

Executive Summary

The Nuclear Imperative

India aspires to become a USD 30 trillion economy with a per-capita income of USD 18,000-20,000 by the year 2047. During this period, economy is expected to have very high and sustainable growth rate ($\approx 9\%$). India has announced its mission of net-zero by 2070. It is envisaged that more than 80% of electricity installed capacity and about 2/3rd of electricity generation in 2047 will be met from non-fossil fuel sources. Renewable Energy Sources will play a significant role in meeting the climate commitments of the country. However, the issues of managing intermittency, developing cost effective energy storage, manufacturing of components and access to critical minerals will become increasingly pressing.

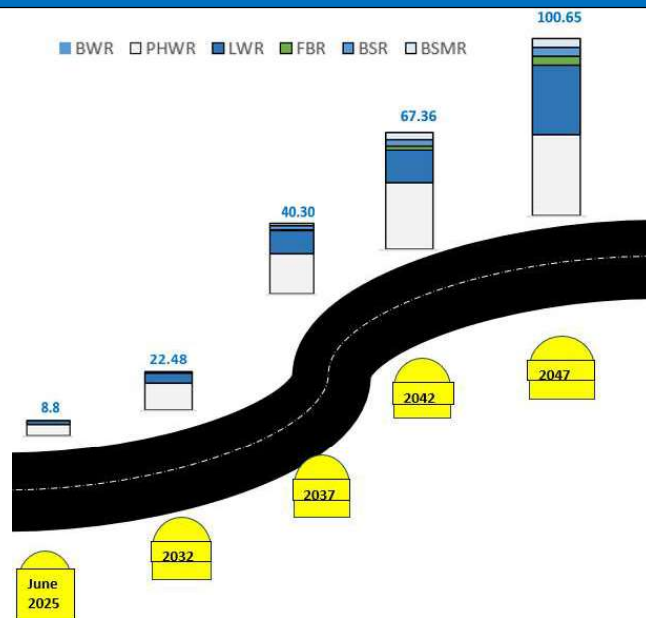
Nuclear Power will be a key player in the energy transition



- ✓ **Nuclear plants are base Load plants**
- ✓ **One of the lowest life cycle carbon emissions amongst energy sources**
- ✓ **Can contribute in de-carbonisation of hard-to-abate industries requiring steady power**
- ✓ **Can also serve non-electric applications like hydrogen production, process steam and desalination**

Target of 100 GW Nuclear Capacity by 2047: The Road Map

The present nuclear installed capacity in the country is 8.88 GW. The goal to reach 100 GW by 2047 calls for more than 10 times expansion of the existing capacity in 22 years' time or an average capacity addition of approximately 4.14 GW per year. With the country's proven research, engineering and execution capabilities, the goal is achievable. Considering the relevant factors, the Committee has arrived at a possible road map. However, the road ahead is challenging and action on several fronts will be required to clear the path ahead.



Suggested Strategies for Reactor Technologies

- ✓ 3 stage nuclear programme to continue to utilize domestic thorium reserve
- ✓ PHWR technology to continue as the mainstay for nuclear capacity addition in next decade
- ✓ Adoption of PWR technology need to be expedited
- ✓ Adoption and indigenization of imported reactor technologies
- ✓ Adoption of technologies and fuel which can hasten utilization of thorium
- ✓ Large reactors for grid applications, small reactors for captive use
- ✓ Future reactor designs should support flexible operation

Challenges and Way Forward

1. Enabling greater participation and engagement

The Atomic Energy Act, 1962 currently does not allow participation of private sector or even state governments. Substantial technical and financial resources will be required for accelerated deployment of 100 GW of nuclear capacity by 2047. The private sector has abundant capital, and inherent efficiency in timely construction and innovation adaption. Further, suppliers and potential operators are apprehensive about some of the provision of the CLND Act, 2010 due to uncertainty about extent of liability.

