Global Warming, Nuclear Power and Resurgence of Renewable Energy: a Political Economic Analysis of the Major Issues in the Choice of Energy Supplies with Special Reference to India

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Arguments in favor of nuclear power have been revived in recent years especially in emerging economies like India. The proponents of the nuclear power have put three arguments to justify their demand. These are: (a) Nuclear energy is safer today due to induction of better and safer technology. (b) Nuclear energy is a better option for mitigation of carbon emission and for combating global warming. (c) India needs nuclear energy to sustain its projected rate of economic growth.

The paper is divided into two sections. The first section focuses on the above three issues. The second section begins with a brief discussion on the alternative energy initiatives taken in different countries of the world, especially in Europe. This section also highlights the alternative energy options that are still open to India but not yet considered by the energy planners of the country.

Introduction:

Arguments in favor of nuclear power have been revived in recent years especially in emerging economies like India. India and USA have entered into a civilian nuclear deal on March 2, 2006, where India has promised to separate its civilian and military installations in return for uninterrupted supply of uranium and access to advanced nuclear technology that in the long run would help the country to fuel its growing energy needs.[2] It was reported that sensing the potential of the deal,[3] a strong contingent of the US business community, under the leadership of US Chamber of Commerce, launched the second phase of its strategic initiative to ensure that the 'deal got through' in the US congress. It was also reported that as a part of a broad public advocacy campaign, the chamber had planned to host 'coalition for partnership with India'. At least three different lobby firms were working simultaneously to seek the nod of US Congress on the nuclear deal.[4]

The steady progress of the proposed India-US civilian nuclear agreement had provided the much-needed political support to the nuclear lobby to come out with ambitious plans for nuclear energy. The Government of India had firmed up plans to set up around five

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[2]The Businesses Standard,3.3.2006

[3] The Indo-US deal has far reaching consequences on the composition of future fuel mix of India's energy supply. It is feared that India in future would rely more on imported uranium than on abundantly available indigenous coal for power generation. With the signing of the deal, $100 billion business opportunities have been created for US firms in energy sector alone. See the Economic Times, 3.3.2006

[4] The Economic Times.3.3.06

new coastal nuclear power stations using high-end reactors of 1,000 MW and above. The stations would be designed to accommodate up to six to eight such reactors. As a result the overall capacity of each station could be gradually ramped up to almost 8,000 MW. The projects were expected to use light water reactors and were most likely to be run using imported fuel.

Haripur- The New Destination: The initiative by the governments to build mega nuclear plants has generated adverse reactions, particularly among the citizens residing around the proposed project sites. The environmentalists and peace activists have also joined them to organize united resistance against such a move. In November 2006, the Chairman of the Nuclear Power Corporation of India indicated that the central site selection committee had identified the project site at Haripur[5] as the proposed site for the mega nuclear plant. Fearing eviction, 4000 odd families of Haripur and surrounding villages have been protesting against the move.[6] Anti nuclear groups from different parts of the country have also expressed their solidarity with the protesters and had registered their opposition to such a massive nuclear program.

The nuclear lobby is not sitting idle. Led by the Chief Minister of West Bengal (India) himself, they have been trying to convince the citizens that for the sake of 'development' and to sustain a higher rate of GDP growth of around 8% per annum, the country would need massive supply of electricity which could be ensured only through establishment of mega nuclear plants.[7] They have also put forward the argument of mitigating 'global warming' through substituting fossil fuel by nuclear energy. The safety concern was discounted by assuring that currently better and safer technologies including nuclear fusion technology for the production of nuclear power were introduced.[8] In a local newspaper, a Physics teacher of a renowned college of Kolkata had assured worried citizens that there was nothing to fear from nuclear radiation as every day almost all human beings 'got exposed to natural radiation'!

In addition to the genuine concern for 'energy security' due to almost total dependence on imported raw material (uranium) for the proposed nuclear plant, three important issues namely 'safety concerns associated with nuclear plants'; 'level of carbon emission' and 'compulsions to meet India's growing energy needs' have emerged during the current debate on the proposed mega nuclear plants. The arguments put forward by the proponents of nuclear energy are as follows:

- Nuclear energy is safer today due to induction of better and safer technology.
- Nuclear is a better energy option for mitigation of carbon emission and global warming.

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[5]Famous for its fish drying industry. Situated under Contai sub division of Midnapore (East) ,200 km from Kolkata

[6] The Telegraph, Kolkata, 20.11.06

[7] The much publicized stand taken by Prakash Karat, the Secretary General of the CPI(M) who opposes the Indo-US nuclear agreement and that of his party colleague Budhadev Bhattacharjee, the Chief Minister of West Bengal, may look contradictory. But a deeper analysis would reveal that Karat's opposition is more on technical issues than opposition to nuclear power.

[8] Ananda Bazar Patrika, December 19, 2006

- India needs nuclear energy to sustain its projected rate of economic growth.

Structure of the paper: The paper is divided into two sections. The first section focuses on the above three issues which justifies the use of nuclear energy. As volumes of research reports, articles; commentaries have been published already to address the first issue, here a broad overview of these recent reports would be presented, in brief. The second section begins with a brief discussion on the alternative energy initiatives taken in different countries of the world, especially in Europe. Further, the alternative energy options which are still open to India but are not yet considered by the energy planners of the country would be explored in this paper.

Section I

Issue no 1: Is nuclear power safe?

Chernobyl nuclear disaster occurred in April 26, 1986 in Ukraine. Even after two decades of the accident, the nuclear industry is still facing resistance across the globe against this form of energy. New findings on Chernobyl indicate that in Belarus, Russia and the Ukraine alone, the accident could have resulted in an estimated 200,000 additional deaths in the period between 1990 and 2004. These numbers differ strongly with IAEA Chernobyl Forum estimates of 4,000 deaths, which were limited to the 'liquidators', or those sent in to clean up the accident evacuees from the 30 km zone and residents of strict control zones. But the radioactive fallouts from Chernobyl clouds touched many territories where more than three billion people lived. Over 50% of these territories across thirteen European countries were dangerously contaminated, claimed a Greenpeace study, [9] released on the 20th year of the Chernobyl disaster.

