POWERING INDIA'S NUCLEAR SECTOR

Small Modular Reactors (SMRs), Reforms & Private Sector Push

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ABOUT THIS REPORT

This report examines India's strategic pivot toward nuclear energy through Small Modular Reactors (SMRs) and landmark private sector reforms. The report investigates critical amendments to long-standing nuclear regulations that could unleash unprecedented investment in clean energy infrastructure. Through extensive research, it evaluates how these changes align with India's Viksit Bharat vision while navigating proliferation concerns, liability frameworks, and public sentiment. With India targeting a tenfold increase in nuclear capacity by 2047, this timely assessment explores how regulatory evolution, international partnerships, and technological innovation could transform the nation's energy landscape while creating a model for developing economies worldwide.

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Executive Summary

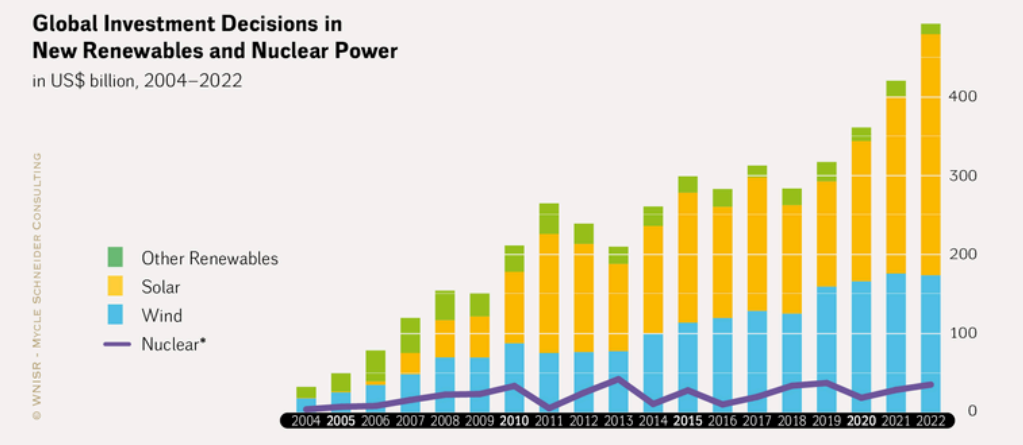
- India faces the dual challenge of meeting rapidly growing energy demands while transitioning to low-carbon solutions to achieve its 2070 net-zero target. As the third-largest energy consumer globally with 446.18 GW of installed power capacity, the country must significantly boost per-capita energy consumption while working toward sustainability.
- At just 8,180 MW (3.15% of total energy mix), India's nuclear sector remains underdeveloped despite decades of expansion ambitions. Nuclear targets have been consistently missed due to regulatory constraints, high upfront costs, and limited government funding capacity.
- The Atomic Energy Act (1962) and Civil Liability for Nuclear Damage Act (2010) have effectively prevented large-scale private investment in nuclear energy. These frameworks grant government exclusive control and create significant liability concerns for potential investors.
- Small Modular Reactors (SMRs) represent a transformative approach with modular construction, enhanced safety features, and lower capital requirements. Each unit generates up to 300 MW(e), functioning as products assembled on-site rather than custom-built projects.
- India is developing indigenous "Bharat Small Reactors" based on existing PHWR technology alongside next-generation Bharat Small Modular Reactors. With a target of reaching 100 GW of nuclear capacity by 2047, government funding alone is insufficient, necessitating private investment.
- The February 2025 budget established a National Nuclear Energy Mission with ₹20,000 crore for SMR development. The government intends to amend both the Atomic Energy Act and the CLNDA to enable private participation and reduce liability concerns.
- Discussions are underway to transfer civil nuclear power oversight from the Department of Atomic Energy to the Ministry of Power, while maintaining DAE control over fuel supply and spent fuel handling.
- India's preferred PHWR technology carries higher proliferation risks than Light Water Reactors, potentially limiting export opportunities. Local resistance to nuclear facilities, intensified after the Fukushima disaster, presents significant challenges for site development.
- The current regulatory framework lacks a truly independent nuclear regulator, creating potential conflicts of interest as private players enter the sector. The Atomic Energy Regulatory Board remains under DAE purview, raising concerns about its independence.
- Implementing targeted amendments to enable private participation while maintaining safety frameworks will be essential. These should focus on enabling public-private partnerships while preserving government oversight of sensitive materials.
- India should establish a statutory independent Nuclear Regulatory Authority separate from the Department of Atomic Energy to ensure transparency and maintain strict oversight as nuclear technologies are managed across multiple stakeholders.
- CLNDA reforms should create balanced risk distribution among government, operators, investors, and insurers, aligning with international liability norms while ensuring fair risk allocation.
- A transparent land acquisition framework with fair compensation and state-backed industrial zones for nuclear projects could reduce acquisition-related resistance while ensuring fair treatment of displaced communities.
- The transformation of India's nuclear sector through SMRs and private investment represents a critical opportunity to meet long-term energy security and climate objectives. With rising energy demands and climate commitments, accelerating private sector participation in nuclear energy is essential for achieving India's ambitious development goals.