Suggested Amendments – Atomic Energy Act

 Wider Participation in Atomic Energy Allow any company rather than Central Govt Company to operate NPP under license	 Wider Participation in handle Fuel Allow any company to handle front end fuel cycle activities under license	 Allay apprehension of take over Specify broad conditions that can trigger takeover of fuel fabrication plant	 Allay Apprehension about novation of contract Production and use of atomic energy may be omitted from the ambit	 Allay Apprehension about suspension/revocation of license Specify Conditions to trigger such action, Provision for appointing administrator.	 Tariff Regulation Distancing Govt from the process, Explore Tariff Based Bidding
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Suggested Amendments – CLND Act



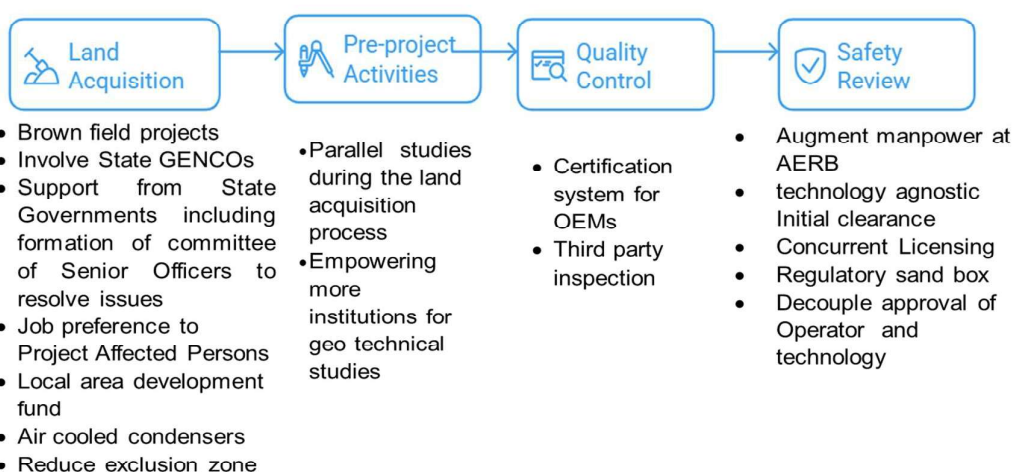
- ✓ **Restricting Liability of the Supplier:** Liability of supplier should be capped and reflected in contract between supplier and operator
- ✓ **Section 46 Rewording:** There should be no civil liability under any other law
- ✓ **Definition of Supplier:** To focus exclusively on providers of critical equipment

2. Reducing Project timelines

The entire process of setting up a nuclear power plant starts with in - principle consent of the concerned State Government, where nuclear power plant is to be located. The time required after consent from State Government culminating into first pour of concrete is about 5 ½ to 6 years. Total time required for construction of nuclear power plant is about 11 to 12 years, which is very high. The process can be made faster by fast-tracking pre-project activities, land acquisition issues, quality assurance issues during construction and AERB process.

