FICCI 100
100 YEARS OF BUILDING TOMORROW

FINANCING INDIA'S NUCLEAR POWER

Key Opportunities and Policy Choices for Achieving 100 GW Nuclear Capacity by 2047

August 2026

Chintan Research Foundation

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Executive Summary

India has set a target of 100 gigawatts (GW) of nuclear capacity by 2047, up from about 8.8 GW today. Achieving this scale will require not only rapid capacity addition but also a financing architecture capable of mobilising large volumes of long-term capital while maintaining affordability, safety, and strategic oversight. India's nuclear programme has historically relied on Government equity, Nuclear Power Corporation of India Limited (NPCIL) internal accruals, and market borrowing. The next phase will require a broader mix of public finance, banks and power-sector lenders, capital markets, private industry, and international finance.

This paper examines how nuclear power's distinctive characteristics shape its financing requirements, assesses international approaches, and considers regulatory, institutional, risk-allocation, insurance, and bankability issues relevant to wider industry participation. It also estimates the investment required for the 100 GW programme and assesses possible tariff-reduction pathways. The study combines secondary research and quantitative analysis with stakeholder consultations and focused discussions with industry participants, financiers, and developers.

Nuclear financing is particularly sensitive to construction duration and the cost of capital because substantial expenditure occurs years before revenues begin. A large reactor may spend eight to twelve years in development and construction, while operating for sixty years or more. The International Energy Agency (IEA) estimates that financing costs can account for 40-60 per cent of the levelised cost of a new nuclear plant. Kudankulam Units 1 and 2 illustrate this exposure: project cost climbed from ₹13,171 crore to ₹22,462 crore, while interest during construction (IDC) rose from ₹753 crore to ₹3,286 crore. The implication is that controlling delays and financing risk can be as important as reducing headline borrowing costs.

The Sustainable Harnessing and Advancement of Nuclear Energy for Transforming India (SHANTI) Act, 2025, and Draft SHANTI Rules and Regulations, 2026, significantly change the framework for wider participation. The Draft Rules provide for a composite build-own-operate-decommission licence and require applicants to demonstrate financial, managerial, and technical capability across the project lifecycle. They also recognise grid-connected, captive, process-heat, and hydrogen applications. The Draft Regulations introduce staged Atomic Energy Regulatory Board (AERB) safety authorisations and regulatory hold points across construction and commissioning. Before finalisation, however, remaining commercial issues should be worked through with key stakeholders, particularly tariff methodology, fuel and heavy-water terms, lifecycle levies, licence transfer, lender-substitution arrangements, and treatment of project special purpose vehicles (SPVs). The final framework should support credible private participation without weakening safety, security, or safeguards.

The paper therefore recommends a differentiated and sequenced financing approach. Construction-stage projects may initially require strong sponsor equity, banks, and Power Finance Corporation (PFC)/Rural Electrification Corporation (REC), export credit where appropriate, and targeted public risk support, while operational assets can progressively refinance through bonds and institutional capital. Project-ready sites, proven and repeatable designs, standard contracts, stronger project management, and deeper regulatory and vendor capacity should be prioritised to lower construction risk and IDC. Lifecycle costs covering liability, insurance, spent fuel, and decommissioning should be transparent before financial closure. Private participation should initially focus on credible sponsors, joint ventures, captive or industrial projects, and proven technologies, before moving toward a broader multi-operator market.

Central Electricity Authority (CEA) modelling reinforces the importance of financing and operating reforms: for a 700 megawatt (MW) pressurised heavy water reactor (PHWR), the modelled levelised tariff falls from ₹8.11/kilowatt-hour (kWh) to ₹6.98/kWh under a coordinated package of financial and operational changes, although these are analytical scenarios rather than guaranteed tariffs. The paper's bottom-up analysis estimates a gross capital requirement of about ₹22.35 lakh crore for the national technology-wise build-out, while the Government roadmap provides a broadly consistent benchmark of ₹19.29 lakh crore, supporting a preliminary range of approximately ₹20-23.3 lakh crore.

The immediate priority is therefore to convert the emerging regulatory framework into a pipeline of well-prepared, financeable, and replicable projects. Successful execution and refinancing of these early projects will provide the strongest basis for widening private participation, mobilising capital at scale, and progressively reducing the cost of nuclear power.

Keywords: *construction risk; cost of capital; energy security; India's nuclear programme; nuclear energy; nuclear financing; nuclear power; nuclear regulation; private participation; project finance; tariff reduction*

Key Recommendations

(1) Finalise the SHANTI framework through focused stakeholder deliberation

The Draft SHANTI Rules and Regulations, 2026, substantially clarify licensing, safety authorisation, and lifecycle responsibilities, yet key commercial issues remain unresolved. Before finalisation, these should be settled through targeted deliberation with developers, lenders, insurers, technology providers, and prospective industrial users, particularly regarding tariff methodology, fuel and heavy-water arrangements, fund/levy rates, licence transfer, lender substitution, and the treatment of project SPVs. The final framework should enable credible private participation while retaining rigorous safety, security, and safeguards requirements.

(2) Align financing with project type and stage of risk

There is unlikely to be a single financing model for the 100 GW programme. Construction-stage projects may require sponsor equity, PFC/REC and bank lending, export credit, and selective Government risk support, while operating assets should progressively refinance through bonds, infrastructure debt funds, insurers, and pension capital. Financing structures should also vary across indigenous fleets, imported reactors, captive/industrial projects, and first-of-a-kind technologies. Public support, including guarantees or interest support, should be targeted and linked to clearly defined risks rather than function as an open-ended subsidy.

(3) Reduce tariff primarily by reducing construction and financing risk

Project-ready sites, repeatable designs, standard contracts, stronger project management, and adequate regulatory and vendor capacity should be treated as financing interventions because delays directly increase IDC. Regulatory milestones such as First Pour of Concrete and later commissioning hold points could, where appropriate, also inform staged financing and monitoring. CEA-identified measures, including debt-equity optimisation, GST rationalisation, O&M escalation, utilisation, and stepped return on equity, should be tested as a coordinated package rather than adopted mechanically. PLF or availability-based tariff norms should similarly be validated against actual unit-level performance before being finalised.

(4) Make risk allocation and lifecycle costs explicit before financial closure

Each project should clearly allocate site and construction risk, technology performance, FX and supply-chain exposure, fuel risk, offtake, liability, and operator failure to the party best able to manage or absorb it. Insurance and reinsurance capacity should be deepened, including periodic assessment of the India Nuclear Insurance Pool and specialised nuclear property cover. The proposed Nuclear Liability Fund, Spent Fuel Management Fund, and segregated decommissioning financial security should have predictable contribution and cost-recovery arrangements so that lenders can incorporate them into project cash flows from the outset.

(5) Sequence private participation around bankable and replicable project models

Early private participation may be more realistic through financially strong sponsors, JVs, captive/industrial projects, and proven reactor designs, followed by wider ownership and competitive procurement as experience develops. The Draft Rules require applicants to demonstrate lifecycle financial, managerial, and technical capability, including sponsor support where a newly formed entity relies on its promoter. Standard project archetypes should therefore clarify ownership, technology support, offtake, fuel, financing, and exit arrangements. Commercial terms for access to fuel, heavy water, and Nuclear Fuel Complex inputs should also be clarified, while options such as pooled heavy-water pricing can be examined rather than presumed.

(6) Build the wider ecosystem needed to lower costs over time

Fleet procurement, design repetition, and phased localisation should be used to build domestic manufacturing depth and reduce foreign exchange (forex) and supply-chain exposure, but cost savings should be demonstrated rather than assumed. Workforce development and regulatory capacity should grow alongside the project pipeline. International finance should be assessed on its full economic terms, including technology price, hedging, localisation, fuel and service commitments, and remedies for supply disruption. Qualifying nuclear activities may also be considered transparently for sustainable-finance taxonomy treatment, subject to lifecycle emissions, safety, safeguards, waste, and disclosure requirements.

(7) Aggregate demand to improve project bankability.

Aggregating demand across credible Indian developers could also improve price discovery, facilitate common design approval and support better localisation terms without requiring all projects to adopt a single ownership structure.

(8) Ensure long-term revenue certainty through appropriate offtake arrangements.

Long-term power purchase agreements (PPAs) and other appropriate tariff or revenue mechanisms should be considered to provide greater certainty of post-commissioning cash flows and improve lender confidence. For early private sector and industrial projects, predictable offtake arrangements will be particularly important for achieving financial closure. Depending on the nature of the project, options such as long-term PPAs, regulated tariffs, captive or industrial offtake arrangements, take-or-pay commitments and other suitable revenue-support mechanisms may be explored to provide adequate revenue visibility while ensuring that risks are allocated appropriately among developers, consumers and other stakeholders.

Overall, the near-term priority should be to convert the emerging SHANTI framework into a small pipeline of well-prepared, financeable, and replicable projects. Successful execution and refinancing of these projects would provide the strongest basis for widening private participation and mobilising capital at the scale required for the 100 GW programme.

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Acknowledgement

FICCI would like to thank all the stakeholders involved in the development of this report. We convey our special thanks to the Members of the FICCI Civil Nuclear Energy Taskforce for their leadership, strategic guidance and valuable inputs in conceptualising this report, Financing India's Nuclear Power.

FICCI would also like to thank Chintan Research Foundation for preparing the report following close consultations with Shri Ajay Talegaonkar - Technical Member, APTEL, Shri. Goutam Ghosh, Chief Engineer, CEA, Shri. Prasenjit Pal, Former Executive Director & Head of Nuclear Wing at NTPC Limited, Shri. Abhinav Jindal, Deputy General Manager & Senior Faculty, NTPC Power Management Institute (NTPC-PMI) and other industry representatives, policymakers, financial institutions, developers and other sectoral experts. The Chintan Research Foundation team undertook comprehensive secondary research, quantitative analysis and stakeholder engagements to deliver a well-rounded analysis, offering a holistic perspective on the financing challenges and opportunities associated with scaling India's nuclear power capacity.

The report broadly examines the financing pathway for achieving India's target of 100 GW of nuclear power capacity by 2047, while addressing the need to mobilise large volumes of long-term capital without compromising affordability, safety and strategic oversight. It outlines key themes including financing models, project bankability, risk allocation, tariff considerations, regulatory and institutional enablers, wider participation of industry, international financing and the investment requirements for the 100 GW programme. The report further presents key policy considerations and strategic recommendations to enable the development of well-prepared, financeable and replicable nuclear power projects, supporting the expansion of nuclear energy as an important pillar of India's energy security and low-carbon growth.

Above all, FICCI would like to thank everyone who contributed to the development of this report and shared their time, knowledge, expertise and valuable perspectives during the course of this exercise. Their collective support and contributions have been invaluable in shaping this report.


SMR
small modula
reactor

Foreword

India's target of scaling nuclear power capacity from appx 8.8 GW today to 100 GW by 2047 will fundamentally hinge on building a robust, long-term financing architecture. Realising an eleven-fold expansion requires transforming not only physical execution capabilities but also the underlying financing and institutional architecture, capable of mobilising large volumes of long-term capital while maintaining affordability, safety, and strategic oversight.

The enactment of the landmark Sustainable Harnessing and Advancement of Nuclear Energy for Transforming India (SHANTI) Act, 2025, along with the Draft SHANTI Rules and Regulations, 2026, marks a historic paradigm shift, creating a forward-looking regulatory framework that welcomes private sector investment, joint ventures, and captive industrial participation alongside public sector leadership.

This next phase of growth will require a broader mix of public finance, banks and power-sector lenders, capital markets, private industry, and international finance.

This paper, developed by FICCI jointly with Chintan Research Foundation, thus provides an insightful and rigorous roadmap for unlocking nuclear finance in India. It analyses the distinct economic lifecycle of nuclear assets, evaluates global financing archetypes, examines risk-allocation and bankability enablers, and outlines actionable policy levers to significantly reduce construction-period risks, Interest During Construction (IDC), and delivered electricity tariffs.

Bases in-depth consultation with industry stakeholders, the paper recommends a differentiated and sequenced financing approach. It proposes financing models during construction phases and then on the operational aspects. Focussing on lifecycle cost analysis and private participation, it attempts to draw out short-term, medium-term and long-term priorities.

