

The background of the slide is a dark, industrial setting. In the center, a yellow robotic arm is welding a component on a truck chassis, with bright sparks flying. To the left, a large, cylindrical, blue-lit machine is visible. In the foreground, a glowing yellow atomic symbol is superimposed over a blue, grid-like pattern that resembles a globe or a data visualization. The overall atmosphere is high-tech and futuristic.

Finovista

HARVESTING NUCLEAR ENERGY FOR DEFENCE THROUGH SMALL NUCLEAR REACTORS

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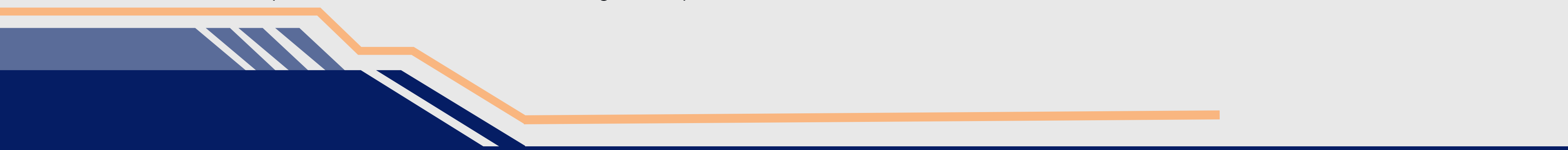
Reviewed By : Gp Capt Manoj Pandey



INTRODUCTION

Small nuclear reactors, including small modular reactors (SMRs) and microreactors, play a growing role in defense by powering military bases, forward operations, and resilient infrastructure worldwide. Their compact, factory-built designs enable rapid deployment and reduce reliance on vulnerable grids or fuel convoys. Not only these have Key Military Applications, these reactors address vulnerabilities like grid dependence and logistics in contested areas. The US is pioneer in harnessing Nuclear energies for defence productions, right at the place of requirements during war and contingencies. However, it is due its global reach and strategic imperatives. For example the U.S. Department of Defense pursues microreactors (1-20 MW) for bases, with programs like Project Pele for mobile 5 MWe units and ANPI selecting eight suppliers for on-site systems at installations. They support critical loads, communications, water treatment, and drone operations without diesel resupply. Similar nuclear outreach is seen in the Chinese military, France eco-system etc. Considerably they are the three major powers when harnessing nuclear energy for defence production, which today, has become small, manoeuvrable and ensuring uninterrupted and clean supply of energy for manufacturing defence requirements.

India too, has enough scope to enhance its capability. Presently, it generates 8GWe of nuclear power energy for electricity, and its scope has not been increased to a promising 100 GWe by 2047 under currently passed SHANTI bill by the Parliament in the winter session of 2025. This demands a great attention to keep a check on radio-activity and strict controls addressing liability factors so that the Small Nuclear Reactors become a reality like the western powers. This is the need of the time and country like India must not shy from it. Good news is that India's SMR push aligns with "Make in India" for potential defense manufacturing and exports.



