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# *The Civil Nuclear Programme: The Last Decade and the Outlook for the Near Future*

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On the nuclear front, epoch making changes have happened during the past ten years, and have been widely debated within India. The changes have enjoyed bipartisan support notwithstanding such debates.

A beginning was made during the early years of this century when India and the USA began a dialogue to negotiate - what is termed as the 'Next Steps in Strategic Partnership' (NSSP). NSSP was announced in January 2004 when India and the USA agreed to expand cooperation in three areas that included civilian nuclear activities. While it was presented as a step in the direction of facilitating high technology trade, as far as civilian nuclear activities were concerned, the situation on the ground did not change.

By the time NSSP was announced, India had mastered the art of setting up larger Pressurised Heavy Water Reactors (PHWRs) as evident in the construction of 540 MWe PHWRs at Tarapur. However, the paucity of uranium reserves in the country was preventing India from accelerating the growth of the nuclear installed capacity in the country. A study[1] completed in 2004, to forecast the growth of electricity requirement in India with a view to determining, on a quantitative basis, the role of nuclear energy in India's electricity mix conclusively proved the need for a significant role for nuclear energy. It was evident that initiatives to improve uranium availability would be necessary to install more PHWRs. Additionally, due to a mismatch in the production of uranium and its demand, reactors already constructed and in operation were facing shortages, and the capacity factors of operating PHWRs started declining. The Department of Atomic Energy intensified its efforts to locate more uranium in the country; but exploring uranium and opening new mines and mills is a time consuming task involving decades of effort. It was evident that some additional initiatives would be needed.

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Subsequent to the announcement of the NSSP, there were notable exchanges between India and the USA. The visit of the then US Secretary of State, Condoleeza Rice, to New Delhi in March 2005 is particularly important as it laid the ground work for the visit of the then Prime Minister of India, Dr Manmohan Singh, to Washington in July 2005. The agreement reached during the July 2005 visit led to historic changes that followed, and are described below.

## India-USA Joint Statement of July 2005 and Subsequent Developments

Before going into the details of the Joint Statement, it is important to recapitulate certain crucial details. India had, and continues to have, an active nuclear weapons programme; it is also not a signatory to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and the USA enacted Atomic Energy Act before the International Atomic Energy Agency (IAEA) safeguards were fully evolved. The USA negotiated Nuclear Cooperation Agreements (NCA) with other countries in accordance with the provisions in its act and practices which were introduced by it prior to the evolution of IAEA safeguards. While IAEA is implementing stringent controls with regard to the accounting of nuclear material, the USA continues to have elements related to the implementation of safeguards by itself in its practices.

Beginning from the discriminatory nature of the NPT, India had certain experiences in international dealings on this subject, and it was necessary to move very cautiously. NPT provides for peaceful nuclear explosions and, until mid-nineteen seventies, IAEA organised annual seminars on the uses of peaceful nuclear explosions. Short-term schools on uses of peaceful nuclear explosions were organised by nuclear weapon states. After India's peaceful nuclear experiment at Pokhran in 1974, the concept of peaceful explosion was deleted from the discourse on the subject. Therefore, it was necessary for India to move very cautiously on the subject. The caution is evident in the Joint Statement of 18 July 2005 and the Separation Plan presented to the Parliament on 11 May 2006.

In the Joint Statement, the USA (i) recognised India as a state with advanced nuclear technology; (ii) committed to work to achieve full civil nuclear energy co-operation with India; (iii) work with friends and allies to adjust international regimes to enable full civil nuclear energy co-operation and trade with India; and (iv) consult with partners about India's participation in the ITER[2] project. India on its part agreed to (i) identify and separate

civilian and military nuclear facilities and programs; (ii) voluntarily place its civilian nuclear facilities under IAEA safeguards; (iii) sign and adhere to an Additional Protocol with respect to civilian nuclear facilities; (iv) continue India's unilateral moratorium on nuclear testing; (v) work with the USA for the conclusion of a multilateral Fissile Material Cut Off Treaty; (vi) refrain from transfer of enrichment and reprocessing technologies to states that do not have them and supporting international efforts to limit their spread; and (vii) ensure that the necessary steps have been taken to secure nuclear materials and technology through comprehensive export control legislation, a through harmonization and adherence to Missile Technology Control Regime (MTCR) and Nuclear Suppliers Group (NSG) guidelines.