In the post Chernobyl phase, even after implementation of higher security system and precautionary safety measures, nuclear plants across the globe had experienced many 'precursors' or 'near misses' which could have led to a core melt down leading to many more Chernobyl type accidents.

It has been reported[10] that between 1986 and 2006, US reactors had experienced 8 'significant near misses'; 49 'important near misses' and 142 'additional near misses'. The US Nuclear Regulatory Commission (NRC), in their analysis, could associate with the following four initiators for most of the events that could have led to a meltdown. These were: (i) reactor trip that includes loss of main feed water; (ii) loss of off site power (LOOP); (iii) small break loss of coolant accident (LOCA); and (iv) steam generator tube ruptures. Between 2005 and early 2006, at least four incidents[11] in the

[9] A. Yablakov, I. Labunska and I Blokov, 2006, The Chernobyl Catastrophe: Consequences on Human Health, April, Greenpeace, http://www.greenpeace.org/international/press/reports/chernobylhealthreport.

[10] Davis and Fritsch, 2006

[11] (i) Waterford 3, in Louisiana, August 29, 2005; (ii) FirstEnergy's Perry Plant in Ohio, January 2005; (iii) Dominion's Kewaunee Plant , Wilkinson, April 26, 2006; (iv) Catawba Plant., May 20, 2006, see Davis and Fritsch, 2006

[11] ibid

USA nuclear plants were reported to be associated with either due to loss of off-site power or problem with coolant system. The most alarming feature of the NRC analysis of the precursor events (near misses) was its inability to predict accidents. The analysis showed, most of the reactors that had experienced precursor events were not on the NRC's watch list. [12]

A precursor event can deteriorate into a major radioactive release when the containment of the reactor fails. NRC document and other studies indicated that the containment of General Electric Mark 1 & 2 reactors and Westinghouse ice condenser reactors were particularly susceptible to failure under accident conditions. Forty US reactors that were in operation had such containment and those 40 reactors experienced 50 of the 'near misses'.[13] If the performance of the nuclear plants of a technically advanced country like USA are so alarming, one can easily guess the number of 'near misses' the nuclear establishment of the developing countries like India faces while running the old reactors.

It has also been claimed that after the Chernobyl accident in 1986, new generation nuclear plants have been introduced to avoid any such disaster in future. Here, a brief over view of the major findings of few such studies would be presented to assess the actual situation. One such study[14] reported that at the beginning of 2005 there were 441 nuclear power reactors operating in 31 countries and there existed four broad categories of nuclear reactors, which were in operation or under development. These were

Generation I: prototype commercial reactors developed in the 1950s and 1960s.
Generation II: the vast majority of the reactors in commercial operation worldwide.
Generation III: the 'advanced reactors' which were being built in some countries, notably in Japan.
Generation IV: reactors currently being developed with an objective of commercial use within next twenty to thirty years.

An analysis of the shortcomings, as documented against each different models of nuclear reactors including the third generation advance reactors, fails to assure the critiques, on the safety aspects of the nuclear power.

The fourth generation reactors- Initiatives and Outcomes: In future, the largest increase in nuclear power generation is projected for the developing world, where a potential market for Generation IV is seen .Currently; there is a move to develop smaller units, which may be built independently or as modules in a larger complex, with capacity added incrementally as required. The driving forces for small nuclear power plants are the reduction of the financial risk and the need for integration into smaller grids in many developing countries.[15] Organized resistance in the most of the developed countries has compelled the nuclear lobby to shift their focus towards emerging countries like China

[12] ibid
[13] ibid
[14] Frogatt, 2005
[15] Frogatt, 2006

and India – the soft targets. The recent Indo-US nuclear treaty is a manifestation of such a strategy.

The nuclear 'fusion technology' is claimed to be safer and cleaner. But at present, 'fusion' is largely a research program. Commercialization not expected for the next 30 to 50 years. 'Nuclear Age' (March 9, 2006) quoting an ex Manhattan Project scientist reported that 'nuclear fusion power stations will never be a practical source of electricity - the obstacles remain too great'. Though 'never' is a very strong prediction but the above statement underscores the complexity of the nuclear fusion technology. Moreover, some of the experiments are at its nascent stage. For example, the International Tokmark Experimental Reactor (ITER) - $4 billion project was expected to begin in 2006 with experiments starting about eight years later.[16] The fate of 'fuel cell' is also uncertain and it would take over a decade to commercialize the process.

In 2000, the US Department of Energy (DOE) launched the "Generation IV International Forum (GIF)" to develop an 'innovative nuclear systems (reactors and fuel cycles)'. It was projected to reach technical maturity by about 2030, which many experts believed to be an optimistic target. By 2005, 10 countries[17] as well as EURATOM[18] were participating in that initiative. In 2001, almost a similar initiative (allegedly inspired by Russian Federation), the International Projects on Innovative Nuclear Reactors and Fuel Cycles (INPRO) was initiated and funded by IAEA. By November 2004, 21 countries/entities[19], with the noted exception of USA, became members of INPRO.

Again, on February 28, 2005, to strengthen research and development for Generation IV reactors, the United States, Canada, France, Japan and the United Kingdom signed the International Forum Framework Agreement, in Washington. The thrust of the agreement was 'in developing systems for the generation of hydrogen as well as electricity.'[20]

The developing world has been projected as the largest market for the new generation reactors. Analysts alleged that in the name of Generation IV initiative, a label has been created 'to sell the illusion to the public that a completely new generation of reactors is being developed, which is free from all the problems which are plaguing current nuclear installations.' [21] It has also been reported that experts were not very enthusiastic on the new reactor concepts. According to them, a new nuclear power plant should be based on evolutionary, not revolutionary technology. They also cautioned against "too much innovation" which could lead to new problems with untested designs.[22]

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[16] Jefferson et al. 2005, Sustainable Energy – Choosing among Options, MIT

[17] Argentina, Brazil, Canada, France, Japan, Republic of Korea, South Africa, Switzerland, United Kingdom, United States

[18] The European Atomic Energy Community (Euratom) - set up in 1957 - is legally separate from the European Community (EC).

