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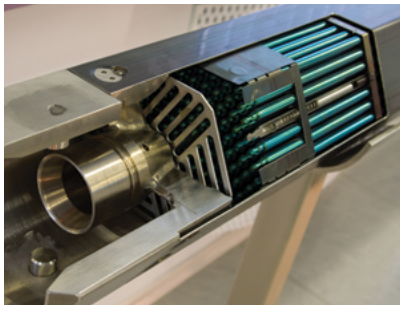
Emerging technology snapshot

Small modular reactors

Small Modular Reactors (SMRs) are nuclear fission reactors capable of generating up to 300MWe and are inclusive of microreactors (up to 30MWe). Their relatively enhanced safety, smaller size, modularity and potential for transportability offers possible advantages in a variety of civilian and military applications when compared to conventional nuclear reactors. Design, licensing, supply chain issues and public perceptions are some of the challenges to overcome for widespread acceptance.



Enabling Science and Technology

Accident tolerant fuels

Advancements in accident tolerant fuels and components offer better performance and enhanced safety. Examples include advanced cladding materials, doped pellets, TRistructural-ISOtropic particle (TRISO) - fuels (which are more resistant to oxidation, corrosion, and irradiation than traditional reactor fuels) and novel designs such as extruded metallic fuel rods.

Components

The physical components of SMRs like cooling systems, reactor cores and heat pipes are hot topics in research and patenting. Safety enhancing features including containment vessel shielding and cooling systems, integrated reactor systems, enhanced heat exchangers and self-diagnosing autonomous reactors are all under active development.

Climate change mitigation

SMRs can alleviate carbon emissions from fossil-fuel based systems and could replace diesel generators in Canada's North. SMRs can be integrated with other systems to produce both power and heat for industrial applications, and can be combined with renewable energy sources like wind and solar to create hybrid systems that take advantage of the benefits offered by each technology.

Hydrogen production

Hydrogen, produced from water electrolysis, is viewed as a key component towards achieving net-zero emissions. SMRs offer one of the most promising innovations for hydrogen production, since they produce the high temperatures needed to generate hydrogen. The UK government has set a target for a demonstrator by the early 2030s.

Military applications

SMRs could provide low-maintenance, long-running, reliable and scalable mobile power for military use. Applications include the use of floating SMRs to power weapons systems, microreactors capable of powering underwater reconnaissance drones, desalinization of water for remote bases, ship propulsion and energy supply for arctic and/or forward military bases.

"SMRs could fulfil the need of flexible power generation for a wider range of users and applications, including replacing aging fossil power plants, providing cogeneration for developing countries with small electricity grids, remote and off grid areas, and enabling hybrid nuclear/ renewables energy systems."

Advances in Small Modular Reactor Technology Developments, International Atomic Energy Agency, 2020.

Signals

Academic
Academic literature is dominated by China, with seven of the top ten organizations by publication volume. The US ranks second and Canada third, led by the University of Regina, Canadian Nuclear Laboratories and Ontario Tech University.

Government
Canada's Small Modular Reactor (SMR) Action Plan is Canada's plan for the development, demonstration and deployment of SMRs for multiple applications at home and abroad.

Collaboration
In March 2022, the governments of Alberta, Saskatchewan, Ontario and New Brunswick announced a joint strategic plan for the use and deployment of SMRs in their respective provinces.

Defence
In 2022, the US Department of Defense (DoD) invested ~US$300 million in Project Pele, a high-temperature, gas-cooled microreactor to be designed by BWXT Technologies and slated for testing in 2025.

Corporate
Companies actively pursuing Canadian SMR deployments include Global First Power, Terrestrial Energy, Holtec International, GE Hitachi Nuclear Energy, X Energy, Moltex Energy and Advanced Reactor Concepts.

"While the upfront costs may be lower than conventional nuclear reactors, SMRs will still need years, if not decades, to pay back their investment, raising worries that SMRs could fall into the same pits as their bigger brethren."

Irfan, U. The nuclear industry's big bet on going small, June 27, 2023.

Impact

Social
Although SMRs provide carbon-free electricity, and some countries are adding new capacity, public opposition and safety concerns have led many to begin phasing out nuclear power.

Policy
The International Atomic Energy Agency (IAEA), of which Canada is a Board member, has launched a Nuclear Harmonization and Standardization Initiative to accelerate the safe and effective deployment of SMRs through common regulatory and industrial approaches.

Economic
SMRs can potentially cut build times in half and lower costs through factory manufacturing, scalable designs and portability when compared to conventional nuclear reactors.

Environmental
To meet net-zero goals the IAEA estimates a need for global nuclear capacity, such as SMRs and microreactors, to expand by 10GWe per year until 2030.

Defence
SMRs could potentially offer safety and security benefits for defence applications, ensuring operational readiness by providing safe and continuous power, while supporting greenhouse gas emission reductions.

"Ninety percent of US military installations have an average annual energy use that can be met by an installed capacity of nuclear power of 40 MWe or less. Most DoD installations will seek one or more microreactors in the 2 MWe to 10 MWe range."

Roadmap for the Deployment of Microreactors for U.S. Department of Defense Domestic Installations. Nuclear Energy Institute, October 2018.

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