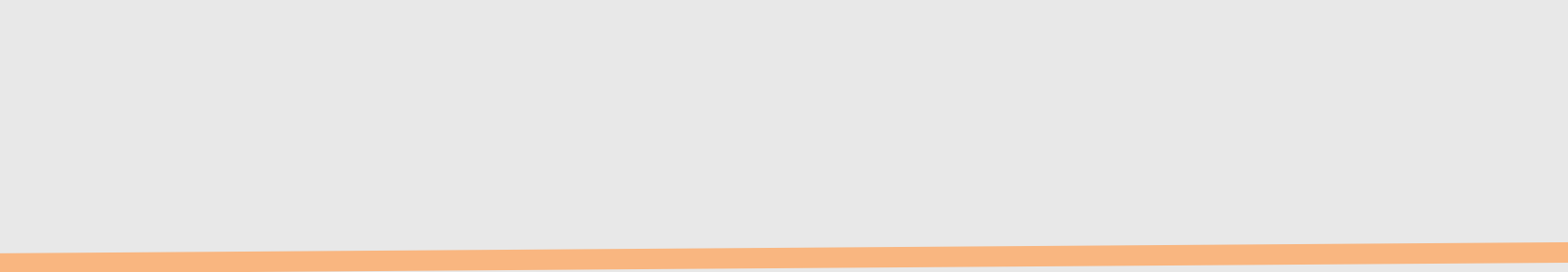



THE NEED

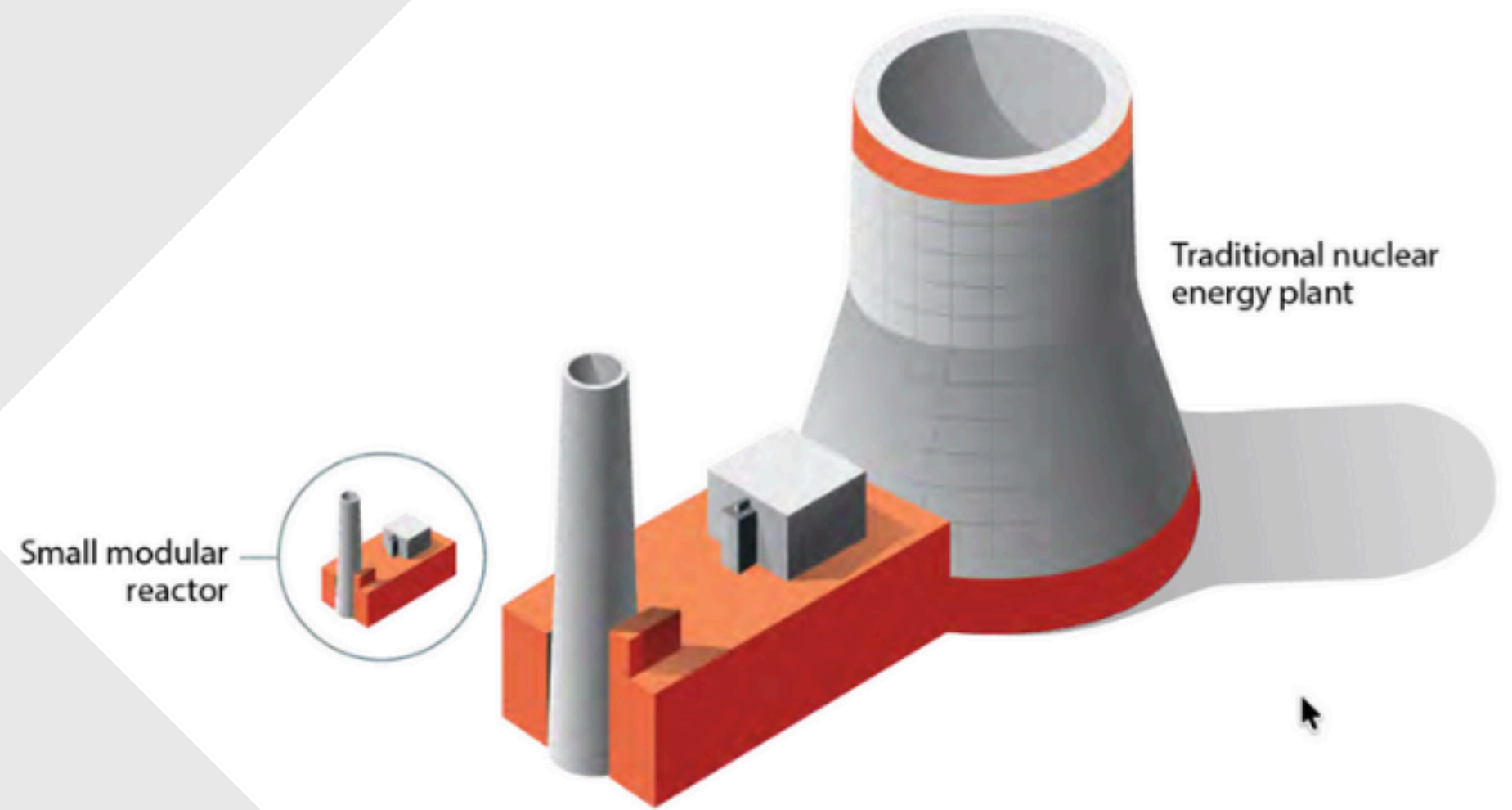
Modern defence institutions rely on continuous, high-quality power for surveillance systems, command-and-control networks, data centres, protected communications, and logistics infrastructure. The traditional reliance on grid power and diesel-powered generation exposes military facilities to fuel supply risks, bad weather, cyberattacks, and kinetic disruptions. Small Nuclear Reactors (SMRs) and microreactors are emerging globally as viable [1] solutions to improve defence energy resilience by supplying dependable, long-duration, low-carbon baseload power in both remote and strategically essential sites. The United States, China, and France three of the world's top nuclear powers are examined in this report for their approaches to small reactor technologies that have direct or indirect implications for defence energy security. Therefore, the research examines how India's varied topography and strategic needs could selectively benefit from such systems while acknowledging the related governance, safety, and cost difficulties, drawing on similar global experiences.

