BHARATIYA NABHIKIYA VIDYUT NIGAM LIMITED

6

DEPARTMENT OF ATOMIC ENERGY

COMMITTEE ON PUBLIC UNDERTAKINGS
(2014-2015)

SIXTH REPORT

(SIXTEENTH LOK SABHA)

LOK SABHA SECRETARIAT

NEW DELHI

CPU NO. 986

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BHARATIYA NABHIKIYA VIDYUT NIGAM LIMITED

DEPARTMENT OF ATOMIC ENERGY

सत्यमेव जयते

Presented to Lok Sabha on 28.04.2015

Laid on the Table of Rajya Sabha on 28.04.2015

LOK SABHA SECRETARIAT

NEW DELHI

APRIL 2015 / VAISAKHA 1937(S)

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COMPOSITION OF
COMMITTEE ON PUBLIC UNDERTAKINGS (2014-15)

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22. Shri Tapan Kumar Sen

Secretariat

1. Shri M.C. Sharma – Joint Secretary
2. Shri M.K. Madhusudhan – Director
3. Shri Tirthankar Das – Deputy Secretary
4. Shri Sunny Goel – Executive Assistant

INTRODUCTION

I, the Chairperson, Committee on Public Undertakings (2014-15), having been authorized by the Committee to submit the Report on their behalf, present this Sixth Report on Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI).

2. The Committee on Public Undertakings (2013-14) had selected the above subject for detailed examination. Since the examination of the subject could not be completed during the term of that Committee, the Committee on Public Undertakings (2014-15) reselected the subject to complete the unfinished task.

3. The Committee on Public Undertakings (2013-14) had taken Oral Evidence of the representatives of BHAVINI on 24 August 2013. Thereafter, the Committee (2014-2015) took oral evidence of the representatives of Department of Atomic Energy on 6 January 2015.

4. The Committee considered and adopted the Report at their Sitting held on 24 April 2015.

5. The Committee wish to express their thanks to the representatives of BHAVINI and Department of Atomic Energy for tendering evidence before them and furnishing the requisite information to them in connection with the examination of the subject.

6. For facility of reference and convenience, the Observations / Recommendations of the Committee have been printed in bold letters in Part-II of the Report.

New Delhi
27 April 2015
7 Vaisakha,1937 (S)

SHRI SHANTA KUMAR
Chairperson,
Committee on Public Undertakings

CHAPTER - I

OVERVIEW

A. INDIA'S NUCLEAR ENERGY PROGRAMME

The nuclear energy programme in India has been visualized to grow in three stages. The programme is sequential and each stage has fuel cycle linkages in which spent fuel from one stage is reprocessed to obtain fuel for the next stage. Stage I consists of natural uranium fuelled, Pressurized Heavy Water Reactors (PHWRs) which have a power potential of about 320 GW years. Stage II consists of Fast Breeder Reactors (FBR) using plutonium as fuel which have the power potential of about 40,000 GW year. Stage III based on Thorium-Uranium 233 fuel cycle has the potential of 155000 GW years.

Nuclear energy offers the most potent solution to long term energy security. India has to successfully realize the three stage development and thereby tap its vast thorium resources to became truly energy independent beyond 2050. The commercial deployment of thorium requires a significant capacity of FBRs and development of technologies for thorium utilisation.

Having obtained commercial success in the Stage I-PHWRs, to attain energy security for the Nation, Stage II Fast breeder Reactors was taken up for implementation.

B. ROLE OF BHAVINI

To facilitate implementation of Stage II expeditiously and enable commercial borrowings, a Special Purpose Vehicle (SPV), BHAVINI which is a Government Company was floated under the Companies Act.

Stage-I- PHWRs are under Nuclear Power Corporation of India Limited (NPCIL) which are operating reactors in commercial domain. Stage-II- Fast Breeder Reactors are under Bharatiya Nabhikiya Vidyut Nigam Limited to focus, develop and enrich on FBR technology. To support FBR technology financially, first prototype FBR with debt equity ratio of 20:80 was conceived. This debt equity ratio will have adverse impact on NPCIL capital structure, if FBR were under NPCIL domain. Further a dedicated company needs to pay focused attention on a technology which has huge potential. BHAVINI was thus formed in parallel to NPCIL.

BHAVINI's role in implementing Stage II is procurement, construction, commissioning and operation of Fast breeder Technology based nuclear power station(s) as a safe, environmentally benign and economically viable source of electrical energy.

C. CORPORATE MISSION, OBJECTIVES AND FUNCTIONS

The Corporate Mission of BHAVINI is to plan, execute and upgrade an integrated program of Fast Breeder Technology based Nuclear Power Stations on a safe, environmentally benign and economically viable source of electrical energy.

Moreover, BHAVINI's objective to develop economically viable fast breeder reactor for energy security for the future generation is in consonance with its Corporate Mission.

The functions of BHAVINI are stated to be as follows:

- To plan, execute and operate an integrated programme of Fast Breeder Technology based nuclear power station/s for generating electricity on a commercial basis.

- To own, operate and manage, or to operate and manage as an agent, power stations and ancillary facilities of every kind and description and promote research and development,

- Participate in selection of suitable sites for fast breeder power stations and ancillary facilities, construct, commission, operate and maintain them, coordinate their installation and operations with other organisations,

- ensure safe and efficient disposal of waste products, participate in fuel cycle management,

- ensure proper evacuation of power from power stations by providing for associated transmission facilities required for the purpose or otherwise and undertake all measures required therefore or incidental to any or all of the above.

- To exchange, distribute and sell power in accordance and within the regulatory, legal and statutory framework.

Giving a brief introduction about the Company, the acting CMD stated during evidence as follows:

> "…BHAVINI is a public sector undertaking under Department of Atomic Energy. This was incorporated as a separate PSU, a Government company in October 2003 and BHAVINI is mandated to construct, commission and operate fast breeder reactors and this marks the beginning of second stage nuclear programme where fast breeder reactor technology is being put on commercial scale. So the first commercial fast breeder reactor is being constructed by BHAVINI."

D. ORGANISATIONAL STRUCTURE

According to the Company, Chairman and Managing Director, Director (Technical), Director (Finance), two Government part time Directors, four official part time Directors constitute BHAVINI Board of Directors. Chairman and Managing Director and two full time functional Directors with the support of Executive Director (Operations), Project Director, Deputy General Manager (Human Resource), Deputy General Manager (Finance and Accounts) and Deputy General Manager (Contracts and Materials Management) steer the programme of BHAVINI under the guidance of Board of Directors.

It has also been informed that induction of two Independent Directors is required in the Board of the Company to comply with AEC guidelines and proposal for appointment of Independent Directors has been submitted to the Government.

In this regard, when the Company was asked about the AEC guidelines regarding the composition of the Board of Directors and to what extent they differ from DPE guidelines, the Company in a written reply submitted as follows:

> "AEC guidelines regarding the composition of the Board of Directors are as under:
>
> The Board shall consist of:
>
> (a). Full time Chairman-cum-Managing Director assisted by whole time (executive) directors, whose number shall not normally exceed 50% of the actual strength of the Board.
>
> (b). Non-executive (Part-time) Directors:
>
> In order to provide a liaison role and a channel of communication between the DAE and BHAVINI, Additional Secretary/Joint Secretary dealing with BHAVINI matters will be appointed as Government representative from the Department of Atomic Energy as non-executive director. Directors representing the Government, at any time, shall not exceed two.
>
> Keeping in view the technology used in BHAVINI and the sensitivity/ confidentiality of information, other non-executive positions on the Board will be filled up by officers of the level of Director, BARC; Director, IGCAR; AS/JS/Adviser drawn from the Ministries like Power, Environment & Forests and Planning Commission and also by officers of the level of Director/Executive Director drawn from PSUs in power sector.
>
> (c) Non-official independent directors.

With a view to make the Board professional and broad based, two professionals of eminence from industry in private/non-government sector with a high degree of proven ability may also be inducted as non-executive (non-official) independent directors.

Difference of AEC guidelines from DPE guidelines on composition of Board are:

(a) DPE guidelines state that “The number of nominee directors appointed by Government/other CPSEs shall be restricted to a maximum of two.

(b) Further one-third of the Board Members should be Independent Directors for BHAVINI being non-listed company."

When asked about the rationale behind having separate guidelines with regard to composition/appointments to Board of Directors of BHAVINI, the Company replied as follows:

“Pursuit of the objectives set for the Company involves management of certain unique challenges unlike other Public Sector Enterprises in the country. BHAVINI’s organisational role encompasses implementation of an entire spectrum of activities from developing technology, design, engineering and construction to commissioning, operation and maintenance of fast breeder reactors. BHAVINI is required to achieve these objectives entirely by indigenous efforts without access to external resources, either technological, financial or in terms of human resource expertise. Expansion of fast breeder reactor programme in the commercial domain also calls for development of industries for design, manufacture and supply of equipment, systems and various other materials to meet the highest technical standards. The several constraints, within which the Company has to operate, call for special powers and operational freedom being made available to it with a view to sustain and grow, especially in a liberalised and competitive environment, to fulfil the long-term objectives before it.

For this, BHAVINI needs to build, sustain and continuously improve a conducive and enabling work and social environment for nurturing and developing scientific and, engineering talents coupled with commercial acumen and, accordingly, it is envisaged that the Company should have the operational flexibility required to develop a framework for human resource development that would aid the objective of attracting talent, their retention and development besides maintaining high motivational levels among its employees. With this objective Board members are drawn from BARC, IGCAR and other government units.”