After the joint statement, the USA started working towards a legislation to facilitate nuclear trade with India, and India worked on finalising a separation plan. In the separation plan eventually finalised, India decided on facilities to be placed under safeguards and the time table for doing so, and also stated that classification of future facilities as civilian or strategic will be determined by India. Two key points need to be highlighted here. One is that determination whether a facility is civilian or strategic is to be done by India. The second is the fact that India will adhere to '*an* additional protocol' and not '*the* additional protocol'. Additionally, India articulated its right to have a strategic reserve of uranium, and to take corrective measures to ensure uninterrupted operation of its civilian nuclear reactors.

To facilitate nuclear cooperation with other countries, Section 123 (Cooperation with other nations) of the US Atomic Energy Act provides for including several conditions in an NCA and this includes fullscope safeguards. Section 128 (Additional Export Criterion and procedures) calls for IAEA safeguards with respect to all peaceful nuclear activities in case of countries classified as non-nuclear weapon states by the NPT. Section 129 details conduct resulting in termination of nuclear exports, and includes detonation of a nuclear explosive device, termination or abrogation of IAEA safeguards, material violation or abrogation of safeguards, and engaging in manufacturing or acquisition of nuclear devices. To facilitate nuclear trade with India the USA enacted Hyde Act[3] and Section 104(a) of the Hyde Act provides waiver with respect to India not having fullscope safeguards and having a weapons programme.

Negotiations to conclude NCAs with the USA, France and Russia went on in parallel. Negotiations with all countries went on for several rounds. One particularly difficult issue was to make the USA agree to include reprocessing consent in the NCA. Despite several issues, India was admitted to the ITER

project even before the negotiations were completed. An India Specific Safeguards Agreement (ISSA) was negotiated with the IAEA, and the Nuclear Suppliers Group relaxed its guidelines on September 6, 2008 thus enabling international civil nuclear trade with India - a country outside the NPT – and having an active nuclear weapons programme. Subsequently, NCAs were signed with France, USA and Russia; an Additional Protocol to the ISSA was negotiated with the IAEA, and has since been signed and ratified. India started buying uranium from the international market for fuelling its reactors.

The process of signing agreements has continued, and India now has about ten NCAs including with Kazakhstan, Canada and Australia.

The safeguards agreement refers to India's strategic programme; fuel supply assurances; strategic reserves of nuclear fuel; and also corrective measures that India might make to ensure uninterrupted operation of its civilian nuclear reactors. It also refers to India's nuclear policies – three stage programme and use of nuclear energy for the welfare of the people and other peaceful purposes. It is limited to application of safeguards to facilities offered by India, provides for offering facilities for safeguards on campaign mode, and is an umbrella agreement. It has an Annex which was populated only when there was clarity about how cooperation would proceed. India's separation plan provided for offering nuclear facilities and reactors for safeguards in a phased manner, and India completed all its obligations as per the time table in December 2014.

Additional protocol obligates India to inform the IAEA about nuclear exports, and grant long-term visas to safeguards inspectors deputed by IAEA.

With this background, one can now examine the recent issues. In the language of nuclear law, a term 'nuclear material obligated to country X' is used. It includes nuclear material supplied by country X, and also the nuclear material which has been used as fuel in a reactor supplied by the country X. The USA, Canada, Australia and Japan track the material obligated to them. There could be situations where nuclear material is supplied by country X and reactors by country Y: then the spent fuel will become obligated to two countries. To obviate tracking by multiple countries, the USA has a section titled 'Multiple Suppliers' Controls' in its NCAs with other countries. This section provides for tracking by one country which is pre-determined through exchange of documents. Such a section is not there in the NCA between India and the USA.

