Workshop 1: Visioning Session
Toronto, March 8-9, 2018

April 10, 2018

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Executive Summary

This report provides a summary of discussion from the first workshop associated with the Small Modular Reactor Roadmap – *Visioning Session* held in Toronto on March 8th and 9th, 2018.

Introduction to the Small Modular Reactor Roadmap

A **Small Modular Reactor (SMR)** is an advanced nuclear reactor that produces electric power up to about 300 MWe, designed to be built in factories, and shipped to a site for installation as required. SMRs provide a range of benefits including reduced greenhouse gas emissions, improved affordability, shorter construction and installation times, a wider range of users and applications, site flexibility, and integration with renewables.

In its October 2017 response to the House of Commons Standing Committee report on Nuclear Energy, the Government committed to initiating a dialogue with key stakeholders to develop a **Canadian Roadmap for SMRs** ("SMR Roadmap" or "Roadmap"). The development of the Roadmap was considered critical in light of the following:

- SMRs are a promising potential source of non-emitting power for various applications;
- The technology is at an early stage of development, with many questions that still need answers;
- Future success involves risks and costs, potentially involving both the private and public sectors across Canada; and
- A pan-Canadian approach would help guide important decisions and reduce uncertainty.

Initial research and analysis in support of the Roadmap identified three main applications/markets for SMRs domestically, which are listed below.

1) **On-grid power** generation to replace fossil fuel plants in the existing electric power grid system (~150 to 300 MWe).
2) Providing non-emitting heat and power for **heavy industry** sites such as resource extraction operations (~10 to 50 MWe).
3) Replace existing diesel power generation for electricity, district heating, and desalination in **off-grid northern and remote communities** (~1 to 10 MWe).

Approach to the SMR Roadmap

The approach to developing the SMR Roadmap involves a series of workshops with key stakeholders to gain their perspectives on potential applications/markets and technical solutions. Four workshops have been scheduled between March and June 2018. The first of these workshops was the Visioning Session, which was held in Toronto on March 8-9, 2018. Three subsequent workshops are to follow with each focusing on a specific application/market listed above (i.e. On-Grid Power, Heavy Industry, and Off-Grid Northern and Remote Communities).

These workshops are also supported by five Working Groups that have been tasked with conducting analysis and providing insight into key aspects that will impact a future pan-Canadian SMR industry. The areas of study for the five Working Groups are Technology, Economic and Finance, Indigenous and Public Engagement, Waste, and Regulatory Readiness.

Results from the Visioning Session

The Visioning Session included a series of presentations and roundtable discussions. The presentations were provided by potential end-users groups (or proponents of these groups) for each of the three applications/markets, with each providing a brief description of their current context, priorities and challenges, and how SMRs could support their organizations moving forward. Additional presentations were provided by co-chairs/chairs of the Technology, Economic and Finance, and Waste Working Groups, as well as representatives from Natural Resources Canada (NRCan). These additional presentations provided input for consideration into the roundtable discussions. A complete list of presenters is included in Appendix A.

The roundtable discussions were used to collect input from the participants on several topics. These topics involved economic and financial considerations, off-grid applications/markets, and waste management. Results from the roundtable discussions led to the formulation of a potential visioning statement for the Roadmap, along with accompanying requirements needed to support the visioning statement. These are provided below.

Potential Vision Statement for the SMR Roadmap

SMR technology deployed in the future that is providing clean energy to northern and remote communities, and in on-grid and heavy industries applications.

Requirements to support the potential visioning statement include:

1. Risks related to first of a king (FOAK) to be shared among public (federal, provincial, and municipal) and private sectors.
2. Costs associated with any SMR technical solution needs to be competitive relative to its competition (specifically natural gas and diesel).
3. Certainty in regulatory processes, standards, timeframes, and costs.
4. Engagement and education of the public to ease concerns and improve “social license.”

Next Steps in the SMR Roadmap Process

Discussions during the visioning session revealed that there are many different viewpoints to consider when framing the future of SMRs in Canada. There are no self-evident directions and solutions, and there is much dialogue needed to understand and balance the various inputs.

Three additional workshops are planned between April and June 2018, each focusing on a unique application/market. While the discussions at the Visioning Session were purposefully broad in nature, those in subsequent workshops will be more focused and targeted. As such, it will be critical to engage with and have the “right” participants at these subsequent workshops. to ensure that the Roadmap captures and considers their needs, priorities, concerns, challenges, and overall perspectives related to SMRs and their potential deployment.

1. Introduction

This report provides a summary of the results from the first workshop associated with the Small Modular Reactor (SMR) Roadmap – *Visioning Session* held in Toronto on March 8th and 9th, 2018. A list of attendees at the workshop is included in Appendix B.

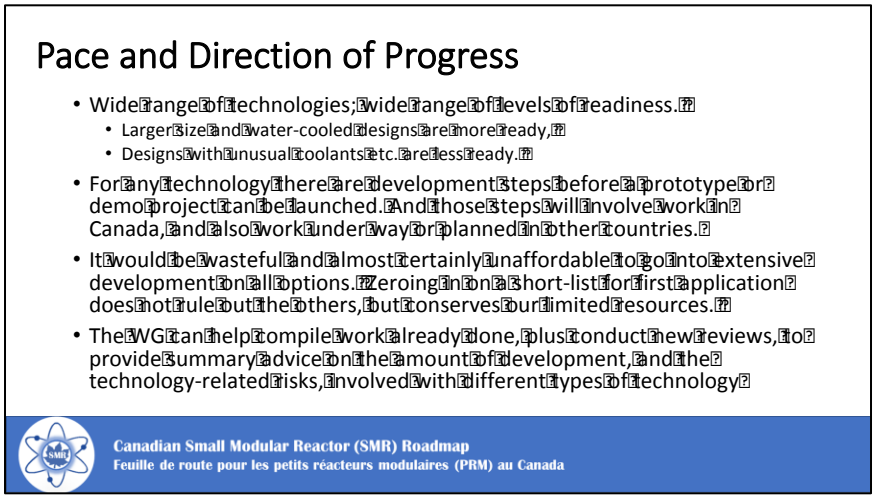
1.1 What is an SMR?

