Non Traditional Security Digest

Nuclear Energy in India

Vol 4 | Issue 2 | March - April 2025

MANOHAR PARRIKAR INSTITUTE FOR
DEFENCE STUDIES AND ANALYSES
मनोहर पर्रिकर रक्षा अध्ययन एवं विश्लेषण संस्थान

Nuclear Energy in India

Introduction

India's nuclear power generation capacity has significantly increased, reaching 35,333 MW. This marks a substantial rise from the 22,480 MW recorded in 2014. The installed capacity has doubled to 8,880 MW, reflecting the government's commitment to expanding nuclear energy. Alongside capacity growth, the government emphasises adherence to stringent safety standards within the nuclear sector. To further bolster the development of nuclear power, the Indian government has approved private sector participation. This strategic move aims to augment resources and expedite the expansion of nuclear infrastructure across the country. The geographical footprint of nuclear facilities is also expanding, with new reactors planned for various locations. This expansion is supported by a significant increase in the budget allocated to the Department of Atomic Energy, which has risen by 170% since 2014. The total budget of the Department of Atomic Energy in 2014 was Rs 13,889 crore which has been expanded to Rs 23,604 crore. These initiatives collectively underscore India's focus on nuclear energy as a crucial component of its future energy mix.

Nuclear safety aspect in India

Government of India (GoI) has emphasized that the it will follows a "safety first, production next" approach, which would include regular safety checks during different stages of different stages of construction and operation of India's new Nuclear Energy Plants. GoI has further highlighted that the plant sites would undergo quarterly monitoring during construction, biannual assessments while operational, and a full safety review in every five years. As per Tata Memorial cente Study, it has been highlighted that radiation-related health concerns around India's nuclear facilities are below national average. With regard to the critical aspect of nuclear waste management in India, it needs to be emphasized that India adheres to global best practices. GoI has highlighted that each nuclear plant stores its waste on-site for the first five to seven years and after that, it is shifted to an 'Away From Reactor' (AFR) facility for long-term storage and eventual reuse.

India's planned expansion in Nuclear Energy Sector

India is significantly scaling up its nuclear energy production with a strategic focus on enhancing capacity and fostering self-reliance in the sector. The government's

recent decision to open the nuclear sector to private players, highlighted in the Union budget, underscores this commitment. Driven by the nation's burgeoning energy demands, projected to triple by 2047, and the imperative to reduce reliance on fossil fuels which currently constitute approximately 70 percent of power generation, nuclear power is positioned as a critical component of India's sustainable energy future.

Currently, India's nuclear power capacity stands at 8,180 MW generated from 24 operational reactors, a substantial increase from 4,780 MW in 2013-14. These plants generated 47,971 million units of electricity in 2023-24, contributing about 3 percent to the country's total electricity generation.

Ambitious plans are underway to further elevate this contribution, with 21 additional reactors, totaling 15,300 MW, in various stages of implementation. A key achievement in this expansion is the successful commissioning of India’s first indigenous 700 MWe Pressurised Heavy Water Reactor (PHWR) at Kakrapar, Gujarat, in 2023-24, marking a significant step towards technological self-sufficiency. India is also making notable advancements in the nuclear fuel cycle, with the Prototype Fast Breeder Reactor (PFBR) achieving critical milestones. This second stage of India's three-stage nuclear programme, envisioned by Homi Bhabha to leverage India's extensive thorium reserves is crucial for enhancing fuel utilization efficiency and paving the way for thorium-based reactors.

Furthermore, the government is actively promoting the development of Small Modular Reactors (SMRs) and Bharat Small Reactors (BSRs). GoI has allocated Rs 20,000 crore for SMR research and development, with a target of at least five indigenous operational SMRs by 2033. The goal is to reach 100 GW of nuclear power capacity by 2047, supported by the newly launched Nuclear Energy Mission for Viksit Bharat. International collaborations with Russia, France, and the US are also being strengthened, including an in-principle approval for six 1208 MW nuclear power plants in cooperation with the US. A joint venture between the Nuclear Power Corporation of India Limited (NPCIL) and the National Thermal Power Corporation (NTPC), named Anushakti Vidhyut Nigam Ltd. (ASHVINI), has been established to further develop nuclear power facilities. The government is also considering amendments to existing legislation to facilitate greater private sector participation in this expanding sector.

