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Sustainability

Nuclear energy: One industry, many reactors

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Key takeaways

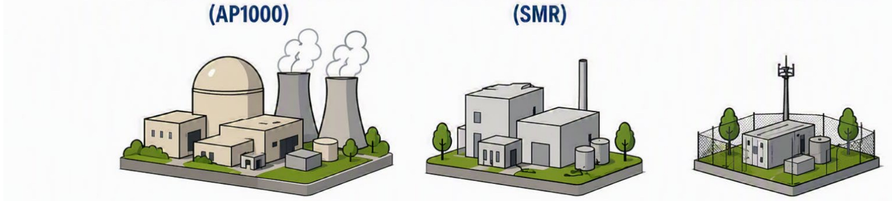
- As power demand grows, nuclear has returned to the forefront of the energy conversation. Yet the industry is far from one-size-fits-all, encompassing a range of reactor technologies designed to serve different markets, applications and deployment models.
- Nuclear power is evolving beyond traditional large-scale reactors. While proven designs continue to anchor utility-scale generation, small modular reactors (SMRs) and microreactors are being developed to serve a broader range of applications through more flexible, modular deployment models, though most remain in the demonstration phase today.
- The future of nuclear deployment will depend on more than reactor design alone. Supply chains, skilled labor, fuel availability and regulatory approvals remain critical challenges, though recent policy initiatives are intended to support licensing, fuel production and broader industry growth.

Nuclear energy has re-emerged at the center of the power conversation, driven by rising electricity demand and tightening supply-demand dynamics across the grid. Yet nuclear is not a single technology. It encompasses a wide range of reactor designs and sizes, each with distinct economics, risks and deployment pathways. Building off our previous nuclear publication (which can be found here: Nuclear energy: Who, what, where, when, why?), this primer unpacks that complexity, grounding the broader nuclear narrative in the practical realities of development, from technology and construction to fuel, licensing and execution.

Reactor sizes

Nuclear power is best understood as a collection of reactor classes differentiated by scale, deployment model and end use (Exhibit 1). Rather than competing directly with one another, these technologies are designed to serve different segments of the power market and, in many cases, can scale alongside one another.

Exhibit 1: Different reactor types have different advantages and risks
Comparison of reactor technologies



	TRADITIONAL REACTOR (AP1000)	SMALL MODULAR REACTOR (SMR)	MICROREACTORS
Firm Capacity (MW)	1,000 – 1,200 MW	20 – 300 MW	1 – 20 MW
Zero-Carbon Generation	●●●●●	●●●●●	●●●●●
Small Footprint / Land Usage	●○○○○	●●●●○	●●●●●
Modularity	●○○○○	●●●●○	●●●●●
Portability	●○○○○	●●○○○	●●●●●