The International Atomic Energy Agency (IAEA) defines SMRs as "advanced reactors that produce electric power up to 300 MWe, designed to be built in factories and shipped to utilities for installation as demand arises." SMRs represent a nuclear option to meet the need for flexible power generation for a wide range of users and applications.

In the morning of the first day of the Visioning Session, Bronwyn Hyland, Program Manager of Small Modular and Advanced Reactor Technologies at the Canadian Nuclear Laboratories presented an overview of SMR technology.

> The word "small" in SMR refers to the power output relative to traditional reactors, where output from current on-grid reactors is typically measured in giga-watts. As described in IAEA's definition above, SMRs refer to reactors that produce less than 300 MWe, with a subset described as "very small" (vSMRs) that produce less than 15 MWe. The physical sizes of SMRs vary, but are generally much smaller than current on-grid nuclear reactors.
>
> The word "modular" in SMR refers to the technology being manufactured in dedicated facilities and transported to sites for installation as needed. This is expected to lead to reduced on-site installation times, advanced quality assurance controls over standardized models at manufacturing facilities, and improved cost efficiencies through economies of series.
>
> The word "reactor" in SMR refers to nuclear technology that will supply power within the SMR. There are currently a large variation of reactor types under development within the industry, and large variations of designs within reactor types.
>
> The benefits of SMRs include reduced greenhouse gas emissions, better affordability, shorter construction and installation times, a wider range of users and applications, site flexibility, and integration with renewables. Further, there are many reasons why Canada is well positioned and should focus its efforts on SMRs including:
>
> - A world class nuclear regulatory framework;
> - An efficient gateway to the North American market;
> - A pressing domestic need for the technology;
> - An existing capable and established supply chain; and
> - A stable political system with a government that is committed to action on climate change.

The following slides from the presentation set out information on the future of SMR technologies as well as some of the important opportunities and risks associated with SMR technologies.



1.2 What is the SMR Roadmap?

In its October 2017 response to the House of Commons Standing Committee report on Nuclear Energy, the Government committed to use its convening power to bring together a dialogue to develop a Canadian Roadmap for SMRs ("SMR Roadmap" or "Roadmap"). The Roadmap would be a plan for the development and deployment of SMRs that addresses the collective needs and challenges of all stakeholders.

Natural Resources Canada (NRCan) convened the Inter-utility Consultative Committee on Nuclear (ICCN) to provide a forum for discussion and dialogue that supports a collaborative and coordinated approach when it comes to nuclear. Membership of the ICCN was open to all provincial and territorial governments and utility representatives regardless of nuclear policy direction in their jurisdiction. The network acknowledged the need for a Canadian SMR Roadmap particularly in light of the following:

- SMRs are a promising potential source of non-emitting power for various applications;
- The technology is at an early stage of development, with many questions that still need answers;

- Future success involves risks and costs, involving both the private and public sectors across Canada; and
- A pan-Canadian approach would help guide important decisions and reduce uncertainty.

As a result, the ICCN agreed to establish a sub-committee for developing a Canadian Roadmap for SMRs, the SMR Roadmap Steering Committee ("Steering Committee"). A listing of the Steering Committee organizations is included as Appendix C. The Steering Committee officially launched the SMR Roadmap process in December 2017.

Initial research and analysis in support of the Roadmap identified three main applications/markets for SMRs domestically, which are listed below.

Three Main Domestic Applications/Markets for SMRs

1) **On-grid power** generation to replace fossil fuel plants in the existing electric power grid system (~150 to 300 MWe).
2) Providing non-emitting heat and power for **heavy industry** sites such as resource extraction operations (~10 to >170 MWe).
3) Replace existing diesel power generation for electricity, district heating, and desalination in **off-grid northern and remote communities** (<10 MWe, with many < 2.5 MWe).

Developing the SMR Roadmap involves a series of workshops to gain input from key stakeholders on their needs, priorities, and perspectives for the future of the industry. Four workshops have been scheduled between March and June 2018. The first of these workshops was the Visioning Session, which is to be followed by three subsequent workshops, each focusing on a specific SMR application/market listed above (i.e. On-Grid Power, Heavy Industry, and Off-Grid Northern and Remote Communities).

These workshops are also supported by five Working Groups that have been tasked with conducting analysis and providing insight into key aspects that will impact a future pan-Canadian SMR industry. The areas of study for the five Working Groups are technology, economic and finance, Indigenous and public engagement, waste, and regulatory readiness.

1.3 Intended Outcomes of the SMR Roadmap

The Steering Committee has identified the following as the intended outcomes for the SMR Roadmap:

- Clarity on needs and priorities of stakeholders and Canadians;
- Understanding of the value proposition of different SMR technology categories;
- Identification of key issues related to regulatory readiness, waste management, and transportation policy;
- Appreciation of risks and challenges; and
- Identification of policy levers that may impact SMR feasibility in Canada.

*In addition, the roadmap process will **seek to encourage and develop broad agreement** among the essential enabling partners on the **way forward** to position Canada for success domestically and for best advantage in the emerging global SMR market.*

1.4 Objectives of the Visioning Session Workshop

The main objectives of the Visioning Session Workshop were to help:

- Ensure the proper focus, structure, content, and participants;
- Inform the activities of the five roadmap working groups;
- Set the foundation for subsequent Roadmap workshops;
- Develop a vision informed by the end-user/demand-side for SMRs in Canada, over the next 10-15 years; and
- Articulate both end-user/community and industry goals.