We hope the information will serve as valuable reference for industry stakeholders, investors, and global partners and the recommendations will find favour with the policymakers for further advancing India's nuclear power capabilities.

Jyoti Vij
Director General
FICCI

Foreword

India stands at a defining moment in its development journey. As we move towards the vision of Viksit Bharat by 2047 and Net Zero by 2070, the question before us is not merely how much energy we generate, but how we ensure that our future energy systems are reliable, clean, secure, affordable, and capable of supporting the aspirations of a rapidly growing economy. In this context, the enactment of the Sustainable Harnessing and Advancement of Nuclear Energy for Transforming India (SHANTI) Act, 2025, and the recently floated draft Rules and regulations under the Act mark a significant milestone. The Act represents one of the most important reforms in India's civil nuclear sector in decades. By reforming the legal and regulatory framework, streamlining licensing procedures, clarifying liability provisions, and creating pathways for calibrated private-sector participation, the Act has opened new possibilities to accelerate nuclear energy deployment in India. It has also sent a strong signal that nuclear energy will play a central role in India's long-term clean energy transition and energy security strategy.

At Chintan Research Foundation, we have consistently engaged with this policy discourse. Over the last year, CRF has organised workshops on private-sector participation in the nuclear power sector; served as a knowledge partner to premier institutions such as FICCI in discussions on civil nuclear energy reforms; undertaken extensive stakeholder consultations; and published several knowledge products with recommendations to strengthen India's nuclear ecosystem. Many of these discussions centred on enabling conditions for investment, regulatory reforms, financing mechanisms, technology choices and the role of industry participation in achieving India's nuclear energy targets.

Our engagement in this space has been further strengthened through our association with FICCI, which has provided an important platform for us to share our research and perspectives with a diverse set of stakeholders. As a knowledge partner to FICCI's roundtable discussions on civil nuclear energy, we value the opportunity to contribute to a constructive dialogue on the reforms, investments, technologies, and institutional frameworks needed to build a robust and globally competitive nuclear energy ecosystem in India. We look forward to deepening this engagement and continuing to contribute to the development and expansion of India's civil nuclear sector. We hope this report will serve as a useful resource for policymakers, industry stakeholders, and other actors working towards this shared objective.

S. Priyadarshi

Shishir Priyadarshi
President
Chintan Research Foundation

List of Abbreviations

Abbreviation	Full form
AERB	Atomic Energy Regulatory Board
ASHVINI	Anushakti Vidhyut Nigam Limited
BHAVINI	Bharatiya Nabhikiya Vidyut Nigam Limited
BSMR	Bharat Small Modular Reactor
BSR	Bharat Small Reactor
CAPEX	Capital Expenditure
CCEA	Cabinet Committee on Economic Affairs
CfD	Contract for Difference
COD	Commercial Operation Date
COP	Conference of the Parties
ECB	External Commercial Borrowing
EPC	Engineering, Procurement and Construction
FBR	Fast Breeder Reactor
FOAK	First-of-a-Kind
FPC	First Pour of Concrete
GHAVP	Gorakhpur Haryana Anu Vidyut Pariyojana
IAEA	International Atomic Energy Agency
IDC	Interest During Construction
IEA	International Energy Agency
INIP	India Nuclear Insurance Pool
IRR	Internal Rate of Return
KAPP	Kakrapar Atomic Power Project
KKNPP	Kudankulam Nuclear Power Project
LCOE	Levelised Cost of Electricity
LWR	Light Water Reactor
MSME	Micro, Small and Medium Enterprise
NCD	Non-Convertible Debenture

NEA	Nuclear Energy Agency
NFC	Nuclear Fuel Complex
NPP	Nuclear Power Plant
O&M	Operations and Maintenance
OEM	Original Equipment Manufacturer
PFBR	Prototype Fast Breeder Reactor
PHWR	Pressurised Heavy Water Reactor
PLF	Plant Load Factor
PPA	Power Purchase Agreement
PSU	Public Sector Undertaking
PV	Present Value
PWR	Pressurised Water Reactor
RAB	Regulated Asset Base
RAPP	Rajasthan Atomic Power Project
RAPS	Rajasthan Atomic Power Station
RoE	Return on Equity
SMR	Small Modular Reactor
UNFCCC	United Nations Framework Convention on Climate Change
VVER	Water-Water Energetic Reactor (translated from Russian vodo-vodyanoi energetichesky reaktor); the Russian-design family of pressurised water reactors
WACC	Weighted Average Cost of Capital

1 India's Nuclear Vision: Financing the 100 GW Target

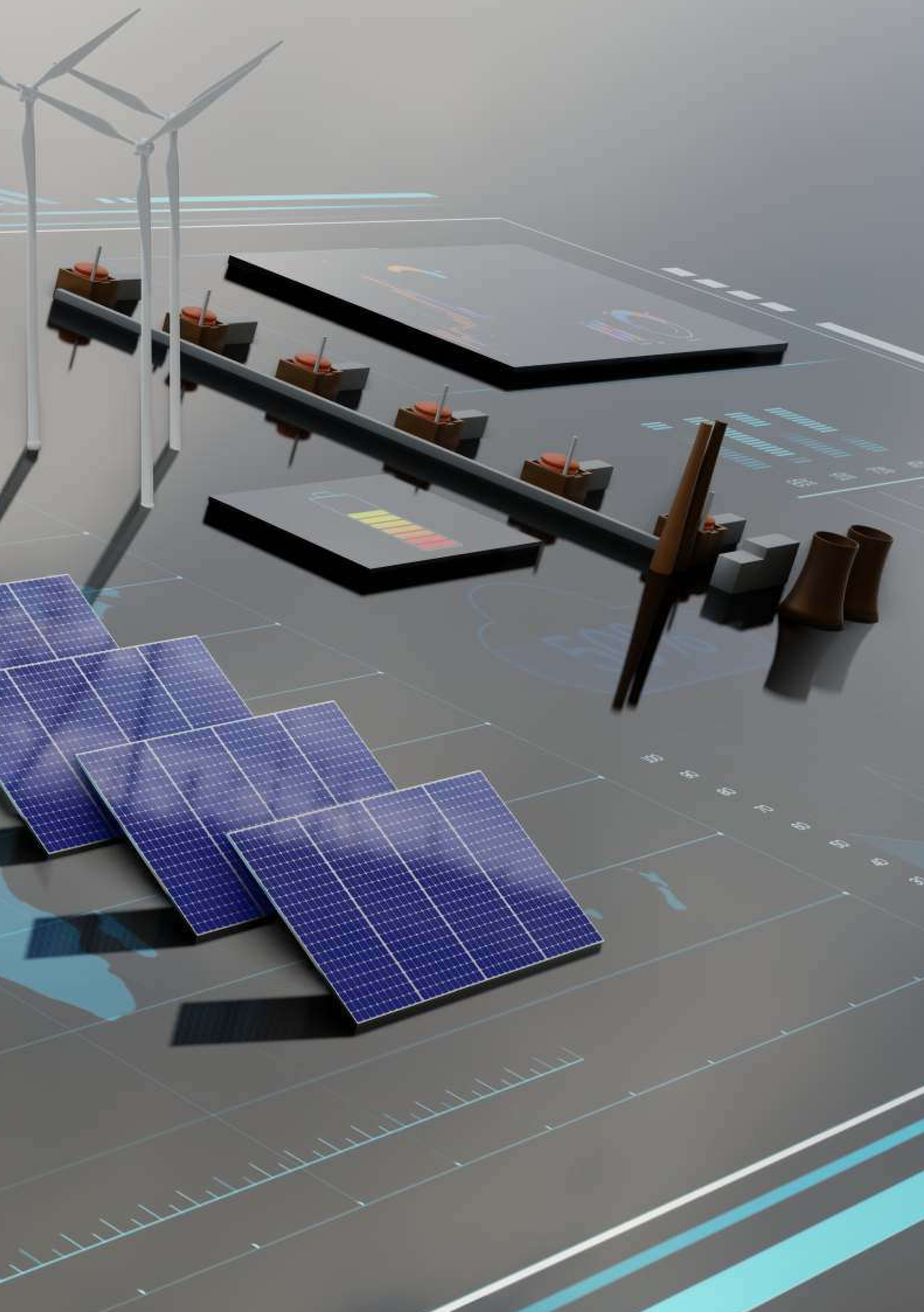
Key message: *India's 100 gigawatt (GW) ambition is not only a capacity target; it is also a financing-system challenge. Moving from approximately 8.8 GW to 100 GW by 2047 requires shifting from incremental public funding towards a diversified architecture capable of mobilising long-term capital without weakening affordability, safety, or strategic oversight.*

The global power system is undergoing a transformation driven by decarbonisation and electrification. Renewable capacity rose from 1,226.53 GW in 2010 to 5,155.01 GW in 2025, while electricity is expected to claim a larger share of final energy demand. Yet variable renewable generation also increases the value of firm, low-carbon power. This has driven a renewed push for nuclear power: global nuclear capacity could reach approximately 1,446 GW by 2050 if announced national targets are met, compared with around 403 GW today and the 1,200 GW ambition associated with the 28th Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) (COP28) declaration to triple nuclear energy (IRENA 2025; World Nuclear Association 2026).

The same need is visible in India. Electricity consumption is projected to rise from about 1,541 terawatt-hours (TWh) today to 6,544 TWh by 2050 under a current-policy pathway and 8,070 TWh under a net-zero pathway. As solar and wind expand, nuclear power can provide stable, round-the-clock low-carbon generation and cut dependence on coal for firm power supply.

India has therefore set a target of 100 GW of nuclear capacity by 2047, up from roughly 8.8 GW – an expansion of more than eleven times the present fleet and an average addition of more than 4 GW each year. The Government roadmap envisages capacity reaching about 22 GW by 2031–32; a further 32 GW under Nuclear Power Corporation of India Limited (NPCIL) beyond 2032 through indigenous pressurised heavy water reactors (PHWRs) and light water reactors (LWRs); pre-project activities for two 500 megawatt (MW) fast breeder reactor (FBR) units based on the Kalpakkam Prototype Fast Breeder Reactor (PFBR) design; and roughly 45 GW to be developed by other central and state public enterprises, private companies, and joint ventures using different technologies and business models. Around 22 GW is already under development (Central Electricity Authority [CEA] 2025).

The financing implications are profound. India's civilian nuclear programme has historically leaned on Government equity, NPCIL internal accruals, and market borrowing – a workable model when annual additions were modest. A 100 GW programme demands a much larger and more continuous flow of capital, as well as investment in fuel-cycle facilities, transmission, manufacturing, skills, waste management, and associated industrial capacity. Public budgets will remain central, but they cannot constitute the sole source. The policy challenge is to mobilise commercial banks, power-sector financial institutions, bond markets, insurers, pension capital, private industry, and international finance while keeping tariffs affordable and preserving strategic control, safety, and public accountability. How to achieve this balance forms the central financing question examined in this paper.



2 Understanding the Financing Challenge

Key message: *Nuclear power's financing challenge arises from the timing of its cash flows: very large amounts of capital are committed years before revenue begins. Construction duration, the cost of capital, and the allocation of development and completion risks therefore shape project economics as much as the reactor technology itself.*

Nuclear power differs from most infrastructure because high capital intensity, long development and construction periods, stringent licensing, and very long asset lives are combined in the same project. Solar and wind can begin earning revenue within roughly 18–24 months and coal projects commonly within four to five years; a large nuclear project may absorb eight to twelve years in development and construction before commercial operation. During that period, debt is drawn progressively, but revenue is absent, so the cost of capital accumulates. The International Energy Agency (IEA) estimates that financing costs can account for 40–60 per cent of the levelised cost of electricity (LCOE) of a new nuclear plant (IEA 2025).

The cost structure is also front-loaded. Civil works, reactor and safety systems, heavy forgings, instrumentation, engineering, and regulatory compliance are incurred before output begins, whereas fuel costs are relatively low after commissioning and plants can operate for sixty years or more at high-capacity factors. This renders construction time and interest during construction (IDC) central financial variables. A schedule overrun pushes up engineering and labour costs, capitalises additional interest, and defers electricity sales at the same time.

