Westinghouse-Bruce Power:

Executive Summary of the eVinci™ Micro-Reactor Deployment in Mining and Remote Canadian Communities Feasibility Study

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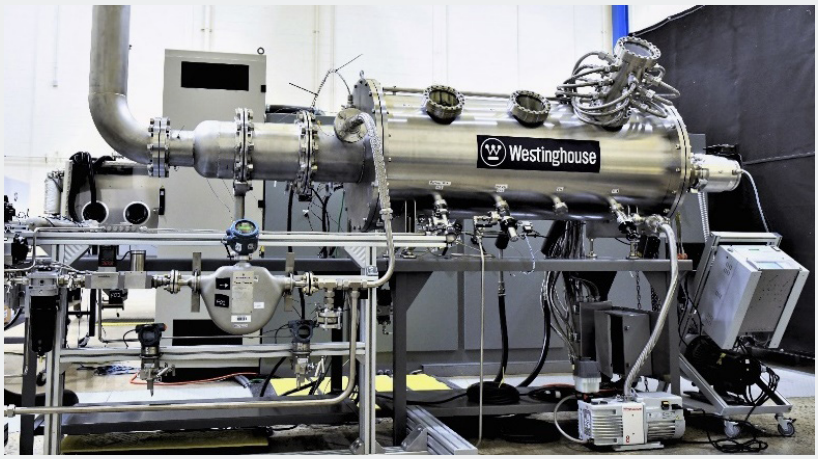


Introduction

As a Tier 1 nuclear nation, Canada is no stranger to nuclear power and its benefits.

Currently, nuclear energy produces about 15 percent of Canada's total electricity, including 60 percent of Ontario's and 30 percent of New Brunswick's power on a day-to-day basis. Canada's nuclear industry also contributes more than $17 billion annually to Canada's Gross Domestic Product (GDP) and supports more than 76,000 jobs across the country.

Canada will need to harness all its electricity assets to best position itself to meet its ambitious greenhouse gas (GHG) targets. There is a growing consensus, internationally, that there is no path to net-zero without nuclear power, a sentiment echoed here in Canada on multiple occasions by Seamus O'Regan, Minister of Natural Resources Canada.

The Canadian government has reaffirmed its commitment to nuclear power with the 2018 release of the Canadian Small Modular Reactor (SMR) Roadmap[1], and the 2021 launch of its SMR Action Plan[2]. Provincially, in 2019, New Brunswick, Ontario and Saskatchewan signed a Memorandum of Understanding (MOU) to support the deployment of SMRs, with Alberta later joining as a signatory in 2020. These actions have established a framework for collaboration at both the provincial and federal levels in support of the deployment of SMRs, and have set the path forward for nuclear energy innovation.

SMRs represent an avenue of nuclear energy innovation that could play a critical role in helping Canada achieve its GHG targets. Of particular interest – and the purpose of this feasibility study – is the role that a subcategory of SMRs (1 to 20 Megawatts electric (MWe) range), referred to as micro-reactors, could play in aiding off-grid communities and industries that have a need for clean and reliable energy options to reduce their dependence upon diesel fuel. Additionally SMRs could be used for community heating and to support new industries such as greenhouses to grow food locally.

This Executive Summary provides a market overview of the opportunity for the deployment of the Westinghouse's eVinci micro-reactor in Canada, a quick look at the benefits of, and potential opportunities for the eVinci micro-reactor, as well as the key federal, provincial, and territorial policy and regulatory enablers needed to achieve it.

1 Canadian Small Modular Reactor Roadmap Steering Committee (2018). *A Call to Action: A Canadian Roadmap for Small Modular Reactors.* Ottawa, Ontario, Canada. www.smrroadmap.ca

2 https://smractionplan.ca/

The Market

The Canadian market for micro-reactors focuses on three distinct areas.

REMOTE COMMUNITIES

There are well over 100 such communities in the Canadian north, and estimates are that these remote communities consume about 90 million litres of diesel fuel[3] per year.