Tracking of nuclear material as practiced by some of the countries undermines the role of the IAEA, and is a practice continuing from the period

when the implementation of safeguards by the IAEA had not matured. This also implies that a country X is concerned with diversion away from civil use of material obligated to it, but not the rest of the material. This was an issue between India and the USA, and has now been sorted out using the 'Canadian template' which involves sharing aggregate data obtained from the IAEA.[4]

## Result of Relaxation of NSG Guidelines

Subsequent to the relaxation of NSG guidelines to facilitate civil nuclear trade with India, uranium has been imported and used in existing PHWRs operated by Nuclear Power Corporation of India Limited (NPCIL). Simultaneously, indigenous efforts in the area of exploration have also shown results, and new mines have been opened. The result of this two-pronged effort has been the increased availability of uranium, leading to an improvement in capacity factors (See Table 1) and greater generation of electricity.

**Table 1**

| Year | CapacityFactor | Generation in Million units |
|---|---|---|
| **2008-09** | 50% | 14,927 |
| **2009-10** | 61% | 18,831 |
| **2010-11** | 71% | 26,473 |
| **2011-12** | 79% | 32,455 |
| **2012-13** | 80% | 32,863 |
| **2013-14** | 83% | 35,333 |
| **2014-15** | 82% | 37,835 |

In parallel, considering the increased availability of uranium, based on both imports and increased domestic production, the construction of more PHWRs has been launched: two units of 700 MWe each – at Rawatbhata in Rajasthan and similar two units at Kakrapar in Gujarat – are already under construction. Several more PHWRs are at various stages of planning. Table 2 below gives the details.

**Table 2**

| S. No. | Site | Number of reactors |
|---|---|---|
| **1** | Gorakhpur, Haryana | 4 X 700 MWe |
| **2** | Bhimpur, Madhya Pradesh | 4 X 700 MWe |
| **3** | Mahi-Banswara, Rajasthan | 4 X 700 MWe |
| **4** | Kaiga, Karnataka | 2 X 700 MWe |
| **5** | Chutka, Madhya Pradesh | 2 X 700 MWe |

An Agreement has been reached with Russia to set up two more reactors at Kudankulam, Tamil Nadu. A vision document aiming to set up a total of 12 reactors (including Kudankulam 1 and 2) in cooperation with Russia has been signed. Specific sites - all in coastal areas – have been earmarked for French and US companies. These include Chhaya Mithi Virdi in Gujarat, Jaitapur in Maharashtra, and Kovvada in Andhra Pradesh. Negotiations are ongoing between NPCIL and its counterparts from the USA and France to set up reactors on the basis of

- Mutually acceptable technical and commercial terms and conditions that enable a viable tariff regime for electricity generated;
- Affordability, sustainability of nuclear fuel resources and credibility of nuclear waste management.

The foregoing statements have several important points embedded in them: first, that the technical and commercial terms should be mutually acceptable; second, tariff should be viable and affordable; third, that waste management should be sustainable and credible. India considers reprocessing as a necessary element of sustainability of fuel resources as well as its strategy for waste management. In all the NCAs India has concluded so far, the reprocessing consent[5] is included and, therefore, the third point is settled. The first two points are yet to be settled by US and French companies, and they are work in progress. There are issues related to high capital costs and the high tariff of electricity generated by the plants designed by the companies in the USA and France. There were some misgivings about India's liability regime but these have now been addressed as described below.

## Civil Liability for Nuclear Damage Act[6]

India's liability law is based on principles followed worldwide, and there is no doubt that liability is strict, is based on the principle of no-fault, is channelled only to the operator, and there is no other legislation dealing with the subject. It also has a section (Section 17) on the operator's right of recourse, and there is no uniformity about such a section in the laws of various countries. In addition, Section 46 of the law is included to ensure that other laws continue to be applicable to the operator, and this is a standard practice in Indian laws and is a saving clause. However, many have erroneously interpreted Section 46 of the law as applicable to both the suppliers and the operators. An Amendment to make Section 46 applicable to suppliers was debated when the bill was examined by the Standing Committee; but it was not accepted. It was also moved in the Parliament, but was rejected. This clarifies the doubt about the

applicability of Section 46 to Suppliers.

Section 17 of the Act deals with operator's right of recourse, and reads as follows.