[19] Argentina, Armenia, Brazil, Bulgaria, Canada, Chile, China, Czech Republic, France, Germany, India, Indonesia, Republic of Korea, Pakistan, Russian Federation, South Africa, Spain, Switzerland, Netherlands, Turkey and the European Commission.

[20] Frogatt, 2005

[21] ibid

[22] ibid

The above analysis clearly indicates that the safety aspects of the existing and next generation nuclear reactors are not encouraging at all. The major findings of a widely cited study[23] titled 'Nuclear Reactor Hazards: Ongoing Dangers of Operating Nuclear Technology in the 21st Century', would substantiate this observation. To quote:

- 'All operational reactors have very serious inherent safety flaws which cannot be eliminated by safety upgrading;'

- 'A major accident in a light-water reactor – the majority of reactors operating worldwide – can lead to radioactive releases equivalent to several times the release at Chernobyl and about 1000 times that released by a fission nuclear weapon. Relocation of the population could be necessary for large areas (up to 100.000 km2). The number of cancer deaths could exceed 1 million;'

- 'The average age of the world's reactors is 21 years and many countries are planning to extend the lifetime of their reactors beyond the original design lifetime. This leads to the degradation of critical components and the increase of severe incidents and could lead to a major accident;'

- 'De-regulation (liberalization) of electricity markets has pushed nuclear utilities to decrease safety-related investments. Utilities are also upgrading their reactors, e.g. by increasing reactor pressure and temperature. This accelerates ageing and decreases safety margins. Nuclear regulators are not able to cope with this new reality;'

- 'Reactors cannot be sufficiently protected against a terrorist threat. There are several scenarios – aside from a crash of an airliner on the reactor building – which could lead to a major accident.'

- 'Highly radioactive spent fuel at reactor sites or reprocessing plants needs constant cooling. If this fails, this could lead to a major release of radioactivity, climate change impacts, such as flooding, sea level rise and extreme droughts seriously increase nuclear risks.'

The Johannesburg Plan of Implementation (JPOI) and the World Summit (2005) had argued for the need to integrate the three components of sustainable development- economic development, social development and environmental protection as interdependent and mutually reinforcing pillars. The Johannesburg Plan of Implementation (2002) had also called for an energy source that was "reliable, affordable, economically viable, socially acceptable and environmentally sound".[24] Nuclear energy undermines all these objectives.

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[23] Greenpeace, 2005

[24] Greenpeace 2006, May

Issue no 2: Global warming and nuclear energy

In early 1970s, developed countries (and their TNCs), lost their oligopolistic control on oil. Organization of the Petroleum Exporting countries (OPEC) power had changed the energy equations of the world. Till the late eighties, developed countries could not counter OPEC power mainly for two reasons: (i) major accidents in the nuclear plants – one in 1979 at the Three Mile Island (USA) and the other in 1986 at Chernobyl (USSR) halted the growth of nuclear energy which was projected, by a section of energy experts as a viable alternative to fossil fuel, (ii) The Soviet Union with its huge oil reserve was not prepared to align with non communist developed countries- most of which were NATO members.

In mid eighties, due to internal conflicts among OPEC member states, there was a glut in the world oil market and the price of crude remained very low. After the disintegration of Soviet Union, new oil barons of Russia and its previous allies, flooded the world oil market with huge supply of crude. Unrestrained supplies from the above sources had further loosened OPEC's grip on the crude supplies. After the Gulf War of 1990, OPEC had temporarily consolidated its control over production and supply. Crude price was moving towards north and was projected to reach to a record high of $21/barrel in 1992. US oil firms with their strong linkages with middle-east crude were also responsible for this rise in price.

The two major nuclear accidents within a span of seven years (1979 and 1986) had pushed the nuclear power to the back seat. In Europe strong anti nuke movement forced many countries to reconsider their ambitious nuclear energy plans. Moratorium on further expansions of nuclear plants was imposed. Moreover, the devastating impact of the Chernobyl disaster dampened the enthusiasm of nuclear lobby, which were in desperate search of some issues to bail them out of the mess. The apprehensions about the consequences of global warming solved their problem -at least temporarily.

The criticisms, which were usually labeled against nuclear energy, were then redirected against fossils fuel. Public opinions were built systematically to consolidate the position of nuclear energy as a 'green energy' in the context of global warming. The much-publicized Rio Earth Summit (1992), which passionately raised the global warming issue, had actually strengthened the hands of nuclear lobby. A vocal section of the media and opinion makers echoed the same arguments as put forward by the nuclear establishment. For example, in India, a renowned columnist had advocated, in a prestigious political magazine[25] of India, for considering nuclear energy in a 'big way'. Simultaneously, the Communist Party of India (Marxists) had also demanded (as early as 1992) a nuclear power plant in West Bengal- the state they were in power since 1977[26].

Major Beneficiaries:

[25] India Today June 15, 1992
[26] Dey, 1992

During last two decades, the 'global warming' and the 'climate change' issues have significantly influenced the political and business leaders across the globe. Some of them have successfully turned the 'apprehension' into an opportunity. The British strategy to combat this 'global crisis', as communicated recently by their Prime Minister is a case in point. According to him, the climate change has offered a 'great opportunity for Britain'. The environmental industry in Britain would employ one million people in next two decades from the current employment of four hundred thousand. It is reported that the Prime Minister had also expressed his determination to make Britain a world leader in the new 'technological revolution required to beat global warming.'[27] During last one decade, to 'cool' the 'hot air', the developed northern countries have created a global market for green and energy efficient technology. After the enactment of the Kyoto Protocol[28], these markets of 'cooling' and 'trading' of 'hot air' are growing at an exponential rate.[29] This new development is also reshaping the global investment pattern in the manufacturing sector. The carbon emission targets as fixed by the Kyoto Protocol are pushing the manufacturing activities to the southern countries. Thus the developing economies of the South are turning 'blue'[30] by absorbing the industrial toxics of the North.