2. Presentations Related to Potential SMR Applications

The Visioning Session included multiple presentations from potential end-users groups (or proponents of these groups) for each of the three applications/markets: On-Grid, Heavy Industry, and Off-Grid Northern and Remote Communities. Generally, each provided a brief description of their current context, priorities and challenges, and how SMRs could support their organizations moving forward. The following sub-sections provide a brief summary and excerpts from these presentations

2.1 On-Grid Applications/Markets

Presentations related to on-grid applications/markets were provided by:

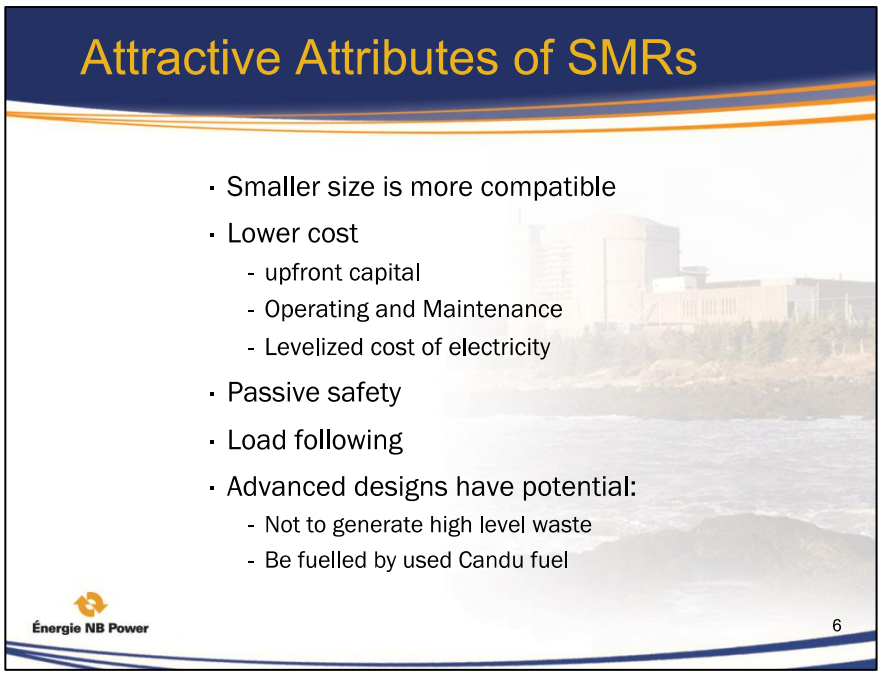
- Paul Thompson, Deputy Chief Nuclear Officer, NB Power
- Iain Harry, Senior Business Advisor, Generation Asset Management and Planning, SaskPower
- Jeff Lehman, Vice President, New Nuclear Development, Ontario Power Generation
- Maury Burton, Manager, Nuclear Regulatory Affairs, Bruce Power

A Changing Landscape in New Brunswick

NB Power employs approximately 2,300 staff and provides power to 350,000 customers in New Brunswick. Generally, New Brunswick contains a small and dispersed population, with industries in highly competitive markets. The electrical grid in the Province is well distributed and interconnected with surrounding jurisdictions. NB Power's current generating sources are a mix of hydro, nuclear, coal, and other fossil fuels, with some of its power generating assets approaching the end of its life.

The power generation landscape is changing in New Brunswick with greater emphasis (from consumers and within NB Power) being placed on a shift away from carbon sources and more

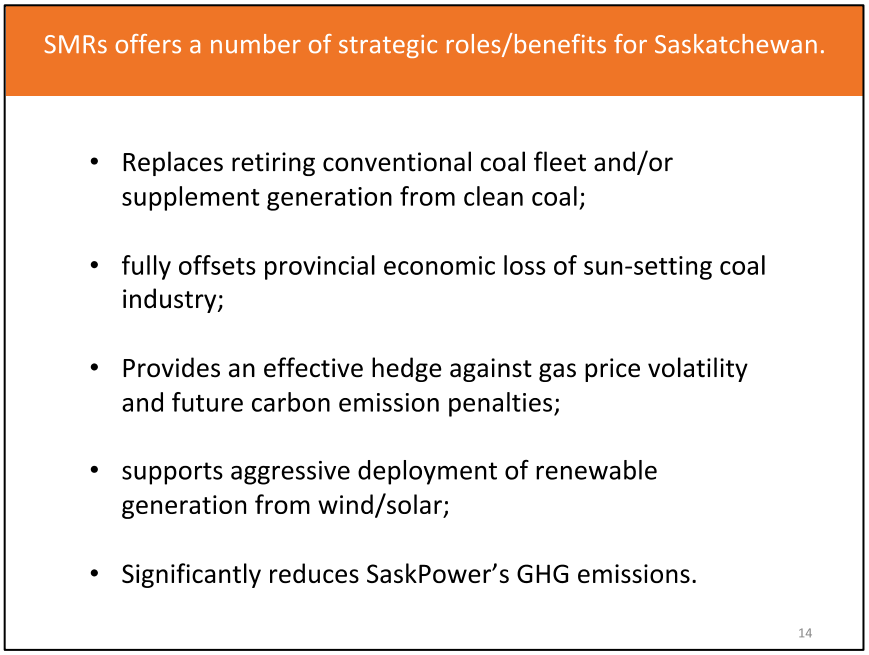
towards renewable generation. There is also the growing potential for electric vehicles in the future, which will result in increased power demands, though the timeframes associated with this increased demand is still unclear. SMRs could play a role in assisting with these pressures moving forward.

