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'The next wave of innovation': Nuclear reactors of the future are small and modular

The pros and cons of small modular reactors and where we could see them generating nuclear power

Emily Chung · CBC News · Posted: Jun 25, 2019 4:00 AM ET | Last Updated: July 4

An illustration shows a NuScale Power module on a truck. NuScale is one of the small modular reactor companies whose designs are going through pre-licensing approval with Canada's nuclear regulator. Many are designed to be small enough to transport by truck or by shipping container. (NuScale Power)

*This story is part of a CBC News series entitled **In Our Backyard**, which looks at the effects climate change is having in Canada, from extreme weather events to how it's reshaping our economy.*

The devastating impacts of climate change caused by burning fossil fuels are forcing countries around the world to look for zero-emissions alternatives for generating electricity.

One such alternative is nuclear energy, and the International Energy Agency — a group focused on energy security, development and environmental sustainability for 30-member countries — says the transition to a cleaner energy system will be drastically harder without it.

Canada's government appears to be on board, saying nuclear innovation plays a "critical role" in reducing greenhouse gas emissions as Canada moves toward a low-carbon future.

While husky Candu reactors have powered some Canadian communities for decades, governments are now eyeing technology of a different scale. The federal government describes small modular reactors (SMR), as the "next wave of innovation" in nuclear energy technology and an "important technology opportunity for Canada."

Here's what you need to know about them.

What's a small modular reactor?

Traditional nuclear reactors used in Canada can typically generate about 800 megawatts of electricity, or about enough to power about 600,000 homes at once (assuming that 1 megawatt can power about 750 homes).

The International Atomic Energy Agency (IAEA), the UN organization for nuclear co-operation, considers a nuclear reactor to be "small" if it generates under 300 megawatts.

Designs for small reactors ranging from just 3 megawatts to 300 megawatts have been submitted to Canada's nuclear regulator, the Canadian Nuclear Safety Commission, for review as part of a pre-licensing process.

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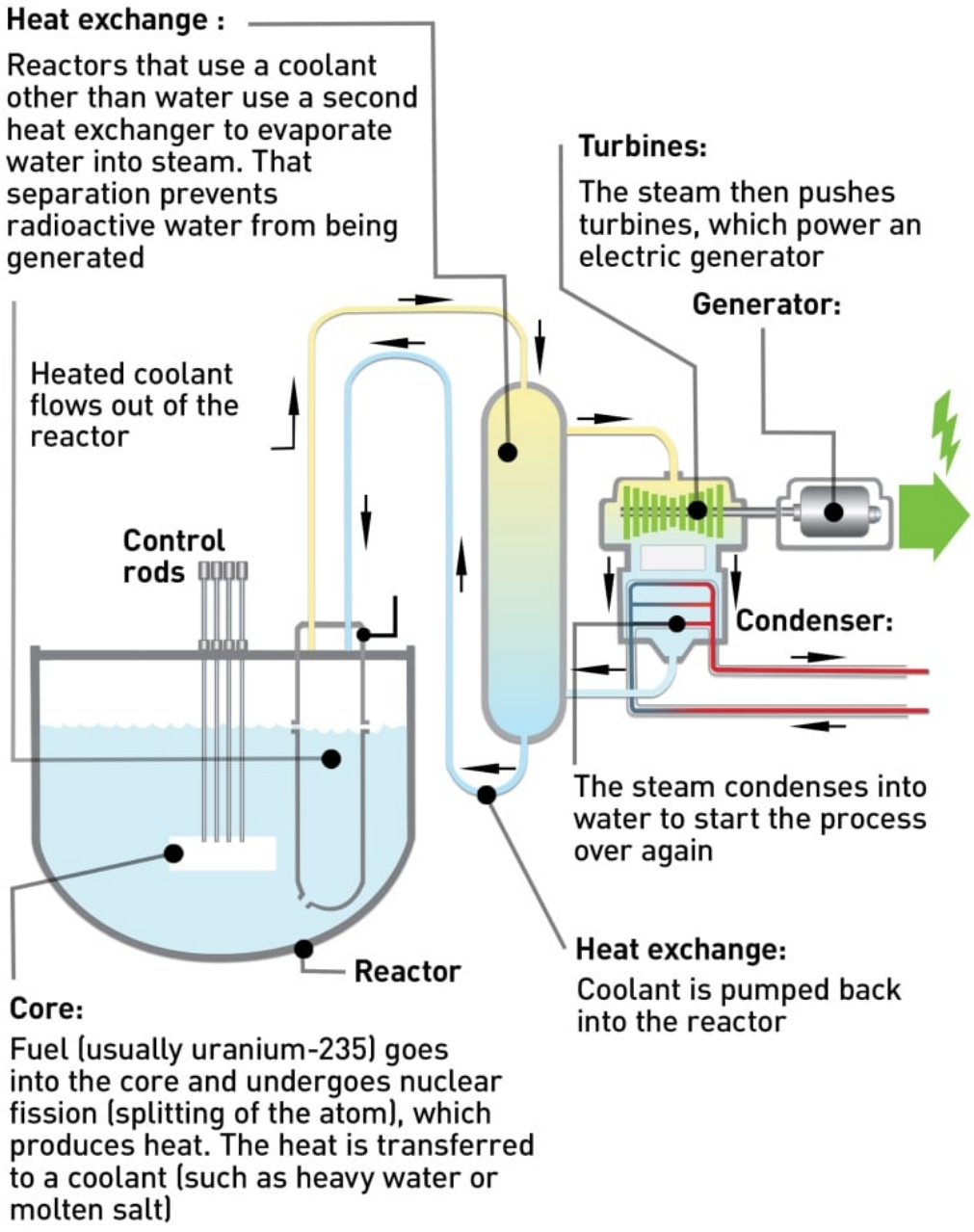
Such reactors are considered "modular" because they're designed to work either independently or as modules in a bigger complex (as is already the case with traditional, larger reactors at most Canadian nuclear power plants.) A power plant could be expanded incrementally by adding additional modules.