Possible Strategies

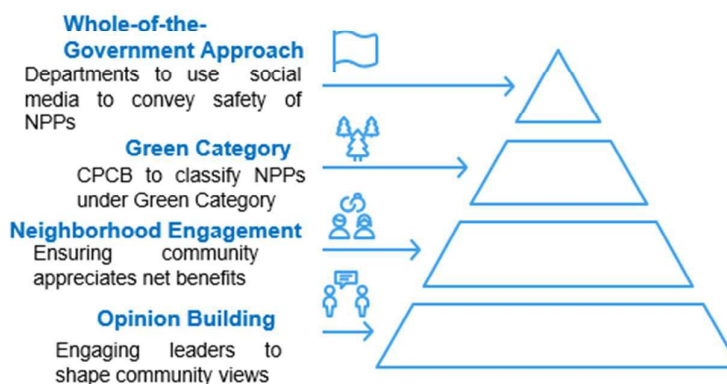
Expediting Project Timelines



3. Improving Public perception

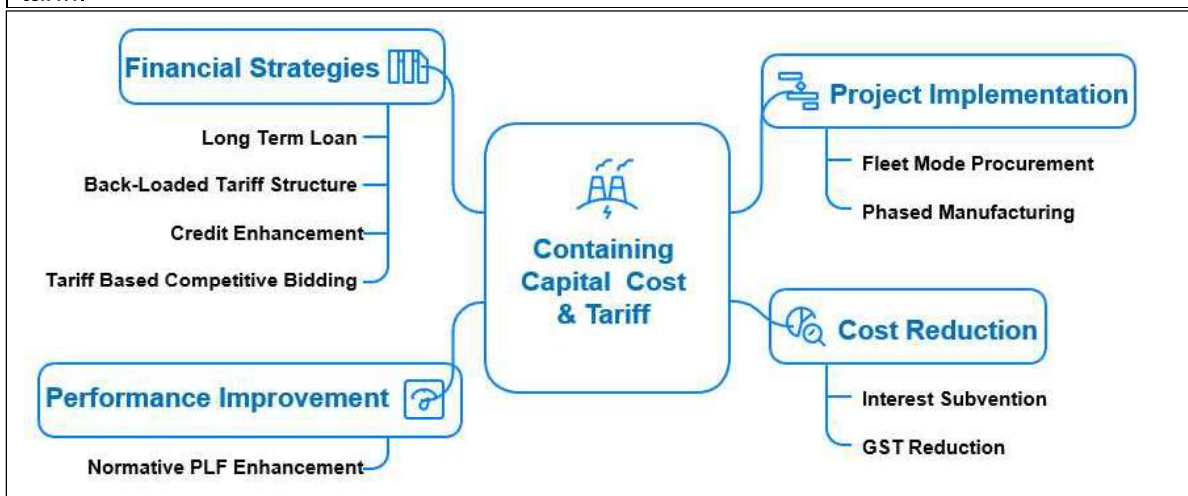
Highest priority is accorded to safety in all aspects of nuclear power viz. siting, design, construction, commissioning, and operation. Risks of nuclear accident are often exaggerated. Misplaced public perception fueled by misinformation by a section of people, often leads to agitation and consequent delay in completion of the projects.

Community Engagement Strategy



4.1 Controlling Capital Cost and Tariff

At present the cost of PHWR reactors is around ₹15-16 Crores/Megawatt which translates to a levelized tariff slightly higher than ₹ 6.00 per kWh as per norms recommended to DAE (excluding water and insurance charges - approx. 15 paise per kWh). If substantial manufacturing of equipment is indigenized, the capital cost of PWR may come down from presently estimated around ₹ 30 Crore per MW to about ₹ 22-25 crore per MW, translating to a levelized tariff of ₹ 6.00 – 6.60 per kWh (excluding water charges and insurance charges). However, delay in project execution can increase IDC and capital cost. Concerted efforts will be required to bring down the capital cost and tariff.



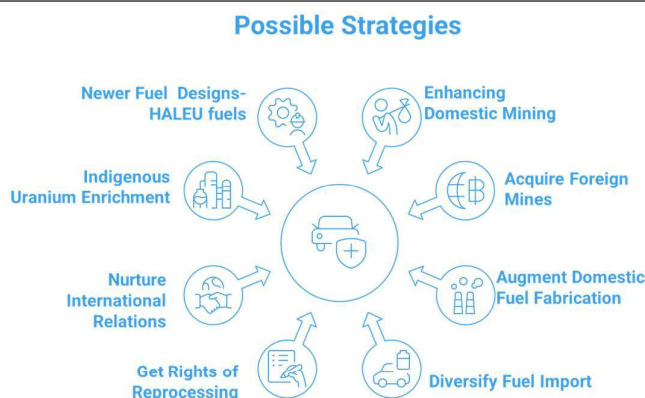
4.2 Financing Strategies

The Committee estimates that the incremental investment required to achieve 100 GW capacity based on anticipated capacity mix will be of the order of ₹ 19 lakh crore. At present, the equity component for NPCIL projects is met through budgetary support from the Government and internally generated reserves. However, in view of competing requirements of other sectors, Government cannot contribute as before, particularly as NPCIL itself plans to leap frog from 8.8 GW at present to about 54 GW in 2047. Arranging such huge capital will be a challenge for public as well as private sector.