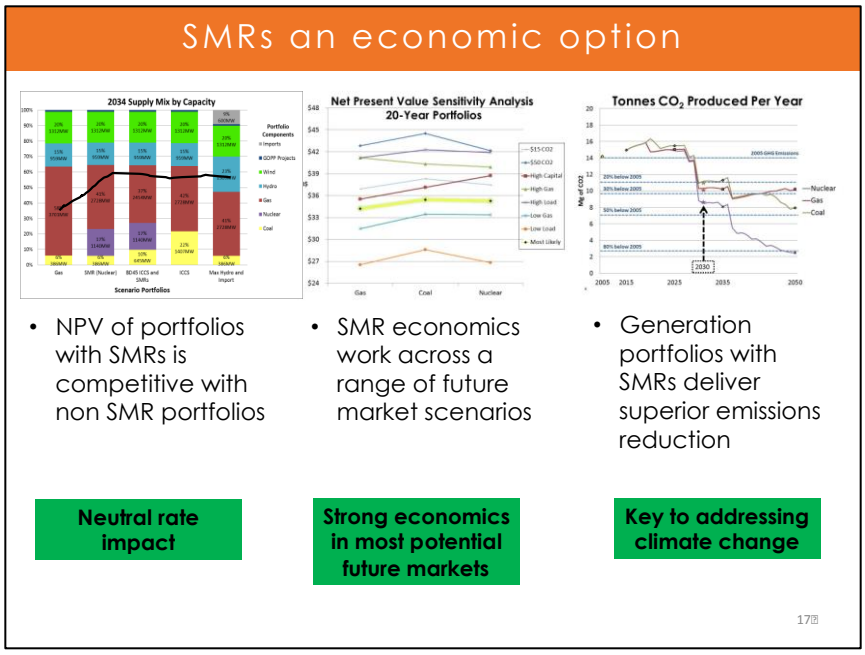


Planning for a Sustainable Power Future in Saskatchewan

SaskPower is Saskatchewan's primary electricity supplier, providing power to 520,000 customers, and employs 3,100 staff. Its current power generating sources include a mix of hydro, wind, coal, and natural gas. The climate is changing for traditional utilities in Saskatchewan. A number of factors are driving this change including an aging infrastructure (i.e. electrical grid, traditional facilities) that will require major capital investments, transformational emissions regulations that will require a move away from coal and other fossil fuels, climate change, disruptive technologies (i.e. distributed energy resources, smarter grids, etc.), and changing customer and stakeholder expectations.

There is also a significant increase in power demand anticipated in the near future. Based on existing SaskPower owned resources and projected demands, the supply/demand gap is approximately 3,500 MW by 2036 (SaskPower's current peak demand is 3,800 MW, with capacity of 4,400MW). Further, SaskPower has established a goal of 40% reduction in emissions by 2030. As such, SaskPower is evaluating all available supply options to meet this challenge moving forward including wind, solar, provincial/regional hydro, geothermal, biomass, among others. It is also reviewing the viability of SMRs, and views it as a potential option.