- Decline in nuclear power threatens global climate goals, IEA says

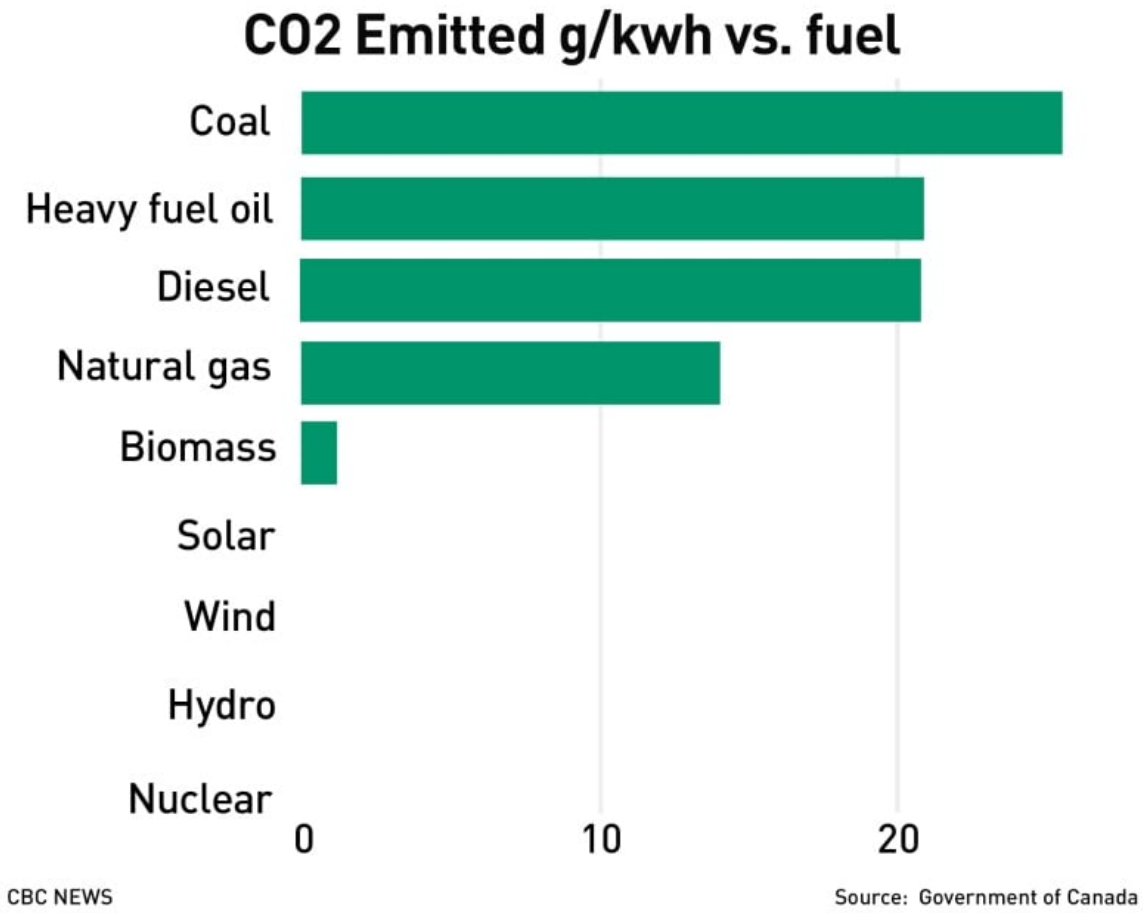
Modules are generally designed to be small enough to make in a factory and be transported easily — for example, via a standard shipping container.