MINING

The Natural Resources Canada (NRCAN) SMR Roadmap identified 24 mines with a total demand of about 600 MWe. Most importantly these mines have demands in the vicinity of the 5-20 MWe range. Most mines have lifespans of between 10 and 35 years, and about 15 new off-grid mines are built per year, representing potential new mining markets for SMRs.

INTERNATIONAL MARKET

The international market for micro-reactors has been estimated in the SMR Roadmap to be between $30 and $35 billion per year from 2030-40. While the demand for energy in these locations is much smaller than for on-grid electricity generation, these communities and mines use large amounts of diesel fuel, which is costly and produces a significant amount of GHG emissions compared to other technologies. That's what makes these remote locations a prime target for more cost-effective and clean nuclear energy.

A reactor facility such as the eVinci micro-reactor could provide a steady supply of non-emitting energy 24 hours per day, 365 days per year. This provides spin-off opportunities for communities to better their conditions based on energy availability.

3 This would emit about 250 kiloton (kT) of carbon per year depending upon the efficiencies of the diesel generators.

The eVinci micro-reactor

In 2020, Bruce Power and Westinghouse Electric Company entered into an agreement to explore applications of the company's leading eVinci micro-reactor technology program within Canada, to provide a reliable source of carbon-free energy. The eVinci micro-reactor is a next-generation micro reactor, essentially a small battery for decentralized generation markets and for micro grids such as remote communities, remote industrial mines, and critical infrastructure.

The features of the eVinci micro-reactor include:

- A nominal 5 MWe heat pipe reactor with a high temperature heat capability of 14 MWt for use in remote locations where grids are inaccessible;
- A design that provides competitive and resilient power as well as superior reliability with minimal maintenance; and
- A design that is very small and allows for standard transportation methods, making it perfectly suited for remote locations and rapid, on-site deployment. It is this unique design and size of reactor that makes it such a viable option for mines and remote and off-grid communities.

