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Deployment of Small Modular Reactors (SMRs) in Canada

Their promise for the decarbonization of our economy

Presented by:

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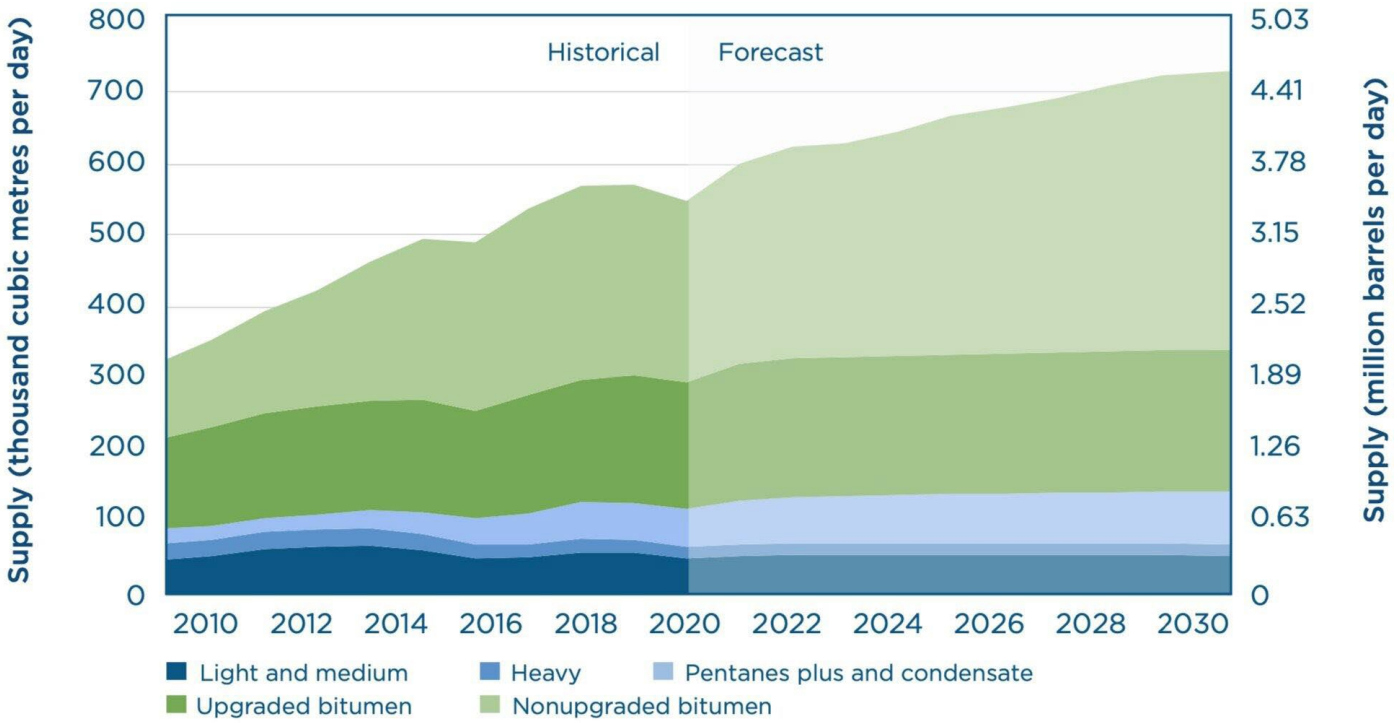
Hydrocarbons have powered our growth

Shaped our society and culture

Influenced every aspect of our lives

The reality today and going forward is… a growing demand for and supply of energy from Alberta's hydrocarbons



Many have decided that Canada needs to get to Net Zero Emissions

Oil Sands operations currently emit roughly 70 Megatonnes (Mt) of GHGs per year.

There is currently no limit on Oil Sands emissions, either by facility or industry-wide.

The Oil Sands industry[1] itself has committed to reducing GHG emissions from oilsands production by:

- 22 Mt per year by 2030, and
- reaching a goal of **"net-zero emissions"** by 2050.