*The operator of the nuclear installation, after paying the compensation for nuclear damage in accordance with section 6, shall have a right of recourse where –*

*a) such right is expressly provided for in a contract in writing;*

*b) the nuclear incident has resulted as a consequence of an act of supplier or his employee, which includes supply of equipment or material with patent or latent defects or sub-standard services;*

*c) the nuclear incident has resulted from the act of commission or omission of an individual done with the intent to cause nuclear damage.*

Rule 24 further explains the right of recourse, and includes two explanations. The word 'supplier' appears only once in the Act, and that is in Section 17. It is not defined in the Act. The supplier is liable to the operator as per Section 17 of the Act. It gives the option of including it in the contract. As per press reports,[7] this was also confirmed by the then Attorney General in his opinion to the Government when he said, 'If the operator chooses not to incorporate such a provision in the contract, it would be open for him to do so.'

The Act does not define who the supplier is. Rule 24 precisely explains who a supplier is under Explanation 1 (b). Legal experts have commented on Section 17 without examining Explanation 1 (b). The explanation has three parts: a supplier could be a person who has provided 'functional specifications' or a person who has provided 'build to print' drawings or a person who has provided 'design or quality assurance services'. For reactors and fuel cycle facilities being designed indigenously, complete design details of the plants are developed by NPCIL or the Bhabha Atomic Research Centre (BARC) or the Nuclear Fuel Complex. In such cases, the responsibility of ensuring safe operation lies with the designer. For reactors to be set up in technical cooperation with vendors from other countries, where the responsibility for the design is shared, the contract has to define details of such sharing, as well as the modalities of the application of Right of Recourse.

Once such modalities have been decided, a supplier can take insurance to protect his interest; such insurance is now available with the launching of the Indian Nuclear Insurance Pool (INIP).[8] INIP was launched on 12 June 2015, and provides insurance products for both operators and suppliers.

Many are of the opinion that Sub-section 17 (b) of the Act makes Indian law incompatible with the Convention on Supplementary Compensation (CSC). Such criticism ignores Article XII.2 of the CSC which provides flexibility to a contracting party. India has signed CSC, and since the insurance product has now been made available by INIP, the Government should move to ratify the CSC.

## Technological Developments in India, Notable Successes and Future Technology Options

On the technology development front, India has been treading a lonely path, and has based its development efforts on a science based approach. This has led to notable successes. Two such successes are covered below.

### Fast Breeder Reactors

The first is the development of fast breeder reactors. India started working on this technology right from the inception of the nuclear programme and a Fast Breeder Test Reactor was first set up. Based on subsequent research and development efforts, the construction of a 500 MWe Prototype Fast Breeder Reactor (PFBR) was launched.

This development was acknowledged by Siegfried S. Hecker[9] while speaking during the Hearing of the US Senate Committee on Appropriations, Subcommittee on Energy and Water Development on 30 April 2008. He said "I found that whereas sanctions slowed progress in nuclear energy, they made India self-sufficient in nuclear technologies and world leaders in fast reactor technologies, while much of the world's approach to India has been to limit its access to nuclear technology, it may well be that today we limit ourselves by not having full access to India's nuclear technology developments. Such technical views should help to advise the diplomatic efforts with India"..

The fact that India is a leader in fast reactor technologies will be demonstrated once the PFBR goes critical in the very near future.

### Waste Management

The second notable success is in the area of waste management. India follows a closed fuel cycle approach as it produces minimum waste per unit of electricity generated and ensures sustainability of fuel resources.

Technologies for vitrification[10] of high level nuclear waste arising from reprocessing plants have been developed and deployed. However, high level nuclear waste has to be stored for a long time. Nuclear waste consists of fission products and minor actinides, and any uranium and plutonium that have not been separated. Minor actinides have a very long half life and their presence in the waste makes it necessary to store the waste for a long time. Scientists have proposed that nuclear waste can be partitioned, a process that separates minor actinides from the waste. The remaining waste would then require storage for a period of about 300 years, which is a historical time frame. Minor actinides can be fabricated into fuel and burnt in fast reactors. The process of burning is called transmutation. Partitioning of minor actinides and their subsequent transmutation are the processes to be mastered to solve the waste management problem. India has set up an engineering scale demonstration facility[11] for partitioning of minor actinides and it is already working. PFBR is nearing completion, and the step remaining to solve the waste problem is to demonstrate the process of transmutation.