Table 2.1: KKNPP Units 1 and 2: Original and Revised Project Cost

Particulars	Initial Cost, Dec. 2001 (` crore)	Revised Cost, Aug. 2014 (` crore)
Russian scope of work	8,508	9,692
Indian scope of work	3,910	7,734
IDC	753	3,286
Foreign-exchange variation	0	1,750
Total	**13,171**	**22,462**

Source: NPCIL/Department of Atomic Energy (DAE) project information as compiled in the underlying draft.
The IDC component rose by about 336 per cent, illustrating the cost of delay and prolonged financing.

Kudankulam Units 1 and 2 clearly illustrate the mechanism. The project began with a financial sanction of ₹13,171 crore, including ₹6,755 crore of equity and ₹6,416 crore of Russian credit at 4 per cent. By August 2014, the project cost had risen to ₹22,462 crore; IDC climbed from ₹753 crore to ₹3,286 crore and foreign-exchange variation added ₹1,750 crore. NPCIL met the additional requirement through term loans, bonds, and external borrowing. The case shows why a low headline borrowing rate does not protect project economics if construction and currency risks are not controlled.

Risk is asymmetric over the project life. Development and construction expose lenders to site, licensing, technology, contractor, supply chain, and policy risks, but once a reactor is operating, the asset can generate stable cash flows for decades. The core financing problem is therefore to bridge the high-risk construction period and then refinance the lower-risk operating asset into cheaper, patient capital.

Table 2.2: Financing Characteristics of Major Generation Technologies in India

Parameter	Solar PV	Coal Thermal	Hydropower	Nuclear
Typical construction period	18-24 months	4-5 years	6-8 years	8-12 years
Capital intensity	Low	Moderate	High	Very high
Fuel cost	Nil	High	Nil	Low
IDC exposure	Low	Moderate	High	Very high
Construction risk	Low	Moderate	High	High
Operating life	25-30 years	30-40 years	70-100 years	60-80+ years
Capacity factor	18-25%	60-75%	35-50%	80-90%

Source: Authors' compilation using NPCIL, CEA, IEA, and International Atomic Energy Agency (IAEA) data.

The comparison does not imply that nuclear is uneconomic; rather, it highlights a mismatch between long-lived economic benefits and the shorter-duration financing structures generally available in commercial markets. Financing design must therefore address construction risk, tenor, revenue certainty, and refinancing rather than focus only on initial capital cost.

2.1 Development Lifecycle: A Financing Perspective

A nuclear project progresses through a sequence of technical, regulatory, and financial milestones involving the developer, the Central Government licensing authority, the Atomic Energy Regulatory Board (AERB), the Ministry of Environment, Forests and Climate Change (MoEFCC), power-sector institutions, and state agencies. The Draft Sustainable Harnessing and Advancement of Nuclear Energy for Transforming India (SHANTI) Rules and Regulations 2026 make the distinction between licensing and safety authorisation more explicit. Each milestone reduces a different uncertainty and can inform when larger amounts of debt may be disbursed. Capital at risk is lowest during initial site investigations; it rises with long-lead equipment and civil contracts; peaks during reactor construction and equipment erection; and begins to de-risk materially at first criticality, grid synchronisation, and commercial operation.

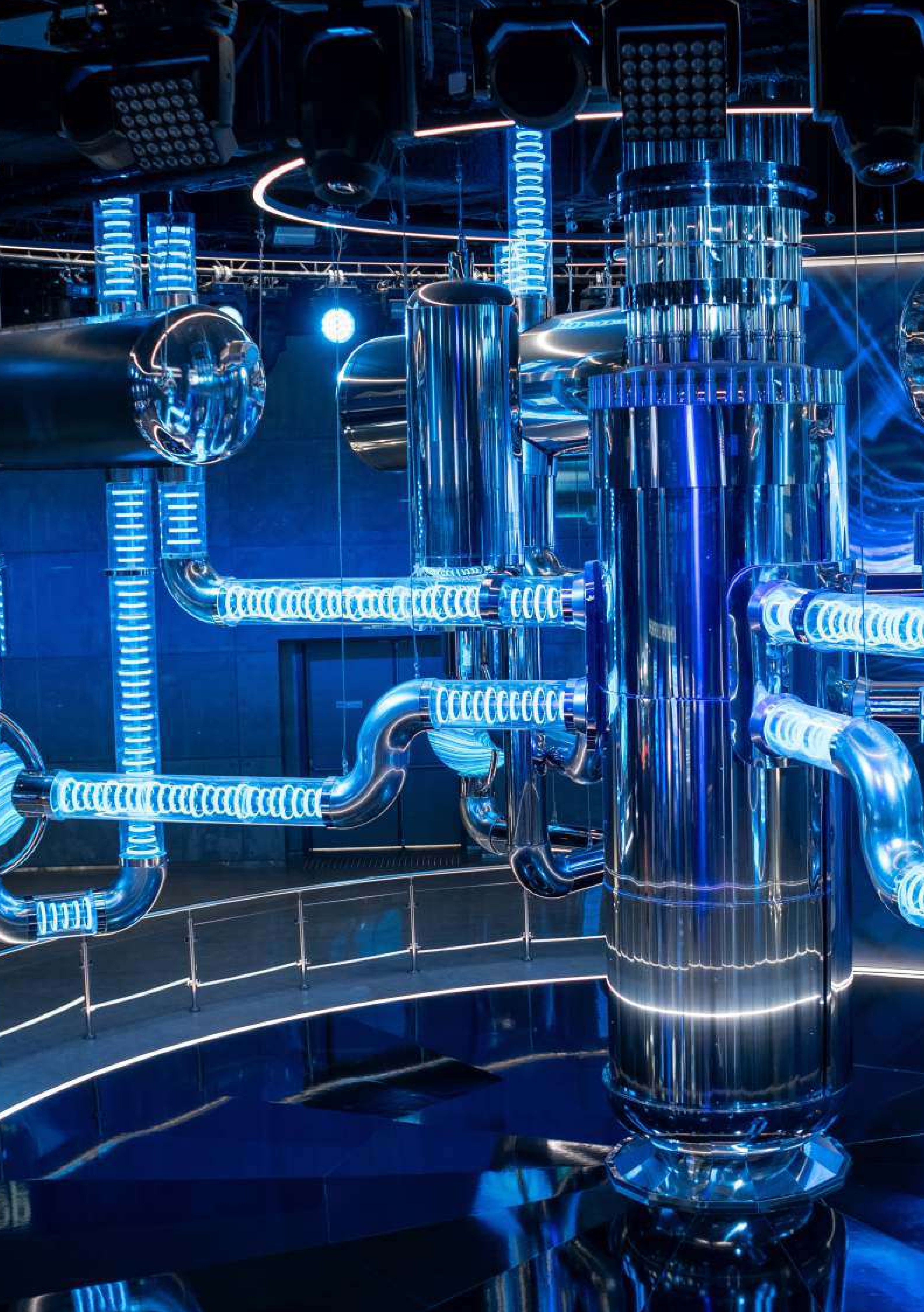
Table 2.3: Development Lifecycle of a Large Indian Nuclear Project

Milestone	Capital Requirement/Typical Finance	Financing Significance
Site investigations	Low; Government/internal resources	Development spending before investment decision
Administrative approval & financial sanction	Moderate; Government/sponsor equity	Formal capital commitment
Long-lead equipment and main civil contracts	High; equity + initial debt	Major procurement and construction exposure begins
AERB construction safety authorisation / possible First Pour of Concrete (FPC) regulatory hold point	Very high; long-term debt drawdown	Peak capital deployment; stage-gated debt can align with verified hold points
Reactor construction and equipment erection	Very high; long-term debt	Maximum debt and schedule exposure
First criticality	Debt substantially drawn	Transition from construction to operating risk
Grid synchronisation / commercial operation	Operating cash flow	Revenue and debt service begin

Source: Authors' analysis based on NPCIL milestone schedules and AERB consenting processes.

2.2 Bankability of Nuclear Power Projects

Lenders ultimately ask whether a project can reach completion and then generate predictable cash flows sufficient to service debt. For nuclear projects, bankability rests on policy continuity, statutory approvals, developer capability, standardised technology, fuel security, a credible tariff and offtake framework, insurable liabilities, and a residual sovereign backstop for risks that private parties cannot absorb. These considerations receive further elaboration in Sections 5 and 6; they constitute financing conditions, not attributes of reactor technology alone.



3 India's Existing Nuclear Financing Architecture

Key message: *NPCIL's existing model has combined Government equity, a 70:30 project debt-equity policy, domestic bonds and bank loans, and concessional Russian credit for Kudankulam. The rapid rise in construction expenditure and borrowing demonstrates why the 100 GW programme will require a broader pool of long-tenor capital.*

NPCIL's audited standalone annual reports from FY2016–17 to FY2024–25 provide the clearest picture of India's pre-SHANTI nuclear financing architecture. During this period, NPCIL was a wholly Government-owned Schedule 'A' Miniratna under DAE and the principal commercial operator and developer of PHWR and internationally partnered LWR projects. DAE was both the administrative ministry and shareholder, so equity timing and project borrowing were embedded in a Government-directed financing system.

3.1 Project Capital Structure and Emerging Diversification

The central rule for under-construction PHWR and LWR projects has been a Government-approved 70:30 debt-equity ratio. Thirty per cent of project cost is met through Government equity routed through DAE and 70 per cent through debt. The policy has applied to RAPP-7&8, KKNPP-3-6, KAPP-3&4, GHAVP-1-4, Chutka, and Mahi Banswara, with the earlier KKNPP Unit 2 financed on a 50:50 basis. The rule caps project leverage but also requires public equity to keep pace with debt drawdowns.

A second track is emerging. NPCIL's FY2024–25 report describes 220 MW Bharat Small Reactors (BSRs) as planned with private capital and Indian industry as anchor customers/co-investors. Jaitapur is also expected to need a combination of sovereign, international, and potentially private finance. This points toward a differentiated architecture rather than a single model for all reactor classes.

3.2 Equity, Debt, and Leverage Trends

Government equity has grown over the period, although the timing and magnitude of annual infusions have varied across years. Paid-up share capital rose from ₹10,806 crore at end-FY2016–17 to ₹19,753 crore at end-FY2024–25. The largest infusions were ₹3,941.82 crore in FY2023–24 and ₹2,077.29 crore in FY2024–25, while FY2018–19 and FY2020–21 had no fresh allotment. This lumpy pattern can create temporary leverage increases when debt is drawn against project milestones before matching equity arrives.

Table 3.1a: Government Equity Infusion into NPCIL Through DAE

Financial Year	Equity Infusion (₹ crore)
2016-17	589.00
2017-18	685.00
2018-19	-

Financial Year	Equity Infusion (₹ crore)
2019-20	1,202.42
2020-21	-
2021-22	815.00
2022-23	225.00
2023-24	3,941.82
2024-25	2,077.29

Source: NPCIL Statements of Changes in Equity, FY2016-17 to FY2024-25.

The debt side has diversified even faster. NPCIL draws on secured bonds/ non-convertible debentures (NCDs), rupee bank loans, foreign-currency term loans, external commercial borrowings (ECBs), and a DAE-administered Russian credit line for Kudankulam. Long-term borrowings rose from ₹25,617.59 crore in FY2016–17 to ₹1,01,052.70 crore in FY2024–25. Russian credit became the single largest category, while bonds grew in absolute value but slipped from roughly two-thirds to under 30 per cent of the borrowing mix. Bank and foreign-currency channels thus bear an increasing share of incremental funding. NPCIL's listed bonds have consistently carried the highest domestic credit rating (AAA), reflecting the strength of the sovereign-linked utility model.

Table 3.1: Selected Indicators of NPCIL Financing, FY2016–17 to FY2024–25

Indicator	FY2016-17	FY2024-25	What the Change Shows
Paid-up share capital (₹ crore)	10,806	19,753	Government equity rose by about 83%, but through uneven annual infusions.
Non-current borrowings (₹ crore)	25,617.59	1,01,052.70	Long-term borrowing nearly quadrupled as construction accelerated.
Bonds/NCDs (₹ crore)	17,314.20	29,930.10	Still important, but a smaller share of total debt.
Bank term loans (₹ crore)	3,200.00	18,637.20	Banks became a major construction-funding channel.
Foreign-currency term loans (₹ crore)	-	9,903.70	New source introduced as funding needs expanded.
ECB (₹crore)	547.76	5,190.87	External borrowing re-emerged at scale by FY2024-25.
DAE/Russian credit (₹ crore)	4,555.63	37,390.83	Largest single debt category by FY2024-25.
Net worth (₹crore)	31,911	65,475	Capital base expanded, but more slowly than debt.
Debt-to-net-worth ratio	0.80x	1.59x	Company-wide leverage roughly doubled.