How do nuclear reactors generate electricity?

Nuclear reactors of all sizes are powered by nuclear fission — the process of splitting atoms of nuclear fuel, typically uranium, into smaller atoms. That generates heat.

In thermal power plants, the heat turns water into steam, and the steam pushes turbines that generate electricity. That part of the process is the same whether the heat is generated by nuclear power, burning fossil fuels such as coal or natural gas, or even concentrated solar energy.



Carbon dioxide emissions for different kinds of fuels: coal, heavy fuel oil, diesel, natural gas, biomass, solar, wind, hydro and nuclear. (CBC News)

What are the advantages of SMRs over traditional nuclear power plants?

Canada's government says SMRs are designed to have lower upfront capital costs and enhanced safety features compared to traditional reactors.

Because of their small size, most could be completely built in a factory and installed module by module, making construction quicker, more efficient and theoretically cheaper, according to the World Nuclear Association, which represents the nuclear industry. Upfront costs, especially, would be lower, since modules could be added as needed instead of being paid for all at once.

Another feature that is predicted to lower the cost is that it's easier to cool SMRs because of their larger surface area-to-volume ratio. That means their safety systems don't need to be as complex. Most can rely on "passive" built-in safety features in the event of a malfunction, rather than special systems that need to be activated.

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Are there other differences between SMRs and traditional nuclear power plants?

Some SMR designs are effectively scaled-down versions of traditional nuclear reactors, but some also incorporate next-generation nuclear technologies and designs.