fig. 1 **eVinci micro reactor core**

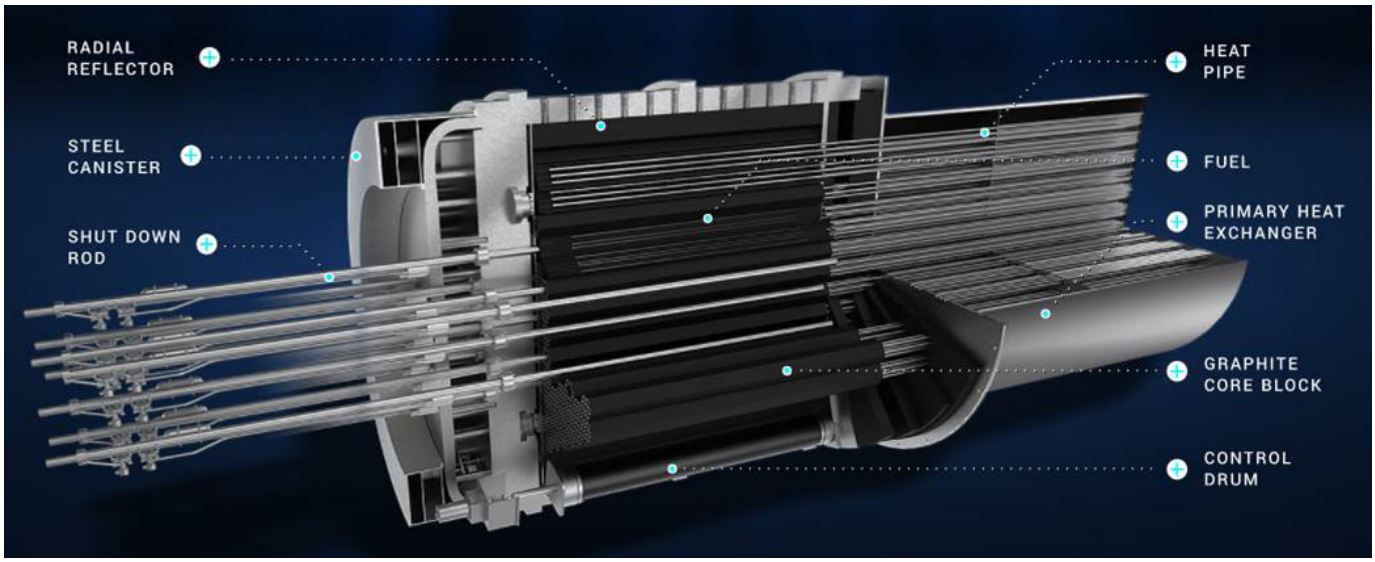
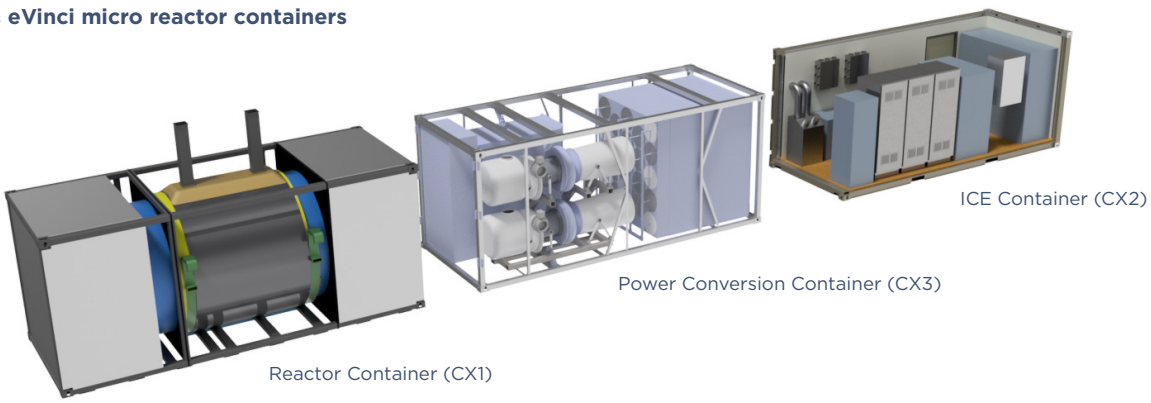


fig. 2 **eVinci micro reactor containers**



Unique features of the eVinci micro-reactor versus competing micro-reactors

IT'S A NUCLEAR BATTERY, NOT A POWER STATION

The eVinci micro-reactor design is self-contained, autonomously controlled and remotely monitored.

IT HAS AN EXTREMELY SMALL FOOTPRINT

The eVinci micro-reactor has no negative impact to the environment, and its integrated and passive safety features require a near-zero emergency planning zone (i.e., less than 0.5 acres).

ITS MOBILITY PROVIDES TRUE OPERATIONAL FLEXIBILITY

The eVinci micro-reactor can be scaled, and transported to new sites before end-of-life, increasing overall supply and demand flexibility.

MANUFACTURING AND CONSTRUCTION

Fully assembled at the manufacturing facility, the eVinci micro-reactor requires little site preparation (about 40 days) following which it can be installed and running within three months after it arrives at the site. As the construction time is minimal, the cost and logistical requirements of managing a construction project at a remote site are low.

IT IS SIMPLE TO OPERATE AND REQUIRES MINIMAL ON-SITE STAFFING

Due to the passive safety features, autonomous operation, and high component reliability, the number of on-site staff required to safely operate the eVinci micro-reactor would be minimal.

