International Journal of Energy Science and Engineering
Vol. 1, No. 2, 2015, pp. 31-39
http://www.publicscienceframework.org/journal/ijese
ISSN: 2381-7267 (Print); ISSN: 2381-7275 (Online)

India's Strategy Toward Energy Development and Energy Security -Challenges and Opportunities

Chanchal Kumar*

Department of Political Science, Janki Devi Memorial College, University of Delhi, India

Abstract

Energy is the prime mover of a country's economic growth. In the last decade India has been one of the most developing countries of the world with an average GDP growth of around 6% and around 8% in last couple of years. With the growing GDP of 8%, India is moving parallel to China in terms of development, but the energy consumption is catching up as well. But the country is finding it increasingly difficult to source all the oil, natural gas, and electricity it needs to run its booming factories, fuel its cars, and light up its homes. According to a report by IEA (International Energy Agency), India needs to invest a total of 800 billion dollars in various stages by 2030 to meet its energy demand. India accounts to around 2.4% of the annual world energy production, but on the other hand consumes 3.3% of the annual world energy supply. And this imbalance is estimated to surpass Japan and Russia by 2030 placing India into the third position in terms of annual energy consumption. Therefore, after summing up all the energy issues, energy security has been identified as the only tool to overcome the energy concerns.

Keywords

Nuclear Energy, Energy Security, India

Received: March 16, 2015 / Accepted: March 28, 2015 / Published online: March 30, 2015

1. Introduction

Energy is the prime mover of a country's economic growth. Availability of energy with required quality of supply is not only key to sustainable development, but the commercial energy also have a parallel impact and influence on the quality of service in the fields of education, health and, in fact, even food security. In the last decade India has been one of the most developing countries of the world with an average GDP growth of around 6% and around 8% in last couple of years. With the growing GDP of 8%, India is moving parallel to China in terms of development, but the energy consumption is catching up as well. But the country is finding it increasingly difficult to source all the oil, natural gas, and electricity it needs to run its booming factories, fuel its cars, and light up its homes. According to a report by IEA (International Energy Agency), India needs to invest a total of 800 billion dollars in various stages by 2030 to meet its energy demand. India accounts to around 2.4% of the annual world energy production, but on the other hand consumes 3.3% of the annual world energy supply. And this imbalance is estimated to surpass Japan and Russia by 2030 placing India into the third position in terms of annual energy consumption. Therefore, after summing up all the energy issues, energy security has been identified as the only tool to overcome the energy concerns.

India boasts a quickly advancing and active nuclear power program. It is expected to have 20 GW of nuclear capacity by 2020, though they currently stand as the 9th in the world in terms of nuclear capacity. An Achilles heel of the Indian nuclear power program, however, is the fact that they are not signatories of the Nuclear Non-Proliferation Treaty. This has

* Corresponding author
E-mail address: drchanchal17@yahoo.co.in

many times in their history prevented them from obtaining nuclear technology vital to expanding their use of nuclear industry. Another consequence of this is that much of their program has been domestically developed, much like their nuclear weapons program.

2. India's Nuclear Energy Power Program

Without adequate and affordable energy to underpin the economic growth of a country, its sustenance and indeed its very survival is at risk. Given the fact that energy is simultaneously (either implicitly or explicitly) linked to maintaining social cohesion, the economic well-being of a country and the military might of a state, it is considered to be the sine qua non of national security. To that extent therefore, all states, whether developed or developing, rising or declining, energy producing/exporting or energy importing, need energy to survive. Energy therefore is an incredibly important component of national security; understood here both in the traditional and non-traditional sense, where the state and the individual are referents, respectively. However, beyond the fact that energy matters to all states alike in the international system, there are glaring differences in how and when energy becomes a grave security concern for states; what aspect of energy is of more relevance and hence of concern to states; and the strategies that states have at their disposal to manage their energy-related insecurities. These differences largely depend on the resources and capabilities states have at their disposal to address their energy security concerns.

The Indian program began even before India achieved its independence, largely through the efforts of Homi J. Bhabha. Bhabha and other Indian scientists persuaded Jawaharlal Nehru that nuclear energy was an area where India had a comparative advantage. It had the nuclear scientists and vast deposits of thorium, a potential source of fissile material. India is both a major energy producer and a consumer. It currently ranks as the world's 7th largest energy producer, accounting for about 2.49 per cent of the world's total annual energy production. It is also the world's 5th largest energy consumer, accounting for about 3,45 per cent of the world's total annual energy consumption. However, owing to its massive population-estimated presently at 1.2 billion which accounts for 16.4 per cent of world population-India's per capita energy consumption is one of the lowest in the world.

