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Nuclear Power: Too Costly to Matter

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The cost per unit electricity varies according to country, depending on costs of raw materials in the area, the regulatory regime, financial and other risks and cost of finance. In case of nuclear power, costs also depend on geographic factors like availability of cooling water, earthquake likelihood etc.

In 2003, the Massachusetts Institute of Technology (MIT) report estimated that new nuclear power in the US would cost 6.7 cents per kilowatt-hour. In 2009 MIT updated the 2003 study, concluding that inflation and rising construction cost had increased the overnight cost of nuclear power plants and thus increased the power cost to 8.44 cents per KWh, which makes it more expensive than all other conventional sources.

In June 2008 Moody's Investment Service estimated that cost of installing new nuclear capacity in the US might possibly exceed $700 per KWe in final cost.

In the May 2009 edition of the IAEA Bulletin, Sharon Squassoni concluded : "A nuclear renaissance would require significant changes by both governments and multinational agencies as well as aggressive financial support." And in June 2009 issue of *Nuclear News*, the monthly magazine of the American Nuclear Society, the editorial commented: "In what was supposed to be a streamlined, straightforward process for design approval and licensing nearly every initiative has taken on unintended complexities. Industry leaders have long bemoaned 'regulatory uncertainty' (in day-to-day operations as well as in license applications), but there are sources of uncertainty in virtually every aspect of the new reactors endeavor." The article concludes: "State governments, federal agencies, reactor vendors, license applicants, and the economy are all contributing to the air of doubt surrounding new reactor projects in the United States."

The initial cost projections touted during the early phase of the recent "nuclear renaissance" were almost one-third of what one would have expected, based on the nuclear reactors completed in the 1990's. The most recent cost projections for new nuclear reactors are, on average, over four times as high as the "nuclear renaissance" projections. On the other hand, low carbon means that are less costly than nuclear, include energy efficiency, cogeneration, biomass, geo-thermal, wind, solar thermal and natural gas. The cost of solar photovoltaics, which is presently more than nuclear, is projected to decline dramatically in the next decade. Carbon capture and storage technology for fossil fuels, not yet available, are projected to be more costly than nuclear reactors. At the same time numerous studies by Wall Street and independent energy analysts estimate efficiency and costs of renewable energy at an average of 6 cents per KWh, which is much more than the cost of power from nuclear reactors in the MIT study (and other recent studies). For this reason, in the US, notwithstanding soaring government subsidies, nuclear power is not attracting private investments.

THE GLOBAL SCENARIO

In the US, an assessment of 75 of the country's reactors showed predicted construction costs to have been US $45 billion but the actual costs were US $145 billion.

For about a decade the US Government, particularly under Bush regime, had been trying its best to revive moribund nuclear industry. From March 2000 to June 2009 the US Nuclear Regulatory Commission (NRC) had extended the licenses of 54 reactors for 20 years. The NRC is still considering license renewal applications for a further 16 units. In 2003 the US Department of Energy (DoE) called for combined construction and operating license (COL) proposals under its "Nuclear Power 2010" programme on the basis that it would fund up to half the cost of any reactor proposals accepted. To encourage the utilities, matching fund of up to about $50 million, per reactor per vendor, is available from DOE (Department of Energy), and any vendor can have total support of up to $200 million.

The Energy Policy Act of 2005 provided financial incentives for the construction of nuclear plants. The incentives include credit for the first 6000 MW of capacity in the first eight years of operation, and federal loan guarantees for the project cost. After putting this programme in place in early 2008, the DoE received 19 applications for 14 plants involving 21 reactors. The US Government has also significantly stepped up R&D spending for future plants that improve or go beyond current designs.

But despite all these efforts the survival of nuclear industry is in great doubt. In 2001, *The Economist* observed that nuclear power, once claimed to be too cheap to meter is now too costly to matter. For, notwithstanding relatively low fuel costs per kwh other expenses are rather high, making the total costs per kwh prohibitive.

In June 2006, the trade journal *'Nuclear Engineering International'* published the 2004 edition of the World Nuclear Industry Status Report prepared jointly by European Renewable Energy Council and Greenpeace, "on the way out - *In sharp contrast to multiple reporting of a potential 'nuclear revival'the atomic age is in the dust rather than in the dawn".*

The British Government's review of economic impact of climate change, widely known as the *Stern Review*, published in 2006, observed: "The costs of energy production and use from all technologies, except for nuclear power, have fallen systematically with innovation and scale of economies in manufacturing and use since the 1970's."