SMALL MODULAR REACTORS: DEFINITION AND DEFENCE CONTEXT

Small modular reactors are nuclear reactors capable of producing up to 300 MWe, although microreactors normally operate in the 1-20 MWe range. These reactors are intended to be modular, factory-built, and fitted with sophisticated safety mechanisms. SMRs' fundamental value in defence applications is not in bulk electricity generation, but in their capacity to provide continuous, reliable power to mission-critical installations, particularly those in distant or strategically sensitive locations.



Unlike diesel generators, which require frequent refuelling and have insecure supply networks, SMRs may run for several years without refilling. This drastically decreases logistics risks while increasing operational autonomy. As modern military systems grow more digital and energy-intensive, ensuring reliable energy supply has emerged as a critical component of national security planning.



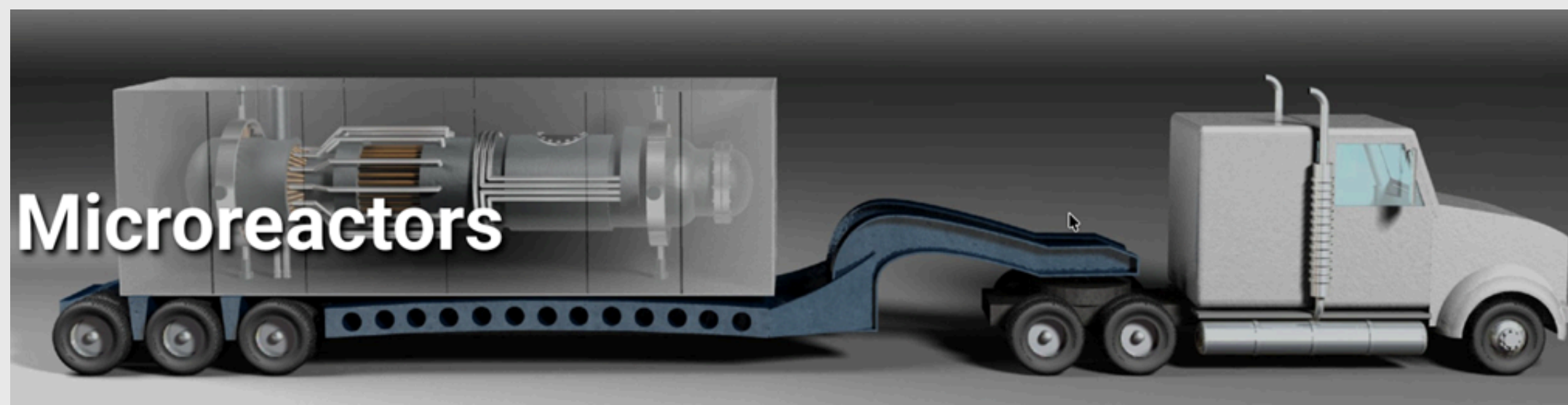
SMR comparison courtesy of Idaho National Laboratory

THE MICROREACTORS

A microreactor is a small nuclear reactor that can operate as part of the electric grid, independently from the electric grid, or as part of a microgrid to generate up to 20 megawatts thermal energy that can be used to generate electricity and provide heat for industrial applications. Most of these small reactors are designed to be portable – many could be hauled by a semitractor-trailer. Microreactors are 100 to 1,000 times smaller than conventional nuclear reactors, while small modular reactors (SMRs) range from 20 to 300 megawatts.

The U.S. Department of Defense is pursuing the concept as its military operations become more energy intensive and require portable, dense power sources. Remote, rural communities in the U.S., many of which fly or truck in diesel to run generators, are considering microreactors since they could generate power on-site. Their potential use as sources of industrial process heat opens up potential new markets for zero-carbon energy for desalination, hydrogen production and other industries.