●●●●● = Excellent ●●●●○ = Very Good ●●●○○ = Good ●●○○○ = Fair ●○○○○ = Limited

Source: BofA Global Research

Key Distinctions

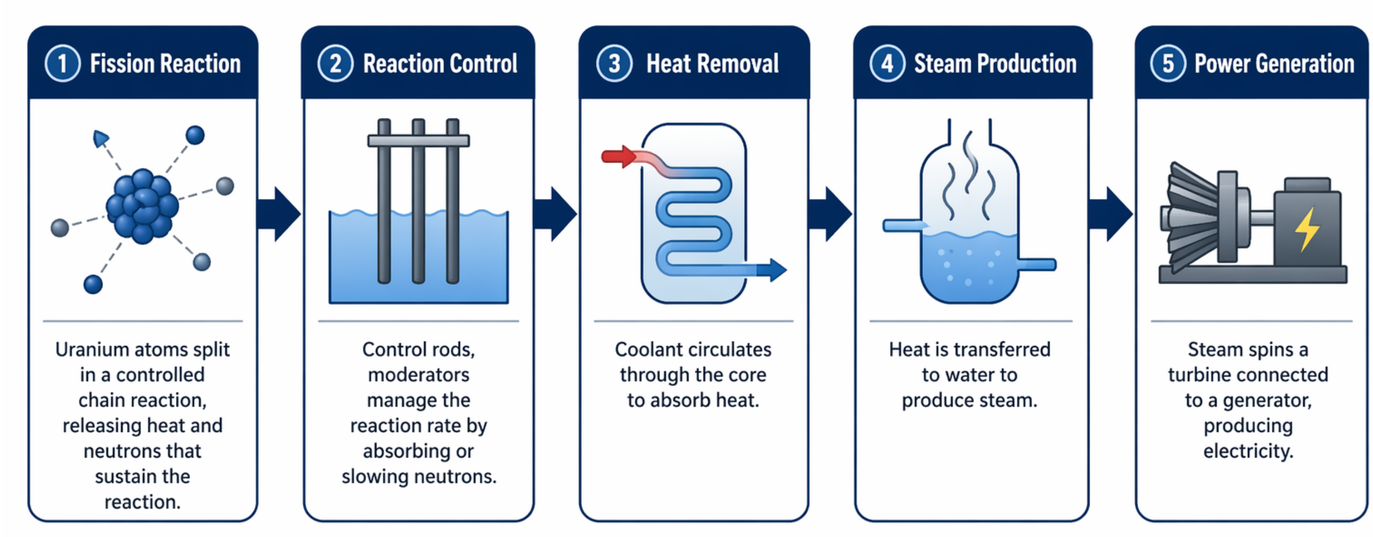
- **Large reactors (≥1 gigawatt (GW)):** Designed for large-scale electricity generation, these reactors provide consistent, high-capacity power and serve as core assets within the grid.
- **Small modular reactors (SMRs)(~50–300 megawatts (MW)):** Mid-scale systems designed for modular deployment across utilities, industrial users and large commercial customers, offering greater flexibility in siting and capacity expansion.
- **Microreactors (≤20 MW):** Small, highly distributed systems intended for niche or off-grid applications where reliability, autonomy or energy security are primary considerations.

Technology

Nuclear power generation is based on a common principle: heat produced from nuclear fission is used to generate steam, which drives a turbine to create electricity (Exhibit 2).

Exhibit 2: In a nuclear reactor, heat is formed by fission

Process for a nuclear fission reaction



Source: BofA Global Research

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Nuclear reactor designs can be grouped based on coolant type, neutron spectrum and fuel configuration. Most reactors currently operating in the US are light-water reactors (LWRs), though a wide range of advanced designs are being developed (Exhibit 3).

Exhibit 3: Gen III & Gen IV+ technologies have different characteristics

Reactor technologies

Reactor Type	Coolant	Moderator	Neutron Spectrum	Operating Temperature	Pressure
Pressurized Water Reactor (PWR)	Water	Light water	Thermal	~300–330°C	High (~150 bar)
Boiling Water Reactor (BWR)	Water	Light water	Thermal	~280–290°C	High (lower than PWR)
Heavy Water Reactor (HWR)	Heavy water	Heavy water	Thermal	~300°C	High
Molten Salt Reactor (MSR)	Molten salt	Graphite (typical)	Thermal / fast (design-dependent)	~600–750°C	Low
High-Temperature Gas Reactor (HTGR)	Helium gas	Graphite	Thermal	~700–800°C	Low
Sodium Fast Reactor (SFR)	Liquid sodium	None	Fast	~450–550°C	Low
Gas-Cooled Fast Reactor (GFR)	Helium gas	None	Fast	~700–850°C	Low

Source: BofA Global Research, Energy Information Administration (EIA), Idaho National Laboratory (INL), Nuclear Regulatory Commission (NRC)