On being asked when the proposal for appointment of Independent Directors was actually sent to the Government and what is the current status of appointment of these two Independent Directors, the Company stated:

"Proposal for appointment of only one Independent Director was sent to Department of Atomic Energy on 3rd August 2013 and is under consideration. For the second position action is being taken by the Company."

When the Company was asked as to how in the absence of these two directors on the board, the matters relating to functioning of the Company are being monitored, BHAVINI submitted as follows:

"Board inter-alia consists of i) Additional Secretary, DAE, ii) Joint Secretary (Finance), DAE, iii) Adviser, Planning Commission, iv) Director(Thermal), Ministry of Power, v) Director, Bhabha Atomic Research Centre and vi) Director, Indira Gandhi Centre for Atomic Research. They are eminent professionals in their area and contribute, guide and monitor various functions of the Company.

As a good corporate citizen, BHAVINI with a view to make the Board broad based, two professionals of eminence from industry in private/non-government sector with a high degree of proven ability will be inducted as independent directors in near future."

On being asked whether DAE has received any proposal from BHAVINI regarding appointment of independent directors on their board, the Department replied as follows:

"BHAVINI has sent a proposal to DAE in this regard. DAE has asked BHAVINI to propose a list of 6 prospective candidates for position of Independent Directors for selection. BHAVINI has shortlisted the names of prospective candidates who could facilitate the growth of BHAVINI. Revised proposal is expected to be received by DAE shortly."

To a query regarding time frame for inducting the independent directors on the board of BHAVINI, the Department stated that the process may take three months time.

Subsequently, the DAE has informed that it approved the appointment of two independent directors to the Board of BHAVINI and sent the same for further processing.

CHAPTER - II

NUCLEAR POWER GENERATION

A. IMPORTANCE OF NUCLEAR ENERGY

According to the Department of Nuclear Energy (DAE), the country's oil and gas resources are inadequate and most of their demand is being met through imports. As per the Integrated Energy Policy (2006) India's coal and lignite reserves are expected to last only for 140 years at 2004-05 production levels and run out in about 45 years if the production increases at 5% every year. The potential renewable resources of hydro and non-conventional sources like wind, solar, biomass etc. are also limited. Thus, it is inevitable that given its huge potential, nuclear energy has an important role in the energy mix of the country, particularly in the context of energy security. The share of nuclear power in the energy mix is thus expected to gradually increase.

It has been stated by DAE that the exact share of nuclear energy in the country's energy mix at a point in time would depend on the share of the other sources. Several projections in this regard have been made and as per one of the projections, Strategy for growth of Electricity in India by Department of Atomic Energy, the share of nuclear energy in the total energy at the primary level, which was 1.72% in 2002-03 is expected to gradually increase to about 16.58% by 2052. In terms of electricity generation, the nuclear share (which was 3.6% in 2012-13 in total electricity generation) is projected to be 26% by 2052.

B. XI PLAN TARGETS

The details of the XI Plan nuclear generation targets, the targets at MTA and the actual generation are given below:

	Generation of Nuclear Power (Million Units)					
	2007-08	2008-09	2009-10	2010-11	2011-12	Total XI Plan
Target	18685	25894	32413	40703	45699	163395
MTA	16956	14927	22000	31232	39492	124608
Actual	16956	14927	18831	26473	32455	109642

The reasons for shortfall in nuclear power generation in the XI Plan were primarily related to shortage of fuel. The target of 163395 MUs was revised to 124608 MUs at MTA stage considering the fuel supply position. The detailed reasons for shortfall were stated to be as follows:

- Demand-Supply mismatch of Domestic Uranium: There was a demand–supply mismatch in domestic fuel from 2003-04 onwards and efforts to augment the same had been initiated. At the time of formulation of XI Plan targets in 2006, it

was expected that there would be an improvement in supply of domestic uranium in the XI Plan period and the targets for generation were set accordingly. However, the domestic fuel supply improvement was seen only towards the later years of the XI Plan leading to shortfall in meeting the targets. It also led to delay in startup of Kaiga-4 after completion of construction and restart of Narora Atomic Power Station (NAPS-2) and Kakrapar Atomic Power Station (KAPS-1) after Renovation and Modernisation, which were awaiting fuel, leading to loss of generation from the units.

- Delay in international cooperation: The fruition of international cooperation was expected at the start of the XI Plan period and it was assumed while setting the targets that imported fuel for reactors to be placed under IAEA Safeguards would be available. However, the international cooperation materialised only in late 2008, and imported fuel was available only from late 2009-10 onwards. This also delayed the start of units RAPS-5&6, which were completed, but had to wait for imported fuel for startup.
- Delay in completion of Kudankulam 1&2 (KKNPP 1&2) projects. The XI Plan targets envisaged a total generation of 29784 MUs from KKNPP 1&2 over the last three years of the plan. However, the completion of the project was delayed due to delays in sequential receipts of equipment from Russian Federation and subsequently, local protests in 2011, which severely impeded the work.

- Delay in completion of PFBR (BHAVINI) projects. There was a shortfall of 2190 MUs due to delay in completion of PFBR, which was originally targeted in the year 2011-12. BHAVINI faced number of technological challenges being first of its kind. PFBR is constructed on an indigenous design, which was also a maiden experience. Therefore, designs kept undergoing changes through the course of manufacturing also. The necessity to use special materials like SS316LN, SS304LN, follow special stringent manufacturing processes and observe stringent tolerances and dimensions never experienced in the past, led to challenges and delays although the equipment were ordered on industries with proven capabilities and after due diligence. The Government has approved revised timeline for completion of PFBR as September, 2016.

C. XII PLAN TARGETS

The XII Plan nuclear power generation targets fixed for NPCIL are 237149 Million Units and that of BHAVINI 1092 Million Units. The year-wise generation targets fixed for the XII Plan and achievements in 2012-13 and 2013-14 (April to December 2013) in Million Units are as follows:

Financial Year	2012-13	2013-14	2014-15	2015-16	2016-17
Target	38000	46167	48688	50678#	58014#
Actual	32863	35333	27292*		

**Apr – Dec, 2014*
[#]includes target of 1092 MUs 2016-17 from BHAVINI
The generation in 2013-14 and 2014-15 (Apr-Dec 2014) includes about 1106 and 2242 Million Units of infirm power respectively, from KKNPP-1

The shortfall in generation was stated to be on account of delay in start of operation of Kudankulam 1&2. The work on the project was delayed due to protests during September 2011 to March 19, 2012; subsequent remobilization in the prevailing atmosphere and building up momentum took time. Further, the commissioning of the project was taken up only after fulfilling the directives of the Hon'ble Supreme Court in July 13, 2013. The Unit-1 was connected to the grid on October 22, 2013 and its power level raised in accordance with the stage-wise clearances of the Atomic Energy Regulatory Board. The unit commenced commercial operation on December 31, 2014. It generated about 3348 Million Units of electricity till its start of commercial operation. Unit-2 is following closely following and the Unit 2 is expected to be operationalised in 2015-16.

D. THORIUM RESERVES

When asked as to whether the government has carried out assessment of the available and extractable reserves of thorium and whether these reserves are sufficient for the three stage nuclear power programme of the country, the Department of Atomic Energy stated as follows:

> "Thorium is abundantly available in India, in the beach sand, placer deposits along the west and east coasts of India. DAE through its Atomic Minerals Directorate for Exploration & Research (AMD) has surveyed almost the entire Indian coastline and identified locations where the beach sand contains significant quantities of monazite, which is the main source of thorium in India. Exploration activities carried out by AMD over the past six decades have resulted in establishing in situ resources of 11.93 million tonnes of monazite in the country, which in turn contains about 1.07 million tonnes of thorium oxide (ThO2).
>
> Unlike Uranium, which can be used as nuclear fuel, thorium cannot be directly used as nuclear fuel. In the first instance, thorium has to be used along with either enriched uranium or plutonium while being put into any reactor. The spent fuel then contains an isotope called uranium-233. This is the second man-made fissile material apart from plutonium. The third stage of Indian nuclear power programme contemplates making use of Uranium-233 to fuel Uranium-233 – Thorium based reactors, to provide energy security to the country for several centuries. The intention of the DAE is to use thorium as the mainstay of its long-term nuclear power programme. Using the nuclear properties of uranium, plutonium and thorium, it can be easily shown that to get a rapid growth of installed nuclear generation capacity in a country like India with limited uranium resources, the large-scale deployment of thorium has to be postponed to the third stage of the Indian nuclear programme after the plutonium-based (Fast

Breeder Reactors) (FBRs) have enabled accelerated growth in the nuclear generation capacity in the second stage of this programme.

BARC and other research organisations under DAE are engaged in various R&D activities to address the utilisation of thorium in different types of reactors. Some important highlights of these activities are as follows:

(i) Thorium Oxide (Thoria) pellets contained in bundles have been used in the initial cores of our Pressurised Heavy Water Reactors (PHWRs). Thoria based fuels have also been irradiated in the research reactors CIRUS and Dhruva. After such irradiation, these fuel elements have been examined in the laboratories at BARC, yielding excellent results.

