INDIA'S CIVIL NUCLEAR NETWORK: A REALITY CHECK

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Ever since the conclusion of the 123 Agreement with the United States, Memorandums of Understanding (MoUs) for civil nuclear cooperation have mushroomed in India. With the International Atomic Energy Agency (IAEA) safeguards agreement followed by the Nuclear Suppliers Group (NSG) clearance, India has embarked on a nuclear energy expansion programme seeking cooperation from 20 countries and two dozen industrial houses. At present, the civil nuclear network that India is carving spans six continents, with eight nuclear deals signed and another dozen in the pipeline. This initiative is expected to generate a mega business of more than US$ 200 billion in the next few decades.[1] However, during the last five years, the domestic-political debate over the Congress-led United Progressive Alliance (UPA) coalition government's ambitious nuclear energy programme has remained contentious. Given the domestic euphoria over the Indo-US nuclear deal and the recent promulgation of the Nuclear Liability Bill to streamline the nuclear supply chain, a reality check on the farsightedness of India's civil nuclear expansion strategy is warranted.

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1. Jason Simpkins, "India's Nuclear 'Explosion' a Cash Generator for Global Energy Companies", http://moneymorning.com/2009/02/24/india-nuclear-energy/

Further projections entail tripling of the production (60,000 MWe) by 2030 and up to 470 GWe by 2050, providing half of India's total electricity requirements.

INDIA'S NUCLEAR GOAL POST

The current installed capacity of nuclear power in India stands at 4,120 MWe with an overall Capacity Utilisation Factor (CF) of its nuclear power plants around 60 per cent.[2] It contributes only 3 per cent of the country's current total electricity production. With its hope for greater international cooperation after the Indo-US nuclear deal, India envisages the production of 20,000 MWe by 2020.[3] The immediate aim is to cater for 6-9 per cent of India's immediate electricity requirement through the nuclear route. Further projections entail tripling of production (60,000 MWe) by 2030 and up to 470 GWe by 2050, providing half of India's total electricity requirements.[4] With such futuristic proposals, India has initiated many advanced researches and technologies. For example, a programme has been initiated to develop a compact high temperature reactor system mainly as a primary energy source to provide process heat for non-grid based electricity. Another futuristic reactor is the Accelerator Driven System (ADS). At this stage, 19 reactors [17 Pressurised Heavy Water Reactors (PHWRs) and 2 Boiling Water Reactors (BWRs)] are in operation and seven others [5 PHWRs, 1 Prototype Fast Breeder Reactor (PFBR), 2 VVERs] are under construction. Around 36 reactors of different varieties [6 PHWRs, 2 Fast Breeder Reactors (FBRs), and 28 Light Water Reactors (LWRs)] have been proposed.[5] The construction work of all these reactors is expected to be complete within a decade.

India's current quest for nuclear energy through international cooperation can be viewed as the second phase of its nuclear networking initiated as

2. The efficiency of nuclear power reactors is measured in terms of CF. Any plant that achieves a CF of 68.5 percent is said to be functioning to its potential. If the CF falls below this figure – as is the case with the 11 reactors in India – then the plant starts losing out on the amount of electricity it was built to produce.
3. "Future Programme", http://www.dae.gov.in/publ/daepres/index.htm
4. "Nuclear Power in India", http://www.world-nuclear.org/info/inf53.html
5. Anil Kakodkar, Inaugural Address at a National Conference organised by the Centre for Air Power Studies (New Delhi) at India International Centre on "India's Nuclear Challenges 2010-2020", on September 29, 2010.

early as the 1950s, when Jawaharlal Nehru, the first Prime Minister, and Homi J. Bhabha, the leading nuclear physicist, set out to garner technology support for harnessing atomic energy for India's socio-economic uplift. While Nehru provided political patronage for nuclear research, Bhabha utilised his personal rapport with foreign nuclear scientists to acquire the necessary resources to establish a country-wide industrial-nuclear infrastructure. During that phase, US was also India's leading supplier of nuclear technology and materials. The US Atomic Energy Commission sold India 10 tonnes of heavy water in February 1955 for use in the Cirus research reactor, a facility Canada had agreed to supply with generous financing.[6] The US was so intent on concluding a nuclear supply contract with New Delhi that it offered the heavy water four years before the reactor's completion. Washington provided New Delhi with more than $93 million in the Atoms for Peace loans and grants between 1954 and 1974.[7] The USA signed an agreement in 1963 pledging supply of nuclear fuel for these reactors till 1993. In return, India agreed to maintain IAEA safeguards on the spent fuel of these reactors. India's first full-fledged nuclear power station 420 MWe Tarapur Atomic Power Station which was built by the General Electric Company of the US on a turnkey basis, became fully operational on February 27, 1969.

Other nuclear supplier countries like Canada, France, Britain, Germany and Soviet Union were also part of India's first phase of the nuclear network. In 1974, towers for the Talcher heavy water plant were transported from West Germany, but unfortunately, lost at sea.[8] Networking with the Russian Federation continued though under the international safeguards agreement. However, this phase came to an abrupt end in 1974 due to India's nuclear test that invited international technological sanctions circumscribing India's nuclear research for the subsequent three decades.

Since 1974, considerable changes have taken place in the global nuclear order. Increasing numbers of countries have joined international nuclear

6. Peter R. Lavoy, "The Enduring Effects of Atoms for Peace", http://www.armscontrol.org/act/2003_12/Lavoy
7. Ibid.
8. *India and the Atom* (New Delhi: Birla Institute of Scientific Research, 1982), p. 70.

International nuclear commerce seems to have become more democratic and competitive than in the previous years for systematic multilateral arrangements like the NSG and IAEA.

commerce and are capable of supplying affordable resources and technology. International nuclear commerce seems to have become more democratic and competitive than in the previous years for systematic multilateral arrangements like the NSG and IAEA. France, Canada, etc have utilised nuclear energy to meet a substantial portion of their electricity demand. Though India remained outside the global nuclear trade, it nevertheless continued its nuclear research indigenously, without sharing it with any other state. This bestowed on India the image of a "responsible" nation that has genuine reason for nuclear energy production to sustain its burgeoning economy. Irrespective of the controversy over the cleanliness of nuclear energy, it is one of the abundantly available and viable sources of energy options for India, especially when the entire world is receptive to its vital concerns.