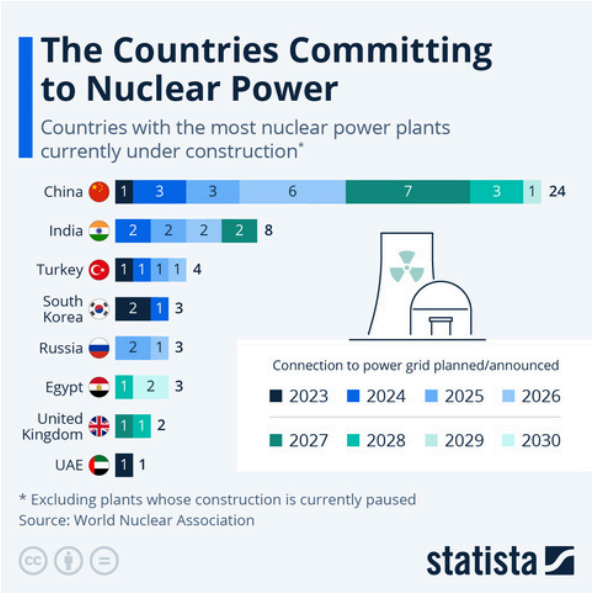
Introduction

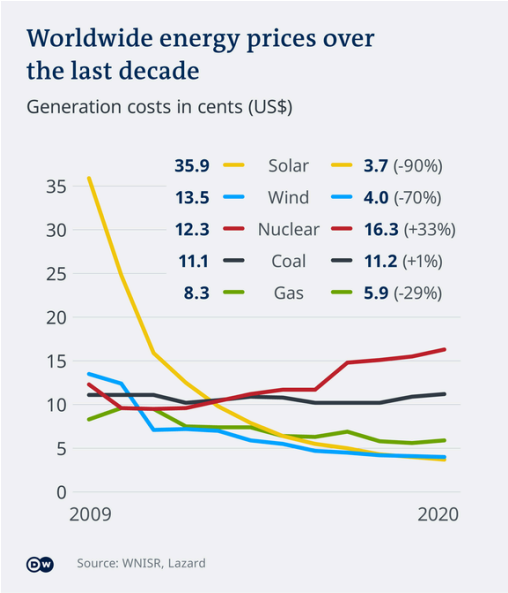
Nuclear energy is shedding its old baggage and emerging as a critical solution to today's energy and climate challenges. The growing global demand for energy, combined with the dire race to reduce carbon emissions, is driving interest and investment in the once-staid nuclear industry.

Nuclear energy, the second-largest source of low-carbon electricity, has long been recognized for its clean energy potential. However, the substantial upfront financial investments, maintenance obligations, and concerns over safety, accidents, and proliferation have historically made countries hesitant to pursue a large-scale transition to nuclear power.

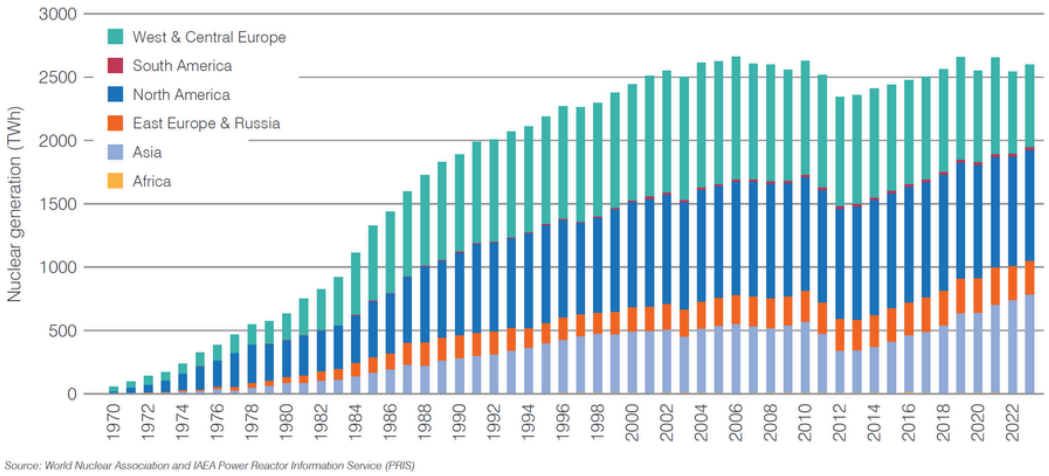
Despite its capital-intensive nature, nuclear energy has experienced a near-renaissance in the wake of the energy crisis triggered by the Russia-Ukraine war and the slow post-COVID-19 recovery of supply chains.[1] This resurgence is marked by a significant global push to integrate nuclear power into national energy grids, increased investment in the sector, and the implementation of policies aimed at advancing cutting-edge nuclear technologies. This momentum is further fueled by unified declarations of Net Zero commitments and ambitious targets to triple nuclear energy capacity by 2050.[2]







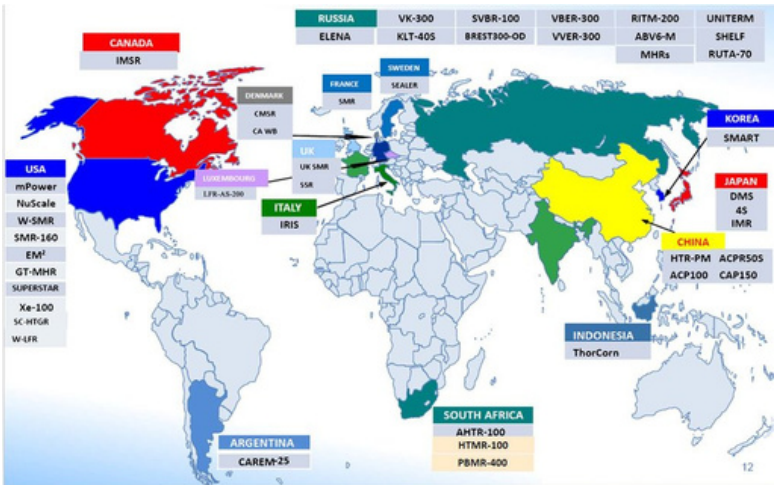
Emerging technologies in the nuclear sector, such as microreactors, advanced modular reactors, advanced accident-tolerant fuels (ATFs), and additive manufacturing, are being developed to make nuclear energy more accessible and scalable for countries. Among these, small modular reactors (SMRs)—currently in the early stages of design, development, and deployment—are being projected as faster and more cost-effective alternatives to traditional large-scale reactors.