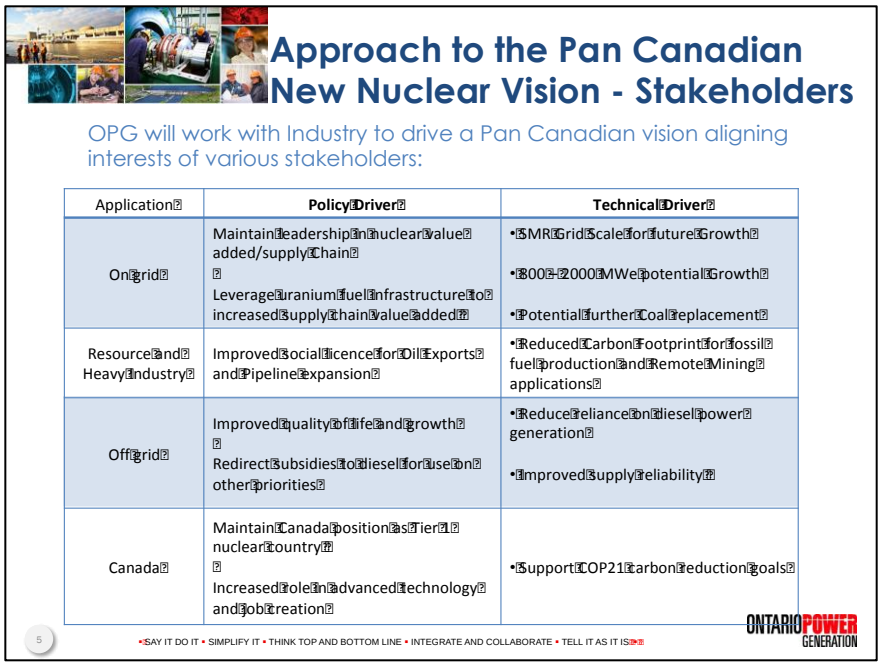


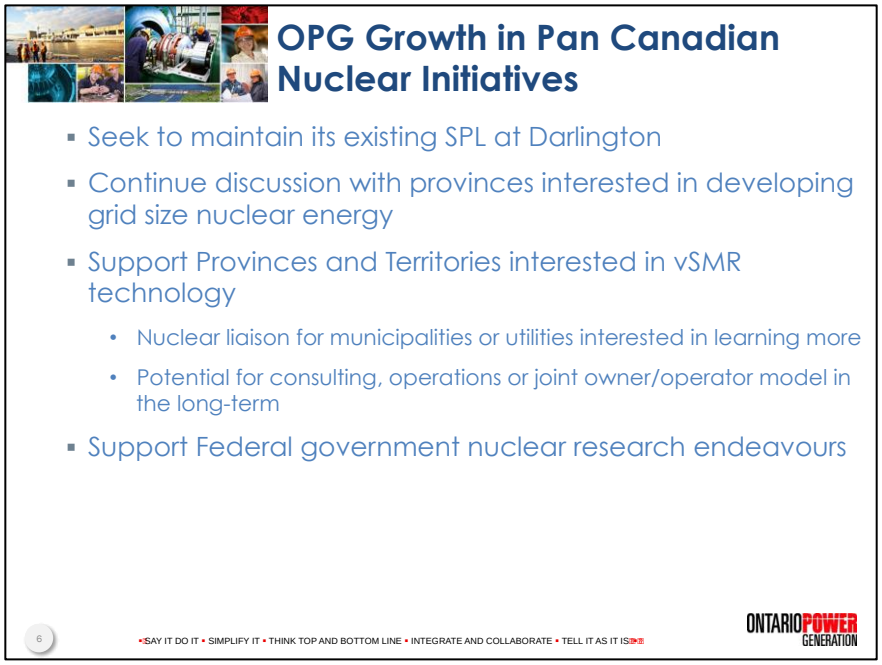


Ontario Power Generation's Support of a Pan-Canadian New Nuclear Vision

Ontario Power Generation (OPG) produces 60% of the electricity that Ontario homes, schools, hospitals, and businesses rely on each day. Its current power generating sources include 66 hydroelectric stations, two biomass stations, a thermal station, wind turbine farms, and two nuclear stations. OPG owns two other nuclear stations that are leased to Bruce Power. In fact, OPG is the largest and most experienced nuclear operator in Canada.

Further, OPG is committed to working with government and industry to support the establishment of a new Pan-Canadian nuclear vision. Its experience in nuclear technology puts them in a unique position, enabling them to play a role in facilitating resources for potential SMR and vSMR vendors. OPG's goals for a Pan-Canadian approach include: aligning on common technology selection criteria; socio-economic benefits to Canadians; and fleet benefits for construction, operations, maintenance, waste management, and decommissioning across Canada.





Bruce Power's Experience with Regulatory Processes and Potential Impacts on SMRs

Bruce Power is the largest private operator of nuclear power plants in Canada, operating eight units leased from the OPG, and has an agreement in place to supply power to the Province of Ontario. Its agreement with OPG is unique in that it is not only responsible for the operation, but also the refurbishment of these eight reactor units (Units 1 and 2 have already been refurbished, the other six units will be refurbished starting in 2020). Also, its agreement with the Province of Ontario is unique in that it dictates profit sharing with the Province once Bruce Power exceeds a certain profit level.

In terms of SMRs, Bruce Power is interested in being involved as an operator. However, as a private company one of its concerns will be its return on investment. Although there is a general assumption that government support will be required for SMRs to be market ready, it will also require private investment, so the economics behind these investments need to be sound.

One the key drivers of costs are the regulatory processes and timelines. Currently, Bruce Power incurs approximately $24 million annually for ongoing regulatory cost recovery fees (licensing fees), and another $8 million for periodic safety reviews for its eight units (in a ten-year licensing cycle), plus other on-going costs to meet regulatory requirements (i.e. quarterly and annual reporting, 5-year updates of safety analysis and environmental risk assessments, etc.). These costs are associated with traditional larger-scale reactors. There will be a need to streamline these regulatory processes, timelines, and costs for SMRs to be feasible as the production outputs for these units, and potential revenue generation, will be smaller. Some areas where these processes could be streamlined and costs reduced include employing a pan-Canadian or fleet model, and requiring one periodic safety review that covers several units (i.e. economies of series).

2.2 Heavy Industry Applications/Markets

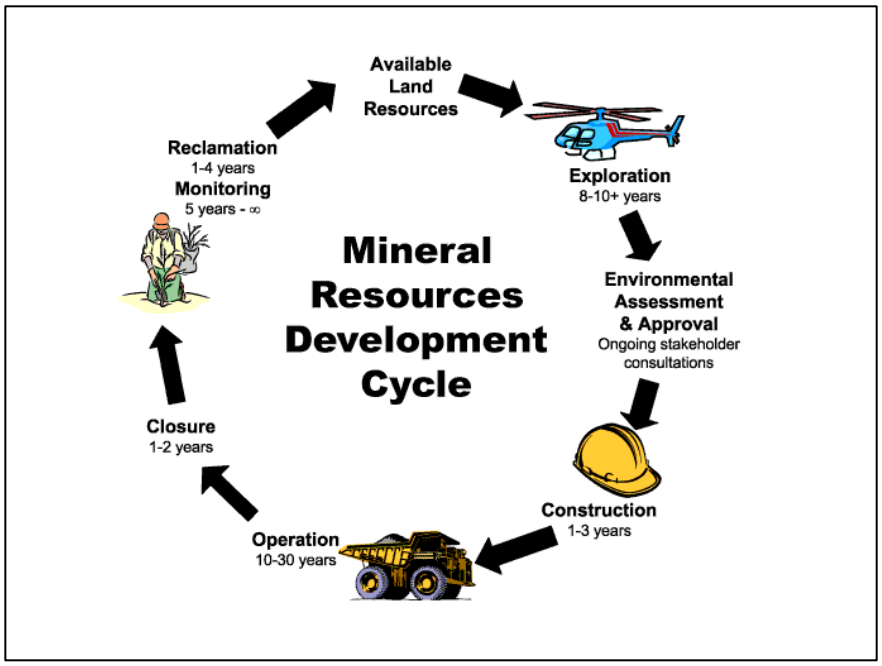
Presentations related to heavy industry applications/markets were provided by:

- Vic Pakalnis, President and CEO, Mirarco Mining Innovation
- Babatunde Olateju, Manager, Carbon Capture and Utilization, Alberta Innovates
- Colin Alie, Manager, Greenhouse Gas and Water, Enterprise Technology, Suncor

SMRs and their Application to Remote Mining Operations

The Canadian mining industry directly employs over 373,000 staff in Canada (with another 190,000 indirect positions), and more than 3,700 companies providing goods, services, and expertise in the industry. It also contributes 19% of Canada’s total export value, and is the top employer of Indigenous peoples with 12,700 direct jobs.

Power demands in remote mining operations require up to a 30-year lifecycle. Currently, power is supplied through diesel generation at most remote sites.



The mining and nuclear industries have much in common. Both industries have myths about them based on a lack of public education, particularly regarding safety. Also, both require significant capital investment from the outset. In the mining industry, these investments are quantified in the billions of dollars.