US DoD is working with developers, private industry, regulators, universities and others to develop, demonstrate, test and validate this new generation of microreactors. As part of its research mission, it is also helping develop new fuels for microreactor designs, many of which will use low-enriched uranium with higher concentrations of uranium-235 than the fuel used in today's commercial power reactors.





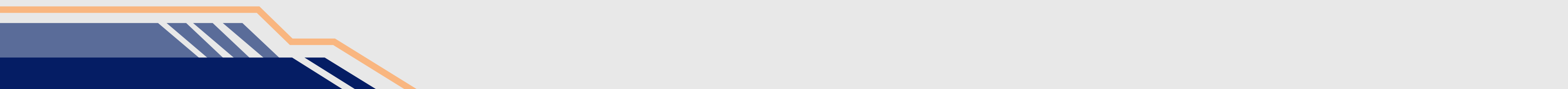
WHY ARE PEOPLE EXCITED ABOUT MICROREACTORS?

- Microreactors can be “right-sized” to location and are easily scalable
- Microreactors can produce more than electricity, including industrial products like hydrogen
- Microreactors have characteristics that enable rapid deployment
- Technology advancements and experience provide improved microreactor designs
- The U.S. advanced reactor industry is developing several microreactor concepts
- The federal government is supporting development through funding and legislation
- INL and the National Reactor Innovation Center (NRIC) are enabling developers by providing technical resources, capabilities and a demonstration site
- A demonstration is foreseen in the next three to five years. The same can be replicated in India after SHANTI bill.

THE ADVANTAGES OF MICRO REACTORS

- Small, non-carbon-emitting sources of electricity and heat
- Fully factory built and installed on-site
- Easily and quickly shipped to and removed from site
- Self-regulating with high degree of safety based on natural laws of physics
- Reliable and resilient sources of demand-driven power
- Easy to operate compared to larger power reactors
- Capable of operating for several years without refueling
- Able to serve a range of energy applications
- Can be integrated with other energy sources in on- and off-grid applications

A number of private sector companies have microreactor initiatives.
International Developments in Defence-Oriented Small Nuclear Reactors





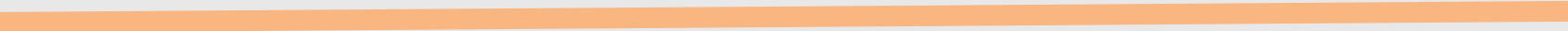

THE UNITED STATES

The most direct way to incorporating nuclear energy into defense resilience planning has been adopted by the United States. The Department of Defense has started programs to investigate nuclear microreactors for military installations after identifying energy assurance as a strategic weakness. The goal of these initiatives is to guarantee business continuity in the event of extended fuel supply interruptions or grid failures.

Project Pele is an important project that aims to demonstrate a transportable microreactor under controlled conditions prior to any practical deployment. The U.S. strategy places a strong focus on environmental evaluation, regulatory involvement, pilot demonstrations, and cautious expansion. The high expense, risk, and operational strain of fuel logistics for remote sites are the main factors driving interest in microreactors, according to an analysis of U.S. defense energy strategy. However, issues with wasted fuel management, physical security, and regulatory complexity continue to be important and influence policy debates.

FRANCE

France's long-standing civilian nuclear knowledge serves as the foundation for its nuclear strategy. The nation is creating compact modular reactor designs for industrial, strategic, and possibly defense-related uses through its state-owned utility EDF. The strategic nature of these reactors is in line with national security goals, even if France has not formally announced the military deployment of SMRs. Additionally, France has established itself as a cooperative partner for nations like India that are interested in cutting-edge reactor technology.

