

Special Analysis

Evaluating the Potential of Small Modular Reactors for Powering HPC and AI Data Centers

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HYPERION RESEARCH OPINION

Artificial intelligence (AI) and high-performance computing (HPC) are rapidly increasing the energy footprint of modern data centers. With projections suggesting that electricity demand from these facilities could more than double in the next several years, the search for sustainable, reliable, and scalable energy sources has become a priority for data center operators. Among the emerging technologies, small modular reactors (SMRs) are attracting significant attention. Unlike traditional large-scale nuclear plants, SMRs offer modular, compact, and consistent power generation, which may make them well-suited for the operational needs of AI-driven, high-density computing environments.

The past few months have seen a flurry of federal action in the United States aimed at modernizing nuclear energy policy and accelerating the deployment of advanced reactors, including SMRs and microreactors. A series of executive orders and Department of Energy (DOE) initiatives are laying the groundwork for new testing pathways and regulatory reforms that could have far-reaching implications for the HPC and AI market. While the full impact of these changes remains to be seen, the intent is clear: to position advanced nuclear as a central pillar of U.S. energy and technology strategy.

SECTOR ANALYSIS

The rise of large-scale AI workloads, including generative models and advanced scientific computing, has placed unprecedented demands on data center energy infrastructure. Modern AI data centers now often require upwards of 80 megawatts (MW) each, and industry leaders are designing and deploying facilities that may exceed 1 gigawatt (GW) in the future. This scale far exceeds power needs for traditional IT facilities. Renewable energy sources, such as solar and wind, play a growing role but face limitations due to intermittency, storage requirements, and land use constraints.

SMRs, typically generating between 50 MW and 300 MW per unit, could help bridge this gap. Their modular design allows for phased deployment and easier integration alongside urban or industrial sites, where land is often limited or costly. Most importantly, SMRs offer the promise of reliable, around-the-clock, carbon-free power, potentially reducing the need for expensive batteries or fossil fuel-based backup systems.

However, SMRs also face notable downsides and hurdles that must be addressed before they can become a mainstream solution for data centers. High upfront capital costs, unresolved regulatory frameworks, long permitting timelines, and questions about nuclear supply and waste management continue to pose significant challenges.

Policy Drivers

Recent federal policy moves have centered on the idea that U.S. technological and economic leadership will increasingly depend on resilient, scalable energy infrastructure. Executive orders issued in May 2025 call for the expansion of domestic nuclear capacity, streamlined licensing for new reactor designs, and pilot programs to test advanced reactors, including those outside traditional national laboratory settings. Following this direction, the DOE has opened applications for private companies to build and operate test reactors, with some aiming to achieve initial operations as soon as 2026.

A notable aspect of these policies is the explicit connection between advanced nuclear deployment and the evolving needs of digital infrastructure. The White House has designated AI data centers and related computing facilities as “critical defense infrastructure,” making them eligible for prioritized nuclear siting, especially on DOE-controlled land. This reflects both the increasing energy consumption of AI and HPC clusters and concerns about national security and grid resilience.

The DOE has also launched a pilot program to support SMR deployment outside national laboratories to further accelerate commercial adoption. This is complemented by targeted funding—\$900 million across two tiers, with the bulk directed toward “first movers” who can help establish the SMR supply chain and demonstrate initial feasibility.

Technology companies are already responding. In late 2024, Google announced a partnership with Kairos Power to build a series of SMRs, aiming to deliver up to 500 MW by 2035 for its own AI and cloud operations. Other hyperscale providers, including Amazon in partnership with X-energy and Dominion Energy, are exploring similar investments; however, precise timelines for these projects are still being clarified. These early projects could establish proof points for SMR-powered data centers in the next several years.

Implications for Energy Supply for HPC and AI

The deployment of SMRs has the potential to change how data centers and research labs meet their energy needs. Unlike legacy nuclear plants, SMRs can be built incrementally and co-located with data centers, allowing operators to scale capacity as demand grows. SMRs have the potential to be deployed “behind the meter”, serving a single data center or campus directly, although regulations on whether SMRs need to be tied into the broader power grid generally remain undefined. Some DOE pilot programs appear to favor flexible arrangements, but future state and federal regulatory decisions could influence how SMRs are integrated into the power system.