India has only 0.4 per cent of the world's total oil reserves, with a reserve to production (R/P) ratio of 21.1 years. While it produces 35.4 million tonnes (mt) or 0.9 per cent of the world's total oil production, it consumes 3.8 per cent or 148.5 mt of oil, making it the world's fourth largest oil consumer. India depends on imported oil for up to 70 per cent of its demand. This dependence is expected to go up to 90 per cent by 2025. With regard to natural gas, its reserves stand at 1.12 trillion cubic metres (0.6 per cent of the world's proven reserves) with and R/P ration of 28.4 years. Currently, India produces only 39.3 billion cubic metres (bcm). However, India's gas demand is set to touch 280 million metric standard cubic metres per day (mmscmd) by 2011-12, which would account for 14 per cent of India's overall energy mix by 2012 form the current level of 10.5 per cent. India's total coal reserves are around 58,600 mt. Incidentally; India is not a very energy resource rich country. Currently, the India's energy resource base status suggests the optimal mix of all the available energy resources to meet its growing demand of electricity which is projected to be about 800GWe by 2032 and 1300GWe by 2050.

With the operation of Kaiga nuclear power reactors, India became sixth in the world to have 20 or more nuclear reactors under operation. Despite the increase of both ranking and the number of reactors, the contribution of nuclear power in generating electricity is still very limited. Lack of cooperation with other countries and limited uranium reserves of low quality are the main reasons behind the poor show.

The Indian nuclear programme was conceived based on, unique sequential three-stages and associated technologies essentially to aim at optimum utilization of the indigenous nuclear resource profile of modest Uranium and abundant Thorium resources. This sequential three-stage program is based on a closed fuel cycle, where the spent fuel of one stage is reprocessed to produce fuel for the next stage. The closed fuel cycle thus multiplies manifold the energy potential of the fuel and greatly reduces the quantity of waste generated.

The first stage comprises of Pressurized Heavy Water Reactors fuelled by natural uranium. Natural uranium contains only 0.7% of Uranium-235, which undergoes fission to release energy (200Mev/atom). The remaining 99.3% comprises Uranium-238 which is not fissile however it is converted in the nuclear reactor, to fissile element Plutonium- 239. In the fission process, among other fission products, a small quantity of Plutonium-239 is formed by transmutation of Uranium-238.

The second stage, comprising of Fast Breeder Reactors (FBRs) are fuelled by mixed oxide of Uranium-238 and Plutonium-239, recovered by reprocessing of the first stage spent fuel. In FBRs, Plutonium-239 undergoes fission producing energy, and producing Plutonium-239 by transmutation of Uranium-238. Thus the FBRs produce energy and fuel, hence termed Breeders. FBRs produce more fuel than they consume. Over a period of time, Plutonium inventory can be built up by feeding Uranium-238.

In the third Stage advanced nuclear power reactors are built which use thorium as a fuel. This stage will kick when sufficient plutonium has been bred in the second stage. In the third stage the uranium blankets in the previous stage are replaced by blankets of natural thorium. This will produce fissile uranium-233. The uranium-233 so produced will act as a fuel for the fast neutron breeding reactors.

In the second stage, once sufficient inventory of Plutonium-239 is built up, Thorium232 will be introduced as a blanket material to be converted to Uranium-233. The status of the first, second and third stages of the nuclear power programme, as per the DAE annual report 2009-10, is as follows:

PHWRs and Light Water Reactors (LWRs): India has currently 20 reactors including two boiling water reactors. Together they have an installed capacity of 4,780 MWe. Six projects are under construction.

FBRs: A 500 MWe Prototype Fast Breeder Reactor (PFBR), being constructed at Kalapakkam, is nearing completion. This will set the stage for the commercial installation of fast breeder reactors in India, the mainstay of the second stage. At Bhabha Atomic Research Centre (BARC), experiments on u-30 per cent Plutonium mixed oxide fuel have been carried out. Substantive burnout rates have been achieved. Two FBRs (1000 MWe) might be constructed in the next eight years. Pre-project activities have been approved. According to S. Banerjee, the chairman of the DAE, the 500 MWe PFBR is at an advanced stage of construction. The spent mixed carbide fuel form the Fast Breeder Test Reactor (FBTR) with a burn-up of 155 GWd/t was reprocessed in the KAE'S Compact reprocessing facility for Advance fuels in Lead cells (CORAL). Thereafter, the fissile material was refabricated as fuel and loaded back into the reactor, thus 'closing' the fast reactor fuel cycle.[1]

Thorium-based reactors: Thorium reactors are still at an experimental stage. It will be a while before appropriate designs are evolve, tested and commercialised, and it could take several decades. A 300 MWe Advance Heavy Water Reactor (AHWR) is being developed at Trombay. Work is continuing on fuel design, safety features and evaluation of the candidate sites for the AHWR. According to the DAE annual report 2009-2010, a newer version of AHWER(AHWER-LEW)- that uses low enriched uranium along with thorium as fuel-has been designed. The newer design will have a much lower requirement of mined uranium per unit of energy produced as compared to most of the current generation thermal reactors.