## Future Technology Options

Technologies developed in India and the recent changes enabling international civil nuclear trade have provided India with several technological options to meet its long-term energy requirements. Since uranium is now available, and India has developed several technologies including compact Pressurised water Reactor (PWR), multiple technology options are available to India to ramp up growth of nuclear installed capacity through such options.

India can use slightly enriched uranium in PHWRs, thereby increasing fuel burn-up and reducing spent fuel tonnage; develop its own Pressurised Water Reactors; develop enriched uranium based fast reactors, and so on. Taking a long-term perspective, India is working on various options for utilising thorium.

Still another possible option is development of Fusion reactors. Institute for Plasma Research, Gandhinagar is a grant-in-aid institute under the DAE, and is spearheading India's quest for the development of fusion technologies. In July 2005, when the India-USA joint statement was finalised and the USA offered to consult with partners about India's participation in the ITER project, a Joint Implementation Agreement (JIA) was being negotiated by six Parties: China, EU, Japan, Russia, South Korea and the USA. Based on the technological strengths of IPR, India joined the negotiations for finalising JIA in December 2005, and was admitted to the ITER project.

Globally, efforts have been made to restrict fuel cycle facilities to a small number of countries by launching initiatives proposing multilateral approaches. In March 2004, IAEA convened a group of experts to explore options and develop proposals for improved controls, including multilateral oversight arrangements, for the front- and the back-ends of the nuclear fuel cycle. The group had eclectic membership: scientists, diplomats and lawyers.[12] The group completed its report in April 2005,[13] and the report outlined five approaches to achieve the objective of restricting fuel cycle technologies to a select few countries. India has to keep developing reactors as well as fuel cycle technologies so as to ensure that it has the status of a supplier nation in any multilateral regime, as and when it evolves.

## Near-future Outlook and Challenges Ahead

Near-term growth of nuclear installed capacity will be governed by an indigenous programme involving construction of PHWRs as already outlined as well as fast reactors which will be launched after completing the PFBR. Construction of more reactors at Kudankulam in technical cooperation with Russia will also take place in near-term. While cooperating with others, particularly the USA and France, arriving at technical terms and conditions that are mutually acceptable and enable a viable tariff regime is appearing to be a big challenge. The key to addressing this challenge is probably increased localization.

India has been recognised as a state with advanced nuclear technology because of the strengths acquired by it in the development of technologies based on a science based approach, and a law based export control regime. In its approach to nuclear technologies, it has been guided by its own national interests, and has been making its technical decisions independent of others. In the business environment that will evolve due to international cooperation with multinational corporations, it has to preserve autonomy in decision making, and ensure precision in transactions so as to preserve background intellectual property that has been painstakingly acquired by academia and industry over the past several decades.

The Atomic Energy Act 1962 permits the manufacture of prescribed equipment[14] by the private sector; but the operation of nuclear power plants is reserved for the public sector - though the Act does permit minority participation of the private sector in the operation of nuclear power plants. As growth in nuclear installed capacity takes place, there will be temptation by

private entrepreneurs to own and operate nuclear power plants. Before making amendments to the Atomic Energy Act to provide for ownership of nuclear power plants by the private sector, adequate preparation is necessary. The need for preparation arises from issues related to safety, security and safeguards.

To regulate safety, it is necessary to bring in legislation to set up a Nuclear Safety Regulatory Authority to convert the *de jure* independence of the Atomic Energy Regulatory Board to *de facto* independence.

System of national safeguards needs to be strengthened. India has been conscious of the issue of physical security of nuclear materials and facilities in view of the geo-political situation around it and has in place adequate systems and policies.[15] India has been participating in the Nuclear Security Summit process from the beginning in 2010 and had announced setting up of a Global Centre for Nuclear Energy Partnership at the first summit in 2010. This centre will focus on several areas including research on and training in nuclear security. Physical security around nuclear facilities is at present provided by technical means as well as by personnel from the Central Industrial Security Force. In case of ownership by the private sector, role of the private sector and the Government has to be delineated and enforced based on unambiguous and legally enforceable terms and conditions.