RATIONALE FOR EXPANDING THE NETWORK

India's current power policy promises electricity availability to all by 2012 but this target seem unachievable given the exponentially growing demand which cannot be met by the present total power generation of 150 GW.[9] Average annual per capita consumption of electricity in India was only about 30 per cent of the world's average in 2007 and 2008.[10] To improve this situation, the absolute amount of energy available for India would have to be doubled by 2020 and redoubled during the next decade. Even if India's per capita energy consumption was to rise to 5,000 kWh from the 600 kWh of today, it would still suffer an energy deficit of 421 GW by 2050.[11] Even if its Gross Domestic Product (GDP) grows at 7-8 per cent per annum, the energy requirements of India are expected to grow at 5.6-6.4 per cent per annum

9. "India Plans Massive Nuclear Energy Boost", http://www.nuclearpowerdaily.com/reports/India_plans_massive_nuclear_energy_boost_999.html, September 30, 2009.
10. The World Bank, "Meeting India's Demand for Electricity", IBRD Results, http://siteresources.worldbank.org/NEWS/Resources/IndiaPowergrid4-1-10.pdf
11. "Uranium Import can Stave Off Looming Energy Crisis: Kakodkar", *Hindu Business Line*, July 5, 2008.

over the next few years. This implies a four-fold increase in India's energy requirement over the next 25 years.[12] Therefore, India will continue to depend on large scale energy import which is vulnerable to price fluctuation. For a large country like India, bulk imports of fuel are neither affordable nor strategically prudent.

Given the country-wide nuclear infrastructure and scientific-technological skills that India is endowed with, nuclear power could be a viable option to overcome future energy requirement.

The domestic energy production scenario is positive. India imports traditional fossil fuels in large quantities to run its thermal power plants that constitute the bulk of its power generation sector. Though India has the fourth largest reserves of coal in the world, they are of low quality and concentrated in some pockets of the country. The transport cost of coal is estimated to be three times the cost of coal when it comes out of the mine. In fact, the Shankar Committee, set up to recommend measures to bridge the demand-supply gap, foresees import of 30-40 million tonnes of high-grade coal by 2011-12.[13] According to the World Energy Outlook 2007, India's coal imports would rise seven-fold by 2030 if the current energy generation mix is not changed.[14]

According to the Associated Chamber of Commerce (ASSOCHAM), India's dependence on oil imports is likely increase to about 85 per cent by 2012 from the current level (2007-08) of 70 per cent, driven by the rising demand for energy.[15] Given the escalated price of crude oil which is unlikely to fall, India's import oil bill will strain its exchequer, impacting the economy severely. Also, the gap between natural gas generation and consumption is increasing and domestic availability is limited. The option of sourcing from the neighbourhood through a network of pipelines has been a matter of geo-political consideration due to the security and economic implications.

12. "Energy Overview", http://www.indiacore.com/overview-energy.html
13. "Capacity Build-up in Coal Essential", *The Hindu*, May 22, 2006.
14. International Energy Agency, "World Energy Outlook 2007", http://www.worldenergyoutlook.org/docs/weo2007/WEO_2007_English.pdf, p. 7.
15. "India's Dependence on Oil Imports to Grow 85 percent by 2012: Report", *Financial Express*, August 17, 2007.

As far as the nuclear energy option for India is concerned, the key to this is uranium which is in short supply in India.

Harnessing renewable energy sources like solar, tidal, hydro, geothermal and biofuels is viable, and India will continue to exploit them increasingly. But none of these options, except hydro power in a few places, is found abundant where large scale power generation is concerned.

Given the country-wide nuclear infrastructure and scientific-technological skills that India is endowed with, nuclear power could be a viable option to overcome future energy requirements and if things move right, it will earn the country substantial foreign exchange in the long run. Also empirical studies in recent days reveal that the Long Range Marginal Cost (LRMC) of nuclear energy or nuclear power supply at locations far away from other sources like coal or hydel would be cost-effective.[16] Owing to reduction in construction time, improvements in nuclear plant capacity factors and efficient resource management in recent years have further rationalised the unit cost of nuclear energy, and thereby, the economics of nuclear power. For example, the Tarapur Atomic Power Plant (TAPP) 3 and 4 has not only been constructed in the scheduled time but also at a cost lower than the original estimation.[17] The Nuclear Power Corporation of India Ltd. (NPCIL), tasked with the design, and construction of these nuclear plants, has completed both plants in five years at a cost of Rs6,100 crore against the estimated cost of Rs 6,525 crore.[18]

Moreover, if India's economy continues to depend upon thermal and coal sources, it is certain that carbon emission would rise significantly. In 1997, carbon emission per person in India was 250 kg, one quarter of the world average.[19] According to the US Department of Energy, India's carbon

16. Yoginder K. Alagh, "Economics of Nuclear Power in India", *Nu-Power International*, vol. 11, no. 1-3, 1997, p. 22.
17. T.S. Subramanian, "A Message from Tarapur", *Frontline*, vol. 22, issue 07, March 12-25, 2005.
18. *IBNLive*, May 22, 2006.
19. R. Bannerjee, "Assessment of Role of Renewable Energy Technologies", Greenhouse Gas Pollution Prevention Project – Climate Change Supplement, Louis Berger Group Inc. Global Environment Team, available at http://www.climatechangeindia.com/gep_ccs/

emissions during 2001 and 2025 will grow by 3 per cent annually, making India the third largest air polluter after the US and China by 2015.[20]

As far as the nuclear energy option for India is concerned, the key to this is uranium which is in short supply in India. The country's reserves stand only at 78,000 tonnes of low-grade ore, which requires processing before it becomes usable for reactors.[21] Four mines in Singhbhum (Bihar) produce only 220 tonnes of uranium concentrate.[22] In addition, 120 tonnes come from byproducts like tailings from phosphate, zinc and copper mines. However, besides the requirements for its weapons programme, India's 17 operating civilian reactors require 500 to 600 tonnes of uranium concentrate annually. Two more mines, one in Meghalaya (Domiasat) and another in Karnataka, may begin operation in the next few years, increasing the output to about 600 tonnes.[23] All these may meet the requirements of the existing reactors but are not enough for the ambitious nuclear power generation that India is planning. Generating 47,000 MW of nuclear energy by 2025, as envisaged by the UPA government, will require huge amounts of uranium. For materialising such an ambitious programme, India will need as much as 100,000 tonnes of new ore but the chances of finding it within the country are slim.