5. Managing the supply of nuclear fuel

The Committee estimated that in 2047, India will need additional 8029 tonnes of natural uranium and 1045 tonnes of enriched uranium annually. Currently, Uranium requirement for 2.4 GW is met from domestic sources and rest is imported. Thus, to meet the target of 100 GW of nuclear capacity in 2047, India would need to augment uranium supplies and also have commensurate processing and fabrication capabilities.



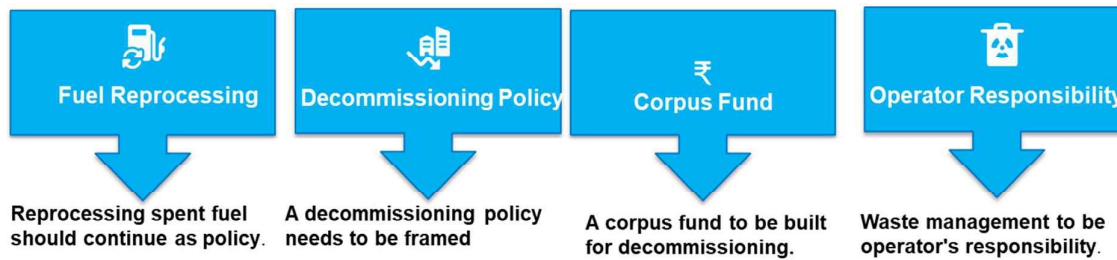
6. Scaling up Production of Heavy Water

India is recognized as the world's largest producer of heavy water, a critical component for PHWRs. Heavy water is used as both moderator and coolant in PHWRs. The present production capacity is sufficient to meet the current demand, however, expansion of capacity would be required to meet the expected PHWR additions. The Committee estimated that the additional requirement will peak at about 6400 tonnes in 2039-40 as per road map.

- ✓ **Enhance Manpower in Heavy Water Board (HWB)**
- ✓ **Additional financial resources to HWB**
- ✓ **Consider Corporatization of Heavy Water Board**

7. Spent Fuel Handling and Decommissioning

The spent fuel contains U-235 in slightly reduced concentration and other isotopes of uranium, plutonium and fission products, and a wide range of lanthanides and other elements. Used fuel must ultimately either be reprocessed to recycle most of it, or prepared for permanent disposal. Reprocessing enables recycling of the uranium and plutonium into fresh fuel, and produces a significantly reduced amount of waste. The annual spent fuel accumulation would be equal to estimated annual fuel requirement. Government will have a substantial role to play in managing the back-end of the fuel cycle. As India embarks on the journey to expand its capacity, there is need to address several challenges relating to back-end management of fuel- including reprocessing of spent fuel and waste management as also decommissioning after useful life of the plant.



8. Creation of a “Design and Site Support Agency”

Currently, the implementation of PHWR technology-based NPPs is being undertaken by the NPCIL. This technology is totally indigenous and would be a prime candidate for adoption by other PSUs and Private Sector entities. However, NPCIL having in its own pipeline expansion plans may find it difficult to hand hold all the new entrants interested in setting up PHWR plants. Therefore, there is a compelling requirement for a dedicated and independent entity to provide technical support to other Utilities, PSUs, and Private Independent Power Producers (IPPs) for PHWR technology and other indigenous technologies as and when they reach the stage of commercial deployment.

An independent agency for “Design and Site Support” under DAE - with experts from BARC, IGCAR and other units.

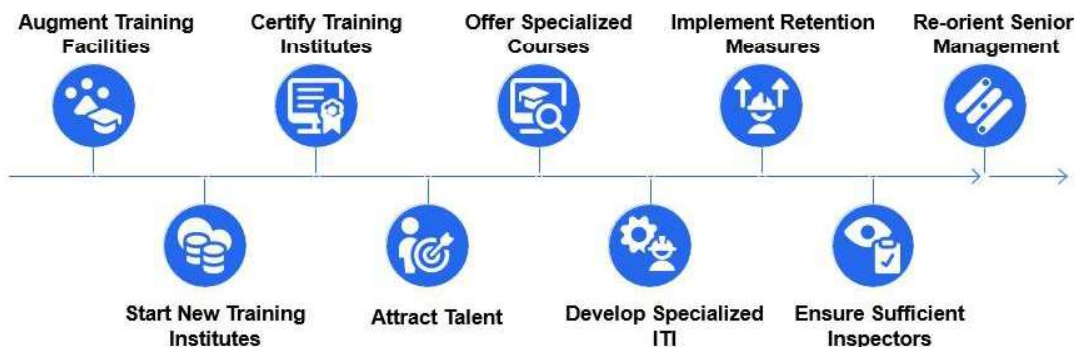
Broad roles:

