Small Modular Reactor Basics

Canadian Nuclear Association

Why small modular reactors (SMRs)?

Reactors on a much smaller scale and in larger numbers than are built today could deliver low-carbon power to homes, offices and businesses, process heat to industry, heat to buildings, and clean fuels such as battery charging or hydrogen for vehicles. The industry making them could:

- Move servicing and refuelling to more **controlled conditions**.
- Achieve **economies of scale in production** of reactors (the reactors may be smaller, but could be more standardized and produced at a lower cost per megawatt).
- **Simplify designs** and add many "**passive safety**" systems.
- **Move the reactor site** occasionally, possibly by installing reactors on floating platforms.
- Locate reactors deep underground or underwater, **avoiding security costs**.
- Have fleets of reactors **operated remotely** from a central control facility.

Canada is an especially promising market for SMRs due to the number of northern, remote and aboriginal communities where SMRs could promote health and economic growth by displacing dirty, expensive diesel generators.

Canada's Energy and Mines Ministers made advancing technology-based energy solutions for these communities a priority of their Distributed Power Generation Action Plan.

Reactors don't need to be big

Most nuclear power reactors are built to a certain scale (600-1000 megawatts of electricity, or MWe), from a reasonable assumption that large scale would minimize power cost.

Nuclear reactors can be orders of magnitude smaller than this. **Reactors that drive marine vessels** (submarines, aircraft carriers and icebreakers) are much smaller than most power plant reactors. These **propulsion reactors** have a sixty-year record of operating in hundreds of moving vessels that spend long periods in **remote places**.

Demonstration units (Canada's early NPD and Douglas Point reactors) and research units (currently operating at six Canadian universities and at research institutes around the world) are also small, extremely low-power, very safe, easy to govern/operate and easily secured. **Canada's AECL (now CNL and SNC) designed small or very small reactors** for research, electricity generation, and district heating.

The Canadian Nuclear Association uses the term SMR to cover both small (about 50 to 300 MWe) and very small (VSMRs -- under 50 MWe) modular reactors.

Who offers small modular reactor designs?

- **Existing vendors** of reactors or major components (examples are SNCL/Candu, Toshiba-Westinghouse, GE-Hitachi, BWXT), with existing markets and demonstrated capabilities.
- Less-known **"start-up" or venture firms**, usually with less familiar reactor technologies (examples are Terrestrial, NuScale, StarCore, Dunedin).

What are the applications?

SMRs are applicable in a wider range of situations than current power reactors:

- **Smaller or decentralized grids**
- Power for **remote communities**
- **District heating**
- **Resource processing**
- **Desalinating seawater**

What's needed to bring the benefits of SMRs to Canadians?

Canada's nuclear industry has discussed SMR issues with Canadian and international policymakers and regulators. Much of this discussion has dealt less with the reactor technology itself than with the systems that support it and enable its benefits.

We all know that aircraft alone can't deliver air travel. A complete set of industry systems is involved: airports, air crews, ground support, traffic control, fuel, maintenance, and good safety regulation. Energy systems similarly require a complete infrastructure, all parts of which add value, employment and knowledge.

International collaboration

The advantages of SMRs are gained by making them in quantity, which works better if we have internationally agreed designs and standards. Canada's closest partners, including the United Kingdom and the United States, are committed to developing SMR technologies.

Due to global awareness of climate change and the need to reach zero net GHG emissions within a few decades, and of the link between electrification and human development in emerging economies, there is increasing acceptance in policy circles that nuclear has a major role to play in the world's shift toward low-carbon energy and greater electricity demand.

SMRs are internationally recognized as an important part of the climate change toolkit, particularly in the USA, UK, Russia, France and China. A Canadian effort that committed to realizing SMRs' potential to cut GHG emissions would not be working alone.

Regulation

Canada's nuclear regulators focus on demonstrating the safety of an entire operating system. This could enable more innovative approaches than the prescriptive measures imposed by some other major jurisdictions. The nuclear industry is talking about SMRs with Canadian and international regulators.

Transport

If SMRs are fuelled and refuelled in a service facility, rather than on the operating site, then the fuelled reactor would be transported as a sealed unit from the facility to the site (and back for servicing or decommissioning). While transport of radioactive materials has an outstanding safety record, particularly in Canada, this nevertheless presents an important challenge for proponents, cargo contractors, regulators (Transport Canada and CNSC) and route communities.

Fuel and waste management

SMR and VSMR designs potentially involve very different fuels and cooling systems from the current fleet of large power reactors, achieving dramatically new levels of efficiency, simplicity, and safety. For Canada, more than in past decades, deploying some of these designs could involve dealing with enriched materials. In most designs, fuel removal and replacement would take place in a service facility, rather than on site, which should also improve efficiency and safety.

Security and safeguards

Manufacturing, fuelling, refuelling and decommissioning small reactors in a factory-like service facility, rather than on the operating site, holds great potential to further strengthen the security and safety of fissile materials and to tighten protections against the unauthorized spread of materials and technologies.

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