Though the degree is unknown, the effects of the technology sanctions on India's nuclear programme have been severe. For the last 30 years, none of its nuclear plants could run to full capacity owing to shortage of uranium and technology. As the civil nuclear deal with the US promises uninterrupted supply of nuclear fuel and technology, the nuclear activities in India that have resumed in the post-Indo-US nuclear deal phase are simply the carry forward to a new height of the first phase of India's nuclear networking initiated after Independence. Therefore, India's efforts in this second phase of nuclear networking with the nuclear supplier countries are far-sighted. When the USA gave the green signal and the IAEA safeguards agreement in

20. Figures as cited by Condoleezza Rice, Remarks at the Senate Foreign Relations Committee on the US India Civil Nuclear Cooperation Initiative, April 5, 2006.
21. "India Needs 1 Lakh Tonnes Uranium, says Kakodkar", *The Hindu*, April 11, 2006.
22. Hari Sud, "India's Quest for Uranium", October 9, 2009, UPI Asia.com
23. Ibid.

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August 2008 brought 14 out of the 22 Indian nuclear facilities under safeguards, many countries expressed willingness to trade with India. France was the first country to enter into a formal understanding with New Delhi, much before even the USA. The latest is South Korea, which enthusiastically expressed this in the joint statement issued during President Lee Myung-Bak visit to India in the last week of January 2010.[24] India has also approached some uranium rich countries in Africa and Central Asia. However, one need not get the impression that New Delhi's current efforts to import uranium and technology comprise endless dependence on outside sources; rather, *these are stop-gap arrangements*[25] until its own thorium fuelled reactors come on stream.

FRAMEWORK OF THE NETWORK

In pursuit of achieving the target, India has set out, first, for an integral and coordinated growth for accelerated capacity expansion of its nuclear energy sector. The strategy is to coordinate among specialised institutions like the Indira Gandhi Centre for Atomic Research (IGCAR), research institutes like the Bhabha Atomic Research Centre (BARC) and academic institutions like the the Indian Institutes of Technologies (IITs) and other universities. The second aspect is placing of an efficient programme management scheme. Strong synergy among the Department of Atomic Energy (DAE), Department of Science (DoS) and Defence Research and Development Organisation (DRDO) is envisaged.

The third is to privatise the nuclear energy sector in a smooth and phased manner. Under the current expansion scheme, more than two dozen industrial houses, both domestic and international, are involved through collaboration and share-holding. Domestic private industrial houses

24. "India–Republic of Korea Joint Statement: Towards a Strategic Partnership", January 25, 2010, Joint Declarations & Statements, http://www.mea.gov.in/
25. "India Needs to Import Uranium Only as 'Stop Gap'," http://www.monstersandcritics.com, August 22, 2006.

like Larson & Toubro (L&T), Tata, Relience, Punj Lloyd, etc. and multinational houses like Westinghouse, Areva, GE, Sandpit, etc. are some of the front runners. A number of state-owned companies of different countries have already signed MoUs with Indian entities and this process is expected to be expedited in the years ahead. Fourth, instead of overburdening the two Public Sector Undertakings (PSUs) – NPCIL and BHAVINI – India is planning to diversify the operational and management responsibilities of nuclear plants among other PSUs like NALCO, Indian Oil Corporation, Indian Railways, ONGC and NTPC which have also expressed interest in such projects.

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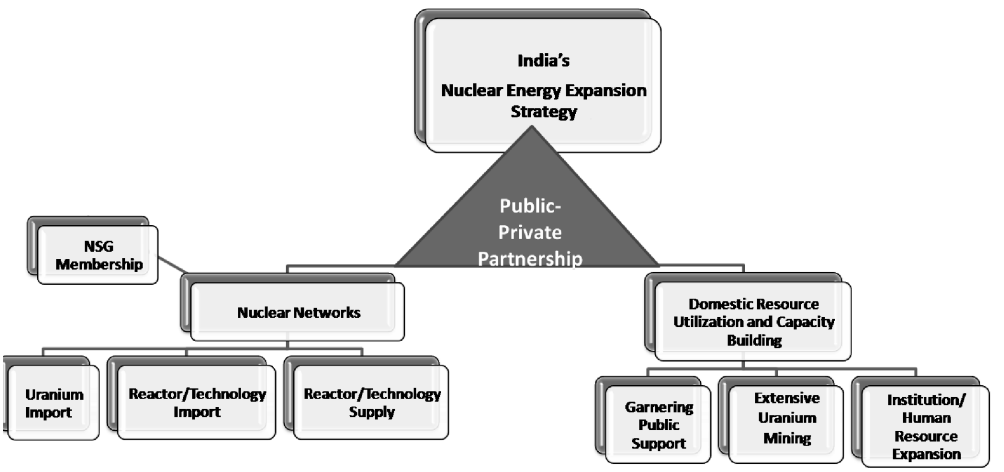
Fig 1



Therefore, India's nuclear networking framework involves both public and private participation, mobilising domestic and international stakeholders. While at the domestic level, India aims to build up its technological and human resource capability for effective utilisation of available resources, at

India sincerely hopes to become an effective stakeholder in global nuclear commerce in the decades ahead. Though at present India plans only to expedite its nuclear energy production, in the long run it expects to export its 220 MWe reactors.

the international level, it strives to acquire more uranium and advanced nuclear technology by attracting international stakeholders. In the long-term, the strategy also envisages effective participation in international nuclear commerce by supplying reactor technology, plant construction, maintenance and services. While attempting all these, NSG membership is imperative, for which New Delhi would initiate lobbying.

TAKING STOCK OF THE NETWORK

India's engagement with different countries in the post-Indo-US nuclear deal period aims to fulfill two important objectives. The first is to meet the immediate to short-term uranium needs of Indian reactors.

Second, India sincerely hopes to become an effective stakeholder in global nuclear commerce in the decades ahead. Though at present India plans only to expedite its nuclear energy production, in the long run it expects to export its 220 MWe reactors that would be ideally suited for the Southeast Asian countries' smaller electricity grids.[26] These reactors have proved their competitiveness in capital as well as unit energy costs and have a demonstrated record of safe operations. India also has the capacity to emerge as a low cost manufacturing hub for nuclear component supplies to the resurgent nuclear industry worldwide. For example, companies like L&T can export nuclear reactor building skills, operation and maintenance services.