According to European Renewable Energy Council & Greenpeace report, "Future Investment: A Sustainable Plan for the Power Sector to Save the Climate", the construction time for nuclear plants has increased from 66 months for completion in the mid 1970s to 116 months (nearly 10 years) for completion between 1995 and 2000. This is happening mainly due to miscalculation in estimated construction times, shortage of experienced manpower and required forging steel to make reactor vessels.

Construction costs worldwide have risen far faster for nuclear than non-nuclear plants, not only due to sharp increase in steel, copper, nickel and cement prices but also to a decaying, rather atrophied, global infrastructure for making buildings and operating reactors. Lack of competence, manufacturing bottlenecks (only a single facility in the world, Japan Steel Works, can cast large forging for reactor pressure vessels), lack of confidence of international finance institution and strong competition from highly dynamic

natural gas and renewable energy systems exacerbate the aging problems of the industry. Presently almost all construction efforts are in Asia—China, India, Russia and South Africa, where governments are planning to expand nuclear power with public money.

The Nuclear Energy Institute is trying to play down the rosy expectations it once created. It now says that the US nuclear orders will come not in a tidal wave but a mere 5-8 plants coming online in 2015-16, then more if those are on time and within budget. But even that seems doubtful. In today's energy market, governments can have only about as many nuclear plants as they can force taxpayers to buy. Nuclear power, with its decade-long project cycle and unattractiveness to private capital, simply cannot compete.

INDIAN SCENARIO

Two decades ago, in 1985, Atomic Energy Commission (AEC) Chairman Srinivasan said: Nuclear power compares quite favourably with coal fired stations located 800 km away from pithead and in the 1990s would be even cheaper than coal fired stations at pithead.

Fourteen years later, in 1999, a Nuclear Power Corporation (NPC, now NPCIL) study observed that the cost of nuclear electricity generation in India remains competitive with thermal electricity only for plants located about 1200 km away from coal pit head, when full credit is given to long term operating cost, especially in respect of fuel prices.

India's present installed nuclear electric capacity is 4120 MW, which contributes about 2.5% of the total capacity. India is aiming at doubling the capacity in the next 5 years and scaling it up 5 times by 2020. The main interest in the controversial Indo-US nuclear agreement was to get support in increasing nuclear power production capacity by procuring uranium and large reactors from other countries. But if India's reactor construction costs are considered one would see that, in each and every case, construction costs have been increased from two to four times. Completion costs of the last ten reactors have on average been 300% over budget. This has happened mainly due to unrealistic cost estimates and time schedules.

ATTRACTIVE OPTIONS

In 2006 renewables other than big hydro electricity (more than 10 MWe) attracted $56 billion of private capital. Nuclear, as usual, attracted nothing. Investors instead favour renewable energy with less construction time, cost and financial risk. These carbon-free modes of generating electricity won $ 71 billion of private investment in 2007 alone. And in 2008 solar, wind and other clean energy technologies (besides nuclear) attracted $ 140 billion compared with $ 110 billion for gas and coal for electrical power generation. This has been reported by the United Nations on 3 June 2009.

China's renewable capacity reached seven times its nuclear capacity and grew seven times faster. In 2007, China, USA, Germany and Spain each added more wind power capacity than the world added nuclear capacity. The same thing was repeated in 2008 and 2009.

Private investors have switched to cheaper, faster and less risky alternative micropower in factories or buildings and renewable sources of electricity except big

hydro-electricity (those over 10 megawatts). These alternatives surpassed nuclear's global capacity in 2002 and its electric output in 2008.

Another competitor is end-use efficiency, 'negawatts', i.e. saving electricity by using it more efficiently. Micropower and negawatts are performing excellently in the global market despite smaller subsidies than nuclear power.

Wind, co-generation and negawatts now provide electricity more cheaply than thermal power plants, whether nuclear or fossil fuelled. Since central power plants are largely mature and their competitors continue to improve rapidly this difference in cost will only widen. Amory B Lovins calculated that all of these three carbon free resources cost at least one-third less than nuclear power per kilowatt-hour, so they save more carbon per dollar. In the near future higher carbon prices of electricity produced from coal will give advantage to all other zero carbon resources—renewables and nega-watts—as much as nuclear.