(ii) The irradiated thoria pins of CIRUS have been reprocessed to obtain U233. The recovered uranium 233 has been fabricated as fuel for the 30 Kilo Watt (thermal) KAMINI reactor which is in operation at Indira Gandhi Centre for Atomic Research (IGCAR) at Kalpakkam.

(iii) The very challenging technologies for fabrication of Thoria based fuel pellets, carrying uranium-233, have been established.

(iv) A 300 MW Advanced Heavy Water Reactor (AHWR) using thorium based fuel has been designed and developed. This reactor will serve as a technology demonstrator for not only the thorium fuel cycle technologies, but also several advanced passive safety features. A Critical Facility was commissioned in 2008 at BARC, and is used for carrying out experiments to further validate the physics design features of AHWR. A project for launching construction of AHWR has been included in the XII plan."

CHAPTER - III

COMMISSIONING OF PROTOTYPE FAST BREEDER REACTOR

Government of India accorded the administrative and financial approval for launch of PFBR in September 2003 with the completion duration of seven years i.e. September 2010. Government of India, in April 2012, has accorded approval for revision of the project completion schedule to September 2014. The present target for project completion is September 2016 as per Government's approval in December 2014.

A. DELAY IN Commissioning of PFBR

During oral evidence held on 6 January 2015, the acting CMD explained in detail about the commissioning of PFBR as follows:

> "The company was incorporated in October 2003 and the first pour of concrete which marks the beginning of these nuclear projects actually commenced in December' 2004. After the tsunami which struck Kalapakkam, this had to be re-done. The work has been going on since June 2005 and today we have almost completed the construction of the project. All the reactor components have been received and they have been evacuated. Now what is happening is that each of these components has been commissioned independently. The integrated commissioning together of all the equipments is being undertaken in BHAVINI now. The physical progress is 97.65 per cent and the Cabinet has approved date of September 2016 for completion of the project and process of integrated commissioning. We would start the process of filling of sodium as sodium is used as coolant in this reactor. Sodium filling in the second fuel filling in the main vessel will start serially. All components one after another other than the sodium pumps would be commissioned and then the fuel will be filled in main vessel where fuel will be loaded and would be heated. We expect that fuel loading could commence by July-August 2015 and then there would be zero power initially. The power would be stepped up gradually because this is the first-of-its-kind reactor in the country and physics experiment like low and high power need to be done for data validation. Eventually we would go for 100 per cent power. This is in brief the present status of fast breeder reactor."

In this regard, the representatives of DAE submitted as follows:

> "...I would also like to submit to the august Committee some of the reasons why BHAVINI is facing considerable delay in execution of this project. Some of the important reasons my colleague has just now mentioned. This is virtually the first of its kind project anywhere in the world. Among the developed countries also, only earlier Soviet Russia, prior to current Russian Federation, had started in 60s and it is said that they are continuing to build the same. They have not come to the completion of the breeder reactor. In effect, the BHAVINI breeder reactor we

are building in India is effectively the first of its kind for us in the country. The second important point is we have what we describe in the scientific community a denial regime. Anything related to this Plant or even any other nuclear plant, mostly we will have to design and build it ourselves. Even the smallest component or part, no other country is prepared to sell it to us. They have extensive means to see if any other importer is indirectly giving that item to the Department of Atomic Energy, they would like to immediately put a halt to the export of that item from that country.

As I have submitted, every single equipment, every single component has to be internally designed, there is always a process of trial and error. They start with an expectation that they need this particular function to be discharged. To discharge that function they design equipment and after designing that they will have to rest it in laboratory conditions. If it is successful in laboratory conditions on a smaller scale they give it for manufacture to an identified commercial manufacturer. After that it has to be verified whether it continues to discharge the expected functions when built on a commercial scale. So, they are in that process. As my colleague has mentioned, they have completed almost 97 per cent of all the equipment. Two items of equipment, very delicate ones, they are still having small degree of problem with them……. we are reasonably hopeful, as of now, that we will be able to complete the execution of the project and commence commercial generation of power by September, 2016."

Acting CMD, BHAVINI further submitted as follows:

"....I can give reasonable assurance to the hon. Chairperson and Members of the Committee that there has been no instance of avoidable delay between 14th September and now. The delays whatever happened have been completely unavoidable. For instance, the initial plan was by February 2014 most of the reactor critical components were to be received and erected and commissioned in Kalpakkam. What happened was many of these equipment were over dimensional and first of the kind for which even technology development could not take place by the designers, the Indira Gandhi Centre for Atomic Research. So, they were being manufactured straightaway. There were several issues in the manufacture because of the stringent specifications, because of the stringent tolerance required. Even the tools and the methodologies were first of the kind. So, they also had to be concomitantly evolved along with the manufacturing process. Because of which a number of components were received after September 14. For example, the air heat exchangers, which are safety grade equipment and then the fuel handling equipment like the fuel transfer machine or the transfer arm, were received late and are being commissioned now. That is one. The second reason is the receipt, erection and commissioning had to be done in a sequential manner and not in a parallel manner. So, non-receipt or delay in receipt of one component resulted in the delay of erection of another component. So, these were the reasons because of which there was this delay. Now, as we have projected, by the end of this year we should be able to start fuel

loading in the reactor and start generating low power initially and then step up power gradually and reach 100 per cent power by September 2016."

DAE further stated as follows:

"The first question is relating to the enormous delay in this project and the hon. Member has expressed the opinion that somebody should be made responsible. While I fully agree with that sentiment, I would like to once again submit to the Committee that this is the first of its kind effort. Nuclear technology is one of the most complicated technologies in the realm of science and technology. What has been done earlier in other countries is the proof of concept. Our scientists also know that such and such a thing can be done to achieve such a result but the actual technological pathways of doing those things and achieving that result is a thing which is left to ourselves to identify, to design and to invent and to actually implement on ground. I would like to humbly submit that our scientists are making the best of their efforts and whenever we do a thing for the first time, it is definitely likely to take more time than initial envisaged and it is likely to take more cost than initially envisaged.

In the same vein, the current project is seeing technological problems. Most recent ones are the detection of neutrons and another piece of equipment. Every single piece of equipment has to be considered as critical for the project. The equipment has to meet all the requirements and all the standards. It has to be approved by the Atomic Energy Regulatory Board before it can actually be utilised in a safe manner. Therefore, I humbly request hon. Members that we place trust in the scientific community with whom we have entrusted this project and I sincerely believe that they are making best possible effort and they should see the completion of this project."

B. CLOSE DOWN OF FAST BREEDER REACTORS

From information provided by BHAVINI, the Committee noticed that out of 18 units / projects using Fast Breeder Technology world over as many as 8 units / projects have been closed down. It was also noted that all these units pertain to developed countries viz US, UK, France& Germany etc. In this regard, on being asked as to why most of the developed countries have closed down their fast breeder reactors particularly in the context of the financial viability and safety/security/environmental threat from the reactors, the DAE in a written reply stated as follows:

"Out of the 8 reactors that have been closed down worldwide, four reactors are of experimental type, EBR_II (USA), ENRICO FERMI-I(USA), DOUNREAY DFR (UK) and KARLSRUHE KNK-II(GERMANY). Most of the developed countries have decided to proceed for generation-4 reactors and are presently engaged in designing Fast Breeder Reactors meeting generation-4 criteria which are being evolved. Japan has Monju & JOYO reactors. These reactors have not started after post Fukushima incident, though the Japan Atomic Energy Commission has

plans to restart them. In Russia BN 600 reactor is under operation and BN 800 is scheduled to commence commercial operation by the end of December, 2014. Russia is also designing a 1200 MWe FBR. France is also in the process of designing generation-4 reactor and the ASTRID reactor is expected to be launched for construction by 2020. Germany took a political decision to phase out nuclear power programme in their country."

In this regard, the representative of BHAVINI stated as follows:

"In Japan, they have got two reactors - Joyo and Monju. Joyo is the experimental reactor and the Monju is a commercial type reactor. So in respect of both the reactors, they had some problems in the refuelling machines. They have rectified all the deficiencies. Post-Fukushima, they are waiting for Government clearance to start all the reactors. So, they expect that the fast breeder reactor will be started. That is the position in Japan.

In Russia, the BN 600 reactor is operating since 1980 and it is operating at a very high capacity for the last 30 years. They have also started one reactor, the BN 800. In December, they made the reactor critical. This year, they will be going for commercial production. In China, they have started one experimental reactor, the CEFR. That is also operating. The European countries have not gone in for fast breeder reactors because they do not require this type of a reactor to generate power. They have got enough uranium from which they can operate the Boiling Water Reactor and the Pressure Water Reactor to get power. But countries like India do not have uranium. That is why, Dr. Baba envisaged the three-stage programme in which with the available uranium in the first stage, we will produce power; the plutonium produced in the first stage will be used for this. Plutonium will go to the second stage and then to the third stage which is thorium based. Unless we have sufficient number of second stage reactors having plutonium which has more breeding ratio and neutron flux, we cannot immediately rush to the third stage. So, at least 15-20 years of operation of the second stage is required so that we have thorium which can be converted into U-233. So, that is the third stage when you are achieving it. This is a step by step programme for India. When we achieve the third stage, maybe after 20 years, India will have sufficient power available through the thorium cycle. Even though we do not have uranium, yet the breeding ratio more than one, enough fuel will be generated subsequent to the commissioning of the third stage. So, this is a stage-wise programme which our country is envisaging. In the second stage, the PFBR is the first reactor to be commissioned and we have to do it very safely to avoid any lacuna in commissioning. As we are telling that the world is watching us, we should not make any mistakes. The experience from other reactors in other countries shows the sodium leak which is the main thing. So, we should have a systematic approach so that with safe condition, we will be commissioning the PFBR."