India emphasizes on Uranium procurement diversification and faster land acquisition

Union Power Minister Manohar Lal emphasized the significance of

diversified uranium fuel sources and expediting land acquisition to augment India's nuclear energy capacity. Speaking at a meeting of the Consultative Committee of the Ministry of Power, the minister outlined strategic measures necessary for scaling up the domestic nuclear energy sector. These measures include amending the Atomic Energy Act of 1962 and the Civil Liability for Nuclear Damage Act of 2010 to facilitate broader participation from private and state entities.

Furthermore, the minister stressed the importance of enhancing public perception and awareness regarding the safety and benefits of nuclear energy. To ensure competitive nuclear tariffs, he suggested introducing tax concessions, classifying nuclear power as green energy, and providing long-term financing options. Diversifying technology choices through competitive bidding and promoting indigenous manufacturing under the "Make in India" initiative were also highlighted as crucial steps. Mr. Lal also pointed out the necessity of expanding the vendor base for specialized nuclear equipment and developing skilled manpower by strengthening nuclear education and training infrastructure.

Facilitating faster land acquisition through brownfield expansions and repurposing retired thermal sites, along with streamlining regulatory approval processes to reduce project timelines, have been identified as essential for increasing nuclear power capacity.

India-US emerging cooperation on Small Modular Reactor (SMR) technology

The US Department of Energy has approved Holtec International's application to design and build nuclear reactors in India, facilitating the transfer of unclassified small modular reactor (SMR) technology to L&T, Tata Consulting Engineers, and Holtec Asia. This move, nearly two decades after the India-US civil nuclear deal, would potentially integrate India into the SMR manufacturing value chain, where China also has significant ambitions. India has recently outlined plans to significantly increase its nuclear energy capacity, aiming for at least 100 GW by 2047, and has established a Nuclear Energy Mission for SMR research and development. Collaboration with France on SMR and Advanced Modular Reactors is also underway. Domestically developed Bharat Small Modular Reactors (BSMR-200) are being designed, with the government aiming for at least five indigenous SMRs to be operational by 2033. These BSMR-200s are being designed and developed by the Bhabha Atomic Research Centre and Nuclear

Power Corporation of India Limited. The time for construction is pegged to be between 60 to 72 months after the receipt of project sanction. Nuclear power is seen as a crucial component of India's energy mix, providing a clean and reliable base-load power source. The government is expected to accelerate private sector involvement in this expanding area.

India-Russia cooperation nuclear energy

India is one of Russia's largest and oldest partners and one of the first customers of foreign nuclear power plants (along with Iran and China). India's partnership was critical for the newly post-Soviet state of Russia in the difficult 1990s when its nuclear industry was on the verge of complete collapse and bankruptcy. India-Russia partnership is so enduring that it even predates the formation of Rosatom in 2007, which replaced its Soviet predecessor Minatom. For India, the Soviet-era contract for the construction of the Kudankulam NPP (KKNPP), signed back in 1988, was the first and still the only completed project for the construction of a foreign NPP in India in almost 40 years. The Kudankulam nuclear power plant (KKNPP) in India's southern state of Tamil Nadu, which is being built by Rosatom, is one of the main projects within the Russia-India bilateral relationship. The first stage of the Kudankulam NPP, with two units, is also the most productive NPP in the country, providing up to a third of all electricity generated by nuclear power units in India, according to the IAEA database. Its two VVER-1000 reactors are also the most powerful in India (1000 MW gross capacity versus 200-700 MW for other nuclear power units) and the only NPP units with pressurized water reactors (VVER in Russian terminology) in the country.

The Kudankulam NPP also accounts for about 30% of the operating capacity of Indian NPPs (2 GW of 6.9 GW according to the IAEA) and 75% of the capacity under construction (4 GW of 5.4 GW). Currently, four more units of the station are under construction and the possible construction of new units according to Russian designs is being discussed, including at other sites.