Historically, nuclear power plants have been large, one-of-a-kind facilities that take years to build and supply power to thousands.[3] However, as energy demands evolve—driven by rapid industrialization in developing countries and the increasing energy needs of sectors like artificial intelligence and data centers in developed economies— smaller, more flexible plants are seen as having great potential to serve energy-intensive industries, urban centers, and remote regions. While SMRs may not single-handedly resolve the challenge of rapid electricity generation, they are estimated to play a key role in easing the transition to large-scale nuclear investments and building trust in the future of nuclear energy.

Small Modular Reactors: The Next-gen of Nuclear Energy

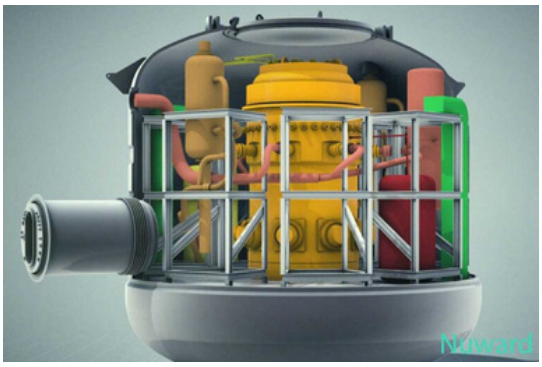
Small Modular Reactors are advanced nuclear microreactors, with each unit capable of generating up to 300 MW(e)— about one-third of the output of conventional nuclear reactors.[4] However, downsizing is not their only differentiator. These fissile reactors are called "modular" because their designs are intended for faster, more efficient construction using factory-built modules rather than individually crafted bespoke components.[5] Essentially, they function more like a product that can be assembled on-site in modules, rather than a large-scale, custom-built project. This modular approach also makes SMRs more financially viable compared to traditional nuclear plants. Additionally, incorporating serialization in SMR manufacturing can further reduce costs by standardizing plant designs, streamlining regulatory compliance, and leveraging efficiency improvements through innovative serial production, ultimately contributing to economies of scale.[6] In contrast to traditional nuclear plants, a number of SMR designs aim to significantly lower the risk of core damage and improve seismic resilience, enhancing safety in the event of potential accidents.[7] SMRs are also believed to be flexible enough to be deployed in remote brownfield sites affected by industrial pollution. Their low-pressure design and passive safety systems allow them to operate without the strict zoning constraints typically required for traditional reactors.[8]



The Status of Different SMR Technologies and the Role of the IAEA to Support Its Member States in SMR Technology Development. IAEA Atoms for Peace and Development Presentation by F. Reitsma.

Currently, approximately 80 commercial SMR designs are under development worldwide, at various stages of design, targeting diverse outputs and applications.[9] These SMRs encompass a range of coolant technologies and design classifications, including land-based and marine-based water-cooled reactors, high-temperature gas-cooled reactors, fast neutron spectrum reactors, molten salt reactors, and microsized reactors, among others at different phases of design, development, and assembly. However, as of now, only two SMRs are operational: the KLT-40S Akademik Lomonosov, a pressurized water reactor (PWR) with a capacity of 35 MWe, developed by OKBM Afrikantov for the Russian floating power station, and the High-Temperature Gas-Cooled Reactor Pebble-Bed Module (HTR-PM), produced by China Huaneng and located at the Shidao Bay Nuclear Power Plant. The HTR-PM has a thermal capacity of 250 MW.[10]

As SMR development progresses and international collaboration on its technology expands, global energy demand continues to rise—with the added pressure to adopt cleaner and more sustainable solutions amid escalating climate challenges. Countries are increasingly trying to shift towards renewables and nuclear energy. However, this transition presents particularly stark challenges in the Global South, where emerging economies face disproportionate climate impacts, often shaped by the legacy of climate colonialism.[11] For countries like India, which straddle the line between developing and developed economies, a sustainable energy transition demands a comprehensive infrastructure overhaul and substantial investments—often exceeding the government's financial capacity. Additionally, with a growing population and rising developmental ambitions, the country's energy demands will only intensify. To advance emerging technologies like SMRs—



French NUWARD design, a 340-MWe power plant that includes two 170-MWe reactor modules in a single building. Photo: CEA

Westinghouse's AP300 SMR, (300-MWe/900 MWth), is based on the licensed and operating AP1000 pressurized light water technology. Photo: Westinghouse

projected as key to facilitating this shift, expanding sustainable energy production, supporting India's 2070 net-zero target, and fueling its burgeoning AI sector—the energy industry must increasingly turn to private investment.

Although SMRs have been discussed in India for nearly about a decade, they have yet to become a commercial reality.[12] However, their potential aligns with a broader shift toward nuclear energy as India seeks reliable, low-carbon power amid rising demand. With increasing global collaboration in SMR technology, India is looking to expand its nuclear footprint, leveraging its strong track record of having operated small-sized reactors (heavy water based) over an extended period of time and cost-effective manufacturing.