Small, quickly built units are faster to deploy for a given total effect than big, slowly built units. Even a few megawatt wind turbine can be built so quickly that the US will probably have one hundred GWe of them installed before it gets its first one GWe of nuclear capacity, if any.

Nuclear reactors must shut down, on average, for 39 days every 17 months for refuelling and maintenance. Fossil fuelled power plants typically fail about 8 percent of the time even in America. In India this happens more often. Any country must install roughly 15% reserve margin of extra capacity.

The big transmission lines are also vulnerable to lightning, storms and other interruption. The bigger the power plant and the power lines, the more frequent and widespread regional blackouts and load shedding will become. Most of the power failures start in the grid. So it is wise to bypass the grid by shifting to efficiently used, diverse resources sited close to the customer.

WIND POWER

Global potential of wind power is 35 times the current world consumption of electricity. The amount of solar energy which falls on earth's surface every 70 minutes is the amount of energy humankind uses each year. If properly farmed, both wind power and solar power can deliver reliable power without significant cost for backup or storage.

In 2008 globally wind power capacity increased by 27000 MWe. In 2009 it increased by 37000 MWe. Global Wind Energy Council (GWEC) hopes wind turbine installation capacity to increase by over 45,000 MWe during 2010. The growth will be driven by USA, China, India and Europe.

As the result of increases mentioned in the previous paragraphs, the global wind power installed capacity has more than doubled during the period from 2006 to 2009 (from 74 GWe in 2006 to 158 GWe in 2009) while nuclear power is fighting hard and with little success to keep its capacity at the same level.

The Global Wind Energy Council (GWEC) projected the possibility of a 17-fold increase in wind-power generation of electricity globally by 2030. Wind could account for

as much as 25 percent of the US electricity by 2050, i.e., an installed wind capacity of 300 GW.

The US wind power installed capacity is 35,159 MWe. DoE has opined that wind power could generate 20% of the US electricity by 2030. In 2008 and 2009 wind power accounted for over 40% of the new electricity capacity addition in the US. American researchers demonstrated that wind energy alone (at around 7.6 US cents per kilowatt-hour) could supply the country's entire demand for electricity projected for 2030. Wind farms would only need to take up land areas of 0.5 million square kilometers, or regions about three quarter of the size of Texas. The physical footprints of wind turbines would be smaller, allowing the area to remain agricultural.

China is rapidly becoming world's number one in wind-power generation, trailing only USA and Germany in terms of installed capacities. Probably by the end of 2010 it will be first in the world in wind power generation. China has already become second only to the US in its national power generating capacity—874GWe per year with an expected future 10% annual increase and is now the world's largest CO_2 emitter, surpassing the US.

Wind turbine accounts for 10925 MWe in India, some 7.4% of its total installed capacity for electricity generation. However, most estimates indicate that India has at least seven times greater potential of wind power generation than the present installed capacity. On 9 September 2009 New and Renewable Energy Minister Farooq Abdulla released a book entitled "Indian Wind Energy Outlook 2009". This report is published jointly by the GWEC and Indian Wind Turbine Manufacturers Association (IWTMA).The report explains how wind energy can provide up to 24% of the India's power needs by 2030 while attracting rupees 47,500 crore in investment every year and creating 213000 'green colour' jobs in manufacturing, project development, installation, operation, maintenance, consulting etc. At the same time, it would save a total of 5500 crore tonnes of CO_2 in that time frame (2030).

10 Indian states–have implemented supporting policies for wind energy. The Ministry of New and Renewable Energy (MNRE) is currently considering plans to introduce generation based incentives.

To sum up the case for wind, it may be mentioned that a network of land-based 2.5 MW turbines restricted to non-forested, ice-free, non-urban areas, operating at as little as 20% of their rated capacity, could supply more than 40 times current worldwide consumption of electricity.

MORE ON RENEWABLES

Renewable energy accounted for 10.5 percent United States' electricity. President Obama called for doubling renewable energy within next three years. In his inaugural address Obama called for expanded use of renewable energy to meet the twin challenges of energy security and climate change. Obama said: "We know the country that harnesses the power of clean, renewable energy will lead the 21st century...Thanks to the recovery plan, we will double this nation's supply of renewable energy in the next three years". Obama's *New Energy for America* plan calls for a US investment of $ 150 billion over 10 years to catalyze private investment. The plan calls for renewable energy to supply 10% of America's electricity by 2012 (presently hydroelectricity constitutes 5.74% of the America's total electricity), rising to 25% by 2025.