REFUELING AND WASTE HANDLING ARE MANAGED OFF SITE

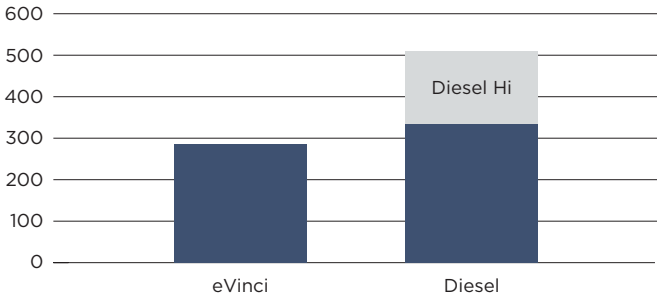
Refueling is designed to be managed by bringing a freshly fueled CX1 reactor container to replace the operating CX1 container when its fuel has been depleted. The unit would only be offline for one day to replace the unit, resulting in almost 100% availability, and a highly reliable source of power. No radioactive materials would be handled or stored on site. All long-term waste will be handled at a licensed facility and will be stored in accordance with Nuclear Waste Management Organization's Canadian Nuclear Waste Strategy. Site decommissioning is easy to accomplish as it only requires removal of the modules, leaving no legacy waste behind.

Economic analysis of the eVinci micro-reactor

An essential element of feasibility is to demonstrate the eVinci micro-reactor's economic competitiveness to meet market needs. An economic analysis shows that.

Depending upon the assumptions used for the price of diesel and the cost of carbon, an eVinci micro-reactor is expected to be 14% to 44% more economic than burning diesel fuel.

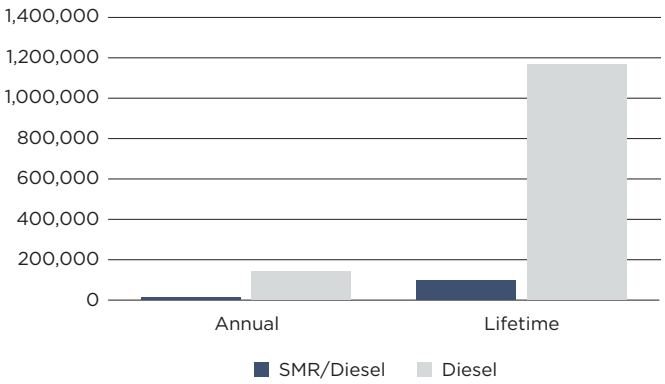
fig. 3 **LCOE eVinci Micro Reactor and Diesel ($/MWh)**



In addition to being economic, the eVinci micro-reactor would make an important contribution to decarbonizing remote communities and the mining industry. In a scenario where eVinci micro-reactors replace diesel power at a mine site, carbon emissions would be reduced by 90%.

Given the simplicity of the design and relatively low investment cost, full-scale demonstrations of the eVinci micro-reactor can be done to secure the confidence in the design and the program.

fig. 4 **Mining Scenario Carbon Emissions (tonnes)**



When it comes to the deployment of new energy infrastructure the costs to consumers is always important. However with the evinci micro reactor their are considerable opportunities to reduce current spending while simultaneously generating further economic benefits to communities. These examples include:

- reducing federal, provincial, and territorial subsidies to allow for new critical infrastructure project investments; and
- reducing end user costs, allowing local remote populations to have more money for other essentials or personal investment,

Regulatory path forward and government support

SMRs represent the next step in the evolution of nuclear energy. To ensure that step lands on solid regulatory ground, Canada's current regulatory and licensing approaches also need to evolve. The regulatory path forward and ultimate acceptance and implementation of this technology will require cooperation between the private sector, the federal government, and the CNSC, among others.

Positively, both the CNSC and federal government recognize the potential of SMR's to help Canada meet its climate change objectives. Thus with the alignment of the CNSC, the government, and the private sector. the path to SMR deployment has considerable momentum.

There are several regulatory hurdles on the path to SMR deployment. These include necessary changes to legislative and regulatory requirements, which were established for larger, grid scale nuclear reactors. As SMRs represent a new technology on a different scale than traditional nuclear reactors, these requirements must be updated to reflect the nuances of SMR's. Presently, a number of regulatory requirements have undergone, or are currently undergoing, regulatory review.