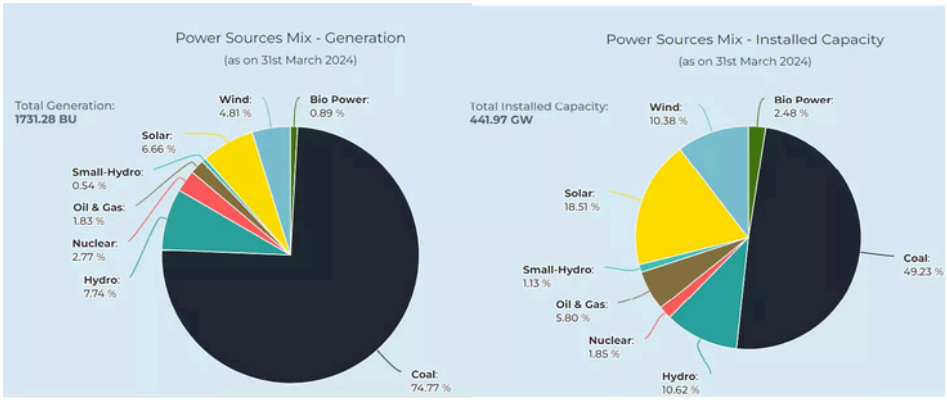
The Linglong-1 SMR reactor integrates the key components of conventional reactors into just one. Photo: Hainan Nuclear Power

The core module of Linglong-1, the world's first commercial small modular reactor (SMR). Photo: China Central Television

Construction of Linglong-1 in China's southern island province of Hainan approved by the International Atomic Energy Agency (IAEA).

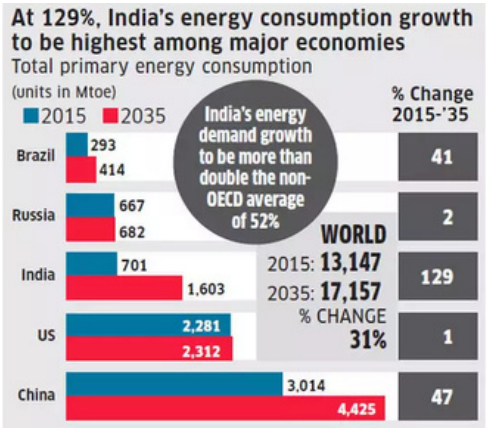
Fueling the Future: India's Energy Landscape

This need for extensive investments in energy transition infrastructure has become increasingly urgent as India navigates rising fossil fuel costs, geopolitical uncertainties, and the challenge of balancing sustainability with growth. To power its expanding tech, industrial, and agricultural sectors, India must significantly boost its per-capita energy consumption while working toward its net-zero emissions target. As the third-largest energy consumer globally, with a population of 1.42 billion and a rapidly growing economy, a heavily fossil fuel-reliant India's energy demand is surging, especially with urbanization.[13] As of 2024, India's installed power capacity stands at 446.18 GW, with renewable energy contributing 46.3% of the total.[14] The country aims to source 50% of its electricity from non-fossil fuels by 2030.[15] However, given the stochastic nature of solar and hydro power, these sources alone cannot meet India's target of 500 GW in renewable capacity by 2030.[16] Additionally, despite the higher upfront costs of nuclear plants compared to other renewables, their smaller land footprint—especially when compared to solar or hydro power—makes them a promising option for balancing rapid development with environmental sustainability.[17] Nuclear energy, which currently makes up just 3.15% of India's energy mix, is essential for facilitating this transition.[18]



Source: Vajiram & Ravi

Recognizing this strategic importance of nuclear power, India has positioned its expansion as a key pillar of its Viksit Bharat (Developed India) initiative, which aims to achieve developed nation status by 2047.[19] As part of this vision, the country has committed to tripling its nuclear capacity from 8,180 MW today to 22,800 MW by 2031-32, with an even more ambitious goal of reaching 100 GW by 2047.[20] However, achieving these targets will require substantial capital investment and strategic policy reforms to drive sectoral growth.



Source: Economic Times

Notably, India's nuclear targets have been repeatedly set and revised over the years. In the 1970s, the country aimed for 10 GW by the 2000s, yet nuclear capacity only remains at 8.2 GW today. Each new target set has been increasingly ambitious (and understandably more challenging) due to shifting governmental priorities, high upfront costs, and budgetary constraints. Given these realities, a crucial step forward is assessing the scale of capital investment required to realize these goals.

Tentative Projections:

India aims to achieve "Viksit Bharat" (developed nation status) by 2047, requiring substantial economic and energy growth. Based on global benchmarks, India's per capita income and energy consumption must see significant increases to support this transformation.

Category	Current	Target/Projected	Calculation	Growth Factor Required	Remarks
Per Capita Income Growth	$2500	$22,000	22,000 ÷ 2,500 = 8.8	8.8	India's per capita income must grow 8.8 times to reach developed status.
Energy Consumption Growth (Per Capita)	1208 kWh	Significantly higher	(Benchmark: Chin a= 4600 kWh, US = 80,000 kWh)	N/A	India must significantly increase per capita energy consumption to reach developed country standards.
Total National Energy Consumption	10,000 TWh	Taking into account rising energy efficiencies, proje cted required national energy consumption:35,0 00 TWh	35,000 ÷ 10,000 = 3.5	3.5	India's total energy demand is projected to rise 3.5 timesconsidering industrialization and rising efficiency.
Power Generation Capacity	450 GW	4000 GW	4000 ÷ 450 = 8.89	8.89	India's total power generation capacity must grow 8.89 times to meet future demands.
Renewable Energy Contribution	200 GW(solar, wind, hydro)	1300–1500 GW	Estimated renewable potential = 1300–1500 GW	N/A	Renewable energy can contribute a major portion of India's power needs.
Nuclear Energy Contribution	8 GW	100 GW	Planned increase to 100 GW	N/A	India is planning to expand nuclear capacity significantly.
Remaining Power Requirement	N/A	2400–2700 GW	Shortfall remaining (assuming 1500 GW from renewables and 100 GW nuclear) 4000 – (1500 + 100) = 2400 GW	N/A	The remaining gap of 2400–2700 GWmust be filled by nuclear and fossil fuels.