During a July 2024 summit, Russia's Vladimir Putin and India's Narendra Modi recognized civil nuclear cooperation as a focus of their cooperation. The joint statement from the summit notes that India and Russia are in talks on a second nuclear plant separate from the KKNPP "in accordance with earlier signed agreements". The Indian Ministry of External Affair's press conference and the joint statement after the bilateral summit also mentioned that India and Russia were discussing localizing the VVER-1200

reactor design and exploring avenues for "joint manufacturing of NPP components as well as on cooperation in third countries". Furthermore, the two sides also discussed NPP fuel supply for Units 3 through 6 of the KKNPP and India plans on long-term supply of Uranium from Russia.

It finally needs to be highlighted that, despite India's openness to cooperation with various countries in the civil nuclear industry, it is still difficult for those countries to offer projects and guarantees for their implementation that are as attractive and convincing as those offered by Russia. For the foreseeable future, Russia therefore will likely remain the largest and only foreign developer of NPPs in India.

India steps towards developing thorium based Small Modular Reactor

Maharashtra government on April, 2025 has signed a memorandum of understanding (MoU) with Russia's state-owned company ROSATOM to develop a small modular reactor based on thorium fuel. The main objective of the MoU is to jointly develop a thorium reactor in Maharashtra, commercialise thorium reactors as per safety standards of the Atomic Energy Regulatory Board (AERB), and establish an assembly line for thorium reactors under the 'Make in Maharashtra' initiative.

Currently, India does not have any operational reactor working on thorium. Therefore, in order to venture in this direction, the initial plan include to form joint working group to facilitate coordination and research for this project. Reports suggests that representatives from Mahagenco, Rosatom Energy Projects, Maharashtra Institution for Transformation (MITRA), and Global Technology Alliance will participate in the project's execution. This MoU was signed in the presence of Maharashtra Chief Minister Devendra Fadnavis between the Maharashtra State Power Generation Co Ltd (MAHAGENCO) and ROSATOM's 'Small Modular Reactor with Thorium Fuel' initiative.

Haryana to have North India's first Nuclear Power Plant

In a significant stride towards bolstering its nuclear energy capacity, India has announced the construction of its first nuclear power project in the northern region, situated in Gorakhpur, Haryana. The Union Minister Dr. Jitendra Singh officially communicated this development in the Lok Sabha, underscoring the government's unwavering commitment to nuclear power generation alongside the reiteration of the strategic importance of the

Jaitapur Nuclear Power Project. The proposed nuclear facility in Haryana marks a crucial expansion of India's nuclear infrastructure into the northern part of the country. According to disclosures from the Department of Atomic Energy, this initiative signifies a tangible step towards achieving the nation's ambitious goal of reaching 100 gigawatts of nuclear energy by the year 2047. The minister also addressed the status of the Jaitapur project, clarifying that the renewal process for its environmental clearance is currently underway, with assurances that all essential ecological and safety protocols are being meticulously addressed.

Further details provided by the minister shed light on the developmental trajectory of the Jaitapur project, revealing that initial approvals were granted in 2008. Subsequent delays were attributed to evolving agreements with French stakeholders. However, with the technical aspects of the collaboration now finalised, ongoing discussions are focused on establishing mutually agreeable commercial terms with the partner entities. Upon its operationalisation, the Jaitapur plant is projected to house six nuclear reactors, each boasting a substantial capacity of 1,730 megawatts, culminating in a total installed capacity of 10,380 megawatts. This output is expected to contribute significantly, accounting for approximately 10% of India's targeted nuclear energy capacity.

An insurance pool amounting to INR 1,500 crore has been established to ensure financial security and mitigate potential risks associated with nuclear operations. The government has also pledged additional financial commitments should the need arise. Furthermore, India has aligned itself with global compensation frameworks, demonstrating a commitment to robust financial safeguards in the event of any unforeseen incidents. These measures underscore the comprehensive approach being adopted towards the expansion of nuclear power generation in the country.

India plans on easing nuclear liability laws

In order to attract foreign investment, India plans to amend its nuclear liability regulations to limit accident-related fines on equipment suppliers. The planned modifications would change the Civil Nuclear Liability Damage Act of 2010, which now makes providers accountable for unlimited compensation in the event of a nuclear accident, according to three senior government sources.

The modifications are a component of the Modi government's larger plan to increase India's nuclear power capacities, in order to

meet India's energy needs and ensure clean energy within the country. The Department of Atomic Energy drafted the draft bill, which complies with international standards that assign the operator, not the supplying firm. The proposed revisions would restrict the time frame for compensation claims to a term specified in the agreement and cap a supplier's responsibility at the contract value.