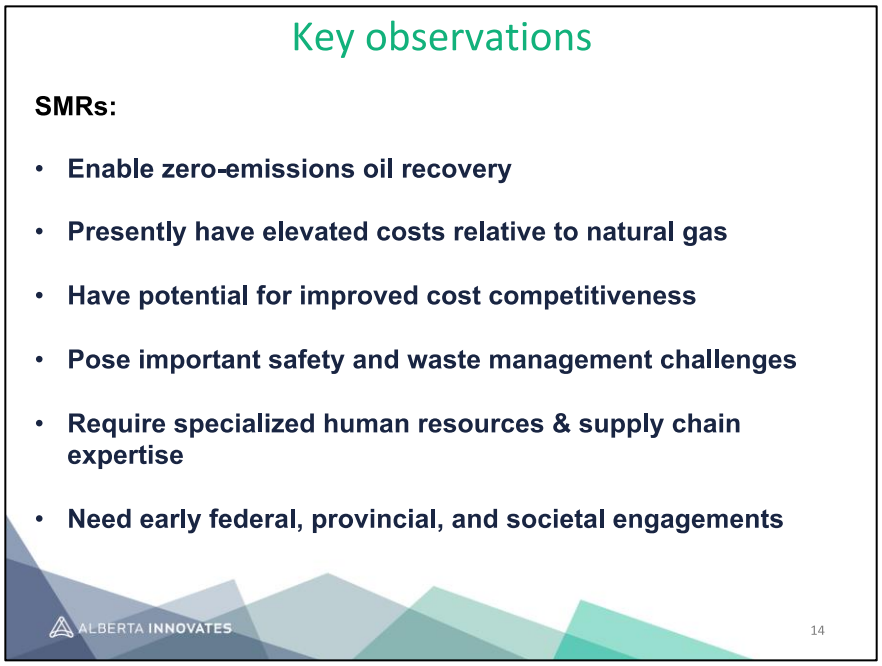
Moving forward, for SMRs to have a role in the mining industry, the most important component for them to succeed is achieving social acceptance from the industry and from neighbouring communities. Also, the technology must make business sense and be more cost-effective than the current diesel generating options. Finally, an SMR must be built within the next five to ten years to participate in the next mining cycle.

SMRs and their Applications in the Oil Sands

In 2015, the greenhouse gas (GHG) emissions in the oil sands were at approximately 71 MT. These emissions are attributable to oil recovery operations including in situ recovery (e.g., steam assisted gravity drainage) as well as surface mining and bitumen upgrading. The majority of these emissions are produced by the consumption of natural gas for steam, electricity, and hydrogen production. A number of relevant policy drivers in Alberta will require the industry to take proactive measures to reduce its GHG emissions; notably: the Climate Leadership Plan and the recently announced Carbon Competitiveness Incentive Regulation.

SMRs could have a role in reducing these emissions, though challenges exist related to economics. Natural gas electricity generation costs approximately $72 per MWh, while initial cost estimates for two reactor technologies (High Temperature Gas-Cooled and Integral Pressurized Water) are $128 and $105 per MWh respectively. However, cost reduction opportunities exist related to using a fleet approach to SMR deployment, attaining competitive financing, achieving degrees of automation, and reducing security requirements.

In terms of deployment within the oil sands, a number of key issues exist. First, the Canadian Nuclear Safety Commission's risk-based grading approach to assess licenses will be needed to ensure a relatively short and consistent licensing/regulatory timeframe, and also keeping in mind the need to engage with provincial regulators in a non-nuclear jurisdiction. Second, early projections on SMRs physical design suggests that it they may be too large to be transported to the oil sands via rail infrastructure, though utilizing trucks may be feasible. Third, there may be a need for a waste disposal site in Alberta, as there is currently no final repository for used nuclear fuel in Canada. Finally, with the lack of new nuclear build projects in North America and Europe over the last 30 years, the supply chain in these regions may have diminished appreciably during this time period.



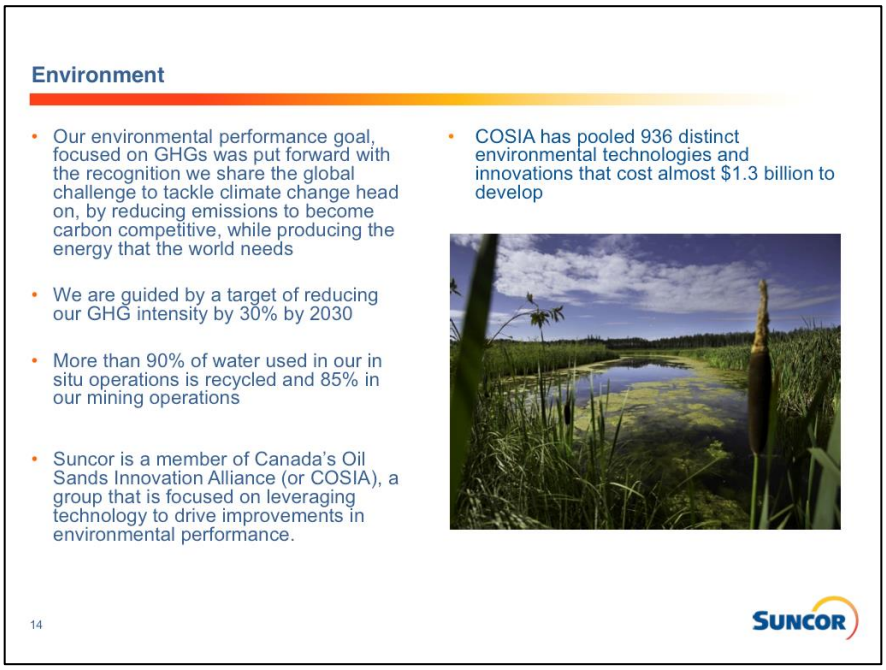
Suncor's Operations and the Potential for SMRs to Support its Objectives

Suncor is an integrated energy company with operations in Canada, the United States, and Europe. Near Fort McMurray, Alberta, in the Athabasca region, Suncor extracts and upgrades oil sands into high-quality, refinery-ready crude oil products and diesel fuel. This involves recovering bitumen from mining, in situ (meaning in place) operations, within the oil sands. Approximately 80% of Canada's oil sands are too deep to mine and requires in situ production using steam-assisted gravity drainage (SAGD) operations. Production either is upgraded into synthetic crude oil for refinery feedstock and diesel fuel, or blended with diluent for sale to market. Suncor is currently evaluating the potential to advance its in situ technologies at commercial scale through the development of an in situ demonstration facility at its MacKay River site.