C. ROLE OF DAE

When asked about the steps taken by DAE for expeditious completion of the project, it replied as follows:

> "Steering committee headed by Secretary, DAE conducts regular meetings on quarterly basis for monitoring the activities of various projects including PFBR being built by BHAVINI. Achievements, constraints, physical and financial progress, forthcoming activities are reviewed critically. These meetings help in identifying and resolving the inter-organisational issues. Further the support extended from different units of DAE to PFBR are reviewed and strengthened wherever required."

On being asked why the resultant time-lag was not envisaged or factored in when the original schedule was proposed despite knowing fully well that the equipments would be manufactured for the first time, the DAE stated:

> "When original schedule was proposed, IGCAR had determined completion time based on technology development of a few critical nuclear components. Since it was not practical to manufacture reactor size equipment during technology development programme, only scaled model or sectors of the equipments were manufactured. When equipment were ordered for manufacture for PFBR and tested, many new issues cropped up including scale up issue, not envisaged during technology development, requiring additional time for resolution."

The Department of Atomic Energy was asked to furnish a detailed statement about the exact road map for the remaining works /stages of completion of the project. In its reply, the Department submitted:

> "PFBR is in advanced stage of completion. Erection of all reactor components has been completed. Most of the supporting systems have been commissioned and are being operated on regular shift basis. Finishing works are under progress which includes testing, integrated commissioning and last mile connectivity from control room.
>
> The following activities are remaining to be done for completion of the project:
>
> - Sodium filling, purification and commissioning of secondary sodium circuits *
> - Sodium filling, purification and commissioning of safety grade decay heat removal circuits*
> - Filling of sodium and purification in Main vessel *
> - Commissioning of sodium pumps
> - Testing of fuel handling equipments in sodium at 200 deg C and at 450 deg C*
> - Commissioning of Neutronic channels & Reactor protection system

- Replacement of Dummy Sub-Assemblies and loading of Fuel Sub-Assemblies*
- First approach to criticality*
- zero power tests*
- Raising of power to 20% of full power and conducting all intermediate power tests*
- Raising of power to 30% of full power*
- Rolling of turbine and synchronizing
- Raising of power to 50% of full power and conducting high power physics tests*
- Raising of power to 90% of full power and conducting high power physics tests*
- Raising of power to 100% of full power and conducting high power physics tests*
- Commercial operation

*indicates that clearances from Atomic Energy Regulatory Board at each stage is required prior to start of the activity.

With completion of all of the above said activities, it is expected that the PFBR project will be commissioned by September 2016.

D. STUDY VISIT OF THE COMMITTEE TO PFBR PLANT, KALPAKKAM

In order to have a firsthand information about the development of the PFBR, the Committee decided to undertake on the spot study visit of BHAVINI's plant at Kalpakkam on 12 February 2015. During their study visit, the Committee found that PFBR complies with the latest state of the art technology; its design is above Gen-III and closer to Gen-III+ reactors.

During informal discussion held with representatives of BHAVINI during the study visit, the Committee were informed that since its inception BHAVINI has been engaged in consistent and concerted efforts with the neighborhood populace to allay their apprehensions, if any, on the safety of nuclear power. Through their continuous activities and participation in the well-being and emancipation of the local people, a symbiotic relationship has been fostered and maintained. This is borne out by the fact of peaceful co-existence of BHAVINI with the local population, even during times of disturbances in the other nuclear power station in the state. Further, technical visit to BHAVINI site is regularly arranged for the students from neighborhood schools/colleges and they in turn are also adequately equipped to allay the fears of people. Industrial visits for technical students are permitted and in-plant training is imparted to have firsthand knowledge on the safety of PFBR. Pictorial pamphlets about the need for nuclear power and on the safety features of PFBR are distributed to the local public. Street plays in regional language are also conducted to educate the public on the need for nuclear power.

CHAPTER - IV

COST OF PRODUCTION AND ECONOMIC VIABILITY ON NUCLEAR POWER

According to BHAVINI, initially the project was to be handled by Indira Gandhi Center for Atomic Research (IGCAR) and the Detailed Project Report (DPR) was prepared by them. However, later on the company (BHAVINI) was formed to execute the project which led to cost escalation due to tax and other additional costs. Explaining the reason for the project being taken away from IGCAR, the Company in a written information stated that IGCAR, Kalpakkam has carried out Research & Development and design of PFBR. Government took the decision to build the project in company mode in view of the long term perspective of many future fast breeder reactors that have to be built in the country on commercial scale. For the implementation of the PFBR project, the Government has approved formation of a Special Purpose Vehicle (SPV) under the companies Act 1956. BHAVINI will construct and operate future Fast Breeder Reactors too.

A. COST ESCALATION OF PFBR

As per information furnished by the Company, the cost of the project in the DPR was Rs. 3440 crore as prepared by IGCAR in the year 2002 and the sanctioned cost was Rs. 3492 crore which was inclusive of 52 crore as the interest during construction. The Committee noticed that the cost of the Prototype Fast Breeder Reactor (PFBR) Project went up by Rs. 2185 Cr. from Rs. 3,492 Cr. to Rs. 5,677 Cr. (increase of 62%) even though 5% escalation per annum had been provided for in the DPR. The reasons for huge cost escalation were stated to be change in tax structure, inflation rate of 11% in 2008, hike in salary of employees and modifications in execution of the project.

When asked about the modifications in the project and increase in cost attributable to these modifications, the Company in a written reply stated as follows:

> "PFBR is prototype reactor and first of its kind in India. Complexity of the project has necessitated substantial changes / modifications in specifications / designs during detailed engineering as well as during manufacturing of components, which resulted in an increase in the cost of raw materials, machines and manpower. Price variation clause as well as changes / modifications in specifications and designs subsequent to placement of orders in few other cases have resulted in increase of cost by Rs. 284 crore."

On being asked to provide factor-wise increase in cost, the Company submitted as follows:

Sl. No.	Particulars	Amount (Rs. in Crore).
1	Escalation (present & future) of core materials such as stainless steel, copper, cement, steel, construction materials, POL and labour for the items covered under all USI	747
2	Changes/modifications in specifications/ designs and effect of price variation clause	284
3	Foreign exchange rate variation	103
4	Tsunami rehabilitation cost	4
5	**Other Items**	
5.1	Items other than at construction facilities not considered under DPR	382
5.2	Taxes and duties	206
5.3	Working capital	136
5.4	Interest during construction	106
5.5	Increase in Housing expenditure	87
5.6	Expenses beyond criticality up to commercial operation	60
5.7	Heavy Duty crawler crane	56
5.8	Credits (Sale of In-firm power)	55
5.9	Sixth pay commission effect on the Project management & superintendence	17
5.10	Induction of CISF	16
5.11	Project Station Building	14
5.12	Contingencies	-61
5.13	Net interest income	-27
	Total	2185

B. ECONOMIC VIABILITY AND SUSTAINABILITY OF NUCLEAR POWER

BHAVINI has stated that the cost of nuclear power generated by PFBR is sure to become competitive as technology of fast breeder reactor reaches maturity, which may, however, take some time. When asked about the expected time frame by which the cost of nuclear power will become competitive and economical in comparison with other source of energy in its written reply, DAE submitted as under:

> "By the time BHAVINI starts construction of FBR 1&2, the experience and lessons learnt from construction, operation & maintenance of PFBR will make Fast Breeder Reactor technology and operation more robust. Besides, the cost of FBR 1 & 2 is expected to be more competitive than PFBR on account of economies of constructing twin units in the same site as PFBR and with minimal changes to PFBR design."

On being asked as to when the company is expected to break even and start making Profits, the DAE in a written reply submitted that BHAVINI is expected to break even when the 500 MWe PFBR operates at 62.8% capacity factor.

In a detailed note on the relative project cost, gestation period, cost of generation, etc. of the each sources of power generation in the country, the DAE reply submitted as follows:

> "The cost of generation or the unit energy cost is the barometer for adjudging economic viability and competitiveness of a source of electricity generation. The cost of generation of hydro electricity, which is highly location specific and intermittent sources like renewable are not exactly comparable to those of base load units of nuclear, coal and gas. The cost of generation of base load generation units broadly comprise capital cost, operation & maintenance costs and fuel costs. Typically, ratio of unit energy cost and fuel cost of nuclear power ranges from 80:20 to 75:25 in a new nuclear power station while in case of new coal power stations, the ratio is typically 40:60 to 50:50; and in case of gas power stations the same ranges from 20:80 to 25:75. Over a period of time, cost of fuel increases and thus thermal power tariffs are highly sensitive to fuel prices whereas tariff of nuclear power is not so.
>
> The cost of setting up power projects is technology specific. The benchmark costs of coal based thermal power stations at 2011 prices range from Rs. 4.01 to 5.37 crore /MW (source: CERC). The overnight costs of nuclear power projects KAPP 3&4 and RAPP 7&8 under construction at 2011 prices work out to about Rs.7.0 crore per MW. The overnight cost of Gorakhpur Haryana Anu Vidyut Pariyojana (GHAVP), for which administrative approval & financial sanction was accorded in February, 2014, works out to 14.71 crore per MW at 2021 price level.
>
> The gestation period of nuclear power plants, which are typically set up as twin units, is five and half years from first pour of concrete (FPC) to commercial operation for the first unit and six years for the second unit. The gestation period of coal power stations is typically around four years."