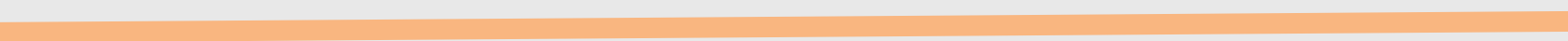





CHINA

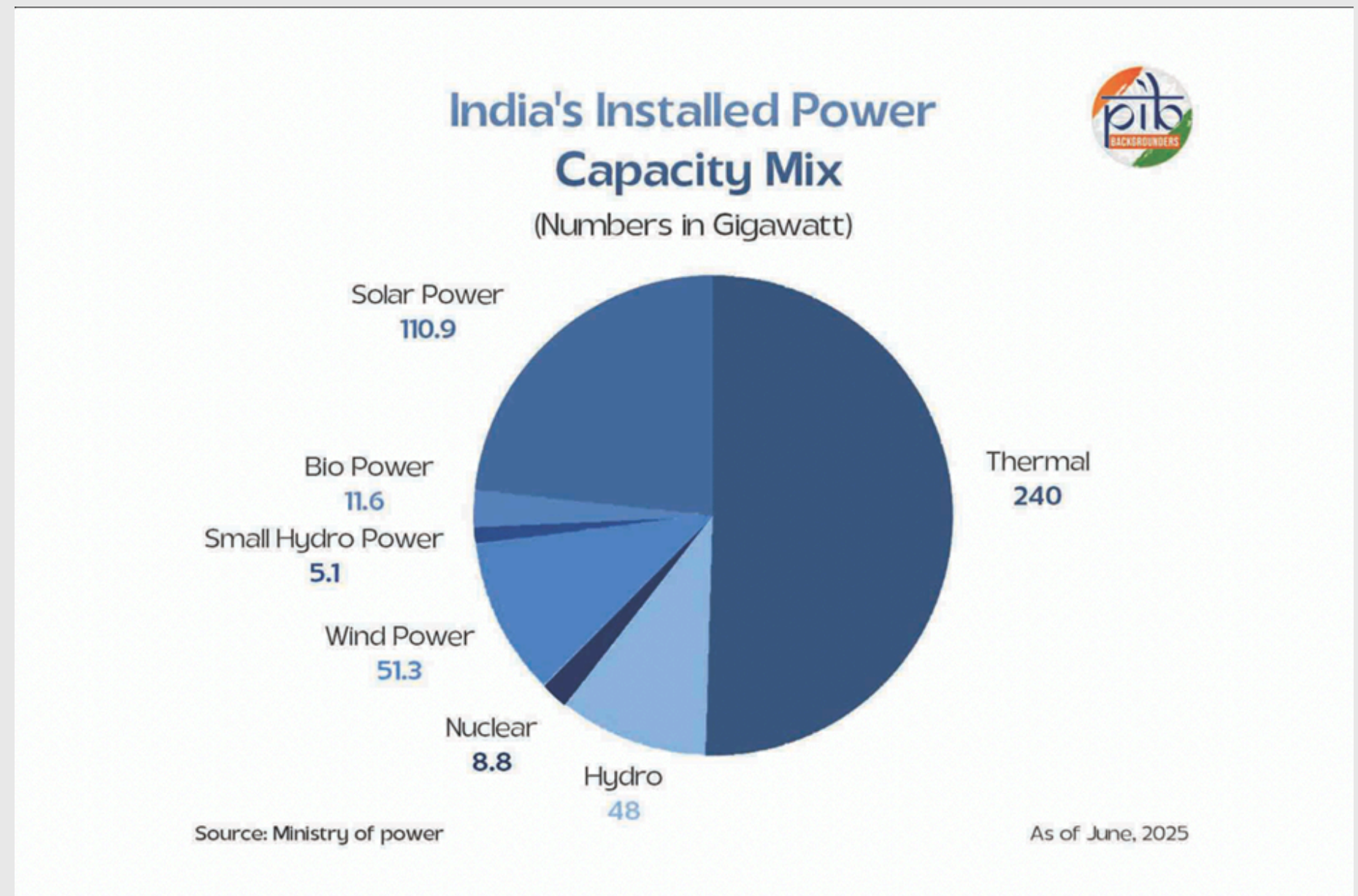
As of right now, China is the only big power with a commercial small modular reactor in operation. China's ability to transition from design to deployment is demonstrated by their high-temperature gas-cooled reactor. China has a major edge in understanding SMR construction, regulation, and long-term operation thanks to its operational expertise. These technologies have obvious dual-use potential, including applications in defence and vital infrastructure, despite being publicly presented as civilian ventures.

The methods of the United States, France, and China demonstrate how nuclear energy is gradually being reconsidered as a tool for national resilience. The United States is carefully testing nuclear microreactors to keep military outposts operational during power outages. France is leveraging its hat strategic objectives without rushing into military service. Meanwhile, China has made the fastest progress, already operated a tiny modular reactor and gained real-world experience. These instances demonstrate that modular nuclear technologies are becoming more relevant for energy security, despite ongoing worries about safety, regulation, and waste.