In this climate change debate, the energy lobby, which desperately tried to take advantage of the situation, was the nuclear lobby. By engaging the proponents of new and renewable energy sources to fight a 'non-issue' like 'green nuclear power', the development of the alternative energy sources could be delayed. Till Johannesburg Earth Summit (2002), NGOs like Greenpeace International, HELIO International et al had to divert substantial part of their limited resources (both financial and intellectual) to counter the nuclear lobby's attempt to establish their credibility as a 'clean and green' energy source. During the 9th Session of the UN Commission of Sustainable Development (UN CSD-9) held in April, 2001, the HELIO International had to launch the 600+ NGOs petition to prevent nuclear energy from being accepted as 'clean' energy and therefore from entering in the clean development mechanism (CDM), as proposed in the Kyoto Protocol (KP).

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[27] http://www.guardian .co.uk/uklatest/story/0,,-7087921,00.html visited November 20, 2007

[28] The Kyoto Protocol is an agreement under which industrialized countries will reduce their collective emissions of greenhouse gases by 5.2% compared to the year 1990. The goal is to lower overall emissions of six greenhouse gases – carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, HFCs, and CFCs. Kyoto Protocol is underwritten by governments and is governed by global legislation enacted under the UN's aegis Governments. It is separated into two general categories: developed countries, referred to as Annex I countries (who have accepted GHG emission reduction obligations and must submit an annual greenhouse gas inventory); and developing countries, referred to as Non-Annex 1 countries (who have no GHG emission reduction obligations but may participate in the Clean Development Mechanism) Any Annex 1 country that fails to meet its Kyoto target would be penalized. (see Wikipedia)

[29] In 1999, the emission trading market was $50 billion, which is likely to reach $13 trillion by 2050. The World Bank had developed a prototype Carbon Fund even before finalization of Kyoto Rule Book to mobilize funds from Northern governments and corporations and pumps them into projects in Southern countries. Among the first investors in the Bank's Carbon Fund were the Dutch government and corporations such as Mitsubishi and Shell. See Corporate Europe Observatory (CEO), November, 2000.

[30] For a detailed discussion on this, please refer to my article 'SMEs: Rising Opportunities in the Emerging Blue Economy', published in October 2007 in the *International Edition* of the ***ie²*** - Magazine of the Engineering Export Promotion Council (EEPC), India . Also uploaded in http://hq.ssrn.com/ as a working paper (October 9, 2007).

It is interesting to note that in 2005, the year when the KP came into force, another attempt was made to establish nuclear energy as a major energy source by conferring the Nobel Peace prize jointly to El Baradei –the Chief of International Atomic Energy Agency (IAEA) and IAEA[31], for promoting peaceful use of atomic power. But the analyses of the competent authorities, such as the UK's Sustainable Development Commission (SDC) showed that nuclear power was a problem, not a solution. The SDC gave a unanimous 'no' to the question 'Is nuclear the answer to tackling climate change or energy security?' Their reasons included 'long-term waste, cost, inflexibility, undermining energy efficiency and international security issues, including accidents, terrorism and nuclear proliferation.'[32]

Due to strong resistance against the proliferation of nuclear energy in the northern countries, the epicenter of nuclear power has shifted to East and South-east Asia. USA along with Australia and Japan has formed the Asia Pacific Partnership on Clean Development and Climate (APPCDC) in January 2006. APPCDC, is an agreement between six Asian – Pacific nations namely Australia; Japan; China; India; South Korea and USA. The spoke person of APPCDC, after its first meeting at Sidney in January 2006, commented: "You have to accept that nuclear power plants, civil nuclear power plants are greenhouse friendly"[33], and after attending the meeting, the Indian Environment Minister suggested that " nuclear power should be used in India to promote our emission reduction."[34] It has been reported that in contrast with North America and most of Western Europe, where growth of nuclear power have leveled out for many years, the 'greatest growth in nuclear generation' in near future is expected in China, Japan, South Korea and India.[35] As of March 2006, the Nuclear Power Corporation of India Ltd (NPCIL), the sole utility implementing nuclear power projects in the country, had a total of 16 operational plants with a capacity to generate around 3,900MW electricity. Six more plants with a combined capacity of 3,000 MW were in an advanced stage of construction.[36]It has been already mentioned that the government of India has already made plans to set up around five new coastal nuclear power stations using high-end reactors of 1,000 MW and above.

All these debates, discussions and initiatives to combat 'global warming' could not achieve the desired objective of limiting carbon emission. The latest IPCC findings on climate change have reported substantial increase in the carbon emission levels. According to it, the annual growth rate of carbon-di-oxide concentration during the last ten years (1995-2005) was much higher (average: 1.9 ppm per year) than the growth rate (average: 1.4 ppm per year) during last 45 years (1960-2005)[37].

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[31] Dey Dipankar(2006), The Political Economy of Global Warming and its Changing Strategic Role, The ICFAI Journal of Environmental Economics, November, 2006

[32] Greenpeace, 2006, May

[33] CAN-Talk,2006

[34] ibid

[35] World Nuclear Association, 2007,Asia's Nuclear Energy Growth, February, http://www.world-nuclear .org

[36] The Hindu Business Line 27.11.06

[37] *Climate Change 2007: The Physical Science Basis, Summary for Policymakers…*

Issue no 3: Does India need nuclear energy?

In 2005, The Planning Commission of India had appointed a very high power committee the 'Expert Committee on Integrated Energy Policy' (Expert Committee) to recommend on the future of India's energy policy. The Committee has submitted its final report in August 2006. Assuming an 8% GDP growth per annum, the report predicted a very high share of coal in the energy mix in the year 2031-32. In that year, the share of coal in the energy mix in India was projected to range between 54.1% and 32% and the share of oil and gas would vary between 41.1% and 31.2%. The projected share of nuclear in 2031-32 ranged between 6.4% and 4%.