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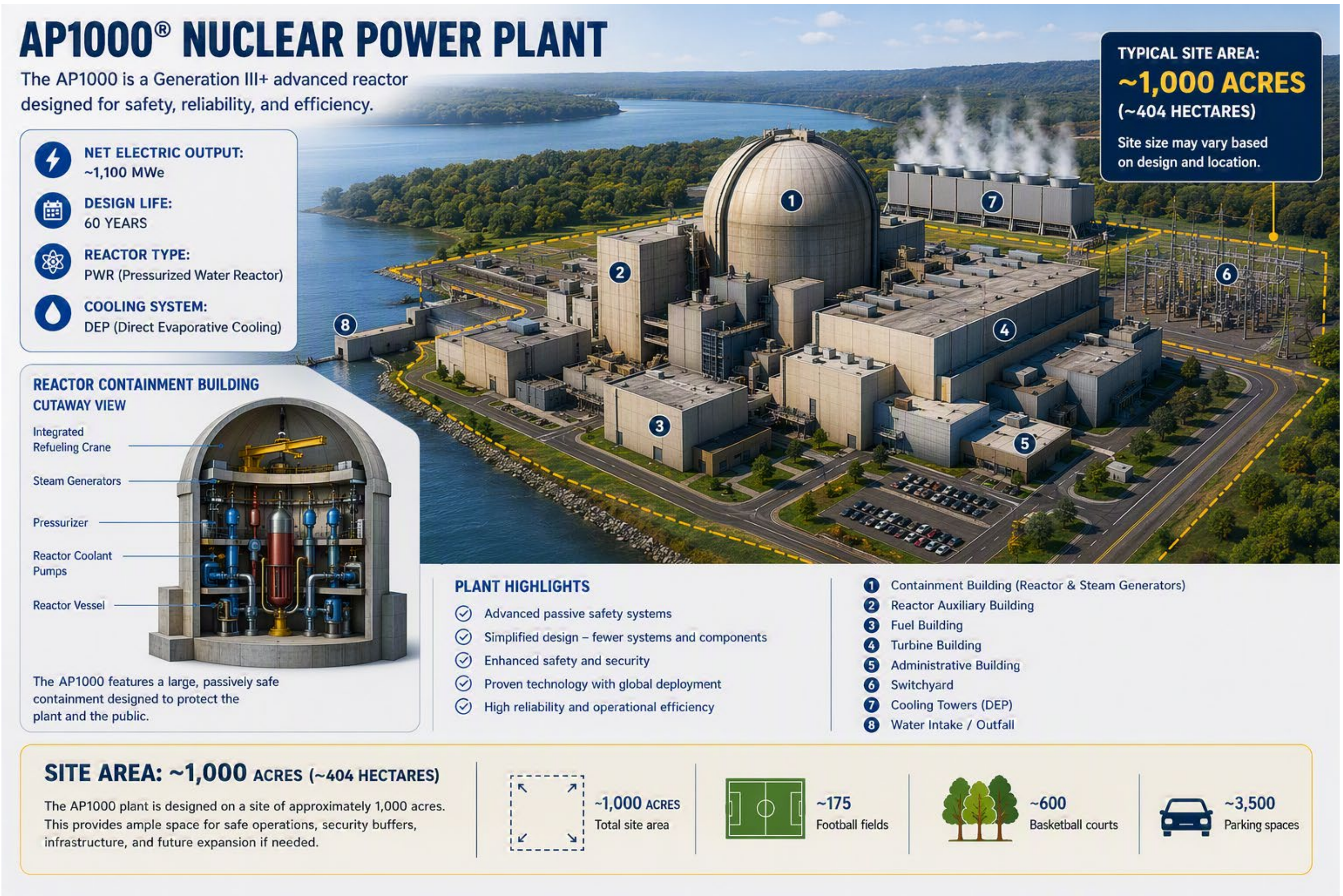
AP1000

The AP1000 is a Generation III+ pressurized water reactor with a capacity of approximately 1.1 GW per unit (Exhibit 4). Its design is centered around passive safety systems that rely on gravity, natural circulation and compressed gas, rather than large numbers of active pumps and diesel-backed safety systems. By reducing the number of safety-critical moving parts, this approach lowers system complexity and supports a more standardized large-reactor platform.