INDIAN SCENARIO

India's nuclear power generation relies on 25 operational reactors across seven sites, delivering reliable baseload electricity amid growing energy demands. In FY 2024-25, Nuclear Power Corporation of India Limited (NPCIL) achieved a record 50 billion units (BUs), or about 56.7 TWh, avoiding nearly 49 million tonnes of CO2 emissions while contributing roughly 3% to total electricity.





CURRENT CAPACITY

Installed capacity stands at 8,180-8,880 MW as of mid-2025, with 25 pressurized heavy water reactors (PHWRs) and light water reactors (LWRs) operational. Eight more reactors totalling 6,600-8,700 MW are under construction, targeting 22,480 MW by 2031-32

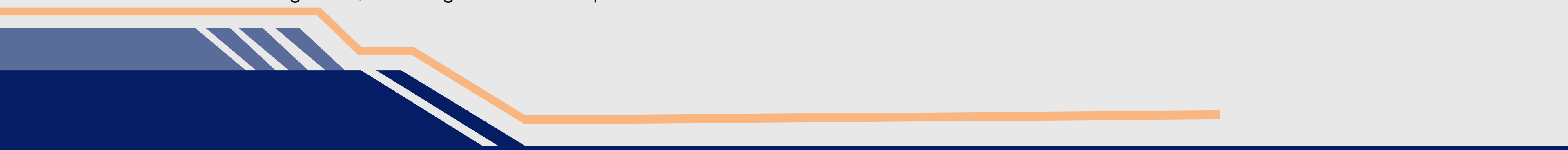
EXPANSION PLANS

The government aims for 100 GW by 2047 under the Nuclear Energy Mission, backed by Rs 20,000 crore for small modular reactors (SMRs) R&D and five deployments by 2033. Initiatives include NTPC's 30 GW pivot, public-private partnerships, and sites in Gujarat, Rajasthan, and beyond.

STRATEGIC ROLE

India's three-stage program emphasizes indigenous PHWRs, fast breeder reactors, and thorium utilization for energy security. Budget 2025-26 and "France 2030"-style investments accelerate SMRs for defense-adjacent manufacturing and net-zero goals by 2070.

Small nuclear reactors, such as SMRs and microreactors, support defense manufacturing in the US, China, Russia, and France by providing reliable, resilient power for bases, remote sites, and high-energy demands like weapons production and testing. These compact systems reduce grid vulnerabilities and fuel logistics, enabling continuous operations in austere environments



WHAT INDIA CAN SEEK FROM THESE COUNTRIES?

USA: India has the potential to work together with the U.S. on advanced small modular reactor (SMR) and microreactor technologies, as well as fuel-cycle expertise and insights into regulatory frameworks and safety measures. Collaborative pilot projects could aid in testing and customizing these technologies for use in India.

RUSSIA PROGRAMS

Russia prioritizes SMRs like the RITM-200 series for remote Siberian and Far East regions, with manufacturing underway for icebreakers and onshore plants like Yakutia. Rosatom leverages Soviet-era expertise in small reactors for defense, space, and export, supporting military power in harsh terrains. India can always seek these technological breakthroughs considering its bilateral reach with Russia.

FRANCE EFFORTS

France's Nuward SMR (300-400 MWe), developed by EDF, CEA, and Naval Group, draws on naval reactor experience for modular, compact power suitable for defense applications. The "France 2030" plan invests in SMRs for industrial and military resilience, emphasizing safety and rapid deployment. India stands to gain from co-developing SMRs, acquiring civil nuclear knowledge, receiving regulatory support, and benefiting from workforce training. France's expertise can enhance both the safe operation of reactors and the strategic energy objectives. France happens to be the third largest military supplier to India. The best practices of France could be harnessed for achieving the manufacturing through SMRs in India.

WHAT THE SHANTI BILL MEANS FOR INDIA'S NUCLEAR SECTOR ?

The Sustainable Harnessing and Advancement of Nuclear Energy for Transforming India Bill aims to open the sector to private players; help India scale nuclear power as part of its clean energy strategy. The government has pitched the Bill as essential to scaling up nuclear power as part of India's long-term clean energy strategy. Concerns around safety, accountability and the implications of opening the sector to private companies are few of the areas where the Govt has to take a decisive step.

