merchant plants and hence 34 cent/kWh cost of generation of nuclear power is taken out of context and is misleading. The correct comparison is amongst the utility owned plants and the levelized cost of generation from California Energy Commission projections is;

Technology	Capacity MW	Levelised cost of generation US C/kWh	% with reference
Small Simple Cycle	50	38.96	100
Conventional Simple cycle	100	36.98	95
Solar PV (Single axis)	50	26.16	67
Solar (Parabolic trough)	250	25.61	65
Advanced Simple Cycle	200	24.76	63
Nuclear power AP1000	1000	16.68	43

The levelized cost of generation of nuclear power as compared to small simple cycle is only 43%.

No doubt the nuclear safety and particularly the public perceptions of the safety have come under question post Fukushima accident. The fundamentals on the potential technology to supply large amounts of uninterrupted stable electricity at affordable & predictable prices in an environmentally benign manner, however, remain equally strong. Post Fukushima, safety of all installation globally is now better and further improving every day.

Finally for energy needs of the country, being huge as they are, we need all sources including renewable and nuclear to be fully exploited. Closing some options would be myopic.

Sudhinder Thakur

Column

End of an illusion

One year after Fukushima, the world must embrace another energy paradigm based on renewable sources and climate-friendly consumption.

Beyond the Obvious

PRAFUL **BIDWAI**

THE spate of demonstrations and vigils held across the world on the first anniversary of the beginning of the Fukushima Daiichi nuclear accident sent out an unmistakable message. The rift in perceptions of nuclear power between the public, on the one hand, and the nuclear industry and many governments, on the other, has further widened.

A recent opinion poll conducted by GlobeScan for the BBC in 23 countries shows that a clear majority of people (69 per cent) oppose the building of new nuclear reactors or believe that "nuclear power is dangerous" and want all nuclear power stations to be closed down as soon as possible.

In five of the eight countries which were surveyed in 2005, opposition to nuclear power has increased sharply. Opposition rose from 73 per cent in that year to as much as 90 per cent last July-September in Germany, from 76 to 84 per cent in Japan, from 51 to 82 per cent in Mexico, from 61 to 80 per cent in Russia, and from 66 to 83 per cent in France, which is the world's most nuclear power-addicted country and depends on nuclear reactors for three-fourths of its electricity.

Only about one in five respondents polled in the 12 countries which operate nuclear power plants believes that "nuclear power is relatively safe and an important source of electricity, and we should build more nuclear power plants."

The growing unpopularity of nuclear power coincides with the failure of the "nuclear renaissance" that governments such as that of the United States tried to instigate, a continuing decline in the number of nuclear reactors worldwide, and the increasingly adverse economics of nuclear electricity, besides greater public awareness of the intrinsic hazards of nuclear power generation.

In 2011, 19 reactors were shut down in Germany, Japan and the United Kingdom while six new units were connected to the grid in China, India, Iran, Pakistan and Russia. On March 1, there were just 429 reactors operating in the world, 15 fewer than the number at the historic peak, reached in 2002.

In Japan, home to the world's third largest fleet of reactors (after the U.S. and France), only two of 54 reactors are working. And only one of them is on Honshu, the main island. Attempts to restart reactors are encountering fierce opposition from local authorities and citizens. Five million people have signed a nationwide appeal to abandon nuclear power.Contrary to the perception of many that the global role of nuclear power is increasing, it has been declining. Nuclear power now accounts for about 13 per cent of the world's electricity generation, down from 17 per cent at its peak. As a proportion of the world's final energy consumption, nuclear power accounts for just 2 per cent – in contrast to 18 per cent for renewable energy sources.

Only 30 of the world's 190-odd nations generate nuclear electricity, a small minority. One-half of them are located in the European Union, and they account for nearly half the world's nuclear power generation. Only six countries – France, Germany, Japan, Russia, South Korea and the U.S. – together generate almost three-quarters (73 per cent in 2009) of the globe's nuclear power.

On most projections made even before Fukushima, nuclear power was set to decline as old reactors would retire in the next two decades, and new reactors would replace only about one-third of them. Today, 21 of the world's reactors are 40 years old or older. Another 165, or 38 per cent of the global total, are 30 to 40 years old.

Even if the latter group of reactors is allowed to run until they turn 40, total global nuclear generation will probably decline rapidly very soon. The number of reactors worldwide is likely to decrease further to about 300 in 2020, 200 in 2025 and under 150 in 2030. The shock from Fukushima is almost certain to accelerate this decline.