In terms of its downstream operations, Suncor operates refineries in: Edmonton, Alberta; Sarnia, Ontario; Montreal, Quebec; and Commerce City, Colorado. It also operates 1,690 kilometres of 25 different pipelines throughout North America, and more than 1,450 Petro-Canada branded retail service stations across Canada.

Suncor's long-term strategy focuses on a "triple bottom line" of economic, social, and environmental performance. This involves a safe and performance-driven work environment, minimizing its environmental footprint, and contributing to the well-being of the communities in which it operates.

With this focus in mind, SMRs could play a role in assisting Suncor meet in environmental and innovation targets.



2.3 Off-Grid Northern and Remote Communities

Presentations related to off-grid northern and remote communities were provided by:

- Bruno Pereira, President and Chief Executive Officer, Qulliq Energy Corporation
- Bert Rose, Acting Chair, Qulliq Energy Corporation

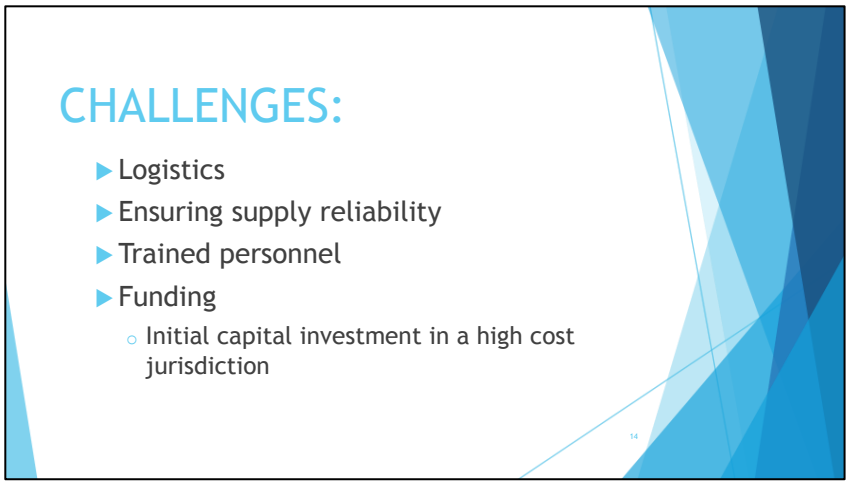
SMRs and Their Potential Deployment in Nunavut

Quilliq Energy Corporation (QEC) provides electricity to Nunavut's 25 communities. It is a territorial corporation owned by the Government of Nunavut, and employs 200 staff. The source of all of QEC's generated power is from diesel plants. It uses approximately 225 million litres of diesel annually.

Nunavut is a very large and unique jurisdiction. Its population is 37,500, and its 25 communities are dispersed across approximately 2 million square kilometres. There are no roads connecting communities, nor are there interconnections for utilities. Power generation facilities are localized in the community.

There is an acknowledgement in Nunavut that the territory will need to move away from diesel as its only source of power in the future. QEC is looking at a number of alternatives, at least to supplement its existing diesel infrastructure, including hydro, deep geothermal, tidal, and nuclear. Some renewable sources such as solar and wind are not feasible in the north due to intermittent supply experienced in the northern climate.

SMRs are a potential option for QEC. However, a number of challenges exist including issues related to logistics, ensuring supply reliability, training personnel, and funding.



Sensitivities Towards Nuclear Exists in Some Northern Communities

If the Roadmap is planning to approach the people of Nunavut about SMRs, those involved in the project should be aware of the nuclear history in the northern territories, and the resulting sensitivities towards the nuclear industry. In 1936, a uranium mine, Port Radium, was opened near the eastern shore of Great Bear Lake in the Norwest Territories, and operated until the 1970s. After its closure, the Dene people of the area learned that the mine produced uranium used by the United States in atomic weapons testing, and potentially in the atomic weapons dropped on Hiroshima and Nagasaki in the Second World War. Upon learning these details, the community was distraught, and sent an official delegation to Japan to offer an apology for their involvement in the tragedy. Since that time, multiple foreign interests (from Germany and France) have looked to open new uranium mines in the northern territories. Each attempt created a "groundswell" of anti-nuclear sentiment from the local communities, and ultimately failed. This anti-nuclear legacy still remains today.

It is this historical context that will create challenges for the Roadmap in approaching northern communities. There will be a lot of questions about SMRs, and a lot of apprehension when they hear that it is based on nuclear technology, but this is largely based on a lack of information. Northern communities will need to find an alternative to diesel, and SMRs may be viable alternative. Some suggestions of how to approach the northern communities during the Roadmap project include:

1. Rename the technology and the Roadmap project so that the word "nuclear" is in the title (e.g. Small Nuclear Modular Reactors Roadmap). The Roadmap project needs to be up-front and clear from the outset that this is nuclear technology. There is significant negativity towards the word nuclear in many communities. Not implementing these changes may lead to a view that the project is not being open and honest, and could lead to distrust from the communities moving forward.