Presently India produces 150,323.41 megawatt of electricity.[2] Of this staggering 96,044. 74 MW (64.6%) comes from thermal [that includes coal, gas and oil]; 36,916.76 MW (24.7%) from hydro; 4,120 MW (2.9%) from nuclear; and 13,242.41 MW (7.7%) from renewable sources. However, India is envisaging increasing the contribution of nuclear power to overall electricity generation capacity to 9% within 25 years. In 2011, India's installed nuclear power generation capacity is likely to increase to 6,000 MW. Experts say that India plans to produce 20,000 MW by 2020 and if everything goes smoothly with Indo-US nuclear deal, it can even produce an additional 25,000 MW by the same year. The country presently has 17 nuclear power plants and six more are under construction with a total capacity of 3,160 MW. Several others are under the various stages of planning.

At present, India has about 54,000 Megaton (MT) of developed uranium reserves with a processing capacity of about 220 MT per year. Another 23,000 MT can be developed but is facing environmental assessment as well as local opposition. However, India's thirteen reactors alone need about 300 MT per year. This has resulted in its nuclear plants running at reduced plant capacity factors from 90 percent in 2003 to 81 percent in 2004 to 76 percent in 2005. Therefore, the successful conclusion of the civilian nuclear with the United States would result in more uranium imports to keep these plants running.[3]

Despite repeated commitments in the past, currently India's nuclear power generation capability stands at around 3,300 megawatts. With the successful implementation of the civil nuclear initiative, the Indian nuclear power capacity is projected to generate 10,000 MWs, 20,000 MWs, and 150,000 MWs by 2010, 2020 and 2050 respectively. The more India cooperates with nuclear energy and fuel-supplying countries, the easier will be for India to produce more nuclear power to meet its growing energy security challenges. Achieving the projected target would require transfer of tons of uranium from other supplier countries because the uranium available in our country is of low quality. Besides exchange of technology and fuel for nuclear power generation, there would also be cooperation for clean-coal with other countries.[4]

Table 1. India's operating nuclear power reactors

Reactor	State	Type	MWe net, each	Commercial operation	Safeguards Status
Tarapur 1& 2	Maharashtra	BWR	150	1969	Item-specific
Kaiga 1&2	Karnataka	PHWR	202	1999-2000	-
Kaiga 3&4	Karnataka	PHWR	202	2007,2012	-
Kakrapar 1&2	Gujarat	PHWR	202	1993-95	Dec. 2010 under new agreement

Reactor	State	Type	MWe net, each	Commercial operation	Safeguards Status
Madras 1&2(MAPS)	Tamil Nadu	PHWR	202	1984-86	
Narora 1&2	Uttar Pradesh	PHWR	202	1991-92	In 2014 under new agreement
Rajasthan 1	Rajasthan	PHWR	90	1973	Item-specific
Rajasthan 2	Rajasthan	PHWR	187	1981	Item-specific
Rajasthan 3 & 4	Rajasthan	PHWR	202	1999-2000	Early 2010 under new agreement
Rajastha 5& 6	Rajasthan	PHWR	202	Feb & April 2010	Oct 2009 under new agreement
Tarapur 3& 4	Maharashtra	PHWR	490	2006, 05	
Total (20)			4385 MWe		

Source: http://www.npcil.nic.in/main/All Project Operation Display.aspx (accessed December 26, 2010)
Madras (MAPS) also known as Kalpakkam, Rajasthan/RAPS is located at Rawatbhata and sometimes called that Kaiga = KGS, Kakrapar = KAPS, Narora = NAPS

The Atomic Energy Establishment was set up at Trombay, near Mumbai, in 1957 and renamed as Bhabha Atomic Research Centre (BARC) ten years later. Plans for building the first Pressurised Heavy Water Reactor (PHWR) were finalised in 1964, and this prototype - Rajasthan-1, which had Canada's Douglas Point reactor as a reference unit, was built as a collaborative venture between Atomic Energy of Canada Ltd (AECL) and NPCIL. It started up in 1972 and was duplicated Subsequent indigenous PHWR development has been based on these units, though several stages of evolution can be identified: PHWRs with dousing and single containment at Rajasthan 1-2, PHWRs with suppression pool and partial double containment at Madras, and later standardized PHWRs from Narora onwards having double containment, suppression pool, and calandria filled with heavy water, housed in a water-filled calandria **V** The two Tarapur 150 MWe Boiling Water Reactors (BWRs) built by GE on a turnkey contract before the advent of the Nuclear Non-Proliferation Treaty were originally 200 MWe. They were down-rated due to recurrent problems but have run well since. They have been using imported enriched uranium and are under International Atomic Energy Agency (IAEA) safeguards.