Delay in overcoming these challenges poses a risk to Canada losing out on first-mover status with this technology, an important aspect reiterated in the government's 2021 SMR Action Plan. Federal support will be needed both financially and through enabling policy and legislation. Federal actions that could help enable the path forward for deployment of the eVinci micro-reactor include:

THE NET-ZERO ACCELERATOR FUND

The federal government can help provide the necessary capital and share risk with the private sector to enable a demonstration unit to be built.

COOPERATION AND PARTNERSHIP

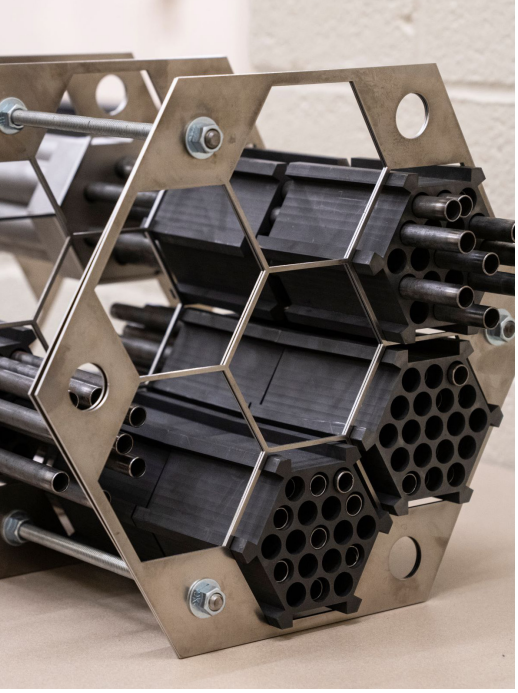
The federal government will be necessary to identify a remote community willing to host an eVinci micro-reactor, replacing their diesel infrastructure. This partnership should start the process of engaging communities and securing the support of community members, including Indigenous groups.

RECOGNITION OF EXISTING SUBSIDIES

Diesel costs are higher in remote communities as the costs of transportation by ice road, ship or air is significant. Governments generally subsidize these costs to reduce the burden on local communities. For a mining community, energy costs are an important input to the economic viability of their mining operations.

STREAMLINING THE REGULATORY PROCESS

Co-operation between different regulatory agencies like the NRC and CNSC to enable regulation/licencing under one jurisdiction and providing some form of credit or streamlined process for applications in Canada.



Summary of key takeaways

The eVinci micro-reactor is designed to be economic, low carbon-emitting, reliable and provide significant flexibility in its deployment.

The eVinci micro-reactor is a feasible option to replace diesel fuel to supply electricity, heat, and other energy needs for remote communities and mines in Canada's north.

A single eVinci micro-reactor is expected to be between 14% and 44% more economic than a diesel generator, depending upon the price of diesel fuel and the price for carbon.