Another important issue is human resource development. India does have systems[16] in place to train needed human resources, but incentives need to be provided to ensure that qualified and trained persons continue to stay in India.

The biggest challenge is going to be site selection and managing public perception. Public misgivings arise because of several reasons. The primary concerns about nuclear radiation amongst a section of the public are due to the fact that human sensory organs cannot detect its presence. Nuclear radiation can only be detected by instruments, and for this people have to rely on scientists employed with the Government. Distrust of the Government by a section of the public is exploited by some. This is done by spreading misinformation through fringe literature or public lectures. Scientific literature is subject to peer review before publication, and the media follows some guidelines. However, there is no code of conduct for fringe literature. It is a challenge to control the spread of such misinformation. The only way to counter misinformation is to keep talking to all citizens in a language that they can understand, and provide factually correct information. This has to be done repeatedly, and at all sites.

## Notes

[1] Grover, R.B. and Chandra, S. (2006), "Scenario for Growth of Electricity in India", Energy Policy, 34 pp 2834-2847.

[2] When first proposed, ITER was an abbreviation for International Thermonuclear Experimental Reactor. Iter is a Latin for 'the way' and earlier detail has been dropped. ITER began in 1985 as a Reagan–Gorbachev initiative with the equal participation of the Soviet Union, European Union, the United States, and Japan. Detailed design was completed in 2001 under the auspices of the IAEA. Negotiation for the launch of the project started thereafter and over the years more Parties joined the original four.

[3] President George W. Bush signed the Hyde Act into law on 18 December 2006.

[4] Suhasini Haidar, 'India agrees to share nuclear data for breakthrough talks', *The Hindu*, 5 February 2015.

[5] In the case of NCA with the USA, while reprocessing consent is included in the NCA, an Agreement on Arrangements and Procedures to implement reprocessing consent was separately negotiated and signed. This is another area where the USA is yet to modernize its practices. When the IAEA has developed procedures for safeguarding reprocessing facilities, why is there a need to have arrangements and procedures?

[6] This section is a summary of a paper on the subject under preparation.

[7] 'Manmohan may carry nuclear liability dilution as gift for US companies', *The Hindu*, 19 September 2013.

[8] 'Indian Nuclear Insurance Pool Launched', *Business Standard*, 13 June 2015.

[9] Siegfried S. Hecker is an American nuclear scientist and metallurgist who served as the Director of the Los Alamos National Laboratory from 1986 till 1997, and is now co-director of the Stanford University Center for International Security and Cooperation (CISAC).

[10] Vitrification is the transformation of a substance into a variety of glass. Nuclear waste is transformed into glass. Glass is suitable for long-term disposal of nuclear waste due to its stability.

[11] Smitha Manohar, V.P. Patel, U. Dani, M.R. Venugopal and P.K. Wattal, (2013), 'Engineering scale demonstration facility for actinide partitioning of high level waste', *BARC Newsletter*, No. 332, May/June 2013, pp. 13–18.

[12] The author was a member of the group, and considers his participation in the group as a period of internship in nuclear law and diplomacy which became useful when he participated in negotiations leading to nuclear cooperation agreements with various countries.

[13] 'Multilateral Approaches to the Nuclear Fuel Cycle: Expert Group report to the Director General of the IAEA', IAEA 2005, INFCIRC/640.

[14] India has a law based export control system, but follows a nomenclature that is different

from that followed by the Nuclear Suppliers Group. Prescribed equipment is the equipment that is in the trigger list of the NSG, and essentially consists of items that are needed for the nuclear island of a nuclear power plant or fuel cycle facilities.

[15] Grover, R.B. (2014), 'The Technological Dimension of Nuclear Security', *Strategic Analysis*, 38:2, pp. 151–156.

[16] R. B. Grover and R. R. Puri, (2013), 'Development of Human Resources for Indian Nuclear Power Programme', *Sadhana*, Vol. 38, Part 5, pp. 1051–106

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