CRS INSIGHT

Small Modular Nuclear Reactors: Status and Issues

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Small modular reactors (SMRs) are nuclear reactors that are sized to be suitable for modular construction. SMRs are generally defined as having electric generating capacity of 300 megawatts (MWe) or less, in contrast to existing nuclear power reactors, which typically exceed 1,000 MWe. A wide variety of nuclear technologies could be used in SMRs, in addition to the conventional light water reactor (LWR) technology in existing U.S. commercial nuclear plants. Many SMR designs are still in development stages, and the projected timelines for initial deployment of SMRs generally range from the present to 2030.

SMRs could offer several benefits relative to large-scale reactors. SMRs require less initial capital investment and allow for greater flexibility in siting and total power output. According to SMR supporters, deploying multiple SMRs sequentially at a single plant site could create the same generating capacity as a full-scale nuclear plant with less financial risk, because each module could begin producing electricity and revenue as soon as it is completed, rather than having to wait for completion of a single large reactor. Most SMR designs employ passive safety concepts for accident mitigation (relying on gravity, natural convection, and other non-mechanical phenomena), reducing reliance on active safety systems.

However, SMRs may also have significant drawbacks. Since SMRs do not have the same economies of scale as larger reactors, they may produce electricity at a higher cost per kilowatt-hour than other energy sources, including existing commercial reactors. The Union of Concerned Scientists raises this point in a 2013 publication critiquing SMRs, which also contends that the inherent safety features of SMR concepts are untested. The lower capital investment required for SMR construction has also been called into question by the Institute for

Energy and Environmental Research, which contends that construction of a modular nuclear plant would require costly early construction of shared facilities, such as a containment structure, intended for use with all planned reactor modules.

The potential impact of SMR technologies on weapons proliferation is unclear. Proliferation concerns for reactors center on nuclear fuel—specifically, the requisite level of enrichment of uranium fuel and reprocessing of spent fuel. SMR technologies requiring higher-enriched uranium fuel would pose a greater proliferation risk relative to typical nuclear power reactors, which use uranium enriched to about 5% of the fissile isotope U-235. In contrast, some advanced SMR concepts use 15-20% enriched uranium (see **Table 1**). The planned treatment of spent fuel for proposed SMR concepts varies, with some developers suggesting that sealed SMR cores could be manufactured, shipped to the site of the power plant, and shipped back to the manufacturer at the end of the core lifetime, still sealed. However, such systems could face technical barriers to safe transportation, and experts disagree on whether sealed cores would decrease the proliferation risk, since they would require relatively high enrichment levels.

To date, the International Atomic Energy Agency (IAEA) identifies 40 small and medium-sized reactor designs under development. SMR concepts using coolants other than light (ordinary) water are less technically understood than water-cooled concepts, and will require further research before commercialization. **Table 1** summarizes SMR development status.

Table 1. SMR Technologies

	Water-Cooled	High Temperature Gas-Cooled	Liquid-Metal Cooled Fast Neutron	Molten-Salt Cooled
Coolant	Light water	Helium	Sodium, lead-bismuth, or lead	Fluoride salt coolant
Moderator	Light water or heavy water	Graphite	No moderator	Graphite
Fuel	Less than 5% enriched uranium	Up to 20% enriched uranium, in fuel pebbles	15-20% enriched uranium	Thorium or low-enriched uranium fuel salt, potentially dissolved into coolant
Sample projects	CNP-300, China PHWR-220, India KLT-40S, Russia	HTR-PM, China	SVBR-100, Russia	IMSR, Canada

Deployment status (nearest-term projects)	Operational (China, Pakistan, India)	Under construction (China)	Under construction (Russia)	In design certification, projected deployment in early 2020s (Canada)

Source: International Atomic Energy Agency, World Nuclear Association, Ux Consulting.

Notes: In reactors, a moderator is a substance that slows down neutrons, which increases the chance that a given neutron will cause fission in a fuel atom.

In recent years, U.S. interest in SMR development has increased. The Department of Energy (DOE) began the SMR Licensing Technical Support (LTS) program in 2012 to accelerate deployment of near-term SMR projects. DOE also has provided some funding for non-LWR SMR concepts through the Office of Advanced Reactor Technologies. The LTS program is scheduled to conclude in 2017.

- The first grant awarded under DOE's LTS program was a 50-50 cost-share to Babcock and Wilcox (B&W) in November 2012, to support the development of the 180 MWe mPower design. However, B&W shelved the project in April 2014 due to lack of investors, and DOE stopped sending funds in November 2014. The mPower project was terminated in March 2017.
- In March 2013, DOE granted another award through its LTS program to NuScale Power to support development of its 45 MWe design. DOE allocated up to $217 million over five years in a 50-50 cost-share. NuScale projects that a demonstration of its SMR will be operational at Idaho National Laboratory by 2024.
- In March 2012, DOE signed agreements with three companies to allow construction of demonstration small reactors at the Savannah River Site (SRS) facility using private-sector funding. However, interest in the proposed SRS demonstrations reportedly has waned in recent years.
- In 2016, a group of U.S. SMR developers and potential customers formed the SMR Start consortium to advocate for increased government support for commercialization of SMR designs. SMR Start calls for the DOE's LTS program to be extended to 2025 with increased funding.

Continued SMR development would be supported by several bills currently pending in the 115th Congress. The Advanced Nuclear Energy Technologies Act (S. 1457, Sec. 640) specifically names reactors "of modular size" as a type of advanced nuclear reactor requiring further research and development. Additionally, Section 106 of the Nuclear Energy Innovation and Modernization Act (S. 512) would require the Nuclear Regulatory Commission to report on emergency planning zones for SMRs. The nuclear provisions in the Energy and Natural Resources Act of 2017 (S. 1460) are similar to those of S. 1457.

This CRS Insight was originally prepared by research associate Luisa Kenausis.