As of March 1, a total of 61 reactors are "under construction" in 14 countries, including 10 units that are being built for over 20 years. Four countries have what could be described as active construction programmes. China is building 26 reactors, Russia 10, India

seven and South Korea three. The remaining 10 countries have either one or two projects under way. Only India and Pakistan launched new construction sites in 2011, while two projects were abandoned in Japan. The post-Fukushima Chinese freeze on all new nuclear projects continues.

Banks have never been keen to finance nuclear power, which *Forbes* magazine once called "the biggest managerial disaster in history". Standard and Poor's found "nuclear generation to have the highest overall business risk compared with other types of generation". Citigroup GlobalMarkets Inc published a report entitled "New Nuclear – The Economics Say No". This identified construction costs, power price and operational costs as large and variable enough to be dubbed "The Three Corporate Killers".

After Fukushima, many banks are convinced that nuclear power has no future. As the Swiss investment bank UBS puts it: "At [Fukushima], four reactors have been out of control for weeks – casting doubt on whether even an advanced economy can master nuclear safety ....We believe the Fukushima accident was the most serious ever for the credibility of nuclear power."

This is the case despite the fact that nuclear power has lost $1 trillion in subsidies, cash losses, abandoned projects, according to energy expert Amory Lovins. Nuclear power continues to be subsidised through publicly funded research, loan guarantees, artificially low limits on liability, state investments in uranium enrichment and waste management, and eventually, dumping of decommissioning costs (about one-third to one-half the construction costs) upon the public.

Nuclear power is expensive and getting costlier. Nuclear reactors take 10 to 15 years to build, with interest bloating up their capital costs and hence generation costs. The nuclear industry has demonstrated no ability to learn from experience. For instance, average construction periods for reactors increased from 74 months in 1976-1980 to 146 months in 1996-2000. Over the past decade, the overnight construction costs of new-model reactors have doubled. The European Pressurised Reactor (EPR) designed by the crisis-ridden French firm Areva, is now quoting for $6,500 or more per kilowatt of capacity, compared with under $1,000 for coal-fired power. The generation cost from reactors such as EPRs is estimated at 9 to 21 U.S. cents per kilowatt-hour (kWh), depending on the financing mode. This is costlier at the upper end than power from the most expensive renewable sources such as solar photovoltaics (whose costs are, however, rapidly falling).

The California Energy Commission projects the cost of nuclear power from a merchant plant at 34 cents, or Rs.17/kWh, which is higher than power from any other source, including wind, biomass, geothermal, solar-thermal, gas or coal. Put simply, this makes nuclear power exorbitant and unaffordable.

There is no assurance that the projected capital costs will not be exceeded. The disastrous experience with the first two EPRs in Finland and France, where they are at least four years behind schedule and 95 per cent over budget, points in the opposite direction.

Unlike renewable sources, nuclear power is inflexible and suitable only for electricity generation, which typically accounts for about a third of primary energy supply. It can only deliver base-load power within a centralised grid. But in many countries, energy consumption is decentralised or distributed, and peak loads matter much more than base loads.

Thus Congress general secretary Rahul Gandhi was factually mistaken when he defended nuclear power expansion on the grounds that it would light up Vidarbha farmer Kalawati's home at night and enable her children to read.

All this makes nuclear power unattractive in any rational scheme of things. But what of the argument that nuclear power can help effectively "decarbonise the energy economy"? It is, of course, undeniable that nuclear fission does not generate greenhouse gases, unlike combustion of coal, oil or gas. But there are emissions in each step of the so-called nuclear fuel cycle, from uranium mining and processing, to fuel fabrication and reactor construction, to reactor maintenance and spent-fuel reprocessing, to eventual decommissioning of reactors and long-term storage of nuclear waste.

CARBON FOOTPRINTS

The carbon footprints of many of these activities are substantial because they involve the use of energy and emissions-intensive materials such as steel and cement and also large quantities of water. Some of these emissions will rise in the future for the same quantity of power generated – for instance, in uranium mining and processing, as high-quality ores get depleted, and in the maintenance of reactors as they age and get increasingly contaminated.

On a life-cycle basis, emissions from a nuclear power plant are variously estimated at between a low 1.4 and a high 288 grams of carbon dioxide-equivalent per kWh of electricity generation, with a mean value of 66 grams/kWh. This is much lower than emissions from burning coal (about 1,000 gm/kWh) or natural gas (about 440 gm/kWh).