Following the Fukushima accident in March 2011, four NPCIL taskforces evaluated the situation in India and in an interim report in July made recommendations for safety improvements of the Tarapur BWRs and each PHWR type. The report of a high-level committee appointed by the Atomic Energy Regulatory Board (AERB) was submitted at the end of August 2011, saying that the Tarapur and Madras plants needed some supplementary provisions to cope with major disasters. The two Tarapur BWRs have already been upgraded to ensure continuous cooling of the reactor during prolonged station blackouts and to provide nitrogen injection to containment structures, but further work is recommended. Madras needs enhanced flood defences in case of tsunamis higher than that in 2004. The prototype fast breeder reactor (PFR) under construction next door at Kalpakkam has defences which are already sufficiently high, following some flooding of the site in 2004.

3. Future Plans and Projections

DAE/NPCIL vision is to achieve 20,000 MWe by the year 2020. The XI Plan proposals envisage setting up of 8 indigenously designed 700 MWe PHWRs, and 10 Light water Reactors of about 1000 MWe each, based on imports. In addition pre-project activities for setting up of 4 FBRs and an Advanced Heavy Water Reactor (AHWR) are also planned to be taken up in the XI Plan (2007-2012). The 4 FBRs will be taken up in the XII Plan (2012-2017). Larger capacity Nuclear Power Plants can be set up based on imports, subject to developments on international cooperation.

The possible nuclear power capacity beyond 2020 has been estimated by Department of Atomic Energy (DAE). In energy terms, the Integrated Energy Policy of India estimates share of nuclear power in the total primary energy mix to be between 4.0 to 6.4% in various scenarios in the year 2031-32. The study by the Department of Atomic Energy (DAE), estimates the nuclear share to be about 8.6% by the year 2032 and 16.6% by the year 2052.[5]

The Tarapur 3&4 reactors of 540 MWe gross (490 MWe net) were developed indigenously from the 220 MWe (gross) model PHWR and were built by NPCIL. Tarapur 3 & 4 cost about $1200/kW, and are competitive with imported coal. Future indigenous PHWR reactors will be 700 MWe gross (640 MWe net). The first four are being built at Kakrapar and Rajasthan. They are due on line by 2017 after 60 months construction from first concrete to criticality. Cost is quoted at about Rs 12,000 crore (120 billion rupees) each, or $1700/kW. Up to 40% of the fuel they use will be slightly enriched uranium (SEU) - about 1.1% U-235, to achieve higher fuel burn-up - about 21,000 MWd/t instead of one third of this. Initially this fuel will be imported as SEU.

Table 2. India's nuclear power reactors under construction

Reactor	Type	MWe gross, net, each	Project control	Construction Start	Commercial operation due	Safeguards Status
Kudnkulam 1	PWR (VVER)	1000, 950	NPCIL	March 2002	3/2012 but delayed	Item-specific
Kudankulam 2	PWR (VVER)	1000, 950	NPCIL	July 2002	6/2012 but delayed	Item-specific
Kalpakkan PFBR	FBR	500, 470	Bhavini	Oc 2004	2013	-
Kakrapar 3	PHWR	700, 630	NPCIL	Nov 2010	June 2015	-
Kkrapar 4	PHWR	700, 630	NPCIL	March 2011	Dec 2015	
Rajasthan 7	PHWR	700. 630	NPCIL	July 2011	Dec 2016	
Total (6)		4260 MWe net, 4600 MWe gross				

Source: http://www.npcil.nic.in/main/ProjectConsturtionStatus.aspx (Accessed December 26, 2011)

Kaiga 3 started up in February 2007, was connected to the grid in April and went into commercial operation in May 2007. Unit 4 started up in November 2010 and was grid-connected in January 2011, but is about 30 months behind original schedule due to shortage of uranium. The Kaiga units are not under UN safeguards, so cannot use imported uranium. Rajasthan-5 started up in November 2009, using imported Russian fuel, and in December it was connected to the northern grid. RAPP-6 started up in January 2010 and was grid connected at the end of March. Both are now in commercial operation.

In mid-2008 Indian nuclear power plants were running at about half of capacity due to a chronic shortage of fuel. The situation was expected to persist for several years if the civil nuclear agreement faltered, though some easing in 2008 was due to the new Turamdih mill in Jharkhand state coming on line (the mine there was already operating). Political opposition has delayed new mines in Jharkhand, Meghalaya and Andhra Pradesh.

A 500 MWe prototype fast breeder reactor (PFBR) is under construction at Kalpakkam near Madras by BHAVINI (Bharatiya Nabhikiya Vidyut Nigam Ltd), a government enterprise set up under DAE to focus on FBRs. It was expected to start up about the end of 2010 and produce power in 2011, but this schedule is delayed significantly. Construction was reported 81% complete at the end of November 2011. Four further oxide-fuel fast reactors are envisaged but slightly redesigned by the Indira Gandhi Centre to reduce capital cost. One pair will be at Kalpakkam, two more elsewhere.