Before releasing their final report in August 2006, the Expert Committee had submitted a 'draft report' in December 2005. A comparative assessment of different composition of fuel mix in 2031-32 (assuming 8% GDP growth rate) as projected in the 'draft' and 'final' reports convey enough indication about the external pressure which might have influenced the policy recommendations of the Expert Committee while preparing the final report. The changes in the 'fuel mix' composition projecting the maximum and minimum range of the coal and nuclear energy's share in 2031-32 as documented in the 'draft' and 'final' report of the Expert Committee, is a case in point. (Ref: Table 1)

Table 1: Projected Fuel Mix (%) Scenario in 2031-32

Fuel Mix	Draft Report (Dec, 2005)		Final Report (Aug, 2006)	
Oil	28.0	29.0	25.7	22.8
Natural Gas	7.0	12.0	5.5	9.8
Coal	65.0	42.0	54.1	41.1
Hydro	0	4.0	0.7	2.2
Nuclear	0 (Min)	6.0 (Max)	4.0 (Min)	6.4 (Max)
Renewable	0	2.7	0.1	5.6
Non-Commercial	0	5.0	9.8	12.0
Total	100.0	100.0	100.0	100.0

Source: Planning Commission, 2005, 2006

The above table indicates two major changes in the 'Final Report' released in August 2006, compared to the 'Draft Report' released in December, 2005. (i) The 'draft report' projected a much higher share of coal in the future energy mix. The range was between 65% and 42.0%, and this was much higher as compared to the range between 54.1% and 41.1% in the 'final report'.(ii) In the 'draft report', the share of nuclear power in the projected energy mix of 2031-2032 ranged between 0% and 6%. But in the 'final report', this projected range has been increased to 4% and 6% respectively. This clearly indicates, energy experts appointed by the Planning Commission, believed (at least till December 2005) that for the next two and half decades the energy needs of India with a projected GDP growth rate of 8% per annum, could be managed without any contribution of nuclear energy. But in the 'final report', nuclear energy became an important contributor to the energy options projected by the same group of experts. The minimum share of

nuclear energy in the fuel mix' in 2031-32 as per different alternative projections made by them, was increased to 4% from 0%, as projected earlier in the 'draft report'.

The question naturally arises; what factors did compel these changes in the major policy recommendations within a span of eight months? The reasons could be the following:

The 'draft report' was prepared when Mani Shankar Aiyar was the Minister of Petroleum, Oil and Natural Gas. He initiated key negotiations with China, Iran and Pakistan to form Trans-Asian energy cooperation. Analysts claimed that due to his independent attitude, he earned the wrath of few western energy lobbies. A plan to pipe gas from Iran to India via Pakistan had particularly worried US policymakers. The Prime Minister of India acted promptly to allay their concerns by replacing this high profile and independent-minded petroleum minister, in January 2006, with a right wing politician. His sudden removal from the Ministry of Petroleum had raised suspicions in India about the Prime Minister's willingness to align his economic and foreign policy more closely with US interests. [38] As if to substantiate this, India, had voted against Iran in the General Assembly.

It was feared that the India – US deal on civilian nuclear program (entered into in March 2006) would accelerate the growth of nuclear energy and imported uranium might replace a good amount of indigenous coal as a feedstock for power generation.[39]

All these factors strengthened the apprehension that the strong policy recommendations of 'the draft report' on energy security would get diluted in the final report.[40] The apprehensions were proved right.

In the revised and final report, relatively more emphasis was laid on nuclear power though the country has enough non-nuclear energy options to meet the energy demands of its growing economy. More over, the Expert Committee had mentioned in its report that India was poorly endowed with uranium. Available uranium supply could fuel only 10,000 MW of the Pressurized Heavy Water Reactors (PHWR) – a second-generation CANDU reactor. Further, India was extracting uranium from extremely low-grade ores (as low of 0.1% uranium) compared to ores with up to 12-14% uranium in certain resources abroad. This made Indian nuclear fuel 2-3 times costlier than the international supplies. [41]Different studies[42] on the cost of atomic energy in India concluded that production cost of nuclear power significantly exceeded the price charged to the consumers. Nuclear energy was made to look competitive by extending huge subsidies to the production of 'heavy water'.

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[38]EIU Views wire Via Thomson Dialog News Edge COUNTRY BRIEFING, http://www.tmcnet.com/usubmit/2006/02/27/1412052.htm

[39] Dey, 2006a

[40] Dey 2006a

[41] Planning Commission, 2006

[42] See Ramana, 2007

India has substantial reserve of thorium. To use it as nuclear fuel, the fertile thorium has to be converted to fissile material. For this, the Indian government had envisaged a three-stage nuclear power program.[43] But the new nuclear program seems to have discarded these plans to indigenize India's nuclear program by relying more on imported fuel. Dependence on foreign countries for such a critical input will make the country's economy more vulnerable to external factors.

Section II

Alternative energy initiatives- a global perspective:

According to the *Renewable Global Status Report (2006 Update[44]),* a record investment of $38 billion occurred during 2005 in new renewable energy capacity. This was an increase from $30 billion in 2004. Germany and China were the investment leaders, who invested about $7 billion each, followed by the United States, Spain and Japan. The report also claims that after years of indecision, major economies across the globe have taken the initiatives to develop renewable energy sources and a section of the world leaders have started to realize that resources and efforts should be allocated for the development of the clean and renewable energy. These forms of energy have shown remarkable growth since 2000. The following data from the above source would substantiate the point.

- Solar hot water: existing capacity grew by 23 percent in China and reached record levels across Europe. Construction has begun in the United States and Spain on the world's first utility-scale solar thermal power plants in twenty years.

- Spain became the first country to mandate solar PV in new construction and the second country (after Israel) to mandate solar hot water in new buildings as a national policy.

- Initiatives for grid-connected solar PV multiplied, including California's new policy for a million solar roofs by 2017 and programs in several U.S. states as well as in Australia, China, and the EU.

- Germany leapt ahead of Japan in grid-connected solar PV, adding 600 megawatts (MW) in one year to achieve a higher cumulative capacity. The solar PV industry invested record amounts in new plant and equipment (about $6 billion).

- The bio-fuels industry invested more than $1 billion during 2005. A number of countries dramatically stepped up targets for bio-fuels and at least 10 states/provinces and six countries added blending mandates. Several EU countries enacted new bio-fuels tax exemptions.

[43] Planning Commission, 2006
[44] http://www.ren21.net/pdf/RE_GSR_2006_Update.pdf

- The United States was the leader in wind power additions for the first time since 1992. The wind industry continued international production expansion, including expansion in Australia and China.