Source: NPCIL Standalone Annual Reports, FY2016-17 to FY2024-25.
Project-level 70:30 financing should not be confused with the company-wide debt-to-net-worth ratio.

3.3 The Russian Credit and the Cost of Construction Finance

The Kudankulam Russian credit is structurally different from ordinary corporate debt. Funds are provided to NPCIL through DAE against inter-governmental credit at a 4 per cent coupon, with exchange-rate risk borne by NPCIL. Half of accrued interest is paid annually, and half capitalised; principal is repaid in fourteen equal annual instalments beginning one year after commercial operation of each unit. KKNPP-1&2 was fully repaid by FY2022–23; outstanding credit at 31 March 2025 was ₹26,288.82 crore for KKNPP-3&4 and ₹11,102.01 crore for KKNPP-5&6. The facility lowers the nominal financing rate but leaves currency and execution risk with the Indian project.

3.4 Project-Level Capital Deployment

The following table sets out construction and pre-construction spending across NPCIL's active pipeline.

Table 3.2: Selected Construction and Pre-Construction Expenditure

Project	31 Mar 2024 (₹ crore)	31 Mar 2025 (₹ crore)
RAPP-7&8 (2×700 MW PHWR)	7,985.01	9,684.84
KKNPP-3&4 (2×1,000 MW LWR)	12,567.64	15,755.35
KKNPP-5&6 (2×1,000 MW LWR)	3,798.21	4,978.97
GHAVP-1&2 (2×700 MW PHWR)	2,153.48	2,839.00
Total ongoing construction projects	**26,677.00**	**33,398.79**
Jaitapur	307.44	319.75
Chutka	218.30	204.74
Mahi Banswara	240.68	268.78
Kovvada	106.56	54.56
Kaiga 5&6	158.18	286.06
Total pre-construction / upcoming	**1,031.16**	**1,133.89**

Source: NPCIL Annual Reports FY2023–24 and FY2024–25, Expenditure During Construction / Upcoming Projects notes.

The data point to two conclusions. First, capital is already being deployed across a broad pipeline before revenue begins, rendering schedule control and refinancing critical. Second, even NPCIL's sovereign-linked balance sheet has needed a growing mix of bonds, banks, bilateral credit, and foreign borrowing. Scaling from today's programme to 100 GW will therefore require additional sponsors and financial institutions rather than simply expanding the historic model proportionately.

4 Regulatory and Institutional Enablers

Key message: *Regulatory certainty is a financial asset. Clear institutional responsibilities, predictable licensing milestones, and stable rules reduce schedule uncertainty and the risk premium demanded by lenders, while preserving the rigorous safety oversight on which nuclear expansion depends.*

Nuclear regulation is primarily concerned with safety, radiation protection, and environmental safeguards, while also influencing project financing outcomes. Given the sensitivity of financing costs to construction timelines, the timing and predictability of approvals, standards, institutional responsibilities, and cost-recovery arrangements can affect risk perception and IDC. A rigorous regulatory process can remain compatible with efficient financing where requirements and timelines are clear and predictable, while uncertainty or changes during project development may increase financing costs. The Draft SHANTI Rules and Draft SHANTI Regulations, 2026, now provide additional detail on the proposed licensing and safety-authorisation architecture; as draft instruments, they are treated here as an indication of the emerging framework rather than as final legal requirements.

Under the Draft Rules, an eligible person may be granted a single composite licence covering building, owning, operating, and decommissioning a nuclear power plant or reactor, subject to site, design, and capability requirements. The Draft Regulations separately provide for AERB design approval and staged safety authorisations for siting, construction, commissioning, operation, and decommissioning. This separation between Central Government licensing and AERB safety authorisation is relevant to project sequencing and lender due diligence.

4.1 Institutional Architecture and Staged Risk Reduction

India's nuclear financing framework involves multiple institutions whose decisions influence project readiness, risk allocation, and the timing of capital deployment. Understanding their respective roles is therefore important for assessing how regulatory, policy, and operational responsibilities translate into financing outcomes, as summarised in Table 4.1.

Table 4.1: Core Institutions and Their Financing Relevance

Institution	Primary Responsibility	Financing Relevance
DAE	National policy, programme planning and strategic oversight	Policy continuity, sovereign support, and fuel-cycle coordination
NPCIL / licensed developer	Project development, construction, and operation	Sponsor capability, borrower strength, and execution record
AERB	Safety regulation, design approval, and lifecycle safety authorisations	Predictable safety review and regulatory hold points can reduce regulatory and schedule uncertainty
MoEFCC	Environmental clearance and compliance	Determines project readiness and legal risk

Institution	Primary Responsibility	Financing Relevance
Cabinet Committee on Economic Affairs (CCEA) / Government approval	Administrative approval and financial sanction	Enables major capital commitment
CEA / power-sector institutions	System planning, tariff, and grid integration inputs	Supports offtake, tariff design, and system integration

Source: Authors' compilation from DAE, AERB, MoEFCC, and Government of India publications.

India's historic advantage has been institutional continuity: DAE, NPCIL, and AERB have built up decades of technical and operating experience, while standardised PHWR designs allow lessons to transfer between projects. The post-SHANTI market will add developers and technologies, so this capability will need to be scaled rather than diluted.

For financing purposes, predictable sequencing and adequate regulatory capacity remain important. The Draft Rules introduce licensing hold points and generally envisage issuance of a licence within 180 days from admittance, subject to all requirements being fulfilled and information being furnished; this should not be read as a guarantee of end-to-end licensing within six months. The Draft Regulations allow AERB to specify regulatory hold points at stages such as excavation or First Pour of Concrete, initial fuel loading, first criticality, and power ascension. These milestones can provide reference points for staged financing, while the financing consequences of each milestone would still need to be determined contractually.

The Draft Regulations also provide for a scoped review where a reactor design is already under construction or operation in India, while designs not previously reviewed by AERB or not covered by existing regulatory documents may require more extensive review and additional submissions. This could support learning from repeated designs, but the extent of any schedule or cost reduction will depend on implementation and should not be assumed in advance.

The draft framework also distinguishes the duration of the statutory licence from periodic safety authorisation. A nuclear power plant or reactor licence would ordinarily be linked to the design life, whereas safety authorisation would generally remain valid for ten years unless otherwise specified by AERB and would be subject to renewal and safety review. Long-tenor lenders would therefore need to treat periodic safety review as a recurring compliance milestone rather than assume that a single safety authorisation would cover the full financing tenor.

5 International Financing Models: Lessons for India

Key message: *No country has financed new nuclear capacity through a single instrument. Successful programmes combine public leadership, long-tenor capital, predictable revenues, vendor accountability, and a clear route for refinancing once construction risk falls.*

Nuclear finance falls between sovereign infrastructure and commercial power generation: a reactor absorbs large capital before earning revenue but can operate for six decades or more. International experience therefore points to layered structures rather than ordinary non-recourse project finance. India should adapt these principles to different project types - repeated PHWR fleets, imported large reactors, industrial/captive projects, and future small modular reactors (SMRs) - rather than apply a single template (Barkatullah and Ahmad 2017; Terlikowski et al. 2019).

5.1 Financing Models and Their Indian Relevance

State-backed and utility balance-sheet financing has played a significant role in many large nuclear programmes. Countries such as China, France, Russia, and South Korea have combined state utilities, policy banks, guarantees, and broader industrial-policy support to finance nuclear expansion and manage construction-related risks. In India, entities such as NPCIL, NTPC Limited (NTPC), Anushakti Vidyut Nigam Limited (ASHVINI), and other public-sector enterprises may therefore continue to play an important role in the initial phase of expansion. At the same time, public-sector participation does not remove project execution risks, and considerations such as design standardisation, cost benchmarking, and appropriate allocation of responsibility for delays remain relevant. Government-to-Government and export-credit finance is particularly relevant to imported technologies. Long tenor and concessional coupons can be attractive, but the full package must include procurement conditions, hedging, rupee depreciation, localisation, and geopolitical exposure. India should therefore negotiate finance together with technology transfer, phased localisation, fuel and service commitments, performance guarantees, and remedies for export-control or supply disruption.

Vendor finance and vendor equity can align the technology supplier with completion performance through deferred payments, supplier credit, minority equity, or performance-linked milestones. For first units, turnkey or target-cost arrangements can also reduce interface risk. Vendor balance sheets are finite, however, and they cannot substitute for Indian responsibility for sites, regulation, grid connection, fuel, tariff, and liability (Aggregating demand across serious Indian developers could improve price discovery) common design approval, and localisation terms without forcing all projects into one ownership structure.

Revenue support is equally important. Long-term power purchase agreements (PPAs) or regulated tariffs give lenders predictable post-commissioning cash flow; contract for difference (CfD)-type mechanisms can stabilise revenue but may create a large public top-up if market prices remain below the strike price. For early Indian projects, regulated cost-plus tariffs, two-part tariffs for flexible designs, or back-loaded structures may be more workable. A regulated asset base (RAB)-type mechanism can lower IDC by permitting recovery on approved construction expenditure, but shifts risk to consumers; in India, it is better viewed as a targeted facility for certified expenditure, industrial users, or interest subvention rather than an open-ended national levy.

Industrial-consumer structures such as Finland's Mankala model combine equity and committed demand. The Draft Rules expressly contemplate captive nuclear generation and allow reactors to supply electricity, process heat, hydrogen, or hybrid combinations; they also identify potential captive uses such as aluminium, cement, data centres, and semiconductor fabrication. This broadens the range of possible industrial business models, although the proposed single composite licence would place lifecycle obligations on the licensed entity rather than treat the project as a simple power-purchase arrangement. Consortium structures would therefore still require clarity on ownership, operator capability, offtake, open access, transmission, and exit.

Finally, guarantees, blended finance, and refinancing should be used selectively. Power Finance Corporation (PFC), Rural Electrification Corporation (REC), and public banks can anchor construction lending while Government covers defined sovereign or first-of-a-kind risks. Concessional capital is too scarce to fund the programme as a whole. Once commercial operation is achieved, construction risk falls, and operating assets can refinance into bonds, infrastructure debt funds, insurers, and pension funds, releasing scarce sponsor equity for the next project.

Table 5.1: Comparative Assessment of Major Financing Models

Model	Commercial Logic and Risk Allocation	Likely Indian Application
State/utility balance sheet	Strong utility or Government carries long-duration construction and sovereign risk; low credit cost but public balance-sheet exposure.	NPCIL, NTPC, ASHVINI, and first standardised fleets.
Government-to-Government/ export credit	Host and exporting states share finance, technology, and geopolitical risk; procurement and FX conditions matter.	Imported large reactors and specialised equipment, with localisation and disruption clauses.
Vendor finance/equity	Supplier retains part of completion and performance risk; capital is limited.	First units, target-cost packages, and phased localisation.
Long-term PPA / regulated tariff	Offtaker absorbs agreed market-price risk after commissioning.	Early private grid projects and industrial consortia.
RAB-type construction support	Consumers/Government share certified construction finance; lowers IDC but needs prudence review.	Limited, targeted support rather than a broad levy.
Industrial consortium / Mankala	Industrial users provide patient equity and committed demand.	Captive projects, industrial clusters, and mature SMRs.
Guarantee + post-commercial operation date (COD) refinancing	Government covers defined risks; institutional investors enter after completion.	Cross-cutting route to lower weighted average cost of capital (WACC) and recycle capital.