Therefore, India's effort to network the nuclear supplier countries is far -sighted. But the process of selecting a specific country to initiate cooperation should be realistic and far-sighted. The major basis for choosing a country for negotiation for nuclear cooperation has so far been three-fold. First,

26. "India and Russia Sign Civil Nuclear Agreement", http://www.hindu.com/2009/12/08/stories/2009120856260100.htm, December 8, 2009

the amount of uranium reserves in the concerned country; second, the kind of nuclear technology the country is enriched with and likely to share with India; and third, the strength and comfort level of India's bilateral relations with the country concerned. So far, India has formalised civil nuclear cooperation with eight countries and similar deals with a dozen other countries are in the pipeline.

DEALS CONCLUDED SO FAR

France was the first NSG member to ink an MoU (September 30, 2008) with India, as even the Indo-US deal was awaiting Congressional approval.[27] The deal came into force with the exchange of instruments of ratification on January,14 2010. This agreement forms the basis of wide ranging bilateral cooperation from basic and applied research to full civil nuclear cooperation, including reactors, nuclear fuel supply, nuclear safety, radiation and environment protection and nuclear fuel cycle management. According to sources, France has agreed to provide 300 tonnes of uranium to India. A couple of days after the IAEA safeguard agreement was concluded, the French nuclear giant Areva signed a deal worth US$ 12.3 billion with NPCIL to provide India six new-generation reactors at Jaitapur in Maharashtra. In all, 35 French firms are eyeing the civil nuclear sector in India today.

Russia signed a broad-based agreement in the civil nuclear field with India on December 7, 2009, to ensure transfer of technology and uninterrupted uranium fuel supplies.[28] The agreement goes far beyond the Indo-US nuclear agreement, under which Russia has ensured fuel supply guarantee even if India conducts a nuclear test in the future. The pact promises enrichment and reprocessing rights and access to high end technology (light water reactors). While US private companies like Westinghouse and GE have asked India to comply, Russia's state-run nuclear power corporation RosAtom did not request for any liability or insurance cover. According to sources, Russia's state nuclear energy company, Atomenergoprom, said that Russian nuclear

27. "India, France Ink Nuclear Deal", http://economictimes,indiatimes.com?PoliticsNation/India_France_ink_nuclear_deal/articleshow/3546835.cms
28. "India, Russia Sign Nuclear Deal", http://timesofindia.indiatimes.com/india/India-Russia-sign-nuclear-deal/articleshow/5311267.cms

Kazakhstan became the fourth country to sign a nuclear cooperation agreement with India in January 2009.

fuel manufacturer TVEL has supplied the first batch of 30 tonnes of pellets on April 8, 2009, for India's PHWRs.[29] Under the agreement, Russia will set up four new reactors in Kudankulam and another nuclear park of 6-8 nuclear reactors in Haripur in West Bengal.[30] Sergei Kiriyenko, chief of RosAtom expects to build up to 16, reactors in India.[31]

The Indo-US civil nuclear cooperation turned full circle on February 4, 2010, when President Obama certified India's placement of its nuclear facilities under the IAEA safeguards. The economic-strategic benefits that the Indo-US nuclear deal would accrue have been painted vividly. According to the US-India Business Council (USIBC), the deal could add up to US$ 150 billion over the next 30 years.[32] In 2009, the US Commercial Nuclear Mission visited India with 60 senior executives of 30 nuclear power companies. L&T has signed an MoU with Westinghouse of the US for work involving engineering, procurement, construction and manufacturing activities for the AP 1000 modular nuclear reactors. The infrastructure company Punj Lloyd and the US based Thorium Power have signed an MoU to form a 50:50 joint venture to explore commercial nuclear power opportunities.[33] The proposed investment is US$ 1 billion.

Kazakhstan became the fourth country to sign a nuclear cooperation agreement with India in January 2009. The scope of the agreement involves export of uranium from Kazakhstan which is currently the world's second largest producer and caters for 15 per cent of the world's uranium needs.[34]

29. "Russia Confirms Delivery of Uranium Pellets to India", April 15, 2009, No. 43 / News in Brief, http://www.worldnuclear.org
30. "India and Russia Sign Civil Nuclear Agreement", http://www.hindu.com/2009/12/08/stories/2009120856260100.htm, December 8, 2009
31. Anatoly Medetsky, "Medvedev Lands $20B ln Nuclear Deal in Turkey", *The Moscow Times*, May 13, 2010.
32. "US Business Hails $150 Billion 'Opportunity' in N-Deal", October 2, 2008, http://www.prokerala.com/news/articles/a6409.html
33. P.B. Jayakumar, "Punj Lloyd-Thorium JV to Pump in $1 bn", *Business Standard*, January 18, 2009.
34. Utpal Bhaskar, "India to Ink Nuclear Deal with Kazakhstan by Month-end", http://www.livemint.com/2009/01/11235839/India-to-ink-nuclear-deal-with.html, January 11, 2009.

While Kazatomprom, the state-owned nuclear holding company, aims at a comprehensive nuclear agreement, India wants to leverage its agreement with it not only to source uranium but also to use the company's 10 per cent stake in Westinghouse Electric Corporation and tap advanced nuclear technology.

The first African nation to sign a civil nuclear deal with India (on August 31, 2009) was Namibia,[35] which is the fifth-largest producer of good quality uranium in the world. Initially, under the Agreement on Cooperation in Peaceful Use of Nuclear Energy, the two sides will trade uranium and exchange expertise in designing of atomic plants, and train personnel.

India inked an Agreement for Cooperation in the Peaceful Uses of Nuclear Energy with Argentina during President Christina Fernandez de Kirchner's state visit to India on October 14, 2009.[36] The joint statement states that India and Argentina will use the synergies and vast experience of their nuclear scientists and technologists. Taking into account their respective capabilities and experience in the peaceful uses of nuclear energy, the two countries have agreed to encourage and support scientific technical and commercial cooperation for mutual benefit in this field. An Institutional Cooperation Agreement between the Argentina Council on Scientific and Technical Research (COICET) and Council of Scientific & Industrial Research (CSIR) India has been signed in this regard.