When asked about the sustainability and environmental implications of nuclear power, the Department of Atomic Energy in its written reply stated:

> "In terms of sustainability, nuclear power is inherently sustainable. Its potential is huge and the spent fuel can be reprocessed and recycled to multiply its potential manifold. Nuclear fuel is an intense energy source, and very small quantities of fuel are required to fuel a large power plant. For instance, the annual fuel requirement of a 700 MW nuclear power plant (PHWR type) would be about *125 tons* of uranium (about 12 truck loads per year) and for a LWR type NPP, only about 30 tons of enriched uranium (about 3 truck loads per year) *for 1000 MW*, as against 4 to 5 million tons of coal (about 5 to 6 trainloads a day) for thermal

power plant of similar capacity. The latter puts immense pressure on rail, port and other infrastructure, apart from the emissions arising out of transporting such large quantities of coal and resulting environmental impact. Nuclear power plants have no greenhouse gas emissions and are clean. The lifecycle Greenhouse Gas (GHG) emissions of nuclear power plants are comparable to those of renewable like Hydro & Wind. Deployment of Nuclear Power to produce electricity avoids emission of Carbon dioxides, thus help in decarbonisation of environment.

A 1000 MW nuclear power plant thus saves about 6-8 million tons of CO2 emissions annually. Land requirement for setting up nuclear power plants (per MW) is among the lowest as compared to other electricity generating technologies based on coal and hydro. Coal based power plants require additional land for coal and ash handling facilities and for hydro it involves submergence of significant amount of land. Renewable energy resource such as solar and wind require large land area. Further, only about 20% to 30% of the land acquired for setting up nuclear power plants is used for locating plant buildings and facilities. The remaining land is acquired for establishing an 'exclusion zone' around the plant. This is maintained in its pristine form and further enriched by establishing a green belt for endemic species. This attracts a lot of native and migratory birds, animals and other forms of life and rich natural ecosystem flourishes around nuclear power plants."

C. COMPARATIVE TARIFF

According to DAE, the notified tariffs of nuclear power presently in operation range from Rs. 0.97 to Rs. 3.43 per kWh. The tariff of recently commissioned Kudankulam unit is provisionally projected to be about Rs. 3.94 per unit.

The tariffs (2013-14) in respect of generating stations in the central sector of other generating technologies range as follows:

Source / Fuel	**Tariff Range (Rs./kWh)**
Coal (Pithead)	***1.47 to 3.85***
Coal (Non-Pithead)	***3.75 to 5.29***
Lignite	***2.79 to 4.01***
Natural Gas	***3.36 to 4.39***
Liquefied Natural Gas	***9.20 to 12.88***
Liquid Fuel (Naphtha / HSD)	***8.46 to 13.67***
Hydro	***0.79 to 5.91***

Source: Central Electricity Regulatory Commission – Report on Short Term Power Market in India, 2013-14

The generic levelised tariffs notified by CERC for renewable for 2013-14 are:

Source	Tariff Range (Rs./kWh)
Wind	3.93 to 6.29
Solar PV	8.75
Solar Thermal	11.90
Small Hydro	3.75 to 5.16
Biomass	5.49 to 6.24
Biomass Gasifier	5.85 to 6.65

Source: Central Electricity Regulatory Commission – Order dated 28th February 2013 on Petition no. 243/SM/2012 (Suo Motu)

During oral evidence, the representatives of DAE in this regard stated as under:

"..... the cost competitiveness of power and the enormous cost that BHAVNI has run into. I would like to submit that as this is the first project the cost is likely to be more than the second or third projects. In the first project, we will be facing all the technological problems and so, there will be more time and effort required. Once we master the technology, it will become all right. We are already processing a proposal to set up prototype fast breeder reactor I and II. We are completely confident that when we take up the second and third plants, they will be much less costlier and they will be done in a much faster period of time.

Regarding competitiveness of power, I do admit that nuclear power, as of today, may not be of the same cost as that of traditional thermal power. In this regard, I would like to make a small submission. I am sure that all hon. Members are aware of it. When we speak of competitiveness of power, it is not merely capital expenditure. It is true that capital expenditure of coal based thermal power today is about Rs. 5 crore per megawatt. The capital expenditure of windmills and solar power is also coming down. Capital expenditure of nuclear power has come to Rs. 21 crore per megawatt. This is as per the latest nuclear power plant by NPCL in Haryana and approved by the Union Cabinet. But what also is important is the tariff or the cost of power generated. That is more appropriate yardstick or indicator to compare. In Haryana, we have prepared the project report and obtained the approval of the Union Cabinet for Rs. 6.49 per megawatt in the year 2021. It has been estimated by the Ministry of Finance also that this reasonably compares with other modes of generation of power. For all the other modes of nuclear power generation, we are making sincere efforts to achieve approximately the same level of cost of generation. so, my humble submission is that the cost of power finally generated and supplied is likely to be of comparable level to that of other modes of power generation. Let us compare these different methods of generation. For example, when we take wind power, the capital cost of per megawatt could be some amount but it has to be considered in terms of the availability of power. Nuclear power once completed is available 24x7 excepting the maintenance and shutdown periods similar to coal power. But solar power unit or the wind power unit would not be available 24x7 because of inherent inadequacies. So, they are not perfectly comparable on the capital cost point of view."

CHAPTER - V

PROCUREMENT POLICY

When asked about the procurement policy, if any, laid down by the government regarding procurement of technologically sophisticated equipments in the nuclear energy sector, DAE stated that it adopts Government guidelines for procurement by the organisation under its control. The companies lay down their own procurement policies. NPCIL, which was established in 1987, has got procurement manual. BHAVINI has adopted the same for their procurement.

BHAVINI has stated that manufacturing of PFBR reactor and sodium service equipments was awarded to Indian manufacturers with proven track records. In this regard, when asked about the criteria adopted for the selection of the stated manufacturers, the Company in its written reply submitted as follows:

> **"**The manufacturers have been chosen based on the past experience in manufacturing and delivering equipments for nuclear industries adopting high quality. Their financial capability and availability of high technology infrastructure has also been verified before award of contract."

On being asked about the extent of indigenization in the equipment produced for the projects, DAE submitted in its written reply:

> "The construction of PFBR is being facilitated by Indian efforts and indigenous capabilities. More than 95% of PFBR's equipment has been sourced from Indian Industries. However some components like large size valves, seals, SS316LN plates, sodium, variable frequency drives for sodium pumps had to be imported either directly or through suppliers as the required technology wasn't readily available in India. Our endeavor is to indigenise these items too for future FBRs."

In connection with procurement of equipment, the representatives of BHAVINI stated during evidence as follows:

> ".....I would assure all the hon. Members that every equipment that has been installed is to the benchmark of technology. There is time delay. We have to admit that. Whatever has already been installed is functioning as per the requirement at hundred percent design expectation. That assurance gives me a lot of confidence. The Indian industry supplies only very major equipment which has been tried first time. Industries like WEL, L&T are giants. They were facing a lot of technological problems. For that matter, the scientists of Indira Gandhi Atomic Research Centre sat with L&T people, WEL people and solved this problem on day to day basis. That is why this equipment is now delivered. Now, there is no equipment which is not delivered. Only two small equipment like the neutron detectors and radiation monitoring are yet to be delivered by the ECIL."

They further stated:

"The fast breeder reactors operate at a very high temperature of 550 degree centigrade. Whatever PSW reactors are operating till now all over India, they operate at a maximum temperature of only 300 degree centigrade. So, the ECIL till now successfully manufactured the equipment for 300 degree centigrade temperature. It became double now – 550 degree centigrade. When they want to manufacture for 550 degree centigrade, they have manufactured it. We tested it first at 350 degree centigrade and then 400 and 500 degree centigrade. Ultimately, at 500 degree centigrade, it just failed. Then, the BARC scientists spent night and day and came out with a different methodology of plating all the uranium. It is successfully produced, tested and calibrated. It is put in the Kamini reactor at Kalpakkam. It is functioning already. I would like to give the assurance to all the hon. Members that there is no uncertainty involved in this. The final tuning of the instruments in the circuits, getting all the signals in the control room, giving our commands, getting the response correctly, documents, going to the Regulator Board, all this happen. Now onwards, the Regulatory Board comes into the picture at every stage. For the initial fuel loading, the Regulatory Board will come and give clearance. For that, I have to demonstrate the fuel machine, take so many bundles nicely, go back and put back the bundles nicely without any problem. So, this demonstration has to happen.

Then, the coolant, the liquid sodium comes. Many countries experimented with this liquid sodium. They faced some problems and then they had withdrawn it. But in our Indira Gandhi Atomic Research Centre, the fast breeder test reactor successfully demonstrated 30 years of operation without any sodium problem. Now, we have to start liquid sodium purification process. It is a time-consuming process. It cannot be done in three months' time. Nobody in the earth or the world can reduce the timing of that because 1800 tonne of sodium has to be purified. That is the one-time bottleneck which cannot be compressed. With all the inputs put together, I am sure by July we will start loading the fuel and by September, 2015 the reactor would become critical. Then, the low-power, high-power experiment will go on."