Source: *Authors' synthesis based on CEA (2025), Barkatullah and Ahmad (2017), Terlikowski et al. (2019), TERI (2026), and stakeholder consultations.*

5.2 A Differentiated Financing Architecture for India

India should differentiate financing by project type: indigenous fleet projects can use public balance sheets, consortium lending, and domestic bonds; imported reactors should combine export credit with vendor risk-sharing, common design approval, phased localisation, and explicit FX/geopolitical allocation; the first private grid projects need long-term revenue certainty before competitive procurement; construction-period support should be limited to independently certified expenditure; industrial projects can use consortium ownership and take-or-pay commitments; and operational assets should refinance into long-tenor bonds and institutional capital so sponsor equity can be recycled.

The objective is not to subsidise every project indefinitely, but to lower the cost of capital while retaining responsibility. Public support should create repeatable contracts, better data, deeper supply chains, and a path to lower-risk private finance over time.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6 Risk Allocation, Bankability, and Insurance

Key message: *A nuclear project becomes bankable when each material risk has an identifiable owner, an enforceable mitigation mechanism, and a credible residual backstop. Unallocated risk is eventually charged to the tariff, absorbed by the public balance sheet, or used by lenders as a reason not to finance the project.*

Technical feasibility is not sufficient for bankability. A proven reactor can remain unfinanceable if the site is uncertain, the tariff lacks a credible buyer, fuel and back-end obligations are unclear, or lenders cannot estimate the cost of delay. The SHANTI Act, 2025 establishes the legal basis for wider participation. The Draft SHANTI Rules and Regulations, 2026 proposed operational detail by setting out a composite licensing pathway, applicant capability tests, licensing and regulatory hold points, AERB design approval and staged safety authorisations, as well as proposed arrangements for nuclear liability, spent-fuel management, and decommissioning financial security.

6.1 Development, Construction, and Technology Risk

Development risk is concentrated in site suitability, land, environmental clearance, technology choice, and design approval. Consultations indicate that early site studies can cost several crore rupees, detailed investigations around ₹100 crore, and land several hundred crores before construction certainty exists. A pipeline of pre-assessed sites, state participation, or land-for-equity structures can reduce this exposure. The Draft Rules introduce an in-principle approval that may be granted after application admittance where the site or technology has not yet been selected, allowing the applicant to proceed with vendor negotiations and land or infrastructure development subject to specified conditions. The Draft Regulations further provide for AERB design approval, with scoped submissions possible for designs already under construction or operation in India. These provisions may create clearer development-stage milestones, but they do not remove the underlying site, design, or financing risks.

Construction is the largest controllable risk. About 80 per cent of expenditure may be deployed during the main build period, so delay after first concrete carries substantial IDC and defers revenue. The Govt. roadmap quantifies the financial effect of delay; the consolidated evidence is presented in Section 8. Industry stakeholders therefore suggested examining IDC as a distinct construction-finance problem rather than only as an embedded component of completed project cost. The Draft Regulations identify First Pour of Concrete (FPC) as one example of a possible AERB regulatory hold point during construction. This gives FPC clearer regulatory significance but does not by itself establish a financing trigger or a normative IDC-recovery period. Pre-construction studies and long-lead procurement may begin two to three years earlier and should be treated separately. Any special IDC treatment would also need a prudence test: delays within the developer's or contractor's control should not automatically be passed to consumers or Govt.

Technology risks differ by reactor type. Standardised PHWRs offer better cost and schedule visibility but may face bottlenecks in heavy water, large forgings, specialised components, and design-support capacity. For foreign designs, the Draft Rules propose that the selected reactor should have regulatory certification or approval in its country of origin and be operational there or in another foreign country, in addition to Indian design approval and continuing technology-provider support. This could ease some technology uncertainty for imported reactors, but may also affect the near-term eligibility of designs without an operating reference. The Draft Regulations similarly indicate that technologies not previously reviewed by AERB may require a more involved scoping and review process. SMRs and other advanced designs should therefore be evaluated against their specific regulatory maturity, serial-production evidence, and operating record rather than financed as a single homogeneous category (TERI 2023; TERI 2026; Department of Atomic Energy, Government of India 2026).

6.2 Revenue, Tariff, and Fuel Assurance

Revenue certainty is essential because new nuclear projects often face high first-year tariffs when capital recovery and return on equity (RoE) are front-loaded. The CEA's 2026 PHWR study shows that no single concession is sufficient to address this problem. Under the base assumptions, the first-year tariff is ₹7.92/kilowatt-hour (kWh) and the levelised tariff ₹8.11/kWh; a coordinated package combining lower operations and maintenance (O&M) escalation, an 80:20 debt-equity ratio, lower Goods and Services Tax (GST) on nuclear-island equipment, a present-value-neutral stepped RoE, and a 75 per cent normative plant load factor (PLF) reduces them to ₹6.42/kWh and ?6.98/kWh. Removing tax on RoE lowers the levelised result further to ₹6.71/kWh (CEA 2026).

Table 6.1: Illustrative Impact of PHWR Tariff Reforms Estimated by CEA

Scenario		First-Year Tariff (₹/kWh)	Levelised tariff (₹/kWh)
Base Case	Standard DAE Norms 2025; Equity 30%; PLF 72.5%; O&M Esc. 6.00%; GST 18%	7.92	8.11
Case I	O&M Escalation Rate aligned with CERC thermal norms (reduced to 5.25%)	7.85	7.83
Case II	Project Equity Component reduced from 30% to 20% (Debt: Equity at 80:20)	7.55	7.77
Case III	GST on specialized Nuclear Island equipment reduced from 18% to 5%	7.62	7.85
Case IV	Variable (Stepped) RoE structure implemented (PV-equivalent to flat 15.5%)	6.94	8.00
Case V	Normative PLF increased from 72.5% to 75.0% (grounded in 5-yr actual data)	7.70	7.89
Case VI	Coordinated package (Combines Cases I, II, III, IV, and V)	6.42	6.98
Case VI a	Case VI + No Tax on RoE	6.30	6.71
Case VII	Standalone Life Extension to 60 Years; Loan repayment extended to 50 Years	7.58	8.22

Source: *CEA (2026)*

Note: *These are scenario results, not bids or guaranteed tariffs. Each individual reform case is an independent sensitivity against the same ₹8.11/kWh base case; the coordinated package is the combined scenario and should not be interpreted as a sequence in which each individual reduction is added to the previous one.*

However, a full additive pie-chart decomposition of LCOE cannot be reconstructed reliably from these sensitivity cases alone. The CEA model reports tariff outcomes under changed assumptions rather than mutually exclusive cost shares, and financing, depreciation, return on equity, and tax interact. To avoid creating a false decomposition, this paper therefore ranks the observable tariff sensitivities and separately identifies capital expenditure (CAPEX), IDC, O&M, fuel, and tax as cost drivers. A more granular component decomposition would require the underlying project cash-flow model. For precision, the CEA figures in Table 6.1 are levelised tariff results for the modelled PHWR case; they are not a universal LCOE for all nuclear technologies.

As calculated against the common ₹8.11/kWh base, the individual CEA sensitivities cut the levelised tariff by about ₹0.34/kWh for moving from 30 per cent to 20 per cent equity, ₹0.28/kWh for lower O&M escalation, ₹0.26/kWh for reducing GST on nuclear-island equipment to 5 per cent, ₹0.22/kWh for increasing normative PLF from 72.5 per cent to 75 per cent, and ₹0.11/kWh for the PV-neutral stepped-RoE case. The coordinated package reduces the levelised tariff by about ?1.13/kWh to ₹6.98/kWh; removing tax on RoE in addition takes the modelled result to ₹6.71/kWh. These comparisons identify material levers but are not additive because several measures affect overlapping components of tariff. The Draft Rules also add proposed lifecycle financial obligations that could enter future project cash flows. Tariff norms and charges would be determined under Section 37 of the SHANTI Act based on recommendations of a Central Government committee, while operator contributions are proposed for a Nuclear Liability Fund (NLF) and, where applicable, a Spent Fuel Management (SFM) Fund. Decommissioning financial security would also be accumulated over the operating life, segregated from the licensee's other assets, and excluded from liquidation under the proposed framework. The draft instruments do not specify all levy rates or a project-specific rupee-per-kWh effect, so these items are not added to the CEA tariff sensitivities in this paper.

The study also cautions that a longer operating life does not automatically shrink levelised tariff: a 60-year life with 50-year repayment lowered the first-year tariff but raised the levelised figure under the study's assumptions. Debt tenor, depreciation, tariff recovery, and refinancing must therefore be designed together. Fuel is another bankability issue. The Draft Rules would require contracts for assured nuclear fuel and heavy water, where applicable, before initial fuel loading, along with arrangements for spent-fuel and radioactive-waste management. They do not, however, settle the commercial terms, pricing, or parity of access for public and private operators. Stakeholder consultations additionally raised whether fixed-cost recovery should rely primarily on PLF or be linked to plant availability. The issue remains open: 80 per cent, 85 per cent, and 90 per cent were discussed as alternative availability scenarios, not as settled norms. Any availability definition would need to specify the treatment of planned maintenance, forced outages, fuel shortages outside the operator's control, major refurbishment, and the first two to three years of operating stabilisation. A phased approach - lower initial performance assumptions followed by a mature-fleet norm should be tested against consistent unit-level operating data before a regulatory benchmark is proposed.

6.3 Indicative Risk Allocation for Consideration

The risks above are interconnected: a siting delay becomes a construction delay, which becomes IDC and eventually tariff pressure. Bankability does not require eliminating every risk; it requires assigning each risk to the party best able to control or absorb it and providing a credible residual backstop where private markets cannot do so.

Table 6.2: Risk Allocation for an Indian Nuclear Project

Risk	Primary Allocation	Mitigation/Residual Support
Site and land	Developer due diligence; state supports acquisition/local coordination	Pre-assessed sites, land banks, land-for-equity; development spend remains at risk until approval.
Policy, licensing, change in law	Government/regulator for sovereign decisions; developer for compliance failures	Draft licensing timelines and AERB review plans or hold points may improve predictability; contractual change-in-law relief remains relevant.
Design / first-of-a-kind (FOAK) technology	Vendor and developer; Government may support strategic demonstration	AERB design approval; scoped review for repeated Indian designs where applicable; warranties, contingency and milestone-based support.
Construction/contract or performance	Developer, engineering, procurement and construction (EPC) contractor, and vendor	Target/fixed-price packages where suitable, delay damages, independent monitoring, and prudence review.
Supply chain, FX, geopolitics	Developer/vendor for procurement; Government for sovereign restrictions	Localisation, hedging, supplier diversification, strategic spares, and disruption remedies.
Fuel, safeguards, spent fuel, high-level waste	Central Government retains strategic control; operator must secure fuel and back-end arrangements and meet applicable charges.	Assured fuel and heavy-water contracts before loading; spent-fuel transfer and fund arrangements; commercial access and pricing terms to be clarified.
Offtake and payment	Offtaker/identified consumers; developer retains availability risk	Long-term PPAs, pooled procurement, payment security, and performance-linked recovery.
Operator failure/abandonment	Sponsor and lenders for ordinary insolvency; Government for safety/continuity	Step-in rights, reserves, and last-resort takeover mechanism.
Nuclear liability / catastrophic damage	Operator statutory layer; Government/international arrangements above it	Adequate insurance, expanded pool and Nuclear Liability Fund.

Source: *Authors' synthesis based on the SHANTI Act, Draft SHANTI Rules and Regulations (2026), CEA (2025), CEA (2026), and stakeholder consultations.*

6.4 Lender Confidence and Insurance Architecture

Long-term debt is likely to be a binding constraint because banks face exposure limits, asset-liability mismatches, and limited nuclear appraisal capability. Large projects will need consortium lending, specialist advisers, and common due-diligence standards. The Draft Rules make financial, managerial, and technical capability part of the proposed licensing assessment, including construction and five-year O&M cost estimates, sources of funds, financial-stability indicators, fuel and heavy-water arrangements, lifecycle business planning, and qualified personnel. Newly formed entities that rely on parent or promoter support would also be expected to demonstrate that support through financial information and a legally binding undertaking. These provisions do not preclude project-company structures, but they would make sponsor strength and enforceable support relevant to lender and licensing assessments. Financial close should therefore be aligned with design approval, site readiness, core contracts, offtake, insurance, and lifecycle funding obligations, with debt released against independently certified milestones. Stakeholders referred to a reported PFC nuclear loan tenor of around 30 years and asked whether comparable or longer finance could eventually be available to eligible private developers; the paper treats this as a question for lender validation rather than an assumed market term. A PPA of roughly 40 years was similarly discussed as an option for matching revenue visibility to long-lived debt. Institutional investors are likely to be better suited to the post-completion phase, when stable cash flow and lower construction risk can support bonds or infrastructure debt and recycle construction capital.