Indian government is hopeful that the revised law will be approved during the July monsoon session of Parliament. Official statements on the subject have not yet been released by the Finance Ministry, Department of Atomic Energy, or Prime Minister's Office. By opening the door for long-delayed reactor projects and strengthening strategic energy relations between the United States and India, the measure, if passed, could be a turning point in India's civil nuclear program.

Rajasthan Atomic Power Station Unit-7 Connected to Northern Grid

In March 2025, the seventh unit of the Rajasthan Atomic Power Station (Rapp-7) was successfully connected to the northern grid, marking a significant milestone in India's nuclear program. This achievement was announced by the Nuclear Power Corporation of India Limited (NPCIL).

NPCIL stated that the power level of Rapp-7 will be gradually increased to its full capacity, in accordance with the necessary regulatory clearances. Rapp-7 represents the third in a series of 16 indigenous 700 MW pressurised heavy water reactors (PHWR) that are being established across India.

The 700 MW PHWR is projected to play a crucial role in achieving India's ambitious goal of reaching 100 GW of nuclear capacity by the year 2047, as part of the nation's Nuclear Energy Mission. NPCIL estimates that a single 700 MW reactor can generate approximately 5.2 billion units of clean energy annually, which translates to a reduction of about 4.5 million tons of CO2 emissions per year. With the addition of Rapp-7, NPCIL now operates a total of 25 reactors, with a combined capacity of 8,880 MW. Furthermore, an additional 13,100 MW of capacity is currently under construction.

Some latest Suggested Readings

Akbari, R., et al. "Analysis of thorium-transuranic fuel deployment in a LW-SMR: A solution toward sustainable fuel supply for the future plants." Nuclear Engineering and Design 421 (2024): 113090.

Aswal, D. K., and Anirudh Chandra. "Key drivers for achieving India's 100

GW nuclear power ambition." Current Science 127.4 (2024): 1-3.

Durdovic, Martin, et al. "The outlooks of nuclear energy in society: Unraveling public attitudes in the context of climate and energy security challenges." Progress in Nuclear Energy 174 (2024): 105286.

Huang, Anzhong, et al. "From funds to footprints: Unravelling the asymmetric association between nuclear energy technology and environmental quality." Energy 309 (2024): 133006.

Kumar, A. Vinod, et al. "Negligible radiological impact of Indian nuclear power plants on the environment and the public: Findings from a 20-year study." Science of the Total Environment 914 (2024): 169936.

Kurylev, Konstantin P., et al. "The Russian-Indian Scientific and Technological Cooperation in the First Decade of the 21st Century." Vestnik RUDN. International Relations 24.4 (2024): 643-654.

Prabhakaran Nair Sindhu, Anantha Padmanabhan. "Importance of National Level Policies to Support Thorium-Based Advanced Nuclear Reactor Technologies: India as a case study." (2024).

Raihan, Asif, et al. "Nexus between nuclear energy, economic growth, and greenhouse gas emissions in India." *International Journal of Energy Economics and Policy* 14.2 (2024): 172-182.

Raihan, Asif. "Effects of nuclear energy, structural changes, economic growth, and natural resources on India's load capacity factor." Proceedings of the International Conference on Environmental and Energy Economics. 2024.

Verma, Vinod Kumar. "The Role of Nuclear Energy in a Sustainable Future: Benefits and Risks in Addressing Climate Change." Idealistic Journal of Advanced Research in Progressive Spectrums (IJARPS) eISSN–2583-6986 4.03 (2025): 86-92.

Non-Traditional Security Centre

This digest has been prepared by the Non-Traditional Security Centre, Manohar Parrikar Institute for Defence Studies and Analyses, New Delhi.

MANOHAR PARRIKAR INSTITUTE FOR DEFENCE STUDIES AND ANALYSES
मनोहर पर्रिकर रक्षा अध्ययन एवं विश्लेषण संस्थान

Manohar Parrikar Institute for Defence Studies and Analyses
No.1, Development Enclave, Rao Tula Ram Marg,
Delhi Cantt., New Delhi - 110 010
Tel.: (91-11) 2671-7983 Fax: (91-11) 2615 4191
Website: http://www.idsa.in