On being asked about the extent and manner in which the embargo regime is responsible for the delays in the procurement of special items like radiography quality castings etc., the Company stated:

"BHAVINI has placed orders on Indian manufacturers. For procurement of special raw materials such as SS 316LN forged bars etc., main vendors placed orders on foreign countries. Even after placement of orders, the party denied to deliver / manufacture equipments for nuclear installations. Some countries, such as Germany, after completing the manufacturing at the time of final stage of supply have withheld the dispatch due to embargo. Hence, due to embargo problems, limited source of supply and the unique requirement, special components were delayed."

CHAPTER - VI

SAFETY OF NUCLEAR POWER PLANTS

A. SAFETY MEASURES ADOPTED

According to the Company, safety measures adopted for the PFBR including the additional ones which have been / are being put in place keeping in view Tsunami and Fukushima incident are as follows:

a) "Reactor Protection System: two independent systems are provided. Any one system can shut down the reactor.
b) Core-Catcher to collect the molten corium in case of extreme event of melting of seven fuel bundles.
c) Reactor trip is provided in case of a high seismic activity in the plant area.
d) Safety grade decay heat removal system (SGDHR) which requires no electrical or pneumatic power supply for its operation. (It is a passive system and can remove heat from the reactor).
e) 4 Nos. of Emergency Diesel Generators. Two numbers are sufficient to cater to the emergency load requirements.
f) Finished floor levels of all important plant buildings are 9.7 meters above mean sea level (which is nearly double of the maximum water level rise of 4.7 meters observed at site during the Tsunami in the year 2004).
g) Shore protection and Tsunami bund is provided along the sea coast to protect the plant against entry of water during Tsunami.
h) Sodium system :

Many precautions are taken to prevent sodium leakage and fire

- Guard pipe are provided around sodium piping in reactor building.
- Leak collection trays are provided for the secondary sodium piping
- All pipes are having weld joints only (No flange joint)
- Sodium firefighting system is a permanent set up in the plant.

Safety measures adopted in view of Tsunami and Fukushima event

PFBR had faced Tsunami in December 2004. Many novel design features were incorporated and layout changes were undertaken to face any future Tsunami. In light of this, Post-Fukushima requirement of design change was minimal. A stress test was done after Fukushima and PFBR plant was found to be safe. However, as a matter of abundant precaution, the following have been done at PFBR post-Fukushima:

a) Tsunami protection bund provided on the sea side is capable of absorbing the Tsunami surge pressure and reduces the water force. Existing Tsunami bund

height will be increased further. Also Tsunami bund will be extended further to cover Power Island besides nuclear island.

b) Water-tight seal doors will be provided to all the entries to the NICB (Nuclear Island Connected Building) to prevent water entry during any Tsunami.
c) 2 Nos. of 500 KVA each capacity Mobile Diesel Generator sets are provided to hook-up the power supply to control room & emergency lighting in the extreme cases, if all diesel generators fail. They will be stationed at site (placed away from sea) to meet the emergency power requirement. These Mobile Diesel Generators can be hooked up to the existing electrical system to meet the emergency power requirement if all other sources of power at PFBR become unavailable.
d) Diesel operated pumps and bore wells will enable water addition to the spent fuel storage pool (SFSP). This facility will be used if all other normal sources for water addition to SFSP are unavailable. Further, the water level and temperature monitoring will be provided.
e) Provision of solar powered lighting in critical areas of the plant is on the anvil.
f) Emergency preparedness plan has been prepared and rehearsed. This includes plans for onsite and offsite emergency. An emergency response center is being created with adequate provisions/equipment and provision for communication with outside agencies.

The safety of Indian NPPs against external events was reviewed by the Atomic Energy Regulatory Board (AERB) before inception of the project itself. AERB has also reviewed the plant specific parameters to ensure safety under all operation and transient situations. Enough diversity and redundancy has been provided to cater to even the worst situations including natural calamities. Severe natural events such as earthquakes, Tsunami and floods and their possible effects, which inter alia include extended station black out have been assessed and addressed. AERB has already reviewed probabilistic safety assessment report of PFBR. All safety, security and emergency preparedness measures have been instituted. AERB conducts monthly regulatory inspections to ensure that the quality and safety practices are being followed during construction and commissioning of PFBR."

When asked as to whether DAE has laid down any standard operating procedure (SOPs) or guidelines and / or safety manual for being followed in setting up, operation and maintenance of nuclear power plants in the country, DAE in a written reply stated:

"The safety of Indian Nuclear power plants is governed and regulated by Atomic Energy Regulatory Board. AERB has issued Standard Operating Procedure (SOPs) for setting up, operation and maintenance of nuclear power plants in the country."

Further, on being asked whether these SOPs / guidelines / safety manuals are in conformity with guidelines laid down by IAEA, DAE submitted that:

"SOP's for Indian Nuclear Power Plants are not inferior to that of IAEA. It is reiterated that in many instances SOP's are much more stringent in India as compared to international levels."

When asked about the extant status of Nuclear Safety Regulatory Authority Bill, 2011, DAE stated that:

"The Nuclear Safety Regulatory Authority Bill, 2014 which is essentially the NCRA Bill, 2011 along with its official amendments could not be taken up for consideration by Parliament due to dissolution of 15th Lok Sabha. With the change of Government, PMO has directed this Department to carry out inter-ministerial consultations on the NSRA Bill, 2014 afresh. Accordingly, a draft note for the Cabinet on the NSRA Bill, 2014 was sent to various Ministries/Departments for comments. Comments from most of the Ministries/Departments have been received and the same are being examined in the Department."

Explaining the steps taken by BHAVINI to allay the apprehensions among the general public regarding the risks associated with nuclear reactors, the Company in its written reply submitted as follows:

"BHAVINI has been actively engaged in public outreach programme to allay the apprehensions. Public is informed on robust design features and safety aspects of PFBR plant. A glimpse of strategies for outreach program adopted by BHAVINI are as follows:

- Reach to people through press and media
- Reach to people through students and teaching faculties
- Neighbouring villagers are encouraged to visit PFBR site to clear apprehensions in their mind.
- Mark presence of BHAVINI professionals among the neighbouring population and identify ourselves with them.
- BHAVINI Participation in the public gathering like exhibitions etc.
- Industrial visits are being permitted for students and In-plant training has been imparted to a larger extent.
- Base line survey and Medical surveys have been taken up through external agencies and shared with all the concerned.
- Installation of BHAVINI banners in most of the important seminars, conferences, symposiums, workshops etc.
- BHAVINI outreach programme includes seminars on nuclear awareness for the students and neighbouring villagers. However rally, street drama, print and media have facilitated awareness.
- Senior BHAVINI management officials have been periodically visiting schools, universities, engineering colleges, arts & science colleges and given presentation about the nuclear energy for students.

- BHAVINI team in a mobile van with the safety banners have been visiting schools and educating them about the nuclear & industrial safety aspects.

In this way, BHAVINI has developed many educational institutions & students as positive messengers of Department of Atomic Energy."

B. NUCLEAR WASTE MANAGEMENT

The Committee enquired about the directives laid down by the Government for the safe treatment / disposal of nuclear waste emerging out of various nuclear plant operating in the country. In response, the DAE in its reply submitted as follows:

"Most of the radioactive waste generated in nuclear power plant is retained within the fuel assemblies and after discharge of spent fuel from the reactor they are stored in spent fuel storage facility at the power station for a minimum period of 5 years (for Pressurised Heavy Water Reactors) and 10 years (for Light Water Reactors) for cooling down. India follows 'closed fuel cycle' policy in which all the spent fuel is reprocessed after adequate cooling. Hence the spent fuel from the nuclear power station is shifted to the reprocessing plant after cooling. At the reprocessing plant the Uranium and Plutonium is separated from the radioactive fission products and sent to fuel fabrication plant for making fuel for Fast Breeder Reactor based second stage of power reactor programme. Radioactive waste, which is below 3% of the total volume of spent fuel, is vitrified into glass matrix. At the present level of technology, for 4 T/year of vitrified waste product is generated corresponding to the operation of 1 GWe electrical power station for a period of one year, at 80% capacity factor. This waste is then stored at vitrified storage facility for a period up to 40 years. Later this waste can be transported to geological disposal facility for long term storage. Taking into account the projected growth of the nuclear power, sufficient quantity of cooled vitrified waste will be available only after 2070 for transfer into geological disposal facility."

When asked as to what extent the ongoing project of BHAVINI (PFBR) is in conformity with these directives, DAE stated:

"The spent fuel from second stage programme involving Fast Breeder Reactors, being/to be constructed by BHAVINI will be cooled for a period of 3 years and transported to Fast Reactor Fuel Cycle Facility located at the same site. In this facility, fuel will be reprocessed to take out plutonium and the radioactive fission products from the Uranium. The depleted uranium and plutonium will be used for production of fresh fuel for the Fast Breeder Reactors. The radioactive fission product will then be cooled for about seven years before it is taken up for vitrification. Vitrified fission product will be treated in the same manner as stated above."