While these targets, like previous ones, are ambitious and challenging to achieve, they set a crucial direction for India's energy future. But as mentioned earlier, based on these projections, the government alone cannot bear the financial burden of such a massive undertaking. Therefore, it is essential to engage the private sector to facilitate the flow of capital and drive this transformation. However, India's historical laws and regulatory frameworks have long prevented large-scale private investment in the nuclear energy sector. The Atomic Energy Act of 1962, which grants the government exclusive control over nuclear power development, and the Civil Liability for Nuclear Damage Act of 2010, which places full liability on the operator in case of an accident, have long hindered private sector participation in India's nuclear energy sector.

The Atomic Energy Act, 1962: A Gatekeeper

Understanding the Act and Its Role

India's Atomic Energy Act of 1962, originally framed by the Atomic Energy Regulatory Board (AERB), was designed to regulate the development, control, and use of atomic energy for public welfare and peaceful purposes. Over the years, several amendments—introduced through the Atomic Energy (Amendment) Bill in 1986, 1987, and 2015—have adjusted a number of provisions of the Act to accommodate the country's growing nuclear ambitions.

An amendment to Section III reinforced the central government's exclusive authority over the manufacture, development, research, and disposal of atomic energy, limiting private sector involvement. This provision restricts private investment in India's civil nuclear domain, slowing down nuclear energy expansion. Additionally, the Act allows the government to restrict public access to information on nuclear technology, design, and construction, citing safety concerns. While these measures have ensured strict state control over nuclear energy, they have also constrained private participation in the sector.

The NPCIL and its progressive empowerment

Another amendment in 2015 to Section II of the Act modified the definition of a "Government company", allowing the Nuclear Power Corporation of India (NPCIL) to establish joint ventures with other Public Sector Undertakings (PSUs). Under the Act, a government company is one in which at least 51% of the paid-up share capital is held by the central government. Paid-up share capital is the capital received by a company from the issue of shares. The amendment expands this definition to include companies where the whole of the paid up share capital is held by one or more government companies and whose articles of association empower the central government to constitute its Board of Directors. This provision will allow for the formation of joint ventures between Nuclear Power Corporation of India Limited and other government companies.

This modification enabled NPCIL to mobilize more capital while ensuring that these joint ventures remained under government control, facilitating the expansion of India's nuclear power program.[21]

At present, only two PSUs—NPCIL and Bhartiya Nabhikiya Vidyut Nigam Limited (BHAVINI)—both under the administrative control of the Department of Atomic Energy (DAE), operate nuclear power plants in the country.[22] The NPCIL, as the principal overseer of India's nuclear fleet, currently manages 27 reactors across 7 power plants, generating approximately 8,180 MW.[23] Eight additional reactors are under construction, set to contribute 6,800 MW, with ten more in early planning stages, with a completion target of 2031-32.

While the amendments have progressively empowered NPCIL, allowing it to raise capital and expand operations, the impact of this empowerment remains mixed. While NPCIL has been able to increase reactor

capacity, challenges in financing and execution persist, particularly in light of growing calls to liberalize India's nuclear energy sector and allow private investment.

Civil Liability for Nuclear Damage Act (CLNDA, 2010): A Wall Against Investors?

In addition to the Atomic Energy Act, that curbs private capital, another legal impediment is the Civil Liability for Nuclear Damage Act (CLNDA, 2010) which has hindered progress on foreign collaboration and investment in the nuclear energy sector.[24] This legislation was originally enacted to establish a compensation framework for victims in the event of a nuclear accident. The fundamental principle here is that in the event of such an incident, the primary responsibility lies with the operator to provide immediate assistance to those affected. Under India's liability law, the operator liability is capped at INR 1,500 crores. If damages exceed this amount, the government assumes responsibility for additional compensation. To meet this obligation, operators must maintain an insurance pool to ensure prompt relief. While in certain circumstances, operators have the right to recover costs from other responsible parties through legal channels, they cannot delay compensation payments while pursuing such claims.

Now in India, the right to sue the responsible party in a nuclear accident is limited, creating legal ambiguity. Since NPCIL, the sole nuclear operator, is entirely a government-owned body, the government effectively acts as its own insurer. This deters private players from participating, as a potential nuclear accident could entangle them in complex legal disputes with NPCIL—or, essentially, the government itself—seeking damages from private entities, whether domestic or foreign. The law has been known to be nonaligned with international standards. This law was one of the key obstacles on India's end in preventing the 123 nuclear deal with the U.S. from fully materializing—of course along with other challenges such as tax laws, trade restrictions, and labor regulations.[25] Earlier attempts, such as the collaboration between Westinghouse and the Nuclear Power Corporation of India Limited, were ultimately stalled by this very obstacle.[26] It has also remained a major point of contention with France, delaying progress on the Jaitapur power plant.[27] Only Russia has managed to circumvent this hurdle through an intergovernmental agreement, that too leveraging a Soviet-era deal to build a nuclear power station in India that allowed nuclear cooperation while exempting them from liability.[28]

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To overcome these barriers that restrict private and foreign investment in India's civil nuclear sector, active private sector participation is essential. This would first require amending the Atomic Energy Act to permit private involvement and establishing a well-defined role for these private entities. Additionally, for the private

sector, once involved, to contribute meaningfully, uncertainties in the liability law must be addressed and amended in order to ensure clearer provisions for risk-sharing and legal accountability. Resolving these legal ambiguities is also crucial for advancing research and development in the SMR technology. Adequate capital investment in the initial stages is necessary for the SMR industry to achieve economies of scale and drive cost reductions, ultimately supporting India's nuclear expansion.