Exhibit 4: AP1000s typically need about 1,000 acres of land
Diagram of an AP1000 nuclear plant



Source: BofA Global Research, Nuclear Regulatory Commission (NRC)

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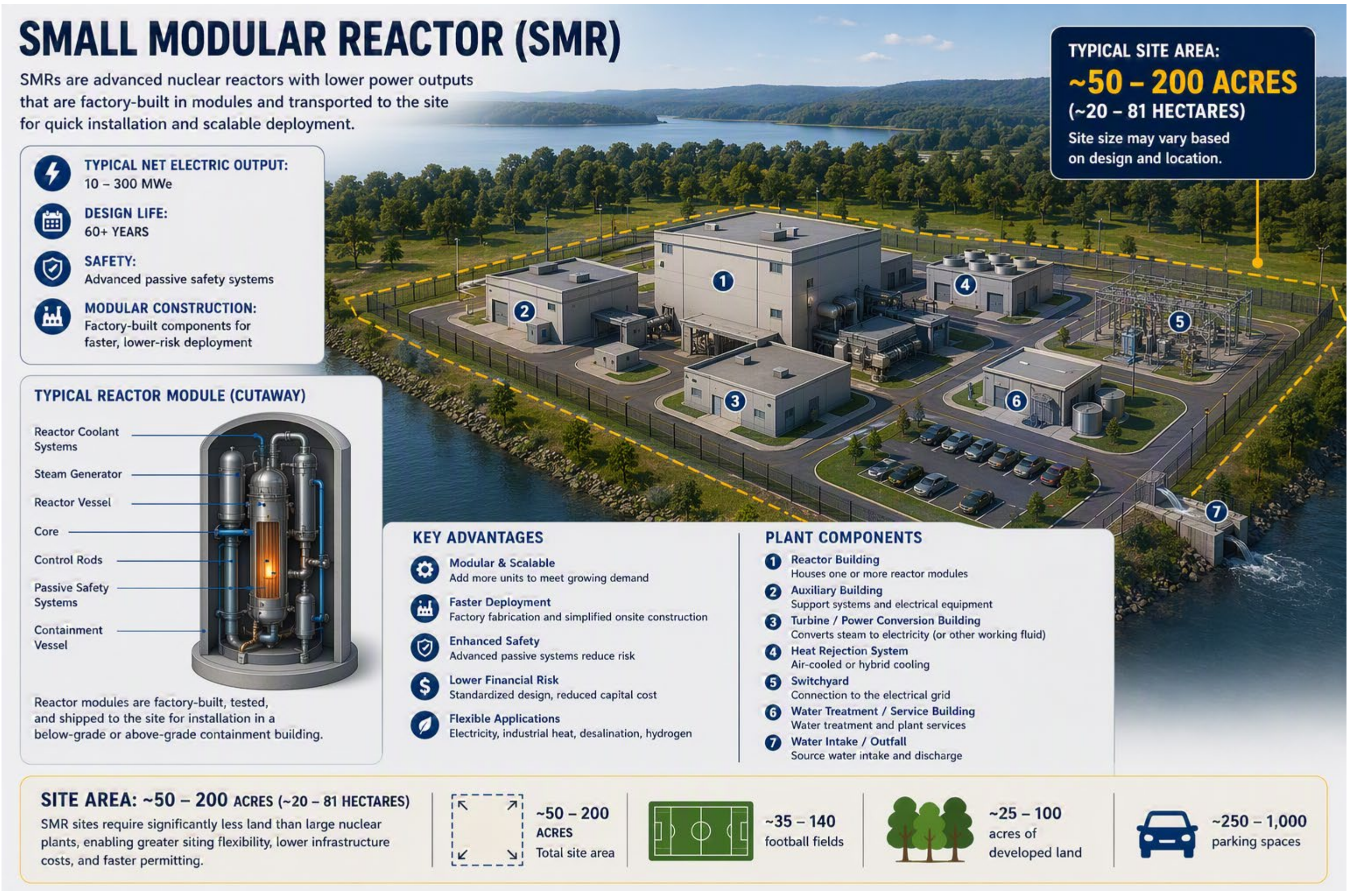
The AP1000's design emphasizes open-top construction, with large structural and equipment modules manufactured offsite and then assembled at the project site. This approach is intended to reduce onsite labor needs, improve quality control through factory fabrication and support a more repeatable, standardized construction process.