The latest 'Renewables 2007: Global Status Report' as released by REN21[45] has claimed that multilateral agencies and private investors have been 'mainstreaming' renewable energy in their portfolios and many renewable technologies have captured the interest of the largest global companies. In 2006, the share of renewable energy in the global final energy consumption amounted to 18%. The share of nuclear energy was 3% and rest 79% was the share of fossil fuels. The corresponding shares in the generation of global electricity were: 18.4%; 14% and 67% respectively. Selected indicators as summarized in Table 2 indicate the high rate of growth of this sector.

Table2: Growth of renewable energy: select indicators

Select Indicators	***2005***	***2007(estimated)***
Investment in new renewable capacity (annual) $billion	40	71
Renewable power capacity (excl large hydro) GW	182	240
Wind Power Capacity GW	59	95
Grid connected solar PV capacity GW	3.5	7.8
Solar PV production (annual) GW	1.8	3.8
Biodiesel production (annual) billion liters	3.9	8
Countries with policy targets	52	66

Source: Renewables 2007: Global Status Report

The World Bank has claimed that the current share of renewable energy and energy efficiency projects in the World Bank Group's energy portfolio has risen to 37% as compared to just 14% in 1994.[46]

Table3: Top 5 countries in terms of existing capacity (as of 2006)

Country Rank	***Renewable power***	***Small hydro***	***Wind power***	***Biomass power***	***Geothermal power***	***Solar PV grid connected***
1stnd	China	China	Germany	USA	USA	Germany
2nd	Germany	Japan	Spain	Brazil	Philippines	Japan
3rd	USA	USA	USA	Philippines	Mexico	USA
4th	Spain	Italy	India	Germany	Indonesia	Spain
5th	India	Brazil	Denmark	Sweden	Italy	Netherlands

Source: Renewables 2007: Global Status Report

A resurgence of renewable energy is observed across all the major economies of the globe (ref to Table3).USA and China, two major consumers of fossil fuel have taken various initiatives to increase the supply of new and renewable energy. But compared to others, the initiatives taken in Europe especially in countries like Germany, Spain, Italy, and Netherlands to develop environmentally benign energy sources deserve special

[45] Visit http://www.ren21.net
[46] 'Germany in push to set G8 emission target', The Financial Times, April 13, 2007

mention. INFORSE (International Network for Sustainable Energy) has already prepared a research documents (Vision 2050) on projected energy mix of EU-25 for the year 2050 based on 100% renewable energy supply.[47]

In March 2006, the European Council had asked the European Commission to look into the option of a 15% renewable energy target for 2015. On December 14, the European Parliament took a resolution for a mandatory target for renewable energy's share of 25% of the over all energy consumption in 2020. Energy experts have predicted that with pro-active policy initiatives, in 2020, a 20% share of the renewable energy in the total energy consumption of EU would be a feasible target. The European Commission has also drawn a detailed road map to achieve that target.[48]

EU is seriously aiming towards a low CO_2 fossil fuel future through the development of clean coal technologies so that after 2020 "near zero emission" power generation can be systematically used in the EU and in the world. Coal is traditionally the key fossil fuel in power generation and by far the most carbon-intensive one. Carbon-di-oxide emitted from coal fired power generation represents 76% of emission from power generation and around 30% of total global emission of carbon di-oxide. But it can also contribute to the security of energy supply and the economy of the EU and the world. It is estimated that compared to the reserves for oil and gas which are expected to last for another 40 and 60 years respectively, at current rate of production, hard coal and lignite would last for another 200 and 130 years respectively. Improved technology with a capacity to reduce coal's harmful environmental effects would change the total energy equation of the globe. The owner of those new generation clean coal technologies would dominate the global energy market in future. Keeping this in mind, EU has envisaged an integrated technological solution combining efficiency improvement of the conversion cycle with the mechanism of 'carbon-di-oxide capture and storage (CCS). This 'Sustainable Coal Technologies' will enable EU to become the 'global leader in technology transfer projects in this area.'.[49]

Alternative energy options before India:

India is one of the few countries, which enjoy the distinction of maintaining a separate Ministry (Ministry of Non-Conventional Energy Sources- MNES), since early nineties, for the development of renewable energy. The performance of the ministry had been very poor since its inception[50]. Though the figures in the table 4 below look very impressive and the installed capacity of electricity production from different renewable sources add up to few thousand megawatts, it is difficult to find the actual production figures from the concerned ministry. Along with the figures on 'installed capacity', figures on 'actual production' would have served the purpose better. Compiling data from different international agencies, it was found that in 2002-03, electricity generated from different

[47] See, http://www.inforse.dk/europe/pdfs/Brochure_Vision_2050.pdf
[48] CEC, Renewable energy road map
[49] CEC, Commissions communications on sustainable…
[50] In 2006, the name of the ministry has been changed to Ministry of New and Renewable Energy Sources (MN&RES)

renewable energy sources amounted to 0.330 MTOE (million tone of oil equivalent). This was equivalent to only 0.10% of the total primary energy consumption of India in that year. Against a total generation of 536.8 billion kwh unit of electricity in 2002-03, the contribution of renewable sources were only 4.1 billion kwh.[51] The table 4 also indicates that the cost of production of solar photovoltaic was very high compared to other renewable sources like wind power.

Table 4: Cost of Generated Electricity from the Renewable Options

Source	Capital Cost (Millions of Rs/MW)	Estimated Cost of Generation Per Unit (Rs/kWh)	Total Installed Capacity(MW) (2003-04)
Small Hydro-Power	50.00-60.00	1.50-2.50	1601.62
Wind Power	40.00-50.00	2.00-3.00	2483.00
Bio-mass Power	40.00	2.50-3.50	234.43
Bagasse Cogeneration	30.5	2.50-3.00	379.00
Bio-mass Gasifier	10.94	2.50-3.50	60.20
Solar Photovoltaic	260.5	**15.00-20.00**	2.54
Energy from waste	25.00-100.00	2.50-7.50	41.43

Source: MNES, *New and Renewable Energy Policy Statement 2005*

India is probably the only nation where the concerned ministry, solely responsible for development of renewable energy sources, could project a lesser share of the same, while preparing plans for the future fuel-mix of the country. For the year 2021-22, the projected share of renewable, as the table 5 indicates, was reduced to 30.9% from the actual share of 33.52% in 2001-02. Moreover, unlike the developed economies, the share of renewable energy in India's total energy consumption look very high due to the dominance of traditional biomass in the total renewable sources. [52] The quality of renewable fuel thus remained very low in India.