Note 1: proposed by Pathways Alliance, which is made up of Canadian Natural Resources Ltd., Cenovus Energy Inc., ConocoPhillips Canada, Imperial Oil Ltd., MEG Energy Corp. and Suncor Energy Inc.

Source: Capping oil sands emissions | Alberta.ca

SMRs are being examined as one way to achieve a Net Zero goal

SMRs are nuclear fission reactors that are smaller than conventional nuclear reactors with typical electrical power outputs of less than 300 MW

Since 2021, New Brunswick, Ontario, Saskatchewan and Alberta have been studying SMRs through a joint memorandum of understanding (MOU). Canada has developed an SMR Road Map and Action Plan.

Findings from a feasibility study in **August 2023** conclude that SMRs are a feasible option for the provision of electricity and steam in the Oil Sands to support net-zero energy production

The integration of an SMR with Oil Sands operation represents a novel application of nuclear technology.

Different SMR technologies exist to address the steam and power demands of Oil Sands facilities.

Source: Small Modular Reactors
Feasibility Study for Oil Sands Applications (SAGD Facility) - August 25, 2023

What are Small Modular Reactors ?

SMRs are nuclear fission reactors that are **smaller than conventional nuclear reactors** with typical electrical power outputs of less than 300 MW

They are considered **modular** because they're designed to work either independently or as modules in a bigger complex. A power plant could be expanded incrementally by adding additional modules.

They are intended to be completely built in a factory and installed module by module, making construction quicker, more efficient and theoretically cheaper.

Safety systems don't need to be 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.

Technologies

Various reactor technologies exist and are under development. SMR designs that are currently under development include designs in the following technology categories:

- **Boiling Water Reactors (BWR)** - The GE-Hitachi BWRX-300 selected for deployment at Ontario Power Generation
- **Pressurized Water Reactors (PWR)** - PWRs are the most common type of nuclear reactor with large operating fleets in the United States, France, and other countries
- **Sodium Fast Reactors (SFR) or Lead Fast Reactors (LFR)** – USA, UK, France, Russia, China all have commercial power/research reactors.
- **High Temperature Gas-cooled (typically helium) Reactors (HTGR)** – USA, UK, Japan have experience with this technology for years.
- **Molten Salt Reactors (MSR)** – research is ongoing at Chalk River Laboratories (Ontario) and Oak Ridge National Laboratory (USA)

Where Can SMRs be Deployed ?

- ✓ **“Existing Grid”** – typically to serve the general population / industry and/or replace existing generation (Streams 1 and 2)
- ✓ **“Edge of Grid / Industry ”** - areas dependent on simple / long transmission lines or independent power generation (Streams 1, 2 and 3)
- ✓ **“Off-Grid”** – Remote communities / mine sites (Stream 3)

Canada's Readiness

Canada's early adoption of SMRs would position the nation as a world-leader in new nuclear innovation and a global SMR technology hub.

- **Stream 1** – a grid-scale SMR project of at least one 300 megawatts (MW) constructed at the Darlington nuclear site in Ontario by 2028. Subsequent units in Saskatchewan would follow, with the first SMR projected to be in service in 2034.

- **Stream 2** – Advanced SMRs of between 100 and 150 MW would be developed at New Brunswick's Point Lepreau nuclear site between 2029 – 2034

- **Stream 3** – a new class of micro-SMRs designed primarily to replace the use of diesel. A 15 MW (or more) demonstration project is under way at Chalk River, Ontario, with plans to be in service by 2030.

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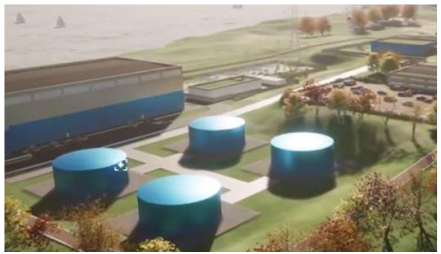

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The Largest Potential Market for SMR in Industry is Alberta

Potential industrial SMR adoption is higher in Alberta than all other provinces combined.