According to S.K. Jain, (7th September 2011) the chairman and managing director of the NPCIL:

> *"With the commissioning of Kaiga- 4 (220 MW) during the year, the number of Nuclear Power Reactors in operation in the country has increased to 20 with a total installed capacity of 4,780 MW including RAPS-1 (100 MW) owned by the Government and operated by NPCIL. With this NPCIL has placed India among top six countries of the world which operate 20 or more reactors. As per separation plan, Nuclear Power Plants RAPS-3&4, RAPS-5&6, KAPS-1&2, were brought under IAEA safeguards domain making it possible to fuel them with imported fuel. With this effort, now operating reactors under safeguards are operating at 100% full power, whereas remaining 10 reactors were operating at 70% full power average."*[6]

Following the Nuclear Suppliers Group agreement which was achieved in September 2008, the scope for supply of both reactors and fuel from suppliers in other countries opened up. Civil nuclear cooperation agreements have been signed with the USA, Russia, France, UK, South Korea and Canada, as well as Argentina, Kazakhstan, Mongolia and Namibia. Between 2010 and 2020, further construction is expected to take total gross capacity to 21,180 MWe. The nuclear capacity target is part of national energy policy.

Table 3. Power reactors planned or firmly proposed

Reactor	State	Type	MWe gross. each	Project control	Start Construction	Start operation
Rajasthan 7	Rajasthan	PHWR	700	NPCIL	Dec 2010	June 2016
Rajasthan 8	Rajasthan	PHWR	700	NPCIL	2011	Dec 2016
Kudankulam 3	Tamil Nadu	PWR-AES 92 or AES-2006	1050-1200	NPCIL	6/2011	2016
Kudankulam 4	Tamil Nadu	PWR- AES 92 or AES- 2006	1050-1200	NPCIL	2012?	2017
Jaitapur 1& 2	Maharashtra	PWR-EPR	1700	NPCIL	2013	2018-19
Kaiga 5 & 6	Karnataka	PWR	1000/1500	NPCIL	2012	2019-21
Kudankulam 5 & 6	Tamil Nadu	PWR-AES 92 or AES-2006	1050-1200	NPCIL	2014	-

Reactor	State	Type	MWe gross. each	Project control	Start Construction	Start operation
Kumharia 1-4, Fatehabad	Haryana	PHWRX x 4	700	NPCIL or NPCIL-NTPC	2012?	
Bargi 1& 2	Madhya Pradesh	PHWR x 2	700	NTCIL or NPCIL-NTPC	2012?	2019-21
Kalpakkan 2& 3	Tamil Nadu	FBR x 2	500	Bhavini	2014	2019-20
Subtotal Planned		17 units	15,000-16,600 MWe			

Source: http://www.npcil.nic.in/main/ProjectConsturtionStatus.aspx (Accessed December 26, 2011)

NPCIL had meetings and technical discussions with three major reactor suppliers - Areva of France, GE-Hitachi and Westinghouse Electric Corporation of the USA for supply of reactors for these projects and for new units at Kaiga. NPCIL said that "India is now focusing on capacity addition through indigenisation" with progressively higher local content for imported designs, up to 80%. Looking further ahead its augmentation plan included construction of 25-30 light water reactors of at least 1000 MWe by 2030. Early in 2012 NPCIL projections had the following additions to the 10.08 GWe anticipated in 2017 as "possible": 4.2 GWe PHWR, 7.0 GWe PHWR (based on recycled U), 40 GWe LWR, 2.0 GWe FBR.

4. Challenges for India's Energy Policy

India is severely energy deficient—more than half its rural households are resigned to darkness after sundown; cities suffer long and frequent power cuts. Per capita power availability in India at 631 kilo watt hour (kWh) is way below the world average.[7] This compares poorly with global statistics of 17,179 kWh in Canada, 13, 338 kWh in USA, or 5,644 kWh in Italy, and even 1,300 kWh in China.[8]

It is imperative for the government to pay adequate attention to the overall picture of sources of energy available to the country and their advantages and limitations. For instance, it would be counter-productive for the nation to solely invest in those energy sources which do not come with the assurance of secure supplies, or those that raise national vulnerability by increasing dependence on unreliable and unstable supplier nations, or cause significant environmental pollution. Therefore, the energy demands need to be met through safe, reliable, secure, and environmentally sustainable fuel sources. This obviously calls for a diversification of energy sources. At the moment, India draws the bulk of its electricity from thermal sources, especially coal. In fact, 55 per cent of the country's total commercial energy need is met by coal-fuelled electricity generation. Hydro power comes a distant second at about 25 per cent, and then renewable sources provide another small share of the electricity at about 15 per cent. Nuclear reactors provide 3 per cent of the total electricity generation. Despite its rather meagre contribution, nuclear energy holds substantive promise from the perspective of meeting India's humungous energy needs in a secure and sustainable low carbon way.