India agreed to initiate civil nuclear cooperation with the world's largest producer and third-largest reservoir of uranium, Canada, on November 29, 2009.[37] Both countries signed an agreement on June 28, 2010, paving the way for Canadian firms to take part in India's multi-billion nuclear energy business over the next 10 years.[38] The Atomic Energy of Canada, Ltd. (AECL)

35. "India, Namibia Sign Uranium Supply Deal", August 31, 2009, http://www.thaindian.com/newsportal/business/india-namibia-sign-uranium-supply-deal_100240902.html#ixzz0dz2wJkK4
36. Anand, "India, Argentina Ink Civil Nuclear Pact & Agreements on Science and Technology", October 15, 2009, http://machinist.in/index.php?option=com_content&task=view&id=2393&Itemid=2
37. "India, Canada Agree on Historic Nuclear Deal", http://ibnlive.in.com/news/india-canada-agree-on-historic-nuclear-deal/106138-3.html, November 29, 2009.
38. "India, Canada Sign Civilian Nuclear Deal", http://www.thestatesman.net/index.php?option=com_content&view=article&id=332728&catid=35

aims to enter into technology, marketing or even ownership partnerships with its Indian counterparts. L&T signed an MoU with AECL during the visit of Stockwell Day, the Canadian International Trade Minister, covering development of the Candu ACR 1000 heavy-water moderated reactor for the Indian market.[39]

A declaration on civil nuclear cooperation between India and Britain was signed on February 11, 2010.[40] The UK's nuclear goods and equipment exports are worth 700 million pounds and its civil nuclear industry provides employment to 80,000 people. Its nuclear industry is also keen to provide 70 to 80 per cent of a new nuclear reactor in India. British companies specialising in nuclear safety and research have resumed contacts with India. However, potential British suppliers are in the private sector, therefore, the British government has raised objections to New Delhi's restrictions on nuclear commerce that is confined to the public sector.

DEALS IN THE PIPELINE

Around eleven nuclear cooperation agreements are in the pipeline and India is in the process of finalising them. On November 11, 2008, during the visit of Belgium's King Albert II to India, the Indian Nuclear Society signed an MoU for technology cooperation with the Belgium Nuclear Society.[41] The two societies want nuclear cooperation between Belgium and India for technologies used in medical research, cancer therapy, crop mutation and such applied sciences. Belgium is specifically seeking Indian collaboration for its Myrrha experimental fast reactor project. Also, it is keen to collaborate with India in the field of thorium technology and has offered to exchange advanced medical technology.

During the Mongolian President's visit to India in September 2009, an MoU on Cooperation in the Field of Peaceful Use of Radioactive Minerals

39. "L&T, Canadian Firm Ink Pact for Nuclear Reactor at Hazira", *The Financial Express*, January 23, 2009.
40. "Britain, India Sign Civil Nuclear Pact: Official", http://www.google.com/hostednews/afp/article/ALeqM5jHWOUAC32W7duhpXH2RWShnmMXdw
41. "Belgium, India Seek Collaboration on Myrrha, ITER Projects", http://www.thaindian.com/newsportal/sci-tech/br-belgium-india-seek-collaboration-on-myrrha-iter-projects_100117710.html

and Nuclear Energy was inked which would enable India to look for uranium in Mongolia. It has invited Indian participation in the uranium mining sector through joint ventures and investment. A team of Mongolian experts has already visited India to discuss the modalities for implementing the deal. In pursuance of the MoU, India has offered a short course on radiography for Mongolian personnel at BARC and assistance to set up a regulatory protection framework in Mongolia. Uzbekistan which possesses 2 per cent of global uranium reserves has been engaged by India. According to, Shyam Saran, India's special envoy, "We are working out (uranium) supply arrangements with Kazakhstan, Uzbekistan, and Nigeria."[42]

On the nuclear waste management and security front, Sweden has offered New Delhi its niche expertise as it eyes India's huge civilian nuclear energy market.

On the nuclear waste management and security front, Sweden has offered New Delhi its niche expertise as it eyes India's huge civilian nuclear energy market.[43] Stockholm is also planning to replace its old reactors with new ones and this can be a big opportunity for India. The first batch of a Swedish delegation came to India last April to hold talks with NPCIL. Swedish companies such as Sandpit, Sweneson, SKB International Consulting AB, Studbook, ES-consult and Rel con Candlepower AB are in touch with Indian private companies such as L&T and Bharat Forge.

India currently is in discussions with Hungary on ways to enhance civil nuclear cooperation. On January 19, 2010, during the official visit of Hungarian Foreign Minister Peter Balazs to India, Indian Foreign Minister S.M. Krishna put across the proposal before him.[44] Also, the Italian Minister for Economic Development, Claudio Scajola, during his visit to India in December 2009, conveyed Italy's interest to cooperate with India in

42. "India to Source Uranium from Nigeria, Kazakhstan, Uzbekistan", *Compass*, October 23, 2008.
43. Manish Chand, "Sweden Offers India Civilian Nuclear Technology", http://www.thaindian.com/newsportal/business/sweden-offers-india-civilian-nuclear-technology_1100213644.html#ixzz0dtokTcYe
44. "India, Hungary Discuss Civil Nuclear Cooperation", *NetIndian News Network* (New Delhi), January 19, 2010.

nuclear energy production.[45] In a joint press statement, Indian Commerce and Industry Minister Anand Sharma and Scajola said, "We share very similar energy requirements.... we are resolved to collaborate in this field also." Recognising India's impeccable non-proliferation record, German Ambassador to India Thomas Matussek expressed (January 10, 2010) Germany's interest in civilian nuclear cooperation with India, but the first step in this direction could be only reactor safety. A Spanish nuclear power plant developer, Cala Casa SL, has approached the Orissa government with a proposal to set up a project.[46]

South Korean President Lee, during his state visit to India, made a strong pitch to supply advanced power reactors at very competitive prices. Korea's state-owned Korea Electric Power Corporation (KEPCO) and NPCIL signed an MoU (August 2009) for bilateral cooperation in the field of nuclear power through technical exchange of data, experience and joint work.[47] Particularly, KEPCO is keen to export its APR-1400 reactors to India. KEPCO and NPCIL have been engaged in a joint study of "licensibility and constructibility" of the APR-1400s in India over the past few months.

At its third summit meeting, the IBSA (India-Brazil-South Africa) forum has welcomed the India-specific safeguards agreement and the decisions of the NSG to adjust its guidelines to enable full civilian nuclear cooperation between India and the international community. Brazil has expressed its happiness to sell uranium to India.[48] Both South Africa and Brazil have huge reserves of uranium and are planning major expansion of their civilian nuclear power plants. Since then, contacts have been resumed and a formal agreement is expected to be signed with Brazil.