- Design & Engineering
- Support in Construction
- Support in Commissioning
- Operation support
- Regulatory Interface

9. Nuclear workforce of Tomorrow

For achieving 100 GW by 2047, large work force will be required with education and training in engineering and to some extent in nuclear science. The Committee has estimated that in 2047, the manpower required will be about 61,000 for operation of NPPs. The peak manpower requirement for construction will be about 1,20,000 in 2041, and for plant design activities will be about 5,500 in 2039. The training institutions under DAE can at present train only 100 and 1200 personnel per annum for design and operation respectively. Recruiting such large number of the personnel with technical and scientific knowledge and training them will be a challenge.

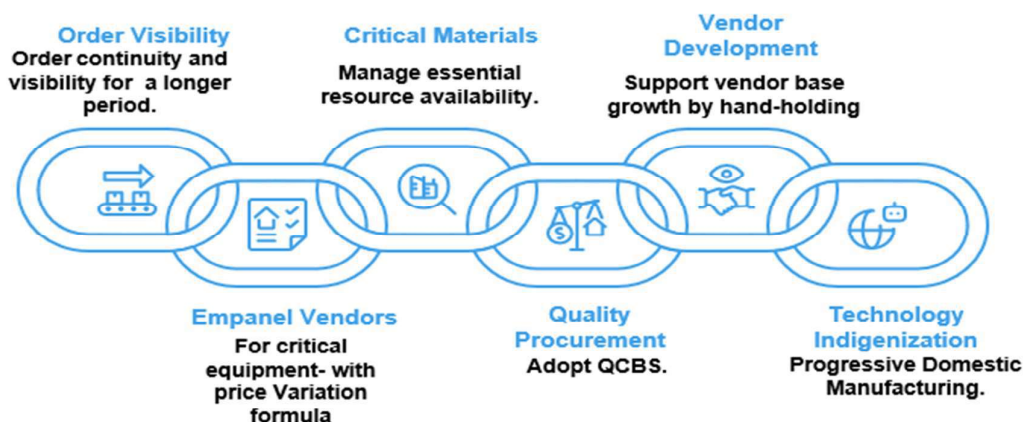
Workforce Development Strategy



10. Strengthening the Supply Chain

Nuclear power projects require highly specialized, complex equipment, which in turn demands advanced manufacturing tools and skills. Due to high complexity in manufacturing and stringent norms, very limited domestic vendors are presently available for supply of equipment and execution of contracts. The vendor capabilities are limited to mainly PHWR technology. Thus, strengthening the supply chain and development of vendor eco-system will be a critical.

Strategies for Strengthening Supply Chain



11. Navigating Insurance Requirements

The Indian Nuclear Insurance Pool (INIP), managed by the General Insurance Corporation of India (GIC Re), offers a floater insurance policy tailored to meet the liability requirements stipulated by the CLND Act, 2010. NPCIL, is the only nuclear operator in the country at present. Though the probability of a nuclear incident is very low, INIP should be ready to take care of any claims arising out of single/multiple nuclear incidents in a year. At present, pay out from INIP will be limited to ₹ 1500 crore. With multiple operators there will be need for augmentation of present capacity of INIP. At present, property insurance for nuclear installations is made available for assets which are in cold zone (outside nuclear reactor zone) and no property insurance is available for hot zone assets (assets within nuclear reactor zone). Property insurance of hot zone assets will be required, so that private operator can transfer their risk to insurance companies. Lenders will also be more comfortable when there is insurance for hot zone also.

Possible strategies for managing Insurance Requirements