The AP1000 is no longer a conceptual technology. It is a licensed, utility-scale nuclear design already operating in the field. As a result, the key remaining considerations center on construction costs, project execution and the economics of deploying additional units, according to BofA Global Research.

SMRs

Small modular reactors (SMRs) are nuclear power plants generally 300 MWe or less per unit and are designed around a factory-based, modular construction model (Exhibit 5). Unlike traditional gigawatt-scale nuclear projects, SMRs represent a shift toward repeatable, standardized deployment (read our prior SMR publication: [Q&A quick guide: Small modular reactors]). Major components can be manufactured in a factory setting and then transported to project sites for assembly, reducing the amount of onsite construction required. Their standardized designs also create opportunities for learning-by-doing, potentially lowering costs over time. In addition, capacity can be added incrementally through discrete modules, allowing capital to be deployed in stages rather than committed upfront.

Exhibit 5: SMRs typically require 50-200 acres of land, depending on design and location
Diagram of an SMR



Source: BofA Global Research, Nuclear Regulatory Commission (NRC)

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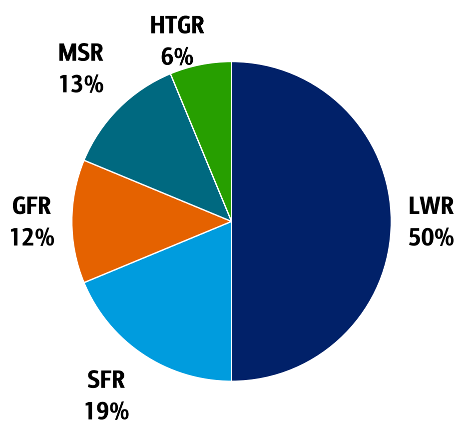
Market landscape

There are dozens of SMR designs globally, with more than 100 projects at various stages of development, though only a limited number are currently operational or under construction. While developers are pursuing a range of reactor technologies, light-water reactor (LWR) designs still dominate the US development landscape (Exhibit 6). According to BofA Global Research, the sector remains largely in a development and demonstration phase rather than broad commercial deployment.

Exhibit 6: LWRs make up 50% of the SMR designs
US SMR designs by technology type (%)