While these stringent regulations made sense in the past—when India's nuclear sector was still developing, proliferation risks were high, and the country faced economic sanctions and concerns over foreign companies evading liability—the landscape has changed. Today, India's energy demands, developmental aspirations, and technological ambitions have grown significantly. With India also striving to advance its AI industry and urbanization, captive power plants powered by SMRs could offer an efficient and reliable energy solution. In light of these evolving demands, opening the nuclear sector to private investment would accelerate expansion, foster innovation, and strengthen energy resilience. The government's push to reform the CLNDA may reflect a strategic shift to attract foreign investment, previously hindered by concerns over supplier liability.

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The Indian government has signaled its intent to reform the nuclear energy sector, emphasizing efforts towards the indigenous development of Bharat Small Reactors (BSRs), encouraging private sector participation, and enhancing technology sharing on Bharat Small Modular Reactors (Bharat SMRs). Here, Bharat Small Reactors (BSRs) refer to India's initiative of deploying smaller versions of its existing Pressurized Heavy Water Reactor (PHWR) technology. Whereas, Bharat Small Modular Reactors (BSMRs) would represent a more advanced and potentially entirely new design, aligning with global SMR developments.[29] While BSRs leverage proven technology, BSMRs could introduce innovative reactor designs, allowing India to develop them alongside the BSR program as part of a broader nuclear expansion strategy.[30] The concept design stage for these BSMRs has been completed, and once sanctioned, they are expected to be constructed within 60 to 72 months. Additionally, plans are underway to increase budget allocations for nuclear energy, reinforcing its role in India's future energy strategy. Three new SMR designs are also being worked on—200 MW and 55 MW Pressurised Water Reactors, and 5 MW Indian Gas Cooled Reactors—to support the rollout of SMRs over the next decade.

Ushering in an Era of Changes

Amidst a global resurgence in attention towards nuclear energy, India is making its own bold strides in the civil nuclear realm, highlighted by its prominent focus on nuclear energy in the 2025 Budget announcement.

The push for reform in India's nuclear energy sector has been building for some time. In the July 2024-25 interim budget, the Finance Minister announced plans to partner with the private sector to develop SMRs.[31] Even earlier, in February 2024, reports emerged that Tata Power, Reliance Industries, Adani Power, and Vedanta Ltd. were invited to invest in nuclear power projects, with each company expected to contribute

approximately $5.3 billion.[32] Sources claimed the government planned to attract a total of $26 billion in private investment to accelerate nuclear expansion.[33] A year before these announcements, an 80-page NITI Aayog report laid the groundwork for private sector involvement in SMR development, highlighting its importance for large-scale energy transition in India.[34] This was followed by an NPCIL Request for Proposal (RFP) in December 2024, inviting private industries to participate in building two 220 MWe PHWR Bharat Small Reactors. The intention is to replace captive power plants, which at present are coal-based, with the DAE-indigenized PHWR models.

In doing so, the RFP indicated that the proposed project would be constructed by the private player acting as USER, under the supervision and control of NPCIL, acting as OPERATOR. Upon completion, the asset would be transferred to NPCIL for operation under a long-term comprehensive O&M agreement (Operation and Maintenance agreement), with all liabilities assumed by the private sector. The private player could then benefit from the captive power or sell the electricity according to tariffs approved by the DAE. Here, if NPCIL serves as the operator and the project is constructed according to its designs, specifications, and under its supervision, then NPCIL will also be responsible for physical protection and nuclear safety. The private sector, on the other hand, will demand full indemnity through a "hold harmless" clause. However, if the private sector entity assumes a larger role, its responsibilities, including liability sharing, must be legally defined. Now, this RFP also raises a host of critical questions—particularly regarding proliferation risks associated with certain SMR designs and the challenge of achieving economies of scale through mass production.

SMR deployment: Potential challenges

For India to reduce costs and scale up SMR deployment, it must mass-produce reactors and eventually enter the export market. However, most of India's existing nuclear power plants are based on CANDU Pressurized Heavy Water Reactor (PHWR) technology, which—while reliable—was primarily adopted due to historical constraints rather than being the most efficient option available today. Post 1974, after India's Peaceful Nuclear Explosion, India was excluded from international exchanges and cooperation. PHWRs, for instance, are often considered to pose a higher proliferation risk compared to Light Water Reactors (LWRs), as they typically operate on natural uranium fuel, increasing the likelihood of weapons-grade plutonium[35] production in their spent fuel through neutron capture in the reactor core.[36] This raises a crucial challenge: how do you pitch such an SMR design to foreign buyers if it carries proliferation concerns? More importantly, where do these Indian SMR prototypes fit within the global SMR supply chain? To mitigate these risks, SMR designs must incorporate longer fuel cycles that potentially minimize proliferation concerns.[37]

Additionally, India's private sector lacks experience in nuclear safeguards and security protocols, making strict oversight essential, particularly during the initial stages of design and production. Ensuring compliance with international non-proliferation commitments will be crucial to building global confidence in India's nuclear program and securing its place in the competitive SMR market.

However, the response from the private sector to this RFP is unknown yet.