The Draft Rules provide for operator insurance, financial security, or a combination of both for nuclear damage, and would allow groups of operators to establish a joint financial-security arrangement in proportion to installed thermal capacity. They also propose an operator-funded NLF, with the levy rate to be notified later. Installations receive different treatment under the draft framework where Government assumes the relevant liability. These provisions provide additional visibility on the proposed architecture but do not resolve the pricing and capacity of insurance for a multi-operator market. The India Nuclear Insurance Pool provides a domestic base; stakeholders suggested capacity toward ₹3,000 crore for an enlarged pool, subject to actuarial assessment. International reinsurance and clearer nuclear-island property and machinery cover would remain relevant for lenders.

Table 6.3: Layered Insurance and Liability Structure

Layer	Risk Covered	Likely Provider/Requirement
1. Conventional construction/property	Civil works, equipment, transit, contractor, and delay-in-start-up	Domestic insurers + international reinsurance; project-specific deductibles.
2. Nuclear-island property/machinery	Hot-zone damage, contamination, and machinery breakdown	Specialised pool/co-insurance + global reinsurers + defined Government excess layer.
3. Operator third-party liability	Statutory operator layer	India Nuclear Insurance Pool (INIP) or successor with adequate per-unit and multi-incident capacity.
4. Government/supplementary liability	Claims above operator layer and exceptional events	Nuclear Liability Fund (operator-funded levy under the Draft Rules), budgetary backstop, and applicable international arrangements.
5. Lifecycle reserves	Spent fuel, decommissioning, waste, and site restoration	Spent Fuel Management Fund where applicable plus segregated decommissioning financial security; rates and charges remain to be notified or determined.

Source: *Authors' synthesis based on the SHANTI Act, Draft SHANTI Rules (2026), INIP arrangements, and stakeholder consultations.*

Government should ultimately retain risks arising from sovereign authority and national obligations – security, strategic fuel-cycle control, safeguards, catastrophic liability above the operator layer, changes in law, emergency intervention, and final spent-fuel/high-level-waste management. Private developers can carry development, procurement, contractor, operating, and performance risks where they have information and control. Support should be explicit, capped, and priced where possible.

7 Enabling Wider Participation of Indian Industry

Key message: *Wider private participation would depend on a supporting ecosystem, including credible developers, pre-developed sites, approved designs, regulatory capacity, capable vendors, long-tenor lenders, and investable operating assets. The Draft SHANTI Rules and Regulations provide additional detail on licensing and safety authorisation, while several commercial arrangements remain to be specified.*

The SHANTI Act changes the legal starting point by allowing eligible entities and joint ventures to participate in nuclear power while the Central Government retains specified strategic controls. The Draft SHANTI Rules and Regulations now provide substantially more detail on how such participation could be licensed and supervised. They propose a single composite licence covering build-own-operate-decommission responsibilities, capability assessments, design approval, staged safety authorisations, and lifecycle obligations for fuel, waste, liability, and decommissioning. As both instruments remain in draft, the commercial implications will depend on their final form and on subsequent notifications, tariff decisions, and contracts. The policy question is therefore shifting from whether private participation is legally possible to how the proposed framework can be implemented in a financeable and repeatable manner.

7.1 Public Institutions as the Platform for Wider Participation

NPCIL remains the principal repository of PHWR design knowledge, operating experience, safety culture, and vendor relationships; NTPC and ASHVINI add balance-sheet strength and large-project procurement capability. They should anchor early projects, but a 100 GW programme cannot lean on them to finance, execute, and handhold every entrant. A staged route can begin with joint ventures, minority stakes in operating assets, EPC/manufacturing roles, and captive projects before wider ownership expands. NPCIL's technology-support role should have a transparent scope and fee so that knowledge transfer is funded without rendering indigenous technology uncompetitive.

7.2 Opportunities and Constraints Across the Value Chain

Wider industry participation in nuclear power can extend beyond project ownership to multiple stages of the value chain, including financing, engineering, manufacturing, operations, and supporting services. The nature of investment opportunities, however, will vary across segments depending on regulatory requirements, technical capability, project pipeline visibility, and the allocation of commercial and operational risks. Table 7.1 outlines the principal areas where Indian industry could potentially participate and the conditions that may enable such investment.

Table 7.1: Opportunities for Indian Industry Across the Nuclear Value Chain

Segment	Potential Participants	What Enables Investment
Project sponsorship/equity	Public sector undertakings (PSUs), large industrial groups, infrastructure investors, industrial consortia	Clear licence, ownership/exit rules, credible sites, and long-term offtake.
Engineering/construction	EPC firms, civil contractors, specialist engineers	Standard contracts, continuous orders, nuclear quality systems, and fair delay-risk allocation.
Heavy equipment/components	Existing vendors and new heavy-engineering firms	Fleet procurement, testing infrastructure, capex support, and qualification to nuclear codes.
Electrical/control/digital	Power-equipment, automation, software, and cyber firms	Approved architectures, information security, and long-term service obligations.
Operations/maintenance	Licensed operators, JVs, and specialist service companies	Training, certification, regulator-approved procedures, and safety culture.
Fuel/back-end interfaces	Licensed logistics/storage/service providers under Government supervision	Safeguards, material accounting, transfer rules, and cost recovery.
Finance/insurance	Banks, PFC, REC, insurers, reinsurers, bondholders, and pension investors	Nuclear project appraisal, credit enhancement, insurance capacity, and refinancing market.
Decommissioning/waste	Engineering, robotics, materials, and remediation firms	Ring-fenced funding, liability clarity, standards, and technical-data access.

Source: *Authors' synthesis based on CEA (2025), Dhanke and Palit (2025), TERI (2026), and stakeholder consultations.*

Three areas may influence the extent to which industry interest translates into investment. First, greater visibility on the project pipeline, including sites, reactor types, developers, and procurement timelines, could support planning for nuclear-grade manufacturing capacity and specialist teams. Second, capabilities remain concentrated across a relatively limited pool of vendors, engineers, inspectors, and fuel-cycle and heavy-water facilities; a larger number of simultaneous projects may therefore require parallel assessment and expansion of these capacities. Third, greater clarity may be required on commercial arrangements relating to imported-reactor pricing, long-tenor debt, insurance, fuel and spent-fuel charges, technology support, and Government step-in provisions. Industry consultations also highlighted the question of whether eligible civilian private operators would have access to fuel, heavy water, fabricated fuel, and specialised Nuclear Fuel Complex (NFC) inputs on terms comparable to public operators, subject to applicable strategic and safeguards requirements. Heavy-water pool pricing and advance planning of NFC capacity were identified as options that could be examined further.

7.3 Standard Project Archetypes and Investible Pipelines

The Draft Rules begin to set out several features that would shape project archetypes. In particular, a nuclear power plant or reactor would operate under a single composite licence covering building, ownership, operation, and decommissioning, while technology may be sourced from an indigenous or foreign developer or provider subject to the proposed conditions. Standard archetypes can therefore still differ in sponsor, technology, offtake, and financing, but the licensed entity would need to demonstrate lifecycle capability rather than rely on independently licensed parties to separate ownership and operating responsibilities.

Table 7.2: Standard Project Archetypes for Wider Participation

Archetype	Structure	Financing/Policy Logic
Public-sector fleet	NPCIL, NTPC, ASHVINI, or another strong PSU builds repeated units	Lowest-risk near-term route using balance-sheet finance, fleet procurement, and regulated tariffs.
Public operator + private capital	Public operator retains operating control; private/institutional investors take project or operating equity	Learning and capital-recycling route; needs governance and exit rights.
Private indigenous project	Eligible Indian entity holds the composite licence for an approved indigenous design with technology-provider support	Requires sponsor capability, AERB design approval, assured fuel or heavy-water arrangements, long-term offtake, and approved transfer or step-in pathways.
Imported technology partnership	Eligible Indian developer + foreign technology provider under an approved design and localisation plan	Foreign design would need origin-country approval or certification and an operating reference; export credit, FX allocation, design support, and supply-disruption protection remain relevant.
Industrial consortium / captive	Industrial users invest through an eligible licensed entity for captive electricity, process heat, hydrogen, or hybrid output	Draft Rules expressly allow captive and hybrid use; combines demand and equity but retains composite lifecycle licensing and applicable tariff or charge obligations.
FOAK demonstration	Government and industry co-fund an SMR/advanced-reactor demonstration	Public support covers learning risk with milestones and a route to serial deployment.
Pre-developed site concession	Public agency completes site studies/key approvals before award	Reduces early uncertainty and can support price discovery once design/tariff rules are settled.

Source: *Authors' synthesis based on the SHANTI Act, CEA (2025), and stakeholder consultations.*

India also needs two linked financing pipelines: bankable projects that can reach construction finance and investible operating assets that can absorb patient institutional capital. Pre-assessed sites, approved designs, standard contracts, and offtake should precede construction; after commercial operation, bonds, infrastructure debt funds, insurers, and pension investors can refinance the asset and release sponsor equity. Strategic importance alone will not attract institutional capital: operating assets need investment-grade credit, predictable cash flow, liquidity, and clear liability.

7.4 Project Preparation, Domestic Finance, and Localisation

The Government roadmap's proposed Design and Site Support Agency could maintain reference designs, coordinate project preparation, undertake site investigations, and prepare standard technical documents. Under the Draft Regulations, the AERB itself would issue design approval and may scope the review of designs already under construction or operation in India. A complementary commercial market-maker could aggregate demand, prepare bankable contracts, coordinate long-term offtake and payment security, house a project-development facility, and connect projects with lenders. These roles can be separate or ring-fenced, but mandates need to remain distinct: the designated Central Government authority for statutory licensing, the AERB for safety authorisation and design approval, the Central Government and DAE for strategic and fuel-cycle responsibilities, power-sector institutions for offtake and tariff interfaces, financial institutions for debt and refinancing, and states for land and local coordination.

PFC and REC are natural anchor lenders because they understand power regulation and can offer longer tenors than many commercial banks; public-sector banks can participate through consortia with specialist technical advisers and a common nuclear-appraisal manual. Stakeholders asked whether public-sector long-tenor nuclear finance could eventually be offered on comparable eligibility criteria to private developers. The appropriate debt tenor, pricing, and risk support should be tested with lenders rather than presumed. Debt service should be aligned with depreciation, tariff recovery, and planned refinancing. Back-loaded tariffs and sculpted repayment can soften the first-year burden while preserving coverage. Long-duration PPAs and credible offtake arrangements may be necessary to support such debt, while capital markets are likely to enter primarily after commissioning through credit-enhanced bonds, pooled operating portfolios, and infrastructure debt funds.

Localisation can benefit from greater visibility and continuity in project orders. Repeated designs may support bulk procurement, learning, and investment in specialised tools and skills, while greater variability in project awards can make long-term capacity planning more difficult. The Draft Regulations provide a potential regulatory basis for repetition by allowing the scope of submissions to be limited where a design is already under construction or operation in India, subject to compliance with current safety requirements. Conversely, designs not previously reviewed may require a more involved scoping process. The extent to which this translates into shorter approval times or lower project costs should therefore be tested through implementation rather than assumed.

Imported-reactor packages need to specify when local manufacture begins, the targeted domestic share, and the price reductions expected from learning. Targeted production support may be considered for large forgings, reactor vessels, nuclear-grade pumps, and control systems where linked to certification, delivery, technology transfer, and potential demand. A further stakeholder view was that the initial private developer market may remain concentrated among a small number of balance-sheet-capable firms; this is best treated as a market-structure question rather than a forecast.

7.5 Taxonomy, International Partnerships, and Human Capacity

Tax and sustainable-finance treatment can widen the capital pool but cannot substitute for bankability. Qualifying nuclear activities should be assessed transparently for inclusion in

India's sustainable-finance taxonomy and non-fossil framework, with eligibility tied to lifecycle emissions, safety, safeguards, waste, decommissioning, and disclosure. The tariff effect of GST and other financing measures is quantified in Sections 6.2 and 8. Stakeholders also suggested reviewing environmental-risk classifications that may not accurately reflect nuclear's emissions profile, without weakening nuclear or environmental oversight.