Source: Energy Information Administration (EIA), BofA Global Research

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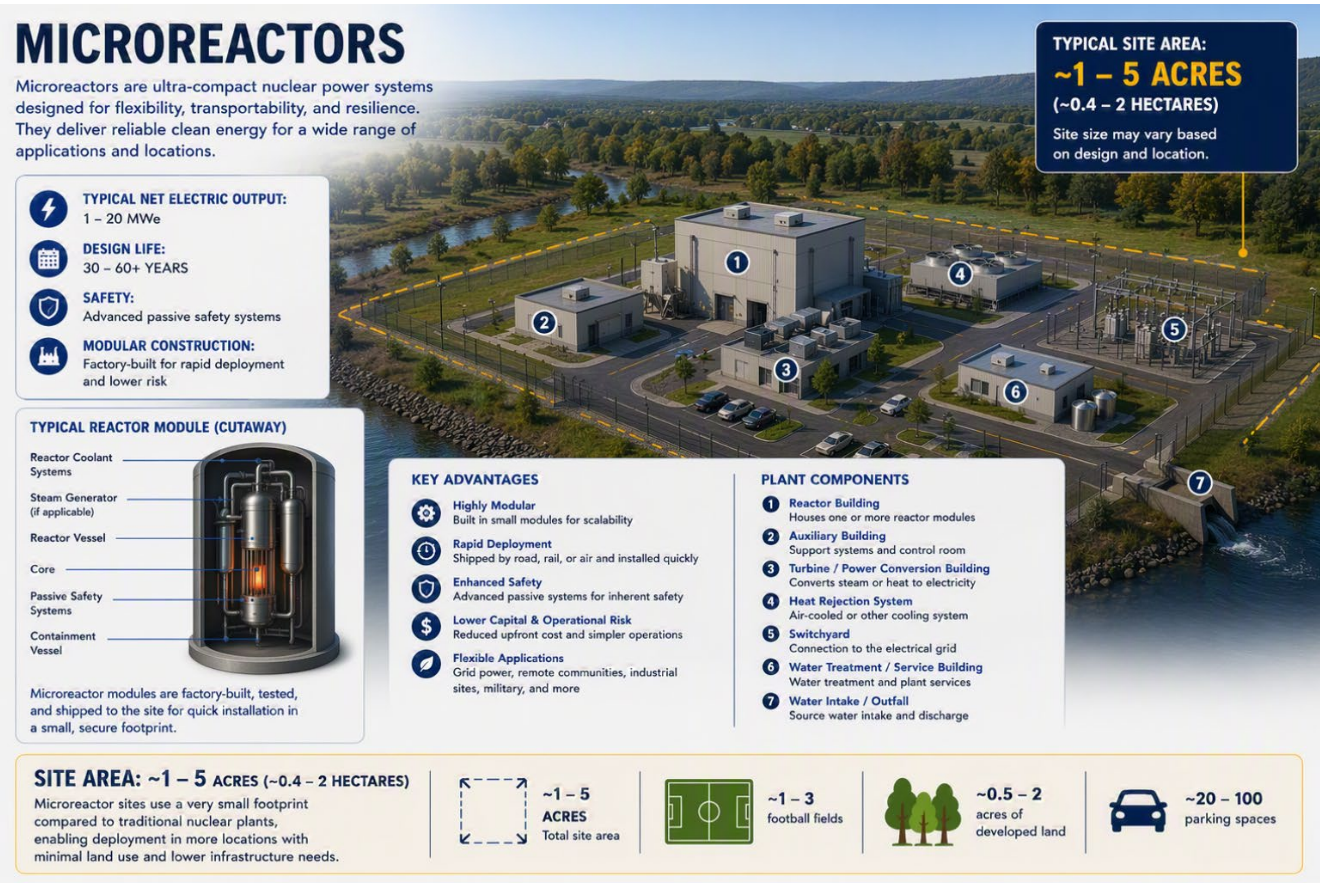
Microreactors

Microreactors are nuclear power systems typically 20 MWe or less per unit, representing the smallest class of advanced reactors (Exhibit 7). They emphasize flexibility, allowing deployment where traditional grid-scale infrastructure is impractical. Many designs incorporate multi-year fuel cycles that reduce refueling requirements and associated logistics burdens, making them particularly attractive for remote communities, industrial sites and defense-related applications.

Exhibit 7: Microreactors need about one to five acres of land depending on the design
Diagram of a microreactor



Source: BofA Global Research, Nuclear Regulatory Commission (NRC)

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Market landscape

A growing number of developers are pursuing microreactor technologies in the US, however, despite increasing interest, most projects remain in the demonstration and pilot phase rather than commercial deployment. According to BofA Global Research, federal government programs continue to play a central role in funding and advancing early deployments, with several initial projects targeted for later this decade.

Supply chain

Large reactors depend on specialized components and complex construction processes, limiting the number of qualified suppliers. Modular designs, on the other hand, shift a greater share of manufacturing from construction sites to factory environments, with the goal of improving consistency, reducing onsite complexity and enabling more standardized deployment. As reactor sizes decrease, component requirements generally become less specialized, expanding the potential supplier base and simplifying project execution.

Workforce availability and quality assurance remain critical across all reactor types. Large projects require significant numbers of skilled tradespeople, including welders, electricians and nuclear-certified inspectors. The US nuclear workforce has declined over prior decades, leading to labor shortages during first-of-a-kind builds.

