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Commentary

India's Nuclear Energy Autonomy: Key Layers

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Summary

India's nuclear energy autonomy rests on reliable baseload generation, diversified and contractually secured fuel supply and an indigenous fuel-cycle capability.

With an installed capacity of approximately 8.7 GW, a plan to raise this to 22.48 GW by 2031–32, and a long-term target of 100 GW by 2047,[1] nuclear power is no longer peripheral to India's energy mix. It is becoming the load-bearing pillar of its baseload strategy—providing the round-the-clock firm power at high plant load factors, something intermittent renewables cannot deliver without extensive storage and grid-balancing infrastructure. Autonomy in this context rests not on autarky but on three interlocking layers: reliable baseload generation, diversified and contractually secured fuel supply and an indigenous fuel-cycle capability.

Baseload Rationale and the Fuel Assurance Imperative

The baseload argument is analytically unambiguous. India cannot industrialise at scale, decarbonise its grid, and maintain dispatchability on intermittent renewable sources alone. Nuclear power's comparative advantage lies precisely in its round-the-clock firmness. Yet baseload capacity without fuel assurance constitutes only nominal sovereignty. The Indo-US 123 Agreement[2] explicitly envisaged an Indian strategic reserve of nuclear fuel and access to international markets under the NSG waiver, the institutional foundation upon which India's current diversified import portfolio rests. Domestic gains are real: the Department of Atomic Energy has augmented uranium oxide resources, and the Jaduguda discovery is expected to extend that mine's operational life by more than 50 years. Even so, India's safeguarded reactor fleet will require substantial imports over multi-decadal horizons, making contract architecture a matter of strategic consequence rather than procurement management.

Diversified Fuel Supply Agreements

Russia is India's only partner that is both building reactors at scale at Kudankulam and contractually guaranteeing lifetime fuel supply for those units. A 2024 contract covers full-lifetime fuel for Kudankulam Units 3 and 4, with TVEL supplying VVER-1000 fuel assemblies from Novosibirsk and shifting both existing and new units to

[1] Mittravinda Ranjan, "**Hard Work Ahead: India's Push for 100 GW Nuclear Capacity by 2047**", *The Economic Times – Energy World*, 6 January 2026.

[2] "**Agreement for Cooperation Between the Government of India and the Government of the United States of America Concerning Peaceful Uses of Nuclear Energy (123 Agreement)**", US Department of State, 2008.

advanced TVS-2M fuel.[3] The introduction of TVS-2M assemblies has already extended refuelling cycles from 12 to 18 months for Units 1 and 2, materially improving plant economics; Units 3 and 4 will commence operations directly on the 18-month cycle. Russia's public commitment to 'uninterrupted' supply, sustained even under sanctions-era geopolitical pressure, anchors India's light water reactor (LWR) fuel security. However, the concentration of both reactor construction and fuel supply with a single partner represents a structural vulnerability that the broader portfolio is designed to hedge against.

Kazakhstan has emerged as India's most consequential partner in uranium volume. A new 2026 agreement with Kazatomprom has superseded the earlier 5,000 MTU contract for 2015–2019,[4] which was of sufficient scale to require shareholder approval under Kazakh law and represented a commitment of at least 50 per cent of the company's total book asset value. The arrangement effectively positions India as an anchor customer for one of the world's largest uranium producers, providing a meaningful structural hedge against spot-market disruptions.

Canada has re-emerged as a major strategic fuel partner. The March 2026 Cameco-DAE agreement covers nearly 22 million pounds of uranium oxide (U_3O_8) between 2027 and 2035, valued at CAD 2.6 billion,[5] making it the single largest uranium contract India has publicly announced and one explicitly embedded in the broader India–Canada strategic partnership reset. Uzbekistan, through its 1,100 MTU contract with Navoi Mining, completes a Central Asian supply corridor that diversifies India's sourcing beyond Russian and Western channels. France anchors cooperation across the full civil-nuclear value chain, from pressurised heavy water reactor (PHWR) fuel supply to the 9.6 GW Jaitapur European Pressurised Reactor (EPR) partnership and emerging Small and Modular Reactors (SMR) collaboration.[6]

Taken together, these agreements reflect a deliberate shift from supplier dependence to portfolio management: the objective is not any single relationship but an ensemble of politically and commercially distinct supply lines that cannot all be disrupted simultaneously.