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National Nuclear Energy Mission and Reforms

Building on this momentum of inviting private participation, in February 2025, the Finance Minister announced the launch of a National Nuclear Energy Mission to drive reforms in India's nuclear sector.[38] The initiative includes an INR 20,000 crore allocation for research and development of indigenous SMRs, with an ambitious goal of producing at least five domestically designed and operational reactors by 2033.

This announcement also signaled the government's intent to amend the Atomic Energy Act (1962) and the Civil Liability for Nuclear Damage Act (CLNDA, 2010) to incentivize private investment and international collaboration to accelerate the expansion of nuclear energy in India. The call for amendments to existing legislation follows closely on the heels of the U.S. lifting restrictions on three Indian organizations (BARC, IGCAR, IRL) from its entity list to boost collaboration and tech access, signaling a broader push to strengthen bilateral cooperation and finally bring the 123 civil nuclear deal to fruition after nearly two decades.[39] In line with this, Holtec International, a private U.S. tech company, recently received clearance from the U.S. Department of Energy (DoE) to design and build nuclear reactors in India. On March 26, the DoE approved Holtec's application under the "10CFR810" regulation (Part 810 of Title 10, Code of Federal Regulations), which had previously hindered the full potential of the nuclear deal. The approval, granted with conditions, allows Holtec to transfer unclassified SMR technology to Holtec Asia, Tata Consulting Engineers Ltd., and Larsen & Toubro Ltd. Holtec had initially also sought to include NPCIL, NTPC Ltd., and the AERB, but the Indian government did not provide the necessary non-proliferation assurances for these entities. Holtec may request to amend the authorization in the future to include them. As of now, this approval is valid for 10 years, with a review after 5 years.

The specifics of these amendments have yet to be disclosed. However, it is likely that the Atomic Energy Act will be revised to allow private sector participation, while the CLNDA may introduce a shared liability framework to ease investor concerns and encourage greater private sector involvement in India's nuclear energy expansion or potentially remove the operator's right to recourse.

SMRs, with their smaller size and modular design, are deemed to lower accident risks, potentially reducing liability concerns. However, if India relies on foreign-supplied reactor designs, suppliers may demand even stronger liability protections. Whether SMRs ease or complicate liability reform will depend on how India structures agreements with international partners. The government's intent to reform the CLNDA is clear, but its ability to implement meaningful change remains uncertain. The principles that shaped the law—strong accountability, and public safety—have not fundamentally changed. Attracting foreign investment will require not just legal amendments, but also political, institutional, and judicial alignment.

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Until further clarity is provided on these amendments, several critical questions remain unanswered: Will private companies due to their lack of experience and expertise in the nuclear market form joint ventures with foreign technology providers such as Westinghouse, General Electric, or Électricité de France? If so, how will these partnerships be structured? Would the government mandate NPCIL's involvement as an operator, as

seen in past deals like the Jaitapur project with France, and as mentioned in the RFP? These uncertainties will shape the future of India's nuclear sector as policy developments unfold.

The Case for Moving Civil Nuclear Power to the Ministry of Power: A Possible Shift in Oversight

In addition to these amendments, discussions on shifting oversight of civil nuclear power from the Department of Atomic Energy (DAE) to the Ministry of Power have also been doing rounds. Just a day before the budget announcement and the declaration of potential amendments to the nuclear acts, a report from the Economic Times, citing an unnamed government official, suggested that 'preliminary discussions' were underway to mandate the Ministry of Power to handle civil nuclear power generation, taking over the baton from the DAE, with fuel supply and spent fuel handling to remain with the latter. Currently, the DAE maintains full control over the entire nuclear supply chain, from research and development to fuel supply and spent fuel management, primarily to mitigate proliferation risks.[40] Notably, this is not the first time that the issue has been raised. In November 2023, Dr. Suman Bery, Vice Chairman of NITI Aayog, also proposed transferring nuclear power plants under the Ministry of Power.[41] His argument centered on meeting the growing energy demands of power-intensive industries, such as AI-driven data centers, potentially through small modular reactors.

While liberalizing the nuclear sector could unlock significant economic benefits, it also raises critical security concerns. As discussions on amending the Atomic Energy Act progress amidst talks of such inter-ministerial transfers, one of the foremost challenges will be ensuring that proliferation risks are effectively managed.

The Department of Atomic Energy (DAE) has historically maintained strict oversight of sensitive nuclear materials, ensuring compliance with international non-proliferation norms. However, the proposed transfer of civil nuclear power generation to the Ministry of Power—potentially with shared responsibilities over fuel management and the added involvement of private players—marks a significant structural shift. If this proposed move was to take place without clear delegation of responsibilities, there is a risk that the safeguards designed to prevent the diversion of nuclear materials or the spread of sensitive technologies could be compromised. The Ministry of Power will need to prioritize security concerns, working closely with the DAE while managing sectoral expansion.

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Opposition and Public Acceptance

Beyond these regulatory challenges, implementing large-scale reforms in India's traditionally conservative nuclear energy sector could also face some political resistance. Historically, the BJP had strongly opposed similar amendments to the CLNDA during Manmohan Singh's tenure, arguing that the provisions shielded foreign operators from liability leaving the government vulnerable to the burden and citizens exposed to the damage—citing instances of the Bhopal gas tragedy.[42] Now, with the BJP leading a coalition government, similar objections from the opposition have resurfaced.[43] The Congress is opposing the proposed amendment, alleging that it is intended to "favor" French and American companies. It ultimately depends on how efficiently the ruling government is able to communicate the urgencies of the challenge. Since these changes are legislative and will have to go through both the houses of the parliament for approval, it will nonetheless be a protracted process.