Measures need to be initiated for reducing the energy intensity in different sectors through changes in technology and processes. Inter-fuel and intra-fuel substitution will have to be optimised. Emphasis has to be placed on maximising the use of renewable sources of energy, with affordable cost, by low income groups in rural and urban areas. Research and development (R&D) efforts are needed in a number of areas to augment energy resources and provide cleaner energy. Considering the threat of climate change and the need to find clean sources of energy, a rigorous R&D programme should be encouraged for the development of new sources, more efficient utilisation and improvement in efficiency applications.

Nuclear safety and security must remain topmost priority for the nuclear establishment. It cannot afford an accident of any sort. Investment in R&D in the third stage of the nuclear programme that will enable the utilization of indigenous thorium should be accelerated so that uranium dependency can be obviated in the future. Greater public awareness on the merits of nuclear energy in India's energy mix must be generated. While none can deny the risks involved in nuclear fission, the investments made in the safety processes and regulatory procedures to minimize these must be adequately brought out. The government must also encourage transparency in calculating the costs of nuclear electricity generation, which ample studies have proven is cost competitive in many scenarios.

In any deposit of uranium in the earth's crust, the natural decay of the mineral through radioactivity produces a radioactive gas called radon. When inhaled, the gas produces its own decay products called "radon daughters." They emit alpha radiation. If these particles become lodged in lung tissue, they can, over a period of several years, cause cancers. The miners were told not to worry unduly about the gas. Their employers advised them, erroneously, that an hour after they had finished work all the radioactivity would have cleared from their lungs. Dr. Kalam in his Special Essay in

The Hindu (Nov 6, 2011) gives a narrative of how he happened to witness personally, while he was President of India, the misery of people living near Jharia coal fields in Jharkhand and the havoc the coal mining has caused to the humans and other forms of life in that place.[9]

In their affidavit in reply before the Bombay High Court in a Public Interest Petition, the Indian Department of Atomic Energy (DAE) admitted that radiation is found in the fish and marine organisms in Thane Creek, but the actual levels of radiation cannot be disclosed in public interest. Located on the edge of Thane creek in the thickly populated Mumbai, is the Bhabha Atomic Research Centre (BARC) which has been discharging its nuclear effluents into the Thane creek for over forty years, thereby contaminated the creek from where fish is regularly caught and sold in the market.

In another Public Interest Petition before Bombay High Court, a social organisation named "Citizens for A Just Society" founded by noted Gandhian, and Freedom Fighter, Dr. Usha Mehta sought disclosure of at least the 90 nuclear issues concerning the nuclear power plants in India compiled by Atomic Energy Regulatory Board (AERB) in its Report titled "Safety Issues in DAE Installations" which listed 135 nuclear issues in all the nuclear establishments. There were six massive affidavits in reply filed by the Department of Atomic Energy (DAE) and Bhabha Atomic Research Centre (BARC) opposing the Public Interest Petition. An additional affidavit was filed by Dr. R. Chidambaram himself as the then Chairman of Atomic Energy Commission (AEC) and Secretary Department of Atomic Energy (DAE) claiming 'secrecy' and 'privilege' and blocked the disclosure of the AERB Report including the 90 issues pertaining to nuclear power plants. Dr. Chidambaram is the present Indian Government's principal scientific adviser.

5. Opportunities for India's Nuclear Energy

India has announced ambitious plans to expand its nuclear energy programme nearly 15 fold in the next 20 years, form the current 4,500 MWe to about 62,000 MW3 by 2032. By 2020, India's Department of Atomic Energy (DAE) plans to install 20,000 MWe of nuclear power generation capacity (the fifth largest in the world). The department has plans beyond 2030 too. According to these plans India will have the capacity to produce 275 GWe (Giga Watt of electricity) of nuclear power by the 2052. This is a truly ambitious plan. Without sufficient quantities of energy, India cannot hope to become a global power. Currently nuclear energy constitutes only about three per cent of the total energy consumed in India. If the current projections are realised, the share of nuclear energy in the total energy output will still be about 20 per cent. India takes pride in its nuclear programme. Over the years, successive governments have fully supported the DAE's plans. This support is likely to continue in the future. India is now getting integrated into the global nuclear regime even though it has not signed the Nuclear Non Proliferation treaty (NNPT). The NSG waiver has, however, allowed India to enter into civil nuclear cooperation with several countries.

According to Kalam and Prime Minister Manmohan Singh, "we should not miss the opportunity to prosper from nuclear power, lest we should pay in the future heavy cost for missing it. This is at best an academic proposition not applicable to India. India is already paying heavily for placing undue importance on the nuclear power. The geographic location of India makes it a strong candidate for harnessing solar energy. But we are missing it because maximum chunk of our energy budget goes to nuclear power."