Though no headway had been made by the Indian government yet with Niger, which is the fifth-largest supplier of uranium, an Indian company, Taurian Resources Pvt. Ltd (Mumbai), has won exclusive rights over 3,000

45. "India, Italy to Cooperate in Nuclear Energy Sector", http://www.theindian.com/newsportal/india-news/india-italy-to-cooperate-in-nuclear-energy-sector_100289457.html
46. "Spanish Firm to Set Up Nuclear Power Plant at Bhapur in Nayagarh", December 11, 2006, http://www.orissadiary.com/ShowBussinessNews.asp?id=3504.
47. Press Release, NPCIL, August 27, 2009, http://www.npcil.nic.in/pdf/press_27aug09.pdf
48. "South Africa~ Brazil Ready to Sell Uranium", *The Peninsula*, October 16, 2008.

sq. km. of the Sahara Desert for exploration and mining of uranium.[49] According to the estimates of the Managing Director of the company, "The area is likely to hold at least 30,000 tonnes of uranium which should be enough to meet India's requirement for the next 1,000 years."[50]

An Indian company, Taurian Resources Pvt. Ltd (Mumbai), has won exclusive rights over 3,000 sq. km. of the Sahara Desert for exploration and mining of uranium.

DEALING WITH HESITANT SUPPLIERS

Despite efforts by India and the USA for accepting New Delhi as an exception, Australia and Japan are still reluctant to open their doors to India for nuclear commerce. Though these countries did not come in the way of the NSG waiver on India, they still are reluctant to trade with a non-NPT (nuclear Non-Proliferation Treaty) country.

After initial hesitation, Australia agreed in principle in August 2007 to export uranium to India "subject to India agreeing to very stringent safeguards and conditions".[51] Defending the Australian government's decision to lift the ban on uranium sales to India, former Australian Premier John Howard spoke to Indian Prime Minister Manmohan Singh (August 16, 2007) after which he announced negotiations between the two countries for a uranium trade pact.[52] But the Australian government's chief nuclear adviser Ziggy Switkowski expects a ban on further nuclear testing by India to be part of any deal and Australia wants to be satisfied that the uranium will only be used for peaceful purposes. After the defeat of the Labour Party led by Prime Minister Howard in the 2007 federal election and the Australian Labour Party coming into power, the momentum and willingness to cooperate with India in the civil nuclear field has waned. However, during the visit of the new Australian Prime Minister Kevin Rudd, to New Delhi, in November 2009, the Government of India pressed

49. Pallava Bagla, "Indian Firm Acquires Uranium Mining Rights in Niger", *The Hindu*, August 19, 2007.
50. Ibid.
51. "Australia to Sell Uranium to India: Howard", http://www.expressindia.com/news/fullstory.php?newsid=90916, August 16, 2007.
52. Ibid.

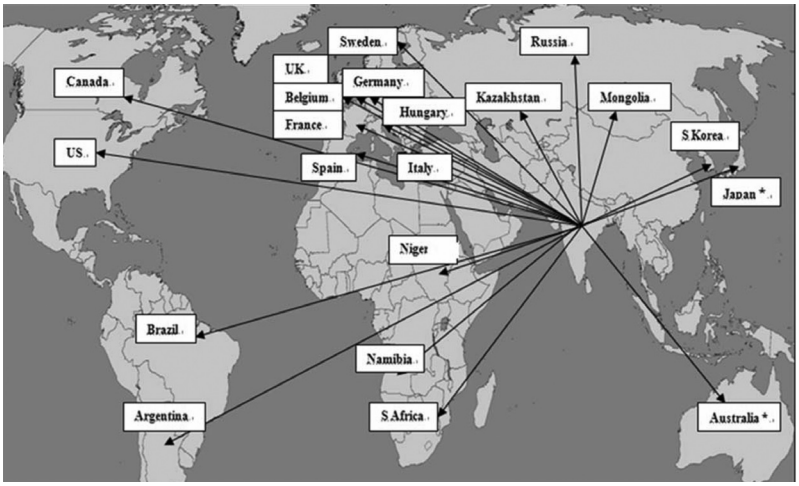
Prior to the NSG's blanket approval for the supply of high-grade uranium, India was facing a shortfall of 50 per cent nuclear fuel.

hard to open up the uranium sales to New Delhi. An international expert panel, whose final report was launched by the Australian Prime Minister himself, has suggested the application of "equivalent disciplines" to help India and other countries meet disarmament obligations. It recommends allowing these countries access to nuclear materials and technology for civilian purposes provided they show a strong commitment to disarmament and non-proliferation.

Japan, though it did not oppose India's efforts to get the NSG waiver, has remained reluctant to commit on a nuclear pact with India. A high-level nuclear delegation from Japan, including representatives from reactor majors Hitachi Ltd, Mitsubishi Heavy Industries and Toshiba Corporation, arrived in India on November 16 2008, for talks with DAE and NPCIL officials.[53] Three leading Japanese firms that are key members of global reactor manufacturing alliances (Hitachi, Mitsubishi Heavy Industries and Toshiba) are in the fray for new light water reactor orders in India. India also formally sought a civilian nuclear agreement with Japan during Prime Minister Manmohan Singh's visit to Tokyo in October 2008 but the Japanese government stopped short of signing a pact with India in view of the strong criticism by the non-proliferation lobby in that country.[54] Japan has often raised the issue of India's adherence to the NPT though it has not overtly obstructed India's efforts at any international fora. The joint statement signed during Japanese Prime Minister Hatoyama's New Delhi visit in December 2009 says that the Energy Ministers from the two countries will exchange views on their "respective nuclear energy policies".[55]

53. Anil Sasi, "Japanese Companies Keen On Indian Nuclear Market", *Business Line*, November 22, 2008.
54. Ibid.
55. "Joint Statement by Prime Minister Dr. Yukio Hatoyama and Prime Minister Dr. Manmohan Singh: New Stage of Japan-India Strategic and Global Partnership", http://www.mofa.go.jp/region/asia-paci/india/pmv0912/joint.html

Fig 2: India's Nuclear Spadework



A REALITY CHECK

India's initial networking and expansion strategy sounds comprehensive. New Delhi has started to gain perceptible benefits through this during the last few months. But the expansion programme would be subject to problems at subsequent stages as nuclear matters are more politics than physics. However, "it would be a good example" for the rest of the world "when India succeeds".[56]