During oral evidence held on 6 January 2015, the Committee expressed apprehensions about possible threat due to theft or loss of highly enriched uranium or plutonium and desired to know as to what safeguards are being taken to ensure there is no theft or loss of the fuel. In response, the representatives of DAE stated as follows:

> "According to the Atomic Energy Act, nuclear fuel is the property of the Government of India, anywhere in any form, right from ore up to the finished fuel, and even when it is being used inside the nuclear power plant after it is used, that is the spent fuel in any form is the property of the Government of India. The Government of India keeps continuous checks and accounts for the fuel, right down to the last gram. We have broadly two types of nuclear power plants right now. When it comes to the verification of fuel accounts, the first type is called within the safeguards of the IAEA. When we bring our nuclear power plants within the safeguards as established by the IAEA, we become entitled to import fuel for those reactors and the IAEA inspectors come in a regular manner to verify how the fuel is being used, how it is being stored, whether it is being accounted for to the last gram. In a similar manner, for what we describe as out-of safeguards plants, those plants which are not under the IAEA safeguards, but are under our own internal safeguards, because for variety of reasons, the Government of India has decided not to place all the nuclear power plants under the IAEA safeguards. So, for the plants which are under the domestic safeguards, the Government of India has a fail-proof system to continuously monitor and scrutinise the safety of the fuel right down to the last gram. I seek to assure the hon. Committee that we need not have any worry on this count. The other point is the use of thorium as a nuclear fuel for power. This conceptually has been admitted that the conceptual knowledge is there. But the actual translation of the conceptual knowledge into actual practice is still considered a few stages away. Right now we are in the second stage. This might come as part of the third stage. It is true that India has considerable amount of thorium reserves in the form of monazite that is found on the sea shores of the country. We have about 10 million tonnes estimated reserves of monazite. Monazite when broken gives rise to thorium. Monazite processing also gives rise to uranium of a small quantity. This thorium can be utilised. One hon. Member asked about the Rawatbhata matter. I would humbly like to submit that Rawatbhata is under the Nuclear power Corporation of India."

C. CIVIL LIABILITY OF NUCLEAR DAMAGES

During evidence held on 6 January 2015, the Committee desired to know about the latest position regarding civil liability for nuclear damage. In response, the representatives of DAE during evidence deposed:

> ".....The next point is about the civil liability for nuclear damages. It us under considerable discussion. The Department of Atomic Energy in consultation with the General Insurance Corporation is working out the developing of a nuclear insurance pool for coming up with an insurance policy for the liability under this Act. For that I had made a request to the Ministry of Finance because as it

stood, the nuclear industry within the country did not have the adequate capacity to raise this nuclear insurance pool. They required Rs. 1,500 crore. That is the maximum liability under this. The domestic nuclear industry all put together could set apart only Rs. 7,500 crore as the nuclear pool because they are restricted by the international norms. Under the international norms, whenever an insurance company creates an insurance pool in a new area of business, it cannot set apart more than three per cent of their networth. So, the net worth of all the general insurance companies in the country put together was only Rs. 750 crore. So, we have requested the Ministry of Finance to extend a sovereign guarantee for Rs. 750 crore. That is under discussion. We also have raised the idea of issuing a catastrophe bonds in a manner similar to that exists in the United States of America and other developed countries. That is also being considered. Once this becomes feasible, the adequate nuclear insurance pool will be created and then the General Insurance Corporation would be in a position to offer a nuclear product. So, we are discussing other developments also with the foreign companies with whom we are right now discussing partnership for nuclear power plants. But they are still under progress."

PART – II

OBSERVATIONS / RECOMMENDATIONS

1. India's Nuclear Energy Programme: Role of BHAVINI

The Committee observe that the nuclear energy programme has been visualized to grow in three stages, which is sequential as each stage has fuel cycle linkages in which spent fuel from one stage is reprocessed to obtain fuel for the next stage. The Committee understand that having obtained commercial success in the Stage – I Pressurized Heavy Water Reactors (PHWRs), Stage II Fast Breeder Reactors (FBRs) was taken up for implementation to attain energy security for the Nation. The Committee feel that BHAVINI, which was formed as a Special Purpose Vehicle (SPV) to facilitate implementation of the Stage II expeditiously has a greater role to play in bringing long-term energy security of the nation. Since nuclear energy offers the most potent solution to long term energy security, the Committee are firmly of the view that India has to successfully realize the three stage development and thereby tap its vast thorium reserves to become truly energy independent beyond 2050. They, therefore, urge upon BHAVINI to make all out efforts for expediting the commissioning of and also ramp up the capacity of FBRs so as to achieve energy security in the country. They also desire that DAE develop adequate technologies for commercial exploitation of vast thorium reserves of the nation.

2. Board of Directors

The Committee note that while the Board of Directors of all Government companies are constituted as per the Department of Public Enterprises (DPE) guidelines, BHAVINI's Board of Directors was constituted as per Atomic Energy Commission (AEC) guidelines. Giving justification for having separate guidelines, BHAVINI stated that pursuit of the objectives set for the Company involves management of certain unique challenges unlike other PSEs. Further BHAVINI's organizational role encompasses implementation of an entire spectrum of activities from developing technology, design, engineering and construction to commissioning, operation and maintenance of FBRs which is different from other PSUs. Notwithstanding separate guidelines for the Company, the Committee find that there were vacancies for two independent Directors and proposal for appointment of only one Director was sent by the Company to DAE on 3rd August, 2013. It was only in February, 2015 that DAE informed the Committee that it has approved the appointment of two independent directors to the Board of BHAVINI and sent the same for further processing. The Committee are of the considered view that since BHAVINI is required to achieve its objectives entirely by

indigenous efforts without access to external resources, either technological, financial or in terms of human resource expertise, timely induction of two professionals of eminence from industry in private / non-government sector with a high degree of proven ability as independent directors in BHAVINI's board would have certainly provided the Company the expertise needed for better operational proficiency in the project management of PFBR. They, therefore, deprecate the flippant attitude of the Management in treating an important matter in an unimportant and unprofessional manner. They, therefore, would like to caution the Company to be careful in future while dealing with such important issues.

3. <u>Nuclear Power Generation vis-à-vis Plan targets</u>

The Committee note with concern that the generation of Nuclear Power declined during the XI Plan period. Despite revision of the target from 163395 MUs to 124608 MUs at MTA stage, the actual power generated was merely 109642. The reasons for shortfall during the XI Plan were stated to be primarily related to shortage of fuel due to demand-supply mismatch of domestic uranium, delay in international co-operation, delay in completion of Kudankulam 1 & 2 projects and delay in completion of PFBR (BHAVINI) projects. Further, delay in completion of Kudankulam also accounted for the shortfall during the XII Plan period as well. The Committee are disquiet to note that targets were fixed by the DAE taking into account presumptive factors and they could not foresee the impending difficulties, which accounted for the shortfall in targets. The Committee are of the considered view that since nuclear energy has an important role in the energy mix of the Country, particularly in the context of energy security, they, therefore, recommend that DAE should make all out efforts to see that all impediments / problems are removed so that the targets set for generation of nuclear power are achieved by all the nuclear plants.

4. <u>Delay in Commissioning of BHAVINI Project</u>

The Committee are concerned to note that there have been inordinate delays in the commissioning of the PFBR at Kalpakkam. As per the original schedule, the project was to be commissioned in September, 2010, which was later revised to September, 2014. The deadline was further extended to September, 2016. The reasons for delay were attributed to factors such as Tsunami (December, 2004), technological challenges involved in manufacturing of the first of its kind equipment and integration of the equipment in a sequential manner etc. The Committee feel that though this project is first of its kind yet such challenges could have been anticipated and the completion schedule

should have been fixed accordingly. Repeated postponement of the deadlines causes enormous time and cost overruns leading to huge loss to national exchequer. Besides, such delay would also hamper India's effort towards achieving energy security in the long run. The Committee regret to note that despite steering committee headed by Secretary, DAE conducting regular meetings on quarterly basis for monitoring the activities of various projects including PFBR in which achievements, constraints, physical and financial progress are reviewed, such review meetings have not yielded any concrete results as the completion schedule has been changed due to various constraints resulting in considerable delay in achieving criticality. During their study visit to BHAVINI's project site at Kalpakkam, the Committee found that the PFBR have incorporated state of the art technology and had achieved considerable physical progress. While appreciating the remarkable work done by the scientists of our country, the Committee hope that the Company will take all necessary steps to expedite the remaining work so that the reactor commissioned within the stipulated revised time schedule.

5. <u>Cost of Production and Economic Viability of Nuclear Projects</u>

The Committee note that the cost of the PFBR project went up from Rs. 3492 crore to Rs. 5677 crore leading to cost escalation of Rs. 2185 crore. The Committee find that although initially the project was planned to be handled by Indira Gandhi Centre for Atomic Research (IGCAR) and the DPR was prepared by them, subsequently BHAVINI was formed to execute the project, which led to cost escalation. Government took the decision in view of the long term perspective of many future fast breeder reactors that have to be built in the country on commercial basis. The Committee wonder why the Government failed to visualize this at the time of conceptualization of the project.