International partnerships will remain important because the 100 GW roadmap combines indigenous PHWRs with large pressurised water reactors (PWRs), FBRs, and later SMRs. Agreements should strengthen domestic capability through design information for Indian regulation, joint engineering, phased localisation, fuel and spare-part commitments, vendor performance security, and remedies for export-control disruption. Export-credit offers should be assessed after hedging and procurement costs, not by the coupon alone; collective negotiation by multiple Indian developers can improve price discovery. Foreign ownership, governance rights, technology access, and exit rules must also be clear within the SHANTI framework for Indian-incorporated entities and joint ventures.

The scale-up of nuclear capacity will also have implications for workforce and institutional capacity. The Government roadmap projects a peak construction workforce of about 1.2 lakh around 2041 and an operating workforce of about 61,000 by 2047. Meeting these requirements would involve expanding the availability of engineers, licensed operators, inspectors, quality specialists, welders, cyber-security professionals, and project managers, alongside corresponding capacity within the AERB. New operators may also require structured training and enhanced oversight during the initial stages of operation. Shared testing facilities, common certification frameworks, and support for qualified Indian vendors to participate in global supply chains could further strengthen domestic capabilities as the sector expands.

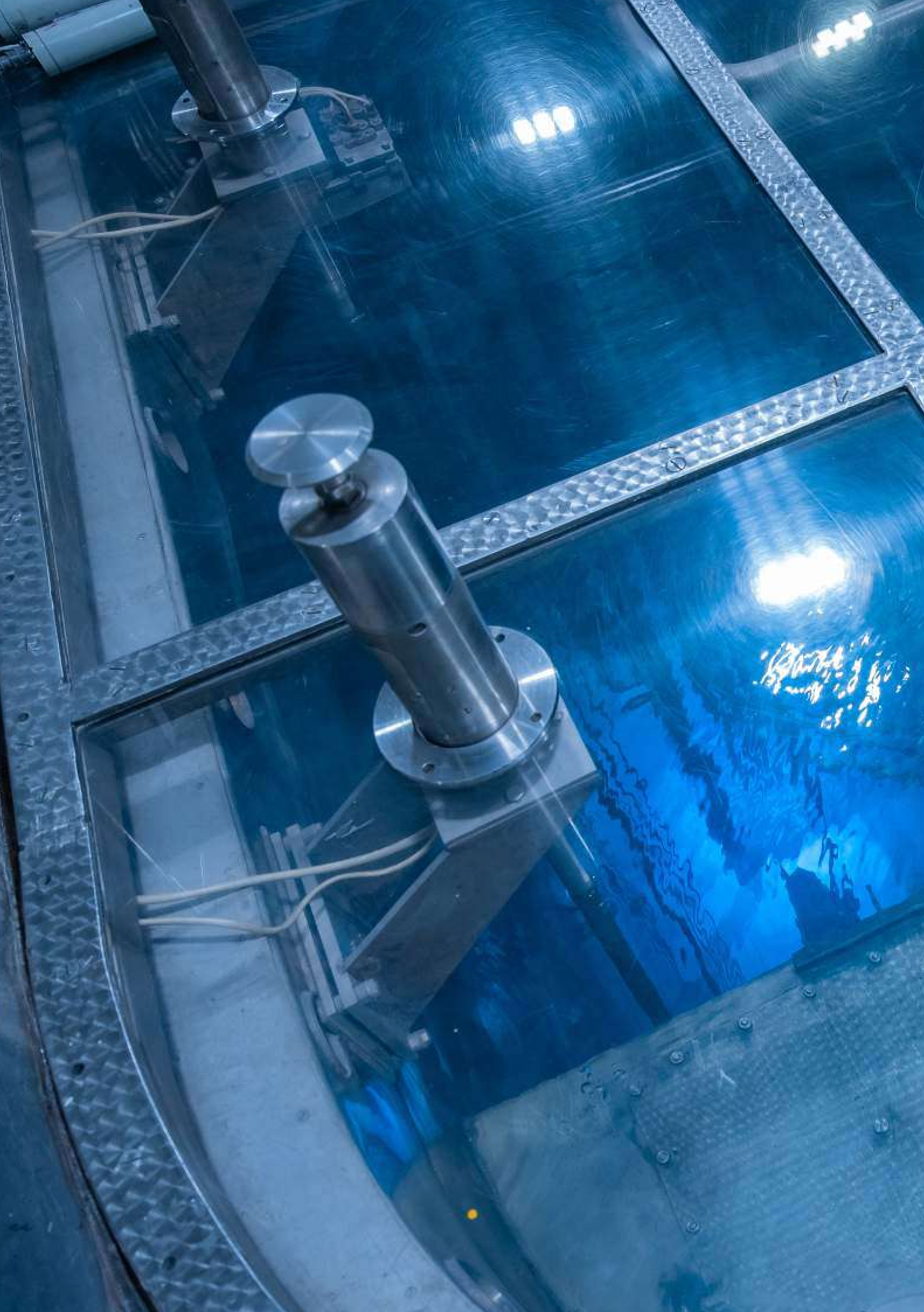
7.6 A Phased Pathway for Wider Participation

A phased approach may help sequence wider industry participation with the development of regulatory, financial, and institutional capacity, as outlined in Table 7.3.

Table 7.3: Sequencing Wider Industry Participation

Phase	Priority Actions	Expected Public–Private Balance
I. Finalisation, demonstration, and standardisation	Finalise the Rules, Regulations, and implementing notifications; test composite licensing, in-principle approval, tariff and fund arrangements, fuel/back-end contracts, insurance, pre-assessed sites, and design approval.	Public enterprises lead; private firms enter through EPC, manufacturing, minority investment, captive demand, and selected development roles.
II. Replication and capital recycling	Repeat proven designs using scoped regulatory review where applicable, expand vendors, build operating records, and refinance completed plants.	Targeted guarantees decline; private ownership grows; banks finance construction and institutions buy operating debt.
III. Mature multi-operator market	Use competitive procurement where designs/contracts are proven, while retaining strategic state control.	Public and private operators coexist; capital markets, consortia, and export-oriented manufacturers finance a larger share.

Source: *Authors' synthesis.*



8 Financing the 100-GW Programme: Investment Requirements, Tariff Pathway, and the Road to Commercial Scale

Key message: *Preliminary modelling points to a gross capital requirement of about ₹22.35 lakh crore for the technology-wise additions in the Government's 100 GW roadmap under the central assumptions used here. A narrower NPCIL/Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI)-led pathway covering about 45.23 GW of additional capacity is estimated at about ₹11.91 lakh crore; the two estimates are complementary and must not be added. For 700 MW PHWRs, CEA modelling places the levelised tariff at ₹8.11/kWh under base assumptions and ₹6.98/kWh under a coordinated reform package, while the Government roadmap indicates a longer-run benchmark near ₹5.7/kWh only under lower capital cost and 80 per cent PLF assumptions.*

8.1 Estimation Approach and Assumptions

The financing requirement is presented through two complementary lenses. Scenario A estimates the gross capital associated with the additional capacity required to take the NPCIL/BHAVINI-led pathway to roughly 54 GW. Scenario B estimates the gross capital value of the entire technology-wise capacity addition in the Government roadmap to approximately 100.65 GW. Scenario A is a subset of the national programme; the two figures are not additive and should not be treated as competing forecasts.

Both are planning calculations rather than project sanctions or cash-flow forecasts. They multiply stated capacity additions by representative capital-cost benchmarks, do not deduct all expenditure already incurred on projects under construction, and do not impose a separate annual inflation path on projects commissioned at different dates. The source benchmarks are also not fully uniform in their treatment of financing cost: the ₹21 crore/MW PHWR assumption explicitly includes IDC, while the available benchmarks for other technologies do not provide a common hard-CAPEX/IDC decomposition. Where a benchmark already includes IDC, IDC is not added again. The national estimate should therefore be read as a planning-price gross capital requirement, not as a decomposition of hard CAPEX versus IDC. A credible national IDC share would require project-level drawdown schedules, construction periods, and financing terms for each technology.

Table 8.1: Capital-Cost Assumptions Used in the Investment Calculations

Technology	Assumption	Basis	Modelling Treatment
PHWR	₹21 crore/MW	CEA PHWR tariff study: ₹21 crore/MWe including IDC	Central all-in planning assumption
PWR/LWR	₹30 crore/MW	Government roadmap: ₹30–35 crore/MW for Russian VVER units	Central assumption at lower end of roadmap range
FBR	₹16.36 crore/MW	₹8,181 crore / 500 MW PFBR	Proxy for future FBRs; not an official fleet benchmark

Technology	Assumption	Basis	Modelling Treatment
BSR	₹21 crore/MW	PHWR-based technology; no separate commercial benchmark available. The 11 August consultation suggested that 220 MW industrial units may cost more per MW than large PHWRs.	Analytical proxy only; test ₹26-27 crore/MW as an unverified small-reactor sensitivity.
BSMR/SMR	₹21 crore/MW	No firm commercial Indian cost benchmark available	Analytical proxy only; first-of-a-kind and serial-production sensitivities required.

Note: *The Government roadmap itself quotes about ₹15-16 crore/MW for indigenous 700 MW PHWRs. The central model retains ₹21 crore/MW because that is the all-in capital-cost assumption used in the CEA PHWR tariff study; the lower roadmap benchmark is tested separately through sensitivity analysis. For 220 MW BSR-type projects, stakeholders suggested that ₹21 crore/MW may understate small-unit costs and indicated 26-27 crore/MW as a possible range. Because this was a consultation view rather than an independently verified sector benchmark, it is tested only as a sensitivity and does not replace the central proxy.*

8.2 Scenario A: NPCIL/BHAVINI-Led Pathway to Approximately 54 GW

Scenario A asks a developer-specific question: what is the gross capital associated with the additional projects required to take NPCIL/BHAVINI-linked capacity to about 54 GW? Using a current operating base of 8.78 GW (excluding RAPS-1) and the project categories in the Government roadmap, the modelled addition is 45.228 GW.

Table 8.2: Detailed Calculation – NPCIL/BHAVINI-Led Additional Capacity

Project Status	Technology	Addition (MW)	₹ crore/MW	Calculation	Cost (₹ crore)
Under construction / commissioning	PHWR	3,500	21.00	3,500 × 21.00	73,500
Under construction / commissioning	LWR/PWR	4,000	30.00	4,000 × 30.00	120,000
Under construction / commissioning	PFBR	500	16.36	500 × 16.36	8,180
Pre-project activities	PHWR	5,600	21.00	5,600 × 21.00	117,600
Pre-project activities	FBR (2×500 MW)	1,000	16.36	1,000 × 16.36	16,360
Planned / site identified	PHWR	7,000	21.00	7,000 × 21.00	147,000
Planned / site identified	LWR/PWR	23,628	30.00	23,628 × 30.00	708,840
Total additional NPCIL-linked capacity		**45,228**			**1,191,480**

45,228 MW of additional capacity → ₹1,191,480 crore = ₹11.91 lakh crore

The ₹11.91 lakh crore figure is a gross modelled project value, not the amount of fresh cash still to be raised. Projects already under construction have absorbed material expenditure; NPCIL's FY2024–25 accounts report about ₹33,399 crore on selected ongoing construction projects and about ₹1,134 crore on selected upcoming projects. A remaining finance estimate would require project-by-project data on expenditure incurred, committed debt/equity, and future drawdowns.

8.2.1 Announced Investment Intentions Outside NPCIL

The company announcements should be retained only as evidence of market interest and the potential scale of private/PSU capital mobilisation. They are not added to the NPCIL estimate or to each other to derive the national investment requirement. Several announcements may overlap with the Government's 46 GW balance, may involve joint ventures, and may refer to partial rather than full lifecycle investment.