INDIA'S GAINS SO FAR

Prior to the NSG's blanket approval for the supply of high-grade uranium, India was facing a shortfall of 50 per cent nuclear fuel.[57] According to a report in *The Times of India*, owing to the critical shortage of uranium, only three of India's 17 nuclear reactors are working to their full potential.[58] The report also says that 11 reactors are not functioning up to the mark and three others remained completely shut down for long-term maintenance

56. "For An Agreement, Respecting Indian Concerns", Interview of Bernard Bigot, Chairman French Atomic Energy Commission, by Pallava Bagla, *The Hindu*, October 11, 2010.
57. Kartikeya, "Uranium Pinch: Only 3 of 17 N-plants Running Full Tilt", http://timesofindia.indiatimes.com/india/Uranium-pinch-Only-3-of-17-N-plants-running-full-tilt/articleshow/5558513.cms, February 11, 2010.
58. Ibid.

till November 2009. Last year, two 540 MW reactors in Mumbai with a Capacity Utilisation Factor (CF) of 56 per cent and 58 per cent, together lost out on 731 million units of electricity. A reactor at Narora (Uttar Pradesh) had the lowest CF of 43 per cent in 2009. After NSG clearance, supplies from France, Russia and Canada have resumed. The first consignment of 60 tonnes of imported uranium from France landed on Indian shores in April 2009. Only three nuclear reactors, which are getting imported uranium, are now working at their maximum capacity. Two of these reactors are in Mumbai and one of them achieved an impressive CF of 99 per cent in 2009. The third is at Rawatbhata in Rajasthan.

According to Anil Kakodkar, additional uranium fuel from overseas suppliers has significantly increased the plant load factor of atomic power stations.[59] At the same time, India's atomic power generation has reportedly gone up by 15 per cent over the past few months and the reactors are operating at an average of 65-70 per cent of their capacity.[60] The plant load factor of reactors outside the safeguards is also increasing as production has gone of up substantially. The first tangible benefit is the restarting of the 20 MW Rajasthan atomic power station using uranium concentrate from France. The plant was shut down for about a year due to a critical shortage of fuel. According to Kakodkar, the generation capacity factor at the atomic power states in Kalpakkam (Chennai), Tarapur (Mumbai), Narora (Uttar Pradesh), Kakrapar (Gujarat) and Kaiga (Karnataka) is better than last year.[61] If things go right, the total amount of nuclear power generation in India would reach 35,000 MW by 2020, predicts the Atomic Energy Commission (AEC) Chairman and BARC Director S. Banerjee.[62]

LIKELY CHALLENGES AHEAD

International cooperation is an imperative for India's ambitious programme but nuclear deals are not the immediate solution for increasing energy supply

59. "As Fuel Supplies Resume, India's Nuclear Power Output Up", http://www.thaindian.com/newsportal/business/as-fuel-supplies-resume-indias-nuclear-power-output-up_100302026.html#ixzz0hWKvkEE8, January 11, 2010.
60. Ibid.
61. Ibid.
62. "India to Produce 35,000 MW of Nuclear Power by 2020", *The Hindu*, March 21, 2010.

instantly. Nuclear matters generally are complex and time consuming. One can mark the amount of time and effort needed between signing an MoU and translating it into a formal agreement for full nuclear cooperation. However, to be competitive and maximise the potential benefits of today's relatively simple nuclear market, India needs to make smart moves. The hunt for energy resources is a challenge, as can be seen in how China has repeatedly outbid India in Africa, Central Asia and Myanmar. For example, in Namibia, India will face tough competition from Chinese,/ Russian and Western companies that are also interested in the country's rich deposits.

According to the IAEA estimates, at least 70 nuclear power stations will be built around the world in the next 15 years.[67] Unnecessary delay in procedural aspects would lead to increased costs as the uranium price is expected to escalate manifold.

According to the IAEA estimates, at least 70 nuclear power stations will be built around the world in the next 15 years.[63] Unnecessary delay in procedural aspects would lead to increased costs as the uranium price is expected to escalate manifold. The big hope to harness an abundance of cheap and clean energy would prove a big bust instead of big business unless opportune chances are exploited intelligently. The overall visible increase in energy production will happen progressively—it cannot happen overnight.[64] However, as the supply chain of resources and technology is just starting, uranium from Kazakhstan could end up in a reactor sold by Russia or uranium from Niger in a reactor supplied by France. Also, suppliers could hold up orders, citing minor excuses. As a precautionary measure, therefore, India needs a stockpile of three to five years' supply of uranium.

India's strategy to source nuclear technology and materials from diversified sources, no doubt, is impressive. But certain potential supplier countries have been surprisingly overlooked. For example, Ukraine

63. "India Scouring World for Uranium", http://www.dawn.com, September 7, 2009.
64. No.5

To kick-start this ambitious programme New Delhi has to first make available large numbers of trained and skilled manpower.

possesses 2 per cent of the global uranium reserves[65] and has a vibrant nuclear energy programme.[66] Also, Jordan possesses 2 per cent of global uranium reserves and has cordial relations with India. So far, no attention has been paid to Jordan which is planning to build its own nuclear power plants by 2015. Other countries in the region like Saudi Arabia, Syria and the UAE, are lucrative destinations for India. Lastly, China, whose reserves comprise only 1 per cent of global uranium reserves and less than India's, has an ambitious nuclear energy programme underway. But India has overlooked the benefits of dealing with China in the nuclear energy sector. At the outset, absence of any nuclear cooperation between India and China would lead to unwarranted competition as both countries are targeting the same source for uranium procurement; competition at this stage will not be healthy since it would simply add to the already worsened bilateral hiccups over certain issues.

To kick-start this ambitious programme New Delhi has to first make available large numbers of trained and skilled manpower. Today, the Department of Atomic Energy (DAE) is estimated to have a workforce of around 70,000 experts.[67] For this expansion plan, the requirement of more nuclear scientists, engineers, craftsmen, construction managers, plant operators and maintenance personnel would swell. Only a few institutions like Indian Institutes of Technologies (IITs)(Kanpur and Chennai) offer courses on nuclear engineering and technology. Therefore, it would be a stupendous task to meet the need for rapid training, education and recruitment of an increasing number of professionals with in a short time.