Fuel

Fuel is one of the most important building blocks in the advanced nuclear ecosystem, as availability, manufacturing capacity and regulatory approval are all critical to deployment. Because many next-generation reactors require specialized fuels, the development of commercial-scale fuel supply chains will be a key factor in determining how quickly advanced nuclear technologies can be brought to market.

HALEU

High-assay low-enriched uranium (HALEU) refers to uranium enriched above the roughly 5% U-235 content used in conventional reactors but below the 20% threshold for highly-enriched uranium. HALEU enables smaller reactor cores and longer fuel cycles, making it a key requirement for many advanced reactor designs.

Historically, commercial HALEU supply has been limited. To address this gap, the Department of Energy launched the HALEU Availability Program in 2024 to support enrichment, fuel processing and deconversion capacity. The government is also working to recover HALEU from existing materials, with a targeted recovery of roughly 10 to 26 metric tons over time.

The first US HALEU production in decades occurred in 2023, though output remains limited. Current production is approximately 900 kilograms annually and is government-owned, with material allocated primarily to research, fuel qualification and early demonstration projects.

TRISO

Tri-structural isotropic particle fuel (TRISO) is key for high-temperature gas-cooled reactors (HTGRs) and certain microreactors. Unlike conventional nuclear fuel, it requires specialized manufacturing and therefore is currently only limited to pilot-scale production. But key development efforts include DOE-led research through the Advanced Gas Reactor (AGR) program and expansion of private-sector manufacturing with DOE support.

Regulatory approval is also required for new fuel designs, manufacturing processes and transportation systems. As a result, scaling TRISO production remains an important step toward the broader deployment of advanced reactors.

Fuel Risk

Fuel availability is a key execution risk for advanced nuclear projects. Many next-generation reactor designs rely on HALEU or TRISO fuel, both of which remain supply-constrained. As a result, reactor technology may be ready before fuel supply is, creating a potential bottleneck for deployment.

Challenges include multi-year lead times for fuel production and certification, potential gaps between reactor licensing and fuel readiness, and the limited supplier base and transportation requirements associated with HALEU. Together, these factors can add uncertainty to project timelines and costs until fuel supply chains reach commercial scale.

Licensing

Licensing is a key determinant of nuclear project timelines, capital deployment and execution risk. Regulatory requirements shape not only whether a project is approved, but also how predictable construction schedules are and how easily reactor designs can be replicated. In the US, commercial reactors are licensed by the Nuclear Regulatory Commission (NRC), whose framework emphasizes safety reviews, environmental assessments and public participation. While this approach provides regulatory certainty, it can also create lengthy approval timelines.

Large light-water reactors benefit from well-established regulatory processes, while frameworks for advanced reactors continue to evolve. For first-of-a-kind projects, licensing can extend four to eight years or longer depending on technology maturity, application quality, public intervention and regulatory resources.

Policy

Recent years have seen a flurry of initiatives to revitalize nuclear energy. A series of coordinated policy moves, demonstration programs, fuel supply efforts and industry partnerships have converged to create the conditions for a potential nuclear resurgence:

- **ADVANCE Act:** Signed into law in July 2024, the ADVANCE (Accelerating Deployment of Versatile, Advanced Nuclear for Clean Energy) Act modernizes the NRC licensing process (making it more affordable and predictable). The legislation also facilitates the siting of new reactors at brownfield sites, supports domestic fuel-cycle capabilities, and includes broader NRC institutional reforms, such as workforce recruitment and retention initiatives, updates to the agency’s mission statement and provisions related to international nuclear cooperation and exports.

- **Executive orders:** On May 23, 2025, the Trump administration issued four executive orders aimed at accelerating US nuclear deployment through licensing reform, expedited reactor testing, expanded national security applications and efforts to strengthen the domestic nuclear fuel and supply chain base. Since their issuance, federal agencies, particularly the Department of Energy, have taken steps to implement these directives. While progress has been made on several fronts, a number of the orders' longer-term objectives remain under active implementation, according to BofA Global Public Policy.

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