Another related issue is the economic viability of the Nuclear Power vis-à-vis other conventional sources of energy. The projected tariff of nuclear power to be produced from Kudankulam appears to be costlier than that of the other generating technologies. DAE's own admission that 'the cost of generation or the unit energy cost is the barometer for adjudging economic viability and competitiveness of a source of electricity generation' speaks eloquently of the competitive disadvantage of the nuclear power vis-à-vis other sources of energy. The Committee have been informed that BHAVINI is expected to break even when the 500 MWe PFBR operates at 62.8% capacity factor, which means that the gestation period of Nuclear Power Plants is very high. However, the Committee are of the considered view that nuclear power is an intense energy source and is inherently sustainable. Moreover, deployment of Nuclear Power to produce

electricity avoids emission of carbon dioxide, thereby helping in decarbonisation of environment. Having appreciated the usefulness of the nuclear power, as a clean form of energy, the Committee urge the Company to make concerted efforts towards reducing the overall cost of Nuclear power to make it economically more viable. They also desire that the nodal Department should ensure that bottlenecks, if any, faced by the Company in the process are sorted out without any loss of time.

6. Procurement Policy

The Committee are heartened to note that notwithstanding the fact that equipment being used in Prototype Fast Breeder Reactor is technologically sophisticated and entails stringent specifications and that the tools and methodologies used are first of its kind. Yet, more than 95 per cent of the equipment for the PFBR is being sourced from Indian industry. The Committee appreciate the efforts made by BHAVINI for procuring its equipment through indigenous sources as this will give fillip / boost for the 'Make-in-India' campaign. The Committee desire that BHAVINI should continue making efforts towards indigenization of the manufacturing of various components and engage more proactively with the Indian companies both in public and private sector for the development of state of the art technologies, so that apart from achieving the objectives of energy security, it will provide a definite boost to the indigenous manufacturing capabilities.

7. SAFETY OF NUCLEAR PLANT

The Committee were informed that in the aftermath of December 2004 Tsunami, many novel design features had been incorporated in Prototype Fast Breeder Reactor (PFBR) which provide a robust safety architecture. Besides, the safety of the plant is governed and regulated by Atomic Energy Regulatory Board (AERB) and the Standard Operating Procedures (SOPs) issued by it are very stringent and rigorously followed. However, the Committee feel that post Fukushima nuclear disaster, there is an increasing apprehension in the minds of the people regarding the safety of nuclear plants. Therefore, the Committee urge upon the Company to take proactive steps to allay such fears from the minds of the people so as to mould a favourable public opinion about the usefulness of the PFBR. A robust media campaign highlighting the significance and importance of the project and its environment-friendly attributes will have to be given adequate thrust. Further, keeping in view the current trends of terrorism, the Department should take adequate safeguards to ensure that there is no theft or loss of nuclear material. Moreover, the Committee would hope that the depleted uranium

and plutonium after the reprocessing of the fuel should be properly cooled and stored before it is ultimately vitrified.

8. Civil Liability for Nuclear Damages

Another related issue which needs to be highlighted in the light of safety of Nuclear Power Plant is the civil liability for nuclear damages. The Committee note that DAE, in consultation with the General Insurance Corporation (GIC) of India is trying to develop a nuclear insurance pool, which will help in coming up with an insurance policy for the liability of nuclear power / energy. The Committee were informed that since the nuclear industry in the country does not have adequate capacity and resources to raise the nuclear insurance pool, DAE has requested the Ministry of Finance for providing with assistance to extend a sovereign guarantee for Rs. 750 crore, which is stated to be under their consideration. The Committee urge upon DAE to pursue this matter with Ministry of Finance at the highest level so that the sovereign guarantee is extended by the Government for creation of adequate nuclear insurance pool so that GIC will be in a position to offer an insurance product for the risks, associated with generation of Nuclear Energy.

New Delhi
27 April 2015
7 Vaisakha,1937 (S)

SHRI SHANTA KUMAR
Chairperson,
Committee on Public Undertakings

COMMITTEE ON PUBLIC UNDERTAKINGS
(2013-14)

MINUTES OF THE SEVENTH SITTING OF THE COMMITTEE

The Committee sat on Saturday, the 24th August, 2013 from 1500 hrs to 1600 hrs in Committee Room 'D', Parliament House Annexe, New Delhi.

PRESENT

Shri Jagdambika Pal - Chairperson

MEMBERS

Lok Sabha

2. Smt. Shruti Choudhary
3. Shri Raja Ram Pal
4. Shri Nama Nageswara Rao
5. Prof. Saugata Roy
6. Smt. Sushila Saroj

Rajya Sabha

7. Shri Janardan Dwivedi
8. Shri Naresh Gujral

SECRETARIAT

1.	Shri A. Louis Martin	Joint Secretary
2.	Shri P.C. Koul	Director
3.	Shri M. K. Madhusudhan	Additional Director

WITNESSES

BHARATIYA NABHIKIYA VIDYUT NIGAM LIMITED (BHAVINI)

1.	Dr. Prabhat Kumar	CMD
2.	Shri T.K. Mitra	Director (Technical)
3.	Smt. Rajani Sankaran	Director (Finance)
4.	Shri K.A. David	Executive Director (Operations)

2. At the outset, the Chairperson welcomed the representatives of Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI) to the Sitting. He also drew their attention to Direction 58 of the Directions by the Speaker regarding confidentiality of evidence before the Parliamentary Committees and asked them to introduce themselves.

3. The Committee, thereafter, took oral evidence of the witnesses in connection with examination of 'BHAVINI'. The CMD, BHAVINI explained in brief the various constraints / problems faced by the Company in the construction of Fast Breeder Reactor Project at Kalpakkam and the reasons for delays in its commissioning. He also made an audio-visual presentation highlighting the achievements of the Company making use of advanced technology in the manufacture of various critical components that go into the making of PFBR. Thereafter, the Chairperson and members raised queries on issues relating to cost escalation, delay in project completion, environmental and safety concerns, etc. In respect of points for which information was not readily available with the representatives of the Company, they were asked to furnish the same to the Committee Secretariat by 6th September 2013.

The witnesses then withdrew.

A verbatim record of the proceedings has been kept separately.

The Committee then adjourned.

COMMITTEE ON PUBLIC UNDERTAKINGS
(2014-2015)

MINUTES OF THE TENTH SITTING OF THE COMMITTEE

The Committee sat on Tuesday, the 6th January 2015 from 1500 hrs to 1630 hrs in Committee Room 'B', Parliament House Annexe, New Delhi.

PRESENT

Shri Shanta Kumar - Chairperson

MEMBERS

Lok Sabha

2. Shri Lal Krishna Advani
3. Shri Ramesh Bais
4. Shri Pankaj Chaudhary
5. Shri Prahlad Patel
6. Shri Ram Sinh Rathwa
7. Prof. Saugata Roy

Rajya Sabha

8. Shri Narendra Budania
9. Shri Majeed Memon
10. Shri Rangasayee Ramakrishna
11. Shri Tapan Kumar Sen

SECRETARIAT

1. Smt. Sudesh Luthra — Joint Secretary
2. Shri M.K. Madhusudhan — Director
3. Shri Tirthankar Das — Deputy Secretary
4. Shri G.C. Prasad — Deputy Secretary

WITNESSES

DEPARTMENT OF ATOMIC ENERGY (DAE)

1. Dr. C.B.S. Venkataramana — Additional Secretary, DAE
2. Smt. Rajani Sankaran — CMD (Acting), BHAVINI
3. Shri K.A. David — Executive Director(Operations), BHAVINI

2. At the outset, the Chairperson welcomed the representatives of the Department of Atomic Energy (DAE) to the Sitting. He also drew their attention to Direction 58 of the Directions by the Speaker regarding confidentiality of evidence before the Parliamentary Committees and asked them to introduce themselves.

3. Thereafter, the Additional Secretary, DAE, briefly outlined the activities and achievement of BHAVINI and explained in brief the various constraints / problems faced by the Company in the construction of Fast Breeder Reactor Project at Kalpakkam and the reasons for delays in its commissioning. Thereafter, the Chairperson and members raised queries on issues relating to cost escalation, delay in project completion, environmental and safety concerns, etc. The representatives of the DAE responded to most of the queries. In respect of points for which information was not readily available with them, the witnesses assured the Committee that written replies in respect of those points will be furnished at the earliest.

The Witnesses then withdrew.

A verbatim record of the proceedings has been kept separately.

The Committee then adjourned.

COMMITTEE ON PUBLIC UNDERTAKINGS
(2014-2015)

MINUTES OF THE FOURTEENTH SITTING OF THE COMMITTEE

The Committee sat on Friday, the 24th April 2015 from 1500 hrs to 1530 hrs in Committee Room 'D', Ground Floor, Parliament House Annexe, New Delhi.

PRESENT

Shri Shanta Kumar - Chairperson

MEMBERS

Lok Sabha

2. Shri Ramesh Bais
3. Shri Dilipkumar Mansukhlal Gandhi
4. Shri Prahlad Patel
5. Shri Ram Sinh Rathwa
6. Shri B. Senguttuvan

Rajya Sabha

7. Shri Majeed Memon
8. Shri Muthukaruppan
9. Shri Rangasayee Ramakrishna

SECRETARIAT

1. Shri M.C. Sharma — Joint Secretary
2. Shri M.K. Madhusudhan — Director
3. Shri Tirthankar Das — Deputy Secretary
4. Shri G.C. Prasad — Deputy Secretary

2. XXXX XXXX XXXX XXXX

3. Thereafter, the Committee considered the draft Report on Bharatiya Nabhikiya Vidyut Nigam Limited and adopted the same without any change.

4. The Committee also authorized the Chairperson to present the Reports to Parliament on their behalf, after obtaining factual verification.

The Committee then adjourned.

XXXX Matter not related to this Report.