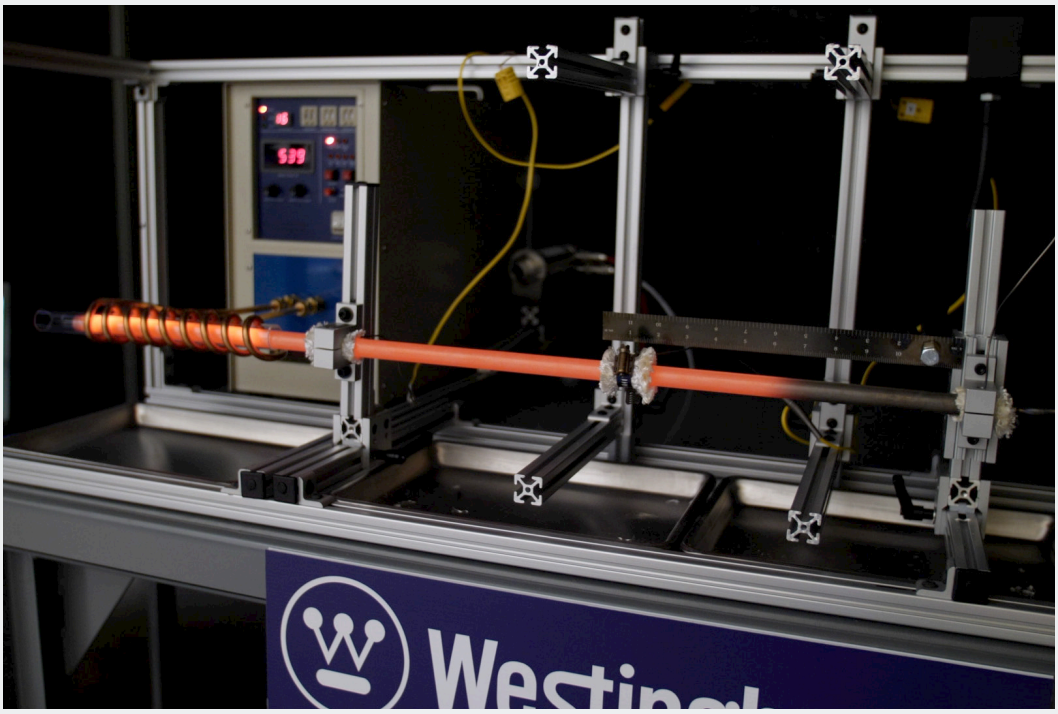
In mining scenarios, the eVinci micro-reactor unit with diesel back-up could reduce carbon emissions by about 90%.

Successful deployment of the eVinci micro-reactor depends upon achieving a regulatory model that considers the unit's size and has a predictable outcome, to reduce risk to operations at the host site.

With appropriate scaling and using a graded approach consistent with CNSC guidance, it is estimated the first commercial unit in Canada should be licensed within three years.

Broad public and host community acceptance will be essential to eVinci micro-reactor deployment.

Business models are feasible where a company can own and operate the eVinci micro-reactor on behalf of the mining company or remote community.



Recommendations

As this study concludes, the eVinci micro-reactor can be a feasible alternative to diesel generation at mines and in remote communities. Deployment of the eVinci micro-reactor can provide opportunities for remote communities and mines to reduce or eliminate their dependence on expensive diesel generation with a more economic option that reduces GHG and other emissions. The availability of reduced cost electricity and heating can also enable multiple opportunities for economic growth.

Engaging with communities, private industry and indigenous rights holders will be critical to secure support for future deployments. Engagement with the CNSC through the Vendor Design Review (VDR) process will also be critical to develop an approach to licensing the eVinci. It is important to address the full range of considerations associated with licensing a micro reactor.

The strong partnership between Bruce Power and Westinghouse has set the stage for the deployment of a leading eVinci micro-reactor program within Canada, to provide a reliable source of carbon-free energy in grid-edge and off-grid communities. These efforts support actions by the federal and provincial governments to study applications for nuclear technology to reach their goal of a Net Zero Canada by 2050. Bruce Power and Westinghouse are committed to advancing future opportunities for nuclear energy to provide a clean, reliable source of electricity and heat, providing a source of jobs and innovation in communities across Canada. Advancing this work will require support across all levels of government and agencies, and we look forward to continuing to develop this opportunity.

Final thoughts

Bruce Power and Westinghouse are leading organizations when it comes to nuclear power. With decades of operational experience, as well as in new plant design and plant management, together these companies are formidable champions to lead the next wave of nuclear innovation.

The strong partnership between Bruce Power and Westinghouse has set the stage for the deployment of a leading eVinci micro-reactor program within Canada, to provide a reliable source of carbon-free energy in off-grid communities. These efforts support actions by the federal and provincial governments to study applications for nuclear technology to reach their goal of a Net Zero Canada by 2050.

Bruce Power and Westinghouse are committed to advancing future opportunities for nuclear energy to provide a clean, reliable source of electricity and heat. Advancing this work will require support across all levels of government and agencies, and we look forward to pursuing this opportunity.

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