However, the 66 gm/kWh mean does not compare favourably with emissions from renewable sources such as wind generation and small hydropower, respectively 2.8 to 7.4 gm/kWh and 17-22 gm/kWh. Similarly, emissions per unit (gm/kWh) for concentrated solar power (8.5-11.3), wave energy (21.7), tidal power (14) and even geothermal energy (15.1-55) are lower than those for nuclear power. Biomass (29-62) is a borderline case, but only at the higher end of the range.

Solar photovoltaics (PV) is estimated by many studies to be broadly comparable in its CO_2 emissions with nuclear power. For instance, according to one estimate, PV life-cycle emissions are 19-59 gm/kWh, compared with 9-70 for nuclear power. A signif-

KIM KYUNG-HOON/REUTERS

ON THE FIRST anniversary of the March 11, 2011, earthquake and tsunami in Japan, two brothers offer prayers for their parents who were killed, in Iwaki, Fukushima prefecture.

icant proportion of the emissions associated with PV comes from energy-intensive production of crystalline silicon, and from vapour deposition processes for thin films. But PV technology is improving. As there is more energy-efficient production of crystalline silicon, and as thinner wafers are used, emissions per unit of PV generation are likely to fall in the next five years – faster than the rate of emissions decline from nuclear, a "mature" technology in which very little R&D (research and development) is taking place.

Besides, nuclear reactors have far longer construction times than renewables. During these long years, emissions from fossil-fuel burning will continue to build up. This represents a significant opportunity cost. If this is taken into account, the picture changes dramatically. Emissions from nuclear power rise by another 59-106 g/kWh. According to Amory Lovins: "Nuclear power is about the least effective method [of abating emissions]: it does save carbon, but about 2 to 20 times less per dollar and 20 to 40 times less per year than buying its winning competitors."

The greatest black mark against nuclear power is its lack of safety and its disaster-proneness. Nuclear reactors are intrinsically hazardous, being relatively high-pressure high-temperature systems, in which a fission chain-reaction is barely checked from getting out of control. Nuclear power is bound up with radiation, which is harmful in all doses, at each step of the nuclear fuel cycle.

Nuclear plants routinely expose surrounding populations to radioactive and chemical emissions and effluents, with harmful effects. They leave behind wastes that remain hazardous for thousands of years because they contain substances with long half-lives (for example, 24,000 years for plutonium-239, and 710 million years for uranium-235). Science knows no way of safely storing such wastes.

Nuclear power is the only mode of energy generation that can undergo catastrophic accidents. Accidents are inevitable in nuclear reactors. Their probability may be low. But their consequences are unacceptable. Their human, environmental and economic damage is unconscionably high and runs into hundreds of billions of dollars. For instance, a study by a highly regarded German institution estimates that a single reactor meltdown will inflict economic damage of $11 trillion on the country, equivalent to double its gross domestic product (GDP).

Nuclear power originated in an era in which growth, to qualify for being desirable, had to be seen as limitless. Within this "more is better" approach, energy consumption was assumed to have no ecological limits; consuming more resources was considered a sign of progress. The greatest supposed virtues of nuclear electricity were that it would be abundant and yet "too cheap even to meter"! Nuclear power proponents still remain entrenched in that thinking. They cannot relate to the ideas necessary for, and the energy strategies relevant to, a climate-conscious world.

CORROSIVE INFLUENCE

Promotion of nuclear power has had a corrosive influence on society and institutions of governance. It has always involved secrecy, opacity and deception, which are antithetical to democracy. Nuclear power evokes fear and loathing in large parts of the world, and can only be promoted by force.

The nuclear industry has compromised regulation and the culture of safety through a collusive "nuclear village" relationship. It has blocked the public's access to information about the risks to which it is subjected. Nuclear power has led to proliferation of nuclear weapons and created vulnerable targets for military attacks and sabotage.

There is a strong case for abandoning nuclear power and moving towards a new energy system based on climate-friendly, safe and increasingly affordable renewable sources, as argued in the last Column (*Frontline*, March 23). Decentralised energy generation, energy efficiency improvement and distributed consumption have a major role here. As does the reorganisation of habitats and reduction of energy intensity of a range of activities.

A precondition for this is that we need to think of energy not in conventional supply-driven terms, but from the viewpoint of meeting the basic needs of our people for energy services in a climate-responsible, austere and equitable manner. Fortunately, we have a framework or road map here in the work of A.K.N. Reddy (www.amulya-reddy.org.in) and Girish Sant of Prayas Energy Group, who died an untimely death in February. We must build on their work. □