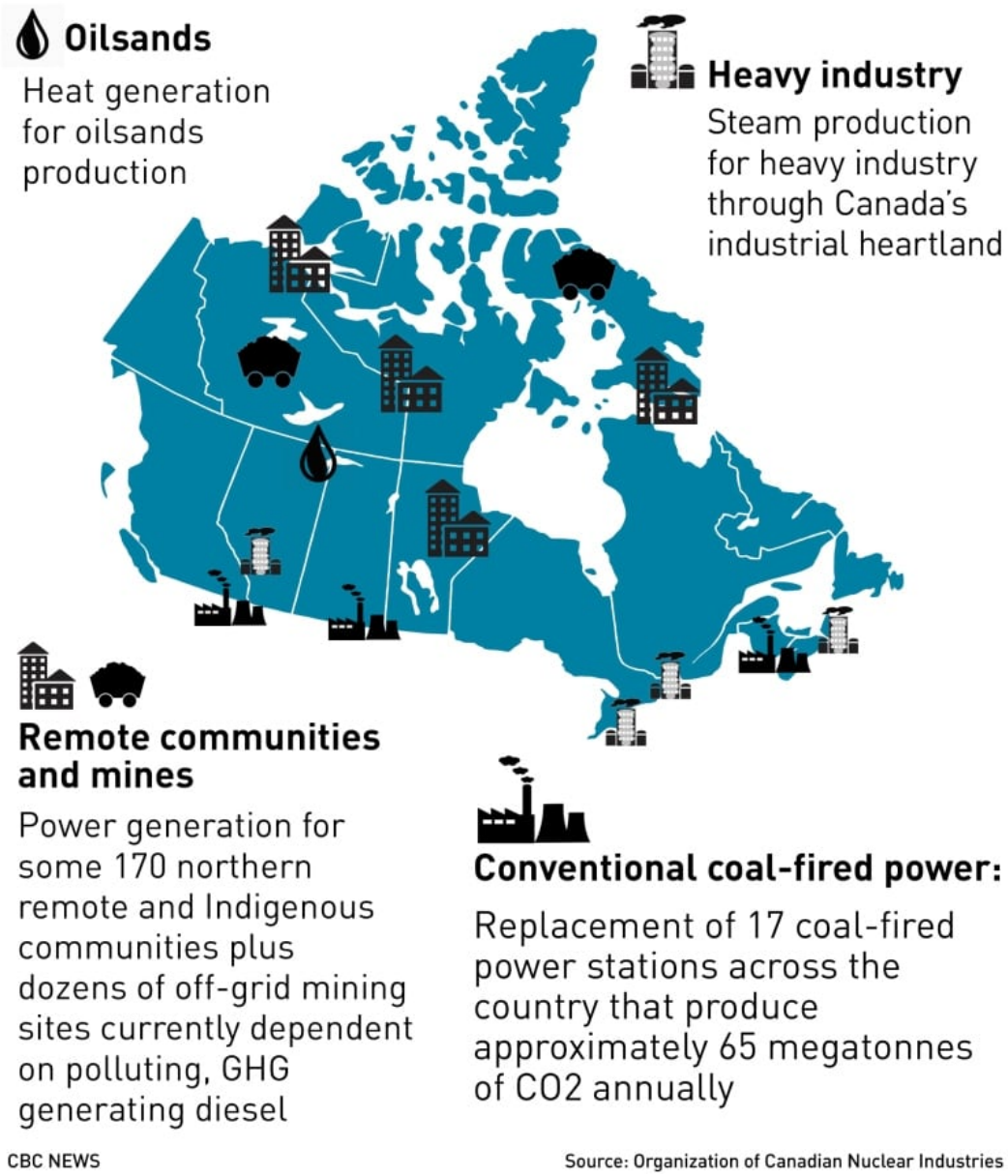
For example:

- **Molten salt reactors** that use molten salt — salt that has melted into a liquid at high temperatures — instead of water as a coolant and dissolve the fuel in the salt. That allows them to operate at regular atmospheric pressure instead of the high pressure that traditional reactors operate at.
- **Liquid metal fast reactors** use liquid sodium or lead as a coolant. Both molten salt and liquid metal fast reactors can reuse and consume fuel from other reactors.
- **High-temperature gas reactors** use an inert gas such as helium as a coolant and can operate at a higher temperature, making them more efficient.

What could SMRs be used for?

In Canada, there are three main areas where SMRs could be used:

- Traditional, on-grid power generation, especially in provinces looking for zero-emissions replacements for CO2-emitting coal plants.
- Remote communities that currently rely on polluting diesel generation.
- Resource extraction sites, such as mining and oil and gas.



What challenges do SMRs face before they're built?