Table 5: Fuel- mix in 2001-02 and Scenario for 2021-22

Fuel Type	2001-02, MMTOE*(%)	2021-22, MMTOE*(%)
Fossil Fuel-Total	285.81(65.30%)	595(66.85%)
Non-Fossil Fuel-Total	151.88(34.70%)	295(33.15%)
Renewable-Total	146.73(33.52%)	275(30.90%)
Grand Total	437.69(100.00%)	890(100.00%)

Source: MNES, *New and Renewable Energy Policy Statement 2005*

* Million metric tone of oil equivalent

[51] Dey 2006a

[52] The renewable sources here consist of hydro (1.73%); biomass (31.76%); wind (0.03%); solar and bio fuel (negligible). That year the total primary energy consumption in India amounted to 437.69 MTOE much higher than the figures mentioned in BP Energy Statistics. The differences in the consumption figures could be mainly due to the existence of large traditional sources like bio mass in the total primary energy mix. If we add the contribution of animal and human energy, the share of traditional source would be higher.

It was always claimed by the energy planners that India had a huge potential for renewable and alternative energy sources. In the absence of any concrete road map, the nation had to wait for the Greenpeace report 'Energy Revolution: A Sustainable Energy Outlook for India', released in April 2007, to assess its true potential. Commissioned by the European Renewable Energy Council[53], the report also provided for a practical blueprint for reducing India's carbon dioxide emissions by 4 per cent in the next 43 years while 'providing for a secure, affordable energy supply, maintaining steady economic development and without relying on hazardous nuclear technologies.'[54]

The energy scenario predicted in the Greenpeace report (ref: table 6 below) is very encouraging. By 2050, the share of renewable energy is expected to reach to 51% from the current 4% [55]and the share of nuclear is likely to decline to 0.2% from the current share of 2%.

Table 6; India's Energy Scenario

Energy Source	2007	2050*
Total installed capacity, GW	120	880
Oil, gas, coal	67%	34%
Large hydro	26%	11%
Renewable energy	4%	51%
Nuclear energy	2%	0.2%

*As projected in the Greenpeace Study. Source: The Telegraph, Kolkata, April 10, 2007

On June 30, 2008 the Prime Minister of India has released the National Action Plan on Climate Change.[56] The action plan focuses on Eight National Missions which will be pursued as key components of our strategy for sustainable development. These include National Missions on Solar Energy, on Enhanced Energy Efficiency, on Sustainable Habitat, on Conserving Water, on Sustaining the Himalayan Ecosystem, on creating a "Green India", on Sustainable Agriculture and finally, on establishing a Strategic Knowledge Platform for Climate Change. While releasing the document, the Prime Minister stated that 'Our vision is to make India's economic development energy-efficient. Over a period of time, we must pioneer a graduated shift from economic activity based on fossil fuels to one based on non-fossil fuels and from reliance on non-renewable and depleting sources of energy to renewable sources of energy.' [57] Though a section of media has hailed the action plan as a clear indication of shift in the future energy mix of the country from fossil to renewable forms of energy, it should be noted that out of eight missions as

[53] Nuclear or renewable, big powers do not want to loose any opportunity to tab the huge energy market of India.
[54] The Statesman, Kolkata, April 10, 2007
[55] This is in line with the figure quoted by President of India in his Independence Day (August 14, 2005) speech where he mentioned about the share of renewable in the total primary energy as 5%.see The Economist, September, 24, 2005
[56] See website of the Prime Minister's office, Govt of India.
[57] http://pib.nic.in/release/release.asp?relid=39898

identified in the action plan, baring the 'energy efficiency' mission, only one mission, the *National Solar Mission* is directly linked to the generation of renewable energy. It may also be noted that the document has been released at a time when the Ministry is desperately trying to complete the procedural issues related to 123 Nuclear Agreement with USA. It is also not clear why the government has planned a national mission on solar energy which till date is very expensive (almost ten times compared to small hydro and wind) in India. (Please refer to table 4). Moreover, in wind energy sector, already few Indian companies like Suzlon Energy[58], have achieved reasonable recognition in the global level. It is a mystery that the 'action plan' document is totally silent on other viable forms of renewable energy sources like bio-gas, small hydro, wind and. tidal energy. Hope, in near future the real reason behind this will be unveiled.

Bio-fuel and Tidal Energy:

Two alternative energy sources, which have attracted renewed attention across the globe in recent past, are: (a) bio-fuel, (b) energy from ocean and river currents. Unfortunately, India has failed to develop any concrete plan to harness these sources.

A section of intellectuals believe that the current century will swing back to 'biological economy'. 'The 20th century has been the age of hydrocarbon. The 21st –century should witness a rebirth of a carbohydrate economy', commented David Morris in the Carbohydrate Economy. [59] The shares of bio-fuel in the energy mix of the major economies of the world are growing. In 2005, global ethanol production increased to 33 billion liters, compared to 30.5 billion liters in 2004 growing at a rate of 8%. The growth rate of US production was 15% and EU grew by 70% in that period. But bio-diesel growth far outpaced that of ethanol. In 2005, the global production of bio-diesel reached to 3.9 billion litters from 2.1 billion litters in 2004.[60] Bio-fuel also attracts various criticisms. Major allegations against this energy sources are: destruction of forest for commercial production of bio-fuel (Indonesia); diverting agricultural land for bio-fuel production thus leading to food crisis (Mexico) and fueling social tension (Uganda). If properly planned, India can produce huge quantity of bio-fuel, avoiding above negative consequences.