India is blessed with immense amount of hydro-electric potential and ranks 5th in terms of exploitable hydro-potential on global scenario with economically exploitable hydro-power potential to the tune of 1, 48, 700 MW. The basin/rivers wise assessed potential Indus Basin (33,832 MW), Ganga Basin (20,711 MW), Central Indian River system (4,152 MW), Western Flowing Rivers of southern India (9,430), Eastern Flowing Rivers of southern India (14,511 MW), Brahmaputra Basin (66,065 MW) with a total of 1, 48,701 MW. In addition, 56 number of pumped storage projects have also been identified with probable installed capacity of 94 000 MW. In addition to this, hydro-potential from small, mini & micro schemes has been estimated as 6 782 MW from 1 512 sites. Thus, in totality India is endowed with hydro-potential of about 2 50 000 MW. However, exploitation of hydro-potential in India has not even crossed 20%. It is so, because the energy budget of India is heavily loaded in favour of nuclear power.

Dr. Srikumar Banerjee Chairman, Atomic Energy Commission & Secretary to Government of India, Department of Atomic Energy, sum up the Indian situation (28^{th} October, 2011) in the following words:

> *"The nuclear power generation during the year recorded an increase of about 40% over the previous year due to increased fuel availability, both indigenous and imported. In particular, the average capacity factor is more than 80%, while that of 7 reactors has exceeded 90%. Construction of four PHWRs of 700 MWe each at Kakarapar and Rawatbhata has been launched. The construction of the 500 MWe PFBR at Kalpakkam has attained 80 % completion. In the field of uranium exploration, about 32,000 tonnes of additional uranium*

> *resources have been established enhancing the country's total uranium reserve to more than 1,72,000 t of U_3O_8 as on date."*[10]

Success in realising its nuclear energy programme will contribute to India's rise as a global power. The private sector in India is getting ready to participate in the yet nascent nuclear engineering sector in the country. Several Indian companies are providing critical components, sub-assemblies, etc. for the Nuclear Power Corporation India Limited (NPCIL)'s various nuclear power reactors.[11] India's international profile as a supplier of nuclear energy design, construction, operation, safety and other services will also increase. India is also trying to position itself as an exporter to small and safe nuclear reactors for countries with smaller needs of clean energy. There are other alternate sources of energy in India waiting to be harnessed, but we are not able to harness them fully and promptly, only because the energy budget of India is heavily loaded in favour of nuclear power.

6. Conclusion

'Energy governance is an area that is growing in importance—if not in tangible results, then definitely in terms of rhetoric. As an emerging power, India can ill afford to not be part of this field and make its mark' (TERI 2010b). The latest World Energy Outlook of the IEA (2011) flags the importance of governments in the area of energy. Energy governance has emerged as a critical area of research and policy making because energy use and deployment in a sustainable and holistic manner depends on good governance practices.

> *India needs to take the initiative and play a larger role in determining any future governance structure or mechanism in the energy sector. The world needs to constantly strive for an understanding of energy security that moves away from a zero-sum approach and that seeks to promote principles and norms that engender long-term energy cooperation, transparency, non-discrimination, accountability and best practices' (TERI 2011b).*

Given that several of the challenges that the world will face in the future will spring from the energy sector, it is important for India to not only be a part of these governance frameworks on energy, but also ensure that they reflect its own interests and concerns adequately.

In a bid to raise the contribution of the nuclear power to energy generation, India plans to install another 25-30 nuclear reactors in the next three decades that is expected to fulfil its plans for 65,000 MW energy.[12] By 2020 and 2050, India is expecting that the nuclear energy would account for 10 per cent and 26 per cent reflecting a significant increase and much more to come in the years to follow. This does not mean that nuclear energy would replace coal, but to some extent it would reduce the burning of fossil fuel and low quality coal, thereby reducing environmental deterioration. Moreover, in the long run nuclear energy would be economical and environment friendly than any other alternatives.

India's nuclear programme is on the verge of taking off. The future of India's nuclear programme will largely depend upon the success of the second and third stages of the programme. India's nuclear energy programme will come of age only when fast breeder reactors and the thorium fuelled rectors are commercialised. India is continuing with it. There are significant challenges that lie ahead but Indian scientists are optimistic. While progress up to 2020 remains reasonably sure, the future beyond 2020 is dependent upon several technological and institutional challenges that have yet to be overcome. But India has the capability to overcome these challenges.

End Notes

1. S. Banerjee's speech at the 54th IAEA conference in Vienna, 22 September 2010, at www.dae.gov.in.
2. Rajender Singh Negi, "*'Nuclear renaissance' only hope for India's energy security*", One World South Asia, 16 August 2009.
3. Ravi Seethapathy, "Nuclear Co-operation with India: Strategy, Economics, Environment", in Karthika Sasikumar and Wade L. Huntley (ed.), Canadian Policy on Nuclear Co-operation with India: Confronting New Dilemmas (Canada: Simons Centre for Disarmament and Non-Proliferation Research, 2007), p. 50
4. Adil Sultan Muhammad, "*Indo-US Civilian Nuclear Cooperation Agreement: Implications on South Asian Security Environment"*, The Henry L. Stimson Center, July 2006, pp. 4-6, available at <www.stimson.org/books-reports/indo-us-nuclear-cooperation-agreement-implications-for-south-asia-regional-security/>.
5. "*Nuclear Power –An alternative*" Dr. S.K. Jain Chairman & Managing Director, Nuclear Power Corporation of India Limited & Bharatiya Nabhikiya Vidyut Nigam Limited.
6. S.K. Jain, "Strategic Review", Nuclear Power Corporation of India, at http://www.npcil.nic.in/main/CmdPage.aspx (accessed 7th September 2011).
7. Union Power Minister Mr Shinde in a reply to a question in the Rajya Sabha and as reported in 'Per Capita Power

Consumption in India', http://www.inrnews.com, 20 August 2007.