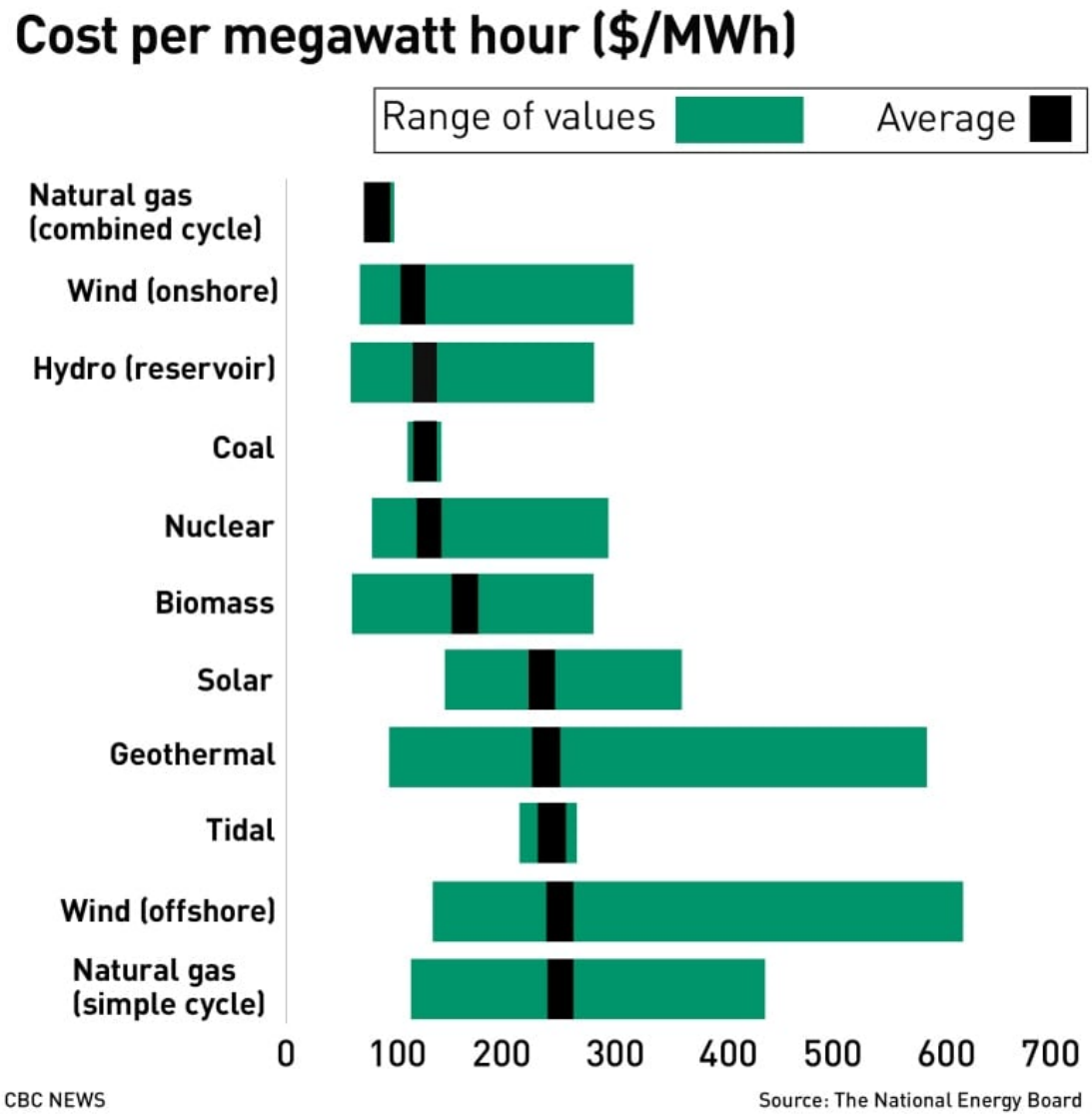
While small modular reactors should theoretically be cheaper than traditional reactors, their actual costs won't be known until some designs are actually built and operating, noted Scott Montgomery, an affiliate faculty member at the University of Washington, who lectures and writes about global energy, in an article in The Conversation last June.

He added that while SMRs are designed to produce less nuclear waste than larger reactors, disposal remains an issue.

The World Nuclear Association says licensing costs for an SMR are "potentially a challenge" as they aren't necessarily cheaper than they are for a large reactor. However, the Canadian Nuclear Safety Commission (CNSC)

notes that licensing costs are a small part of the cost of developing the technology, and include many activities that would have to occur anyway to show the technology is reliable and safe.