Energy from ocean and river currents has remained almost totally un-recovered. No initiative has been taken by the Ministry of New and Renewable Energy Sources to make a proper assessment of its potential. A study by the Department of Trade and Industry, UK, estimated a global potential of 3,000 giga watts per day of electricity from ocean currents alone – excluding river currents. It was calculated that with the available technology, only 3% or 90 giga watts could be produced.[61] The invention of Gorlov

[58] See Dey & Nandi , Suzlon Energy: The Indian Multinational, Icfai Journal of Environmental Economics, November 2007
[59] As quoted in 'Bio-fuels for Our Future –A Primer'…
[60] Renewable Global Status 2006 Updates
[61] Davis J et al

Helical Turbine in the mid nineties (for detail, see box 1) had opened a new opportunity to harness electricity not only from ocean current but also from river currents. It was claimed that using this new turbine, electricity could be 'generated almost anywhere water flows- in man made canals, tidal straits, the open ocean, and un-impounded rivers'.[62]

Box 1: *New Technology for Tidal Energy and Low-head River Power*

- Alexander Gorlov designed a "no head" turbine at Northeastern University, which could capture energy from the flow of water without constructing dams. Gorlov started developing his turbine in 1993, and Northeastern patented it in 1994. Gorlov Helical Turbine (GHT) received the 2001 Thomas A. Edison Patent Award given by the American Society of Mechanical Engineers, which hailed the new turbines' potential 'to alleviate the world-wide crisis in energy'.
- Helical turbines allow unconfined tidal currents, ocean currents, and low-head river flows to be tapped, greatly increasing the locations and flows that can be used to generate electricity, without the negative environmental impacts of dams. Locations with adequate flows for these turbines can be found in many countries.
- Two experimental projects as below would illustrate the range of its potential applications:
- In Uldolmok Strait, South Korea, between Jindo Island and the mainland, tidal currents reach 13 knots. After an initial, successful test of two helical turbines in 2002, the Korean government has begun a second phase to produce a megawatt of power. It is estimated that thousands of such helical turbines could be used to tap the 3,600 megawatts of energy potential in the strait. On a small scale, a project in a tidal stream near the mouth of the Amazon River in Brazil generated power for a small isolated community. Villagers built the turbine and power system. The turbine blades were only imported.
- These two projects illustrated that clean energy could be produced at a large industrial scale using simple equipment. It could also be used on a small scale, and replicated in vast numbers of locations adapted to local conditions and energy needs.

Source :(i) Goreau et al, 2005,(ii) ES&T Online News: Creating electricity with un-dammed hydropower, January 8, 2004, (iii) Davis J, Spring 2005, Alexander's Marvelous Machine , OnEarth Magazine, NRDC.

The Uldolmok Channel pilot project in Korea was an accomplishment. Successful test was carried out in 2002 by the Korea Ocean Research and Development Institute (KORDI), using a 1m diameter Gorlov Helical Turbine (GHT) manufactured by GCK Technology Inc.It produced about 10kW in a 4 knot flow. As a result of this trial a larger GHT (2.2 m diameter) was designed and manufactured by GCK and successfully tested by KORDI in 2004.[63]

Korea has decided to exploit its vast potential of tidal power. Voith Siemens Hydro and Korea-based Renetec have established a joint venture in July 2007 to develop tidal current technology. The new company will produce and market tidal current turbines. Major shares (51%) of the joint venture will be owned by Voith Siemens. In contrast to

[62] ibid

[63] For detail, see the PPT on Tidal Energy by Goreau ,Kurth, Anderson and Gorlov., http://www.globalcoral.org/Tidal_Energy_Overview7.ppt

traditional hydro power plants, tidal current power plants do not need a dam to be constructed for generating electricity.[64]

India has huge potential to produce electricity from free flowing river water. At a time when the Garlov Helical Turbine (GHT) has created enormous enthusiasm amongst energy planners across the globe, in India, baring one state government (Assam)[65], no other state/organization has shown any interest in this novel technology of generating electricity. Instead of pleading for a mega nuclear plant in Haripur, the West Bengal Government should have asked the West Bengal Renewable Energy Development Agency (WBREDA) to explore the potential of generating electricity using this new turbine from the rivers and canals of Bengal specially in the Sunderban region which is famous for its mangroves and 'hungry tides'.[66]

Observations and conclusion:

The previous two sections have dealt in details with various energy options which are available before policy makers of a vast emerging economy like India. All the arguments made by the proponents of mega nuclear plants could be negated with substantial evidences. But in near future, most of the new nuclear power plants are expected to be constructed in Asia.

It has also been observed that since 2002 (Johannesburg Earth Summit), the importance of renewable energy sources in the energy mix of the major economies have been increasing. Apprehending the extreme consequences of global warming, environmentalist and civil society organizations world over have demanded for more environmentally benign energy supplies. This 'demand pull factor' has definitely increased the importance of renewable energy sources.

But few important questions have emerged out of this discussion. First, why has the Indian state aligned itself with the nuclear establishment without fully exploiting other alternative energy sources? It would be naïve to believe that the political establishments were not aware of these negative consequences of nuclear power. Second, would the state be able to sustain this alliance in the long run? Third, is there any 'supply push factor' along with the already identified 'demand pull factor', behind this resurgence of renewable energy? Fourth, could this resurgence of renewable energy be an outcome of a new strategic move by the major energy utilities to manage the energy system of 21st century in a different way?

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[64] JV Forms to Develop Tidal Current Turbines in South Korea, July 27, 2007, http://www.renewableenergyworld.com/rea/news/story?id=49458

[65] Referring to the Helical Turbine, the Minister of State for Power, Industry and Commerce, Pradyut Bordoloi, stated that the 'State's future energy needs could be met by a technological breakthrough that has helped Brazil and South Korea to generate electricity from rivers flowing in plains.' See The Assam Tribune, Gauhati, March 18, 2007, http://www.assamtribune.com/scripts/details.asp?id=mar1807/at02

[66] Courtesy Amitava Ghosh's famous novel 'The Hungry Tides'

To get a clear picture of the emerging paradigm shift in the management of energy services in the 21st century, elaborate analyses of the above questions are essential. However, this is beyond the scope of this study.

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