Second, as India is planning to invite private industries, both domestic and international, to participate in the nuclear energy sector, it is likely to

65. "Supply of Uranium", http://www.world-nuclear.org/info/inf75.html, accessed on October 21, 2010.
66. "Ukraine Plans Uranium Plant Construction", http://www.rbcnews.com/free/20100112132701.shtml, accessed on October 21, 2010.
67. Manpreet Sethi, "N-Powering India: Opportunities and Challenges", in Kapil Kak ed., *Comprehensive Security for an Emerging India* (New Delhi: KW Publishers, 2010), p. 257.

face two major challenges . First, the Indian manufacturing industry may not be able to shoulder the responsibility, given the high technology content of the nuclear energy sector. Only one Indian private industrial house – L&T – is nuclear accreditation certified.[68] Therefore, the need would be for smooth transfer of technology from research institutions to industry and from the public sector to the private sector. Second, as far as collaboration with international industrial houses is concerned, the challenge is how to keep the autonomy of decision-making in India's hands. Also, by dealing with a wide range of domestic and international players, the chances of professional friction would be more.

Third, though India's plan to diversify its nuclear sector by sharing responsibility with other domestic PSUs like NALCO, Indian Oil, ONGC, etc., sounds wise, it needs careful planning. Negotiations with these units on commercial contractual obligations would involve painful and time consuming structural-legal arrangements. As a corollary, diversification of the programme would necessitate stringent safety and security arrangements. Given the frequency of terror incidents and the presence of a smuggling network in and around India, ensuring foolproof security to the expanding nuclear infrastructure would pose a serious problem.

Fourth, while expediting nuclear cooperation with other countries, India has also undertaken new exploration activities. The UCIL has taken up four new uranium mining projects in the Indian states of Jharkhand (Mohuldih), Andhra Pradesh (Tummalapalle), Karnataka (Gogi), and Meghalaya (Domiasat).[69] Mining activities in these sites would pose multiple challenges, the foremost being opposition from environmentalists. The Environment and Forest Ministry of India is under tremendous pressure to thoroughly examine the likely impact of these projects before granting them clearance. This would certainly delay the nuclear expansion programme. Moreover, new mining activity would result in displacement of the local people, leading to

68. "Heavy Manufacturing of Power Plants - India", http://www.vaec.gov.vn/userfiles/file/heavy%20industry.pdf, p. 5.
69. "India to Open New Uranium Mines, Boost Nuclear Power", *Indian Express*, August 10, 2009, accessed on October 22, 2010.

rehabilitation problems. Furthermore, the other major aspect of nuclear energy production that causes public concern is waste management and the safety of the power plants. However, the IAEA's Nuclear Technology Review 2009 projects that India's Public Acceptance Index for nuclear energy production is in the ascendance. According to the estimate, the index has raisen to almost 90 per cent in 2008 from 60 per cent in 2005.[70] If this is true, public resentment over displacement and rehabilitation would turn this index downward.

Fifth, though the Civil Nuclear Liability for Nuclear Damage Bill 2010 approved by the Indian Parliament in September 2010,[71] satisfies critics for its stringent provisions, it would distract potential investors. The Bill, in the present form, goes against global practice by placing the liability on the suppliers, and for a long period, up to 80 years. It also does not prescribe or clarify whether India should ratify the Convention on Supplementary Compensation for Nuclear Damage or follow the Vienna and Paris Convention models. Given the provision of a huge amount of Rs 1,500 crore as compensation, it is doubtful whether any foreign or Indian company would now be willing to invest in, or supply to, India. Therefore, the challenge India is likely to face in the coming years is how to make the legal and regulatory regime attractive for private investors while ensuring that human life in India not undervalued.

Lastly, within a few years, India's nuclear energy production will show signs of expansion but it would not be as rapid as expected, for obvious reasons. Unforeseen contingencies may lead to inordinate delays in reactor construction and supply of uranium. Though India's thorium-fuelled reactors (third stage) are envisaged to cater to India's energy needs, there can be no pre-determined dates for the advent of the third stage. Estimates vary from 2020 to 2040. Any unwarranted delay in the current expansion programme would further delay the third stage.

70. Report by the Director General IAEA, "Nuclear Technology Review 2009", http://www.iaea.org/About/Policy/GC/GC53/GC53InfDocuments/English/gc53inf-3_en.pdf, July 31, 2009.
71. Sukla Sen, "The Civil Liability for Nuclear Damage Bill 2010: Some Tentative Observations", http://www.cndpindia.org/e107_plugins/content/content.php?content.67

CONCLUSION

It is now a matter of speculation as to how New Delhi will use this window of opportunity to its advantage. At present, the strategy seems concentrated on the import side of the programme only. Though many countries have shown interest in purchasing India's small reactors, New Delhi has not taken up the issue seriously yet. However, this cannot be initiated without India becoming a part of the NSG, for which it should now strive, putting in its credentials for consideration. India also does not qualify on a key pre-requisite that all members need to have – NPT membership. This is where US support will be crucial. It is expected that the US will facilitate the NSG to "evolve a criterion" for India to join the grouping. India, on the other hand, may offer to join the Convention on Supplementary Compensation.

While engaging constructively with all the major players, India should not ignore China. Despite contentious bilateral issues, nuclear commerce between India and China is possible. The nuclear component in the Sino-Indian trade basket would be prudent in many ways. First, such cooperation would foster exchange and purchase of nuclear technology between the two emerging Asian powers, which will restore some balance in India's foreign policy undertaking. Second, since China is planning a major expansion of its nuclear energy programme and is expected to become the second biggest consumer of the radioactive metal, India should seek cooperation with Beijing, to become mutual stakeholders in each other's programmes. In the process, foreign companies involved in China's programme will also get interested in India's programme; thereby, it would be in mutual interest.

To maintain its global image as a "responsible" nation while dealing with a greater number of players, and to take along with it the increasing domestic public support , India needs to devise a delicate balance. Professional negotiating competence needs to be at par with the global standard. On the domestic front, public concern regarding cost-effectiveness, safety, impact on the environment and rehabilitation due to mining activities may rise. If not addressed promptly, it would lead to public opposition movements, resulting in project delays and disputes. As public perception on anything

nuclear is blurred, the necessity is to formulate a nuclear information management system involving the scientific community, the public and the media for dissemination of the appropriate information.

Finally, the present political leadership must take into confidence all political groups as nuclear projects generally are long-term undertakings. Therefore, a change in the national political leadership should not alter or hamper the initiatives made. A concerted effort by all the stake holders – the scientific-political leadership, the public, the media and private industrial houses – is warranted to achieve the ambitious nuclear goal India has set for itself.