8. International Energy Agency (2006).
9. "*Need to Revisit the Role of Nuclear Power for India's Energy Security*", Buddhi Kota Subbarao, 17th December, 2011.
10. S. Banerjee's speech on 28th October, 2011.
11. Larsen and Toubro (L&T) provides critical equipment and construction services to India's nuclear power plants. Walchandnagar (WIL) supplies major core equipment to NPCIL. Godrej precision machinery is engaged in fuel handling and the manufacturing of positional systems for the NPCIL. Avsarala Technology Ltd has done refurbishing work for the nuclear power reactors. There are several big and small companies gearing up to participate in India's nuclear power projects.
12. T.V. Paul, "*The US-India Nuclear Accord: Implications for Non-proliferation Regime*", International Journal (Canada), vol. LXII(4), Fall 2007, pp. 858-59.

References

[1] Chameides, Bill. 2010. '*Whose Oil Curse Is It*?', Scientific American, 30 November, accessed from: http://www.scientificamerican.com/article.cfm?id=whose-oil-curse-is-it, accessed on 5 December 2010.

[2] Ebel, Robert and Rajan Menon. (eds.). 2000. *Energy and Conflict in Central Asia and the Caucasus*. Oxford: Roman and Littlefield.

[3] Faris, Stephan. 2007. '*Fool's Gold'*, Foreign Policy, 31 July, accessed from: http://www.foreignpolicy.com/story/cms.php?story_id=3914&print=1,

[4] last accessed on 14 November 2010.

[5] Friedman, Thomas L. 2006. '*The Really Cold War'*, The New York Times, 25

[6] October, accessed from: http://query.nytimes.com/gst/fullpage.html?res=9807E6D6173FF936A15753C1A9609C63, accessed on 13 November 2010.

[7] Giordano, Mark et. al. 2005. *'International Resource Conflict and Mitigation'*, Journal of Peace Research, 42(1): 47-65.

[8] Gupta, Eshita and Anant Sudarshan. 2009. '*Energy and Poverty in India', in Ligia Noronha and Anant Sudarshan* (eds.). India's Energy Security. New York: Routledge.

[9] International Energy Agency (IEA). 2007. World Energy Outlook 2007: China and India Insights. OECD/IEA: Paris.

[10] International Energy Agency (IEA). 2010. World Energy Outlook 2010. Paris: OECD/IEA.

[11] International Trade Centre. 2010. 'Trade Competitiveness Map', accessed from: http://www.intracen.org/appli1/TradeCom/TP_IP_CI_P.aspx?IN=00&RP=5 66&YR=2008&IL=00%20%20All%20industries&TY=I, accessed on 13 December 2010.

[12] Mahanta, Chandan. 2010. '*India's North East and Hydropower Development: Future Security Challenges'*, South Asian Survey, 17(1): 131-146.

[13] Moran, Daniel and James A. Russell. 2009. *Energy Security and Global Politics: the Militarization of Resource Management.* New York: Routledge.

[14] Sharma, Devika. 2009. '*Secure Routes and the Supply of Energy to India'*, Energy Security Insights, 4(3): pp. 23-29.

[15] Sharma, Devika. 2010a. *'India's Energy and Climate Concerns: The Inter linkages, Constraints and Policy Choices'*, in Antonio Marquina (ed.). Global Warming and Climate Change. Prospects and Policies in Asia and Europe. New York: Macmillan.

[16] Sharma, Devika. 2010b. '*Uranium Trade and its Security Implications for India'*, South Asian Survey, 17(1): 91-110.

[17] TERI. 2010b. *'Energy Charter Treaty: Should India Join – An Assessment'*, Prepared for Ministry of External Affairs, Government of India, September 2010.

[18] Tuathail, Gearoid O. and Gerard Toal. 1994. '*Problematizing Geopolitics: Survey, Statesmanship and Strategy'*, Transactions of the Institute of British Geographers, 19(3): 259-272.

[19] Utpal, Bhaskar. 2009. *'NTPC plans power projects in Kazakhstan to secure coal asset'*, Livemint.com, 2009, 15 March 2009, accessed from: http://www.livemint.com/2009/03/15221030/NTPC-plans-power-projectsin- K.html, last accessed on 15 February 2010.