Moreover, land acquisition for nuclear power plants presents another significant challenge, as local communities often resist such projects due to safety concerns. This reluctance has only intensified in the wake of the Fukushima disaster, which led to a global decline in public acceptance of nuclear energy. Beyond safety concerns, the prospect of local displacement further fuels public resistance to nuclear projects. The key question, then, is: after the potential involvement of private industries in the nuclear domain, who will manage this resistance, facilitate communication, and ensure fair compensation?

While the government usually facilitates land acquisition, there are practical and political limits to how much it can intervene. Typically, it establishes industrial zones and then allocates land to private players, but strong public opposition complicates this process. Kudankulam serves as a prime example, where, despite the CNLDA workaround with Russia, local protests delayed construction for years. Many continue to oppose the plant and nuclear energy projects more broadly. If private companies are expected to acquire land themselves, the challenge becomes even greater, raising concerns about feasibility and potential conflicts with local communities.

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However, if the ruling government successfully navigates these amendments, it stands to gain politically by driving domestic industrial development. Some states, such as Andhra Pradesh, have already earmarked over 2,000 acres for potential nuclear power projects.[44] Advancing these initiatives would allow the government to position itself as a champion of energy security, high-skill job creation, and regional economic growth.

Policy Recommendations for Private Sector Involvement in India's Nuclear Energy Expansion

To achieve its 2047 developmental goals and 2070 clean energy ambitions, India must significantly expand its nuclear power capacity. Given the massive capital investment required, for nuclear alone—government funding will be insufficient. Private sector participation can help bridge this gap, accelerating project timelines, fostering technological innovation, and enabling global collaboration. However, this requires key legal, financial, and regulatory reforms, some of which are already underway.

i. Legislative Reforms

- Amendments to the Atomic Energy Act should focus on enabling private sector participation in nuclear power generation and facilitating public-private partnerships (PPPs).
- Revisions to the Civil Liability for Nuclear Damage Act should align with international liability norms while ensuring fair risk distribution among the government, plant operators, investors, and insurers, particularly by removing the operator's right to recourse.

ii. Regulatory Reforms

- Establish an Independent Nuclear Regulatory Authority with statutory powers, replacing the Atomic Energy Regulatory Board (AERB), which currently operates under the Department of Atomic Energy (DAE).
- Clarify licensing frameworks, safety compliance measures, and operational responsibilities to mitigate regulatory uncertainty for investors.

iii. International Collaborations

Explore joint venture models with established global nuclear firms (Westinghouse, EDF, Rosatom) to integrate advanced technologies while keeping fuel supply and critical components under domestic control.

Successful models that India could follow:

- United States: Private companies like Westinghouse and General Electric operate under federal oversight. The government does not own nuclear plants but enforces strict safety, security, and environmental standards.
- France: Électricité de France (EDF), a state-private hybrid, runs the nuclear fleet effectively. (It was fully returned to state ownership in 2023).[45] The French government plays a direct role in nuclear operations, expansion, and policy, ensuring nuclear remains central to energy security.
- China: Uses a joint-venture model, combining public and private resources for rapid nuclear expansion. [46] Nuclear power development is led by state-owned enterprises (SOEs) like CNNC and CGN, but often in collaboration with private and international partners.

Each system reflects national priorities—the U.S. prioritizes private industry, France ensures government control, and China blends state and private efforts for growth.

iv. Safety, Security, and Non-Proliferation Safeguards

- Maintain government ownership over nuclear fuel supply and spent fuel disposal to prevent security vulnerabilities.
- Clearly define liability frameworks under the Civil Liability for Nuclear Damage Act (CLNDA, 2010) to balance operator accountability with investor risk management.

A key prerequisite for such a transition would be the establishment of an independent nuclear regulator. At present, the Atomic Energy Regulatory Board (AERB) is the primary regulatory board within the nuclear domain. However, while technically autonomous, the regulatory board ultimately remains under the purview of the DAE. A previous legislative proposal to grant it statutory independence never materialized. Given the push for private sector participation in nuclear power, a truly independent nuclear regulator will be essential to ensure uniform safety and security standards across both public and private stakeholders. Even if nuclear materials remain under the DAE's ownership, clear legal frameworks must be established to ensure the DAE is not held liable in case of an accident involving private operators. Proliferation risks may not necessarily arise from inter-ministerial friction but rather from gaps in regulation and the need for well-defined responsibilities, especially as such sensitive nuclear technologies are managed across multiple stakeholders, including an inexperienced private sector. This is where the role of a truly independent nuclear regulator becomes crucial—not just in terms of upholding security but also avoiding potential monopolization, favoritism, and regulatory biases vis-a-vis private players. Ensuring strict oversight, transparency, and clear institutional roles will be crucial as India moves toward liberalizing its nuclear energy sector.

v. Land Acquisition and Public Acceptance Strategies

- Consider state-backed industrial zones for nuclear energy projects, where the government acquires land and allocates it to private players, reducing acquisition-related resistance.
- Develop a transparent land acquisition framework that ensures fair compensation and rehabilitation for displaced communities.

India stands at a critical juncture in its nuclear energy journey, with SMRs offering a path to energy security, industrial growth, and clean power. With rising energy demands, climate commitments, and technological advancements, accelerating private sector participation in nuclear energy is no longer optional; it is essential. However, for private sector participation to succeed, regulatory bottlenecks must be addressed, liability laws clarified, and a solid oversight framework established. Balancing innovation with safety, and investment with accountability, will be key to unlocking the full potential of SMRs. Delays in reform will not only hamper progress but also runs the risk of India being left behind in the global nuclear race. If India navigates these challenges strategically, it can accelerate its nuclear energy expansion while ensuring long-term sustainability and self-reliance in the sector.

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