THE NEED FOR A NEW NUCLEAR LAW

Until now, India's nuclear sector has been largely state-controlled, with limited scope for private companies. The central government argues this framework was designed for a far more limited programme and has struggled to keep pace with India's energy needs and technological ambitions.

The government has also tied the Bill to broader goals such as net-zero emissions by 2070, the need for stable power for energy-intensive sectors, and the expansion of non-power applications of nuclear technology in health care, agriculture and industry.

The Shanti Bill proposes a unified law governing the production, use, regulation and expansion of nuclear energy and ionising radiation in India. Its scope goes beyond electricity generation to include non-power applications of nuclear technology in areas such as health care, agriculture, industry and scientific research. Currently, nuclear activity such as licensing, safety regulation and liability are governed by separate laws. The Bill seeks to replace this structure with a single statutory framework covering licensing, safety authorisation, regulation, liability, compensation and oversight. **This should be extended to Defence Manufacturing-leasing out industries for manufacturing under Make in India project.**

The Bill is closely linked to the government's ambition to scale India's nuclear power capacity sharply over the next two decades, including through the development of Small Modular Reactors and indigenous reactor designs. The government has said greater private participation is essential to mobilise capital, technology and execution capacity at the scale required. **This can be harnessed for defence production as is being done by the US, France Russia and China.**⁵

WHAT IS THE NEED FOR REFORM IN NUCLEAR GOVERNANCE IN INDIA?

- Ambitious Capacity Targets: India aims to expand nuclear capacity from 8.8 GW to 22 GW by 2032 and 100 GW by 2047, but NPCIL alone lacks the capital, manpower, and execution capacity to meet these goals.
- Large Financing Gap: Achieving 100 GW requires about Rs 15 lakh crore, while Budget 2025–26 provides only Rs 20,000 crore, making private investment essential to mobilise long-term capital.
- Project Delays: NPCIL projects face chronic delays; private players can improve project management and Engineering, Procurement, and Construction (EPC) efficiency.
- Technology and Innovation Needs: Private participation can accelerate adoption of SMRs, advanced reactors, and global best practices, improving safety and scalability.
- Weak Uranium Supply Chains: Limited domestic production and Government-to-Government (G2G) imports necessitate private involvement in uranium mining, processing, and imports for fuel security.
- Energy Security and Climate Goals: Enhanced focus on nuclear power supports grid stability and achieving net-zero by 2070 complementing renewables with low-carbon baseload power.⁴

CONCLUSION

- India being a nuclear capable country has always prioritised using it for peaceful means for generating energy. There exists a huge potential where it too can go upto 100G.
- We power generation. With Shanti Bill, introduction of private players both India and abroad, there is a huge potential where we can hope to have a mobile nuclear power generation capability
- for defence production, which will be agile, clean and uninterrupted. Its large because it is the future.

SOURCE

¹ Small modular reactors. (n.d.). <https://www.iaea.org/topics/small-modular-reactors>

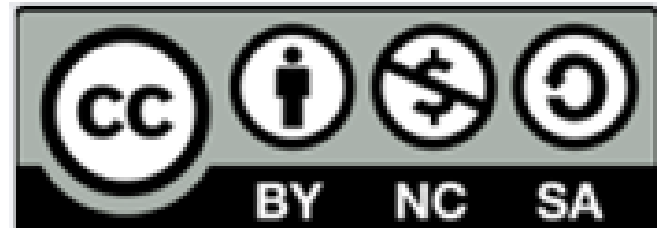
² Department of Defense breaks ground on project Pele Microreactor. (n.d.). Energy.gov. <https://www.energy.gov/ne/articles/departement-defense-breaks-ground-project-pele-microreactor>

³ China begins commercial operation of 1st HTGR. Neutron Bytes. (2023, December 10). <https://neutronbytes.com/2023/12/10/china-begins-commercial-operation-of-1st-htgr/>

⁴ Missouri State University – Defense & Strategic Studies Online. (n.d.). [https://dss.missouristate.edu/Files/MSU-DASSO-2025-Vol 1-No 3-Scheckleman.pdf](https://dss.missouristate.edu/Files/MSU-DASSO-2025-Vol%201-No%203-Scheckleman.pdf)

⁵ The Indian Express. <https://indianexpress.com/article/business/viability-of-smrs-pose-a-question-till-order-books-become-large-value-addition-locally-becomes-near-100-dr-anil-kakodkar-10443658/>

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