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[3] **"Rosatom Makes First Delivery of N-fuel for TN Plant's 3rd Unit"**, *The Economic Times*, 8 December 2025.

[4] Dipanjan Roy Chaudhury, **"Kazakhstan to Supply Fresh Uranium to India Under New Deal to Fuel Nuclear Power Plants"**, *The Economic Times*, 24 February 2026.

[5] Ujwal Jalali, **"India, Canada Ink $2.6 bn Uranium Supply Pact, Vow to Expand Trade to $70 bn"**, *The Tribune*, 3 March 2026.

[6] **"India and France Sign SMR and AMR Partnership Letter of Intent"**, World Nuclear Association, 12 February 2025.

Indigenous Fuel Cycle Capability

The three-stage nuclear programme—PHWRs on natural uranium, fast breeders on plutonium, and thorium-based systems—remains the doctrinal spine of India's long-term nuclear energy calculus. Chronic delays in the deployment of Stage-2 fast breeder reactors, despite the recent criticality of the Prototype Fast Breeder Reactor (PFBR), have created a temporal gap that SMRs are increasingly well positioned to address. The 2025–26 Union Budget's Nuclear Energy Mission allocates Rs 20,000 crore for SMR research and development (R&D),[7] with a target of at least five indigenously developed SMRs by 2033. The Bhabha Atomic Research Centre (BARC) is developing three designs: the 200 MWe Bharat Small Modular Reactors (BSMR)-200, a 55 MWe light-water SMR, and a 5 MWt high-temperature gas-cooled reactor.

Crucially, the BSMRs are PHWR-based and operate on natural or slightly enriched uranium within the existing fuel-cycle architecture. SMRs are therefore not a departure from the three-stage roadmap—a programme designed, in its final stage, to harness India's thorium reserves, among the largest in the world. They are a modular, temporally flexible instrument for sustaining Stage-1 capacity growth while fast-breeder and thorium timelines continue to mature.

The central question is not whether SMRs belong in the programme but how their deployment, dispersed, industrial, and eventually private-sector-financed, can be sequenced to reinforce India's fuel-cycle coherence. Beyond electricity generation, numerous energy-intensive industries require process heat at temperatures that current reactor designs cannot deliver; Gen IV SMRs fuelled by High-Assay Low-Enriched Uranium (HALEU) can reach these elevated temperatures, positioning HALEU-fuelled designs as a key instrument for decarbonising hard-to-abate sectors that neither renewables nor conventional nuclear can presently serve.[8]

HALEU[9] enriched between 5 and 20 per cent U-235 is the enabling fuel for the next generation of advanced reactors and many globally competitive SMR designs. The HALEU is precisely because higher enrichment enables smaller reactor cores, longer refuelling cycles, higher burn-up, and reduced spent-fuel volumes. The global supply

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[7] "**Nuclear Power in Union Budget 2025-26**", Press Information Bureau, Department of Atomic Energy, Government of India, 3 February 2025.

[8] See Chapter 2 "Significance of HALEU fuels in the emerging small modular reactor landscape", in Report titled "**High-Assay Low-Enriched Uranium: Drivers, Implications and Security of Supply**", NEA & OECD, 17 September 2024.

[9] "**What Is High-Assay Low-Enriched Uranium (HALEU)?**", US Department of Energy, Office of Nuclear Energy, 3 December 2024.

picture is acutely constrained. Only two countries have mastered HALEU production at a commercial scale: Russia, through Rosatom's Tenex, the sole full-infrastructure supplier operating at volume today; and China, which possesses industrial-scale enrichment capacity capable of HALEU output, though the terms and reach of its exports remain opaque to outside observers.