Canada doesn't yet have a permanent nuclear waste repository, although the Nuclear Waste Management Organization is currently working to select a site.

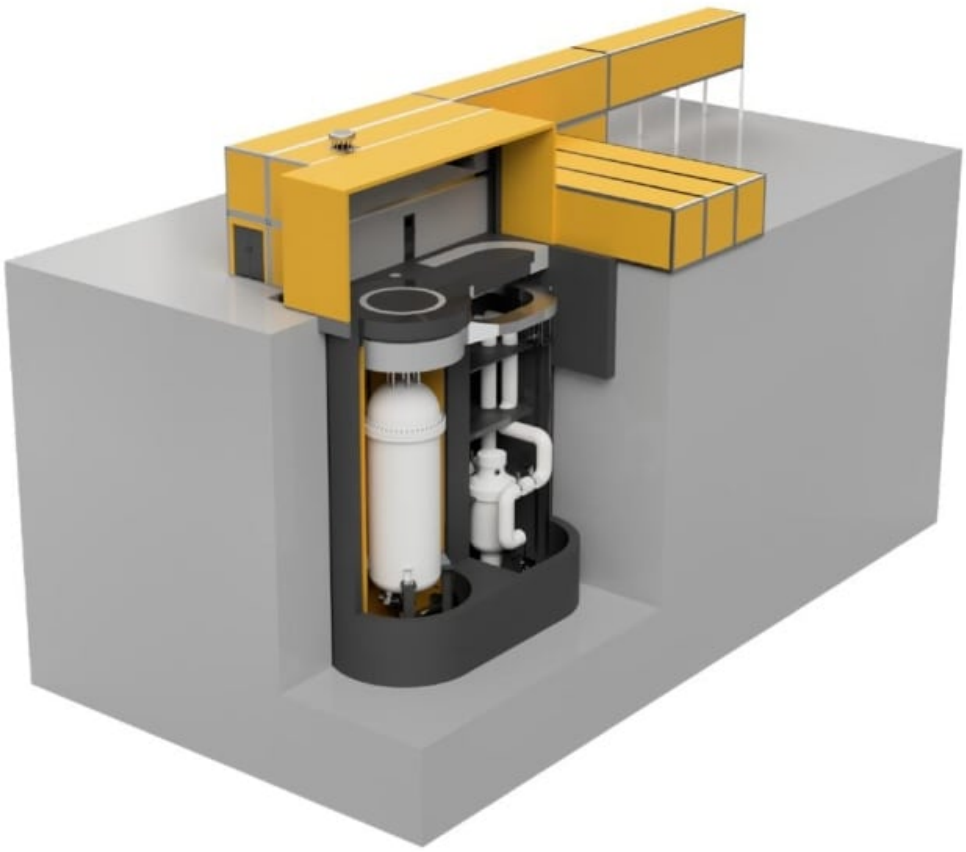


How close are SMRs to operating in Canada?

Not that close.

Natural Resources Canada released an "SMR roadmap" in November, with a series of recommendations about regulation readiness and waste management for SMRs.

In Canada, about a dozen companies are currently in pre-licensing with the CNSC, which is reviewing their designs.



Ultra Safe Nuclear's Micro Modular Reactor Energy System is designed to fit in a standard shipping container. The company is partnering with Global First Power and Ontario Power Generation, which are in talks with AECL and CNSC about preparing a site for a reactor at the Chalk River Laboratories. (Ultra Safe Nuclear)

The furthest project ahead is one involving Global First Power, in partnership with Ontario Power Generation and Ultra Safe Nuclear Corp. In April, it began discussions with the Crown corporation Atomic Energy of Canada Ltd. (AECL) and the CNSC about preparing a site for a reactor at AECL's Chalk River Laboratories. There have been plans to have an SMR demonstration plant built at an AECL site by 2026.

According to the IAEA, there are currently four SMRs in advanced stages of construction in Argentina, China and Russia.

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