But 2009 has not been such a good year for India. However, the renewables' industry is expected to pick up in 2010.

For a couple of years demand for power in India has been growing faster than supply. This has resulted in a net deficit of about 10% to 17% of electricity. At the same time 93,450 MWe in the country (64.6% of the total) is generated from coal, i.e., thermal power. It releases huge amount of carbon dioxide (CO_2) in the atmosphere. So it can't continue in this way for long.

Prominent non-carbon sources of generating electricity includes hydroelectric power, non-conventional sources and nuclear power. Currently hydroelectric power provides 36,877 MWe (24.7%). India has potential for harnessing hydroelectric power. Most estimates suggest potential capacity is four times higher than present capacity, i.e., 150000 MW. In India Aruna-chal Pradesh (50,000 MWe potential), Jammu & Kashmir, Himachal Pradesh and Uttarakhand account for a bulk of the potential capacity.

The current thermal-hydro mix stands at approximately 74:26. The 11th Five Year Plan (2007-12) envisaged total installed capacity addition of 77,700 MWe, out of which almost 60,000 MWe of capacity would be added from thermal plants. This will increase imbalance of thermal-hydro mix. Hydroelectric power is the most suitable technology for meeting peaking power requirements. But environmental impact assessment and resettlement of displaced persons are very important issues when a hydro project is to be considered.

Capital costs of hydro power plants are large, but they can produce electricity for longer periods, which help reduce costs over time. For example, according to the World Bank estimate, more than 40 years old Bhakra Nangal plant now has operating costs of 10 paise per unit only.

Presently non-conventional sources, including small hydro (10 MW and less) produce I3.242MW (7.7%) in the country. Under the 11th FYP envisaged capacity addition of non-conventional energy is 14,500 MW approximately.

India has unveiled some decent solar power plans. In July 2009, government has declared $19 billion plan to produce 20 GW from solar power by 2020 and 100GW by 2030. India has sufficient potential to generate 700 to 100 GW. Now it produces only a few MW. But under the recent plans solar powered equipments and applications would be mandatory in all government buildings including hospitals and hotels. Besides India's four to five million diesel powered water pumps for irrigation, each consuming 3.5 KW on average can easily be replaced. It is very useful in off grid lighting in remote areas.

Although financial cost of solar power is still very high, costs are steadily decreasing with increase in scale of production and R&D efforts. India is blessed with sunshine for about 2300-3200 hours per year. Keeping this in mind about 35,000 sq km area of the Thar Desert in Rajasthan near Jaisalmer has been kept aside for solar power projects. In future 700 to 2100 GW can be generated in this area alone.

Also there lies a possibility to produce around 10,000 MW from geothermal sources, much of which can be exploited in Gujarat. A bulk of the proposed non-conventional power addition is expected through private investment.

CNCLUSION

Producing more nuclear power rather than its cheaper, swifter carbon free rivals will actually reduce and retard climate protection, because it diverts funds away from really green, non-conventional energy technologies, and measures to improve energy efficiency. Even the doubling of existing nuclear capacity during the coming two decades would require some three to four hundred new nuclear reactors. This would cost about a trillion dollar investment and reduce carbon dioxide emissions by no more than a few percent. The same amount invested in proper green options would result in significant environmental goods being produced.□

[abridged]

[source : *Artha Beekshan*, Vol 19, No 1, June 2010]

Inaia's Nuclear Reactor construction costs (Crore Rs)

Station	Original Cost Estimate	Revised Cost	Cost Increase
TAPS 1 & 2	92.99	_	
RAPS 1	33.9S	73.27	More than twice
RAPS 2	58.16	102.54	Approximately twice
MAPS 1	6178	113.83	More than twice
MAPS 2	70.63	127.04	Approx. two times
NAPS l & 2	209.89	745.0	Three and half times
Kakrapar 1 & 2	382.5	1335.0	More than thrice
Kaiga 1 & 2	730.72	2896.0	Approximately four times
RAPS 3 & 4	711.57	2511.0	Three and half times