Elsewhere, the picture is one of ambition not yet matched by infrastructure. The United States, through Centrus Energy, has produced over 900 kg under Department of Energy contracts as of mid-2025, but lacks the industrial scale to support commercial supply. Private efforts are also underway, with Clean Core Thorium Energy collaborating with Idaho National Laboratory and Texas A&M University on HALEU-thorium fuel development.[10] Legislative bans on Russian enriched uranium imports are accelerating domestic buildout[11] without yet resolving the gap.

The United Kingdom is funding a Urenco facility[12] at Capenhurst, with a budget of GBP 196 million and a target of 10 tonnes per year by 2031. France's Orano is in regulatory discussions[13] but is not yet operational at HALEU scale. The structural implication is clear: for the foreseeable medium term, commercial HALEU supply will remain dominated by Russia and, to an uncertain degree, China. That is a geopolitical exposure India cannot afford to inherit uncritically.

India's first-wave BMSRs do not immediately require HALEU. That is, however, precisely the argument for acting now, before demand surges and supply chains crystallise around existing state relationships. Indian experts have proposed deploying fast-breeder reactors, including their use in existing 700 MWe PHWRs with reprocessed fuel feeding advanced molten-salt reactors, as part of a modified Stage-3 pathway.[14] Within this framework, an alternative worth examining is a HALEU-thorium blend for Stage-2 transition, where plutonium conventionally provides the fissile driver; enriched uranium in a HALEU-thorium configuration could serve an equivalent role, breeding U-233 for the third stage while India's fast-breeder capacity continues to scale.

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[10] **"Idaho Researchers Collaborate with US Company to Develop Novel Nuclear Fuel to Preserve, Improve Today's Reactors"**, Idaho National Laboratory, 12 June 2025.

[11] **"U.S. House Passes Ban on Russian Uranium Imports"**, Breakthrough Institute, 13 December 2023.

[12] **"UK Aims for Urenco-Built HALEU Facility by 2031"**, *World Nuclear News*, 8 May 2024.

[13] **"Orano Gives Updates on Uranium Enrichment Plans"**, *World Nuclear News*, 11 September 2023.

[14] Anil Kakodkar, **"Expert Explains | How Thorium Can Power India's 100 GWe by 2047 Mission"**, *The Indian Express*, 16 March 2026.

The US Department of Energy projects that global HALEU demand will exceed 40 tonnes annually by 2030[15]; India's structural exclusion from that supply architecture would be a self-imposed constraint on its advanced-reactor ambitions. A credible Indian HALEU strategy requires three sequenced actions: determining where HALEU genuinely adds value within the three-stage framework, particularly as a bridge to thorium utilisation; developing at least partial domestic enrichment and HALEU fabrication capacity or securing deep long-term alliances with non-Russian suppliers in the US, UK, or France; and constructing the regulatory and safeguards architecture specific to HALEU handling, transport and security.

Whether HALEU-thorium fuel is compatible with current PHWR designs without significant structural modification remains technically flagged by BARC.[16] However, the case for HALEU in India's upcoming advanced reactors and next-generation SMRs remains strategically undeniable. Pursuing advanced-reactor status without addressing HALEU supply would reproduce, at a higher technological level, the very import dependence India is currently working to escape.

Conclusion

India's nuclear trajectory over the next two decades represents one of the most consequential strategic commitments any large democracy is currently undertaking. The internal logic is sound: diversified fuel contracts reduce single-supplier exposure; indigenous SMRs reduce technology dependence; and HALEU optionality preserves advanced-reactor competitiveness. What the logic demands is coherence across all these layers. Energy autonomy in the nuclear domain will not be delivered by any single agreement or reactor design. It will be built, or it will not exist, through the architecture that holds all of them together.

[15] **"DOE Begins Scoping for HALEU Supply"**, *World Nuclear News*, 6 June 2023.

[16] Jacob Koshy, **"Experts Clash Over HALEU-Th Fuel for Indian Nuclear Reactors"**, *The Hindu*, 13 March 2026.

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