This model could help reduce operational risks from outages or price volatility, both issues that can be particularly disruptive for long-running AI workloads. SMRs may also enable data center operators to secure long-term, fixed-price power agreements, potentially improving financial predictability as compute demand rises. By offering pathways for private companies to construct and operate reactors with DOE authorization, recent federal initiatives are aiming to unlock private investment and create a fast track for demonstration and eventual commercialization.

Market and Strategic Considerations

For the HPC/AI market, these developments present both opportunities and uncertainties. Companies that form early partnerships with SMR developers could realize a valuable edge by locking in access to secure, low-carbon, and scalable power. This is particularly relevant for major cloud and AI providers

whose environmental commitments and reliability requirements favor sustainable and resilient energy sources.

Defense installations and national laboratories are expected to be the first major adopters following federal direction, serving as testbeds for broader commercial rollouts. If SMRs prove successful in these settings, they may be adopted by AI data centers and research campuses, enabling larger and more ambitious AI projects.

Challenges for SMRs

Despite the momentum, significant challenges remain. Regulatory coordination is still evolving, and the roles of the DOE, Department of Defense, and Nuclear Regulatory Commission (NRC) in licensing and oversight are not yet fully defined. As noted by the American Nuclear Society's expert advisory group, uncertainty or overlap in regulatory responsibilities could hinder investment and slow progress.

Additional technical and security challenges have also been raised:

- **Transport and Construction:** While SMRs are modular by design, 300 MW units are still physically large and cannot simply be trucked to a site in one piece. Manufacturing, assembly, and construction logistics may prove complex and costly.
- **Fuel and Proliferation Risk:** There are important questions regarding fuel type and security. Some 50 MW SMR designs may require higher-enriched (potentially weapons-grade) nuclear material, whereas larger SMRs can generally use lower-grade fuel. Widespread deployment of smaller, higher-enriched reactors could raise proliferation and security concerns, requiring careful regulatory oversight and international safeguards.

Environmental regulation is another critical consideration, especially compliance with the National Environmental Policy Act (NEPA). While recent executive orders directed the DOE to streamline NEPA processes, any new reactor project, even those under DOE authority, may still undergo detailed environmental impact assessments. These reviews are intended to ensure that siting, construction, and operation do not result in significant harm to local communities or ecosystems. However, if not managed carefully, NEPA compliance could introduce delays, especially if projects face legal challenges or strong public opposition. Efforts to expedite environmental reviews could themselves generate pushback if stakeholders perceive that safeguards are being weakened.

Public acceptance and local siting issues, while perhaps less pronounced for SMRs than for larger reactors, can still present obstacles. Additionally, the ultimate success of these initiatives will depend on ongoing federal investment, effective interagency cooperation, and the development of a robust nuclear workforce and supply chain.

FUTURE OUTLOOK

SMR technology is still in its demonstration phase. Early hyperscalers and DOE pilot programs will help validate the practical feasibility of SMRs for data center applications. As regulatory frameworks mature and supply chains stabilize, SMRs could eventually become commercially attractive for larger-scale deployment. Their modularity offers the flexibility to integrate SMRs into both new and existing data center sites. Still, it may be several years before SMRs achieve widespread commercial adoption at the scale needed to power the next generation of supercomputers and AI workloads.

Globally, the U.S. is not alone in pursuing SMR innovation. Canada, China, and Russia are all making significant investments, and each is positioning SMRs as part of their national energy and technology strategies. For example, China's Linglong One, a 125 MW SMR designed for power generation and industrial use, is slated to become operational in late 2025. In addition, Russia continues to export SMR technology internationally.

By providing the HPC and AI sectors with a potential pathway to reliable, secure, carbon-free, and scalable power, SMRs could become an important part of the data center energy mix. Realizing this vision, however, will require ongoing regulatory modernization, workforce development, and public engagement.

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