Table 8.2.1: Announced Investment Intentions Outside NPCIL

Entity	Reported Target	Reported Investment	As Used in the Paper
NTPC	30 GW by 2047	₹1.28 lakh crore	Illustrative pipeline; part of national 100 GW target
Adani Power	10 GW by 2035	₹1.5 lakh crore	Indicative announcement; not additive
Reliance	7.2 GW	₹2 lakh crore	Indicative announcement; scope/preliminary
Lalitpur Power Generation Co. (Bajaj Group)	5 GW	₹2 lakh crore	Indicative announcement
Naveen Jindal Group	18 GW	₹2 lakh crore	Indicative announcement
Tata Power*	440 MW	Not used as an announced investment figure	Capacity signal only; project cost should be tested separately because small-unit ₹/MW costs remain uncertain.
Hindalco*	220 MW	Not used as an announced investment figure	Capacity signal only; project cost should be tested separately because small-unit ₹/MW costs remain uncertain.

Note: **Tata Power and Hindalco capacity references are retained only as signals of prospective industrial participation. No investment value is imputed because the appropriate ₹/MW benchmark for 220 MW projects remains uncertain.*

8.3 Scenario B: National Technology-Wise Bottom-Up Estimate

Scenario B starts from the technology mix in the Government roadmap. For comparability with that table, it uses the roadmap's stated present-capacity base of 8.88 GW and cumulative 2047 capacity of 100.648 GW, implying 91.768 GW of gross additions. This is roadmap arithmetic rather than a retirement-adjusted net-operating-capacity model; the roadmap separately notes that RAPS-1 is under long shutdown and is to be decommissioned.

Table 8.3: Detailed Calculation – National Technology-Wise Additional Capacity

Technology	Addition (MW)	₹ crore/MW	Calculation	Investment (₹ crore)	₹ lakh crore
PHWR	39,900	21.00	39,900 × 21.00	837,900	8.379
PWR/LWR	36,808	30.00	36,808 × 30.00	1,104,240	11.042
FBR	5,000	16.36	5,000 × 16.36	81,800	0.818
BSR	5,060	21.00	5,060 × 21.00	106,260	1.063
BSMR/SMR	5,000	21.00	5,000 × 21.00	105,000	1.050
Total	**91,768**			**2,235,200**	**22.352**

91,768 MW of additional capacity → ₹2,235,200 crore = ₹22.35 lakh crore

Under the central assumptions, PWR/LWR capacity accounts for about 49.4 per cent of modelled investment and PHWRs about 37.5 per cent; the remaining roughly 13 per cent is distributed across FBR, BSR and BSMR. The concentration in large PWR/LWR projects makes imported technology pricing, localisation, foreign exchange exposure, and financing terms important determinants of the national total.

Table 8.4: Sensitivity of the National Estimate to Capital-Cost Assumptions

Case	PHWR ₹ cr/MW	PWR ₹ cr/MW	FBR ₹cr/MW	BSR/BSMR ₹ cr/MW	Total ₹ lakh crore
Roadmap-style PHWR sensitivity	15.5	30.0	16.36	21.0	20.16
Central paper assumption	21.0	30.0	16.36	21.0	22.35
Higher PWR case	21.0	32.5	16.36	21.0	23.27
Higher small-reactor sensitivity	21.0	30.0	16.36	BSR 26.5; BSMR 21.0	22.63

The Government roadmap provides an independent cumulative financing benchmark of ₹19.2864 lakh crore by 2046–47. Under its illustrative 70:30 debt-equity convention, this corresponds to ₹5.7859 lakh crore of equity and ₹13.5005 lakh crore of debt; the roadmap states that equipment-manufacturing expansion is excluded.

Table 8.5: Government Roadmap: Cumulative Financing Requirement

Financial Year	Total Funds Required (₹ crore)	Equity @30% (₹ crore)	Debt @70% (₹ crore)
2031–32	270,600	81,180	189,420
2036–37	635,100	190,530	444,570
2041–42	1,144,800	343,440	801,360
2046–47	1,928,640	578,592	1,350,048

The central bottom-up estimate is about 15.9 per cent above the Government roadmap benchmark, mainly because the calculations use different technology cost assumptions. The lower-PHWR sensitivity produces ₹20.16 lakh crore, much closer to the Government benchmark. A small-reactor sensitivity using ₹26.5 crore/MW for the 5.06 GW BSR allocation raises the national estimate from ₹22.35 lakh crore to about ₹22.63 lakh crore; this is illustrative because the consultation range has not yet been independently validated. The higher-PWR case remains ₹23.27 lakh crore. A defensible headline is therefore a preliminary gross requirement of about ₹20–23.3 lakh crore, with ₹22.35 lakh crore as the central technology-wise estimate under the assumptions adopted here. These are gross capital requirements, not the remaining financing requirement from 2026 onwards.

8.4 Indicative Tariff Pathway: From Project Finance to Commercial Scale

The programme investment estimate cannot be converted into a single national tariff because reactors are commissioned at different dates and carry different financing, operating and fuel assumptions. Detailed CEA tariff sensitivities for a 2 × 700 MW PHWR are set out in Section 6.2. The consultations also discussed a potentially large tariff benefit from servicing IDC separately during construction, but the quoted stakeholder range of roughly ₹1.25–1.50/kWh depends on drawdown schedules, construction timing and financing terms that are not fully specified in the source material. For the concluding assessment, the published evidence supports the following conditional pathway rather than a single forecast.

Table 8.6: Evidence-based tariff pathway for 700 MW PHWRs

Stage	Assumptions/Conditions	Indicative Levelised Tariff	Interpretation
Base financing case	CEA base: ₹21 cr/MW including IDC; 70:30 debt-equity; 9% loan rate; 72.5% PLF; 18% GST; 6% O&M escalation	₹8.11/kWh	Current analytical reference; first-year tariff ₹7.92/kWh
Coordinated reform case	80:20 debt-equity; 5% GST on nuclear-island equipment; 75% PLF; 5.25% O&M escalation; PV-neutral stepped RoE	₹6.98/kWh (₹6.71 with no tax on RoE)	First competitive band explicitly modelled by CEA
Mature-fleet benchmark	Government roadmap: PHWR capital cost ₹15 cr/MW and normative PLF 80%	~₹5.7/kWh*	Long-run benchmark; not implied by the central ₹21 cr/MW investment case

Note: **The Government roadmap states that the ~₹5.7/kWh estimate excludes water and insurance charges. It also indicates that if substantial indigenisation reduces PWR capital cost to about ₹22-25 crore/MW, an indicative levelised tariff of roughly ₹6.0-6.6/kWh could be possible, again excluding water and insurance charges. These are conditional roadmap estimates, not bids or guaranteed tariffs.*

Tariff estimates are not provided here for FBR, BSR or BSMR because the reviewed sources do not provide sufficiently robust India-specific commercial assumptions for capital structure, O&M, fuel, auxiliary consumption, PLF, depreciation and return on equity. This evidence boundary is important: cost proxies used for the investment estimate should not be converted mechanically into unsupported tariff forecasts.

8.5 Policy Levers for Consideration: How Capital Cost, Financing Cost and Tariff May Be Reduced

The quantitative results clarify how policy reforms translate into business economics. Where CEA or the Government roadmap provides a numerical effect, it is stated below; other measures are treated as risk-reduction channels rather than assigned an unsupported rupee-per-kWh saving.

Table 8.7: Policy Lever, Financial Transmission, and Evidence

Policy Lever	Financial Transmission	Evidence/Treatment
Timely completion, project management, and early public engagement	Avoids additional IDC, escalation, and deferred revenue; reduces risk of socially driven delay when concerns are addressed early	Based on Government Roadmap estimates, one year of delay can add ~3% to project cost. KAPP-3&4 IDC rose from ₹1,532 crore to ₹7,151 crore; the roadmap estimates tariff could have been >₹1/kWh lower if planned IDC had been maintained. No separate tariff coefficient is assigned to awareness programmes.
GST rationalization	Reduces equipment cost, depreciation, and financing charges	According to CEA, nuclear-island GST 18%→5% lowers levelised tariff by ₹0.26/kWh. Roadmap: 18%→12% gives ~3% hard-cost saving and ~₹0.20/kWh tariff reduction. A stakeholder estimate of ~₹0.35–0.40/kWh for 18%→5% is not used as the report estimate because it was not supported by a reproducible model in the consultation record.
Debt-equity optimisation, long-tenor debt, and refinancing	Reduces expensive equity recovery, aligns debt service with asset life, and allows capital recycling after COD	According to CEA, equity 30%→20% lowers levelised tariff by ₹0.35/kWh. Government roadmap also supports longer-tenor loans/refinancing; operating-asset bonds can attract institutional capital once construction risk falls.
Interest subvention, credit enhancement, and sustainable-finance taxonomy	Lowers construction-period financing cost and can widen the pool of eligible long-duration capital	Based on Government Roadmap, one percentage-point construction-period interest subvention can reduce IDC by about 2% of capital cost. No India-specific tariff coefficient is assigned to taxonomy inclusion itself.
Pre-assessed sites, design support, and regulatory capacity	Reduces duplicated studies, redesign, licensing uncertainty, and schedule slippage	No standalone tariff coefficient identified; model through reduced probability and duration of delay.

Policy Lever	Financial Transmission	Evidence/Treatment
Fleet procurement, localisation, and vendor certification	Creates repeat orders, learning, deeper domestic manufacturing, and lower FX/supply-chain exposure	The government roadmap identifies the mechanism but provides no universal percentage savings. Stakeholders also suggested that aggregated commercial procurement might lower quoted equipment prices by roughly 8–10%, but this was an indicative commercial view; it is not embedded in the central investment estimate without bid evidence.
Insurance, liability, and lifecycle funds	Clarifies allocation of tail and lifecycle obligations and can improve lender visibility	Draft Rules propose an operator-funded Nuclear Liability Fund, a Spent Fuel Management Fund where applicable, and segregated decommissioning financial security. Rates and project-specific tariff effects are not yet specified, so no standalone coefficient is assigned.
Visible project pipeline, bankable offtake, and workforce development	Supports investment in factories, skills, and long-tenor finance; reduces stop-start execution risk	No standalone tariff coefficient; these are market-making conditions for scale and repeatability.

The measures are assessed against newer Government, CEA, Draft SHANTI Rules and Regulations, and stakeholder evidence and are presented with their assumptions and limitations rather than as automatic prescriptions.

8.6 Implications for Business Stakeholders and the Road Ahead

Three conclusions follow from the analysis.

First, the financing requirement is of infrastructure-system scale: the NPCIL/BHAVINI-led project set modelled here represents about ₹11.91 lakh crore of gross capital, while the national technology-wise estimate is ₹22.35 lakh crore and the Government roadmap independently estimates ₹19.29 lakh crore by 2046–47. Taken together, the evidence supports a preliminary gross range of about ₹20–23.3 lakh crore, subject to reactor mix, cost benchmarks, and the treatment of projects already under construction.

Second, the cost of capital and the cost of delay are inseparable from tariff. Site preparation, standard contracts, regulator capacity, project management, supply-chain depth, insurance, and public engagement should therefore be treated as components of the financing architecture, rather than ancillary policy measures. Public institutions can anchor early construction risk, while banks and power-sector lenders support construction and institutional investors enter after commercial operation through refinancing and operating-asset bonds.

Third, success should be judged by whether successive projects move down a transparent cost and tariff curve. For PHWRs, the evidence points from a CEA base levelised tariff of ₹8.11/kWh to about ₹6.98/kWh under coordinated financial and operating reforms and, under materially lower capital cost and higher utilisation, toward the Government roadmap's

~₹5.7/kWh mature-fleet benchmark. As standardised projects build operating records and private/institutional capital becomes more comfortable with post-construction assets, public support can become more targeted rather than permanent.

The post-SHANTI challenge is therefore no longer only to establish legal entry for new participants. The Draft Rules and Regulations now set out much of the proposed licensing, safety-authorisation, and lifecycle-obligation architecture, while important commercial details including final eligibility notifications, tariff methodology, fund and levy rates, fuel and heavy-water terms, and lender-substitution arrangements remain to be settled. For business stakeholders, the critical test will be whether this framework provides a visible project pipeline, bankable tariff and offtake arrangements, predictable risk allocation, long-tenor debt, credible insurance, and a workable route to refinance or transfer operating assets without weakening safety, strategic oversight, or public accountability.

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