EPRI

BACK POCKET INSIGHT

P178 RESOURCE PLANNING FOR ELECTRIC POWER SYSTEMS

Advanced Nuclear Reactors in Energy System Resource Planning

by Todd Gorgian and Romey James

Nuclear reactors have provided dispatchable, reliable, carbon-free baseload electricity for decades. Advanced reactors (ARs) may retain these core benefits while also improving safety, having a smaller physical footprint, achieving greater operational flexibility, and providing process heat to decarbonize other economic sectors. These capabilities may allow greater integration of intermittent renewable energy resources while enhancing energy system diversity, reliability, and resiliency.

There are currently 400+ operating commercial nuclear reactors worldwide. Over 80% are light water reactors (LWRs), which use ordinary water as a coolant and transfer heat from a fission reactor to steam turbines that generate electricity. While conventional LWR designs remain the predominant nuclear technology to date, ARs may emerge as a viable option in the coming decade(s). ARs incorporate changes in the use of materials and fuels, system configurations, deployment models, and/or operating paradigms beyond current mature commercial offerings. ARs, defined by EPRI as reactors beyond Generation III/III+ technologies, encompass non-light water designs, light water small modular reactors (lwSMRs), and microreactors. Small modular reactors (SMRs) typically have less than 300 MWe output, featuring modular-based construction and assembly, while microreactors are a subset with less than 50 MWe output.

KEY INSIGHTS

- Advanced reactors (ARs) may offer compelling benefits to energy system portfolios. ARs reactors broadly refer to non-water-cooled designs and light water small modular reactors.
- ARs may achieve lower capital costs and shorter construction timelines through simpler designs and modular manufacturing and assembly. They may also allow flexibility in plant scale and siting.
- AR costs are expected to be high initially and decrease with deployment. Their modularity may enable considerable cost reductions not seen before for nuclear power.
- The Inflation Reduction Act of 2022 offers technology-neutral tax credits for which nuclear is eligible.

Generation III/III+ Large LWRs
ABWR* 1,350 MWe GE Hitachi/Toshiba **AP1000*** 1,117 MWe Westinghouse **APR1400*** 1,450 MWe South Korea **ESBWR*** 1,520 MWe GE Hitachi

* Has received the U.S. Nuclear Regulatory Commission (NRC) license
† Has begun NRC pre-licensing activities
Δ Is a demonstration reactor
^ No commercial option available yet

Advanced Reactors	
Non-Light Water-Cooled	**Light Water-Cooled**
Natrium Reactor† 345 – 500 MWe TerraPower **KP-FHR*Δ** 140 MWe Kairos Power **Xe-100†** 80 MWe (Module); 320 MWe (Plant) X-energy SFR (Russia); HTGR^; MSR^; GFR^; SCWR^	**BWRX-300†** 300 MWe GE Hitachi **SMR-160† | SMR-300** 160 MWe | 300 MWe Holtec† **VOYGR™*** 77 MWe (Module); 308, 462, 924 MWe (Plant) NuScale

SFR = Sodium Fast Reactor; HTGR = High-temperature Gas Reactor; MSR = Molten Salt Reactor; GFR = Gas Fast Reactor; SCWR = Supercritical Water-cooled Reactor

If commercialized, ARs may offer substantial improvements over conventional nuclear with respect to economics, performance, safety, and energy security. Smaller and more modular reactors may allow superior deployment flexibility: scalability (deployed at scale needed), siting flexibility (deployed where needed), and constructability (deployed on schedule and on budget). However, the technology itself is not sufficient to unlock AR's full potential in energy portfolios. Regulatory infrastructure, public perception, supply chain, and project execution are key challenges. No reactor has yet been fabricated in a factory and transported to a site for assembly. This creates uncertainty and first-mover risk.

First-of-a-kind costs are expected to be much higher than n^{th}-of-a-kind costs. Future cost reduction may arise through economies of scale in component manufacturing and utilizing advanced manufacturing techniques for increased standardization and automation in assembly.

The Inflation Reduction Act of 2022 (IRA) allows new technology-neutral investment tax credits (ITC) and production tax credits (PTC) starting in 2025 for any new technology with zero GHG emissions intensity, including new nuclear. Due to the historically high capital costs of nuclear projects, the ITC is likely more advantageous than the PTC. The IRA is expected to boost private sector investment and engagement in the development of AR designs and nuclear fuel fabrication facilities.

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