The adoption of SMRs can reduce industrial greenhouse gas emissions in two ways:

1. SMRs can directly reduce GHGs in the industrial sectors in which they are adopted. For example, an Oil Sands facility can reduce its emissions if it uses an SMR to meet its process heat requirements rather than hydrocarbons. SMRs could reduce industrial GHGs by between 19 and 59 Mt in 2050.

2. SMRs can help produce low carbon energy carriers, facilitating emissions reductions in other sectors. SMRs can help produce biofuels, synthetic fuels and hydrogen. These fuels are critical to decarbonizing transport (especially trucking, marine, air and rail) among other applications.

Source: Navius Research, 2021. Identifying opportunities for small modular reactors to reduce greenhouse gas emissions in Canadian industry.

Other Contributions to Sustainability

- SMRs tend to be designed for a much longer time period between refueling than for conventional reactors, **reducing handling and transport requirements** of nuclear materials and reduces risks associated with transport.

- Manufacturing, packaging and testing of SMR components are likely to be conducted off-site, thereby resulting in **quicker and more efficient assembly on-site** at location, reducing environmental emissions from construction vehicles and equipment.

- SMR designs have **inherent safety features** that serve to minimize the likelihood of some severe accidents associated with other reactors.

- The manufacturing and deployment of SMR modules in fleets **encourages localized and diverse supply chains** that enhance sustainability.

Other Contributions to Sustainability

- **SMRs can be deployed in tandem with renewable energy technologies.**

- SMRs are **Scalable** and can thus adapt to power demands as community / industry needs change. Units can be added when demand increases or some of the modules not used when the demand decreases. The inherent flexibility of the technology means that they are responsive to uncertainty in the future.

- **Modular** design for SMRs offer features such as compact and simplified design. There is the ability to maintain, repair, upgrade, replace, disassemble, or recycle a portion of a plant without having to overhaul the entire plant. Modularity reduces complexity.

- SMRs use standardized modules that can be sized for standard International Standards Organization (ISO) shipping containers. This means that they can be **transported easily by ship, rail, or road, including ice roads**.

Sustainability Challenges

Wastes

- All industrial processes, including the production of nuclear energy, create waste. SMRs use different types of reactor coolants, purification schemes and approaches to inspections and maintenance. This may mean that new contaminants and waste volumes will need to be managed.

- A large scale deployment of SMRs will result in a proliferation of distributed wastes that will have to be managed, whether in local facilities or in a national repository. Waste management costs are currently uncertain.

Investments and Jobs

- While investment and future deployment of SMRs will lead to job creation, it remains uncertain whether the resulting number of jobs exceeds the number of jobs created by investing the same amount of money in a different but comparable energy technology.

Sustainability Challenges

Safety

Safety is well regulated by the CNSC. However, tecause of the novel nature of SMRs, the effectiveness of some of its inherent safety and design features and their environmental performance at a commercial scale of development is not well established.

Market / Competitiveness

There is both real and perceived competitiveness among SMR developers and competition between various forms of green energy / renewables.

In 2022 there were at least 10 developers undergoing design reviews by the CNSC in Canada. There is a need for improved understanding of the issues related to proprietary knowledge and competition among SMR vendors in the nuclear industry marketplace.

Sustainability Challenges

Indigenous Involvement

Indigenous groups expect any project proponent to explicitly recognize their rights to "Free, Prior and Informed Consent" under the United Nations Declaration of the Rights of Indigenous Peoples (UNDRIP).

Implementing mechanisms, practices and procedures to clearly articulate an Indigenous community's willingness and achieve informed consent in relation to an SMR development remains a challenge.

Proceeding without such consent could further undermine the legitimacy, accountability, and trustworthiness of the nuclear regulatory system and the proponent's own credibility.

- In the longer term leading to 2050, installed capacity of SMRs across Canada can measurably help reduce greenhouse gas emissions while providing energy security.
- SMRs are considered a feasible energy source for Alberta's Oil Sands industry.
- SMRs can provide substantial positive contributions to sustainability.
- Sustainability challenges exist – they are recognized and are being addressed by industry and regulators – domestically and internationally.

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