2. Understand that all northern communities are facing similar energy challenges, not just Indigenous communities, and many believe that they are not being adequately consulted. As such, approach these communities to get a sense of their interest in the technology, rather than trying the push the technology. These types of changes will need to be locally driven. Also, remain cognizant that not all communities have the same view

or have the same level of interest (e.g. some northern communities have already inquired about slowpoke reactors).

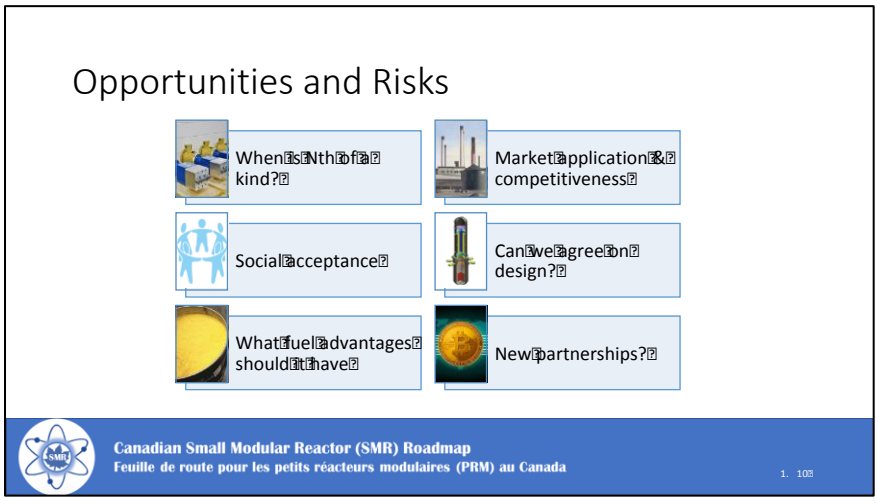
3. Consult with Inuit and other Indigenous organizations (such as the Inuit Tapiriit Kanatami) on how best to approach northern communities, and keep these organizations engaged throughout the process.
4. Consider the spin-off or unintended impacts of introducing the SMR to the community as a replacement to existing facilities (e.g. what is the net impact on jobs?). Also, consider what additional investments will be needed to deploy the SMR (e.g. connectivity, training) and any associated benefits.

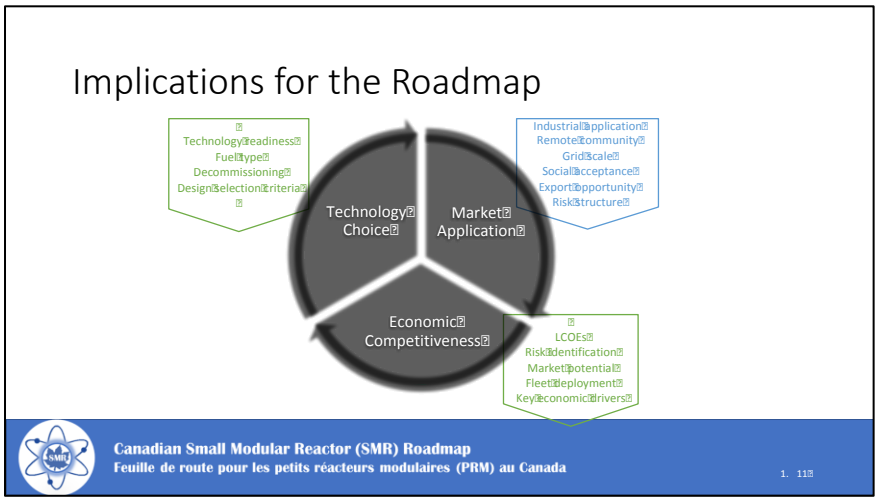
3. Summary of Roundtable Discussions

The Visioning Session also included three roundtable discussions used to collect input from the participants on several topics. These topics involved economic and financial considerations, off-grid applications/markets, and waste management. The following sub-sections provide a summary of the results from these roundtable discussions.

3.1 Economic and Financial Considerations

Prior to the roundtable discussion related to economic and financial considerations, Nicolle Butcher, Vice-President, Strategy and Acquisitions from Ontario Power Generation and the chair of the Economics and Finance Working Group provided an overview of the economic advantages, opportunities, and risks related to SMR technologies, and their implications for the Roadmap.





This presentation was intended to broadly address the current issues and opportunities SMR development presents, and to encourage different perspectives from each working group at the Visioning Workshop. Attendees were then asked to discuss the following question (at their respective table) and report back to the larger group:

> **What are the one or two most important economic matters that needs to be addressed for this "venture to move forward? Does this change for the three "primary" applications/markets?**

The following provides a summary of the results from these discussions.

Establishing a Macro-Economic Business Case for SMRs:
It may be necessary to develop a business case early on that clearly defines the rationale and benefits to investing in and deploying SMRs in Canada. The federal government was involved in the initial phases with the current fleet of full-size reactors, and will again most likely be looked on for support in building any SMR pilot. A business case that defines the potential socio-economic impacts to a pan-Canadian approach to SMRs could help in obtaining public acceptance and support government decision-making.

Sharing Risk Related to the First of a Kind (FOAK):
There is a need for a successful initial demonstration of an SMR, or a FOAK. However, the development and construction risks (and costs) related to FOAK deployment need to be considered and shared among multiple stakeholders, who may include the federal government, the provinces and territories, and the private sector. This would require a clear understanding among the stakeholders from the outset of the benefits to each party, and the distribution of risk sharing will need to reflect those benefits. Further, the distribution of risk sharing will depend on the market application (e.g. remote mining), which may lead to a more tailored FOAK SMR for each distinct application/market.

Achieving Cost Competitiveness:
The technological solution needs to be cost competitive relative to the incumbent competing technologies, specifically natural gas and diesel, in order to be considered a viable alternative and garner private sector interest. This may include a standardized design, and costing would need to consider all lifecycle costs from fuel source to decommissioning. Further, in order to be competitive, certain economies of series would be required or the achievement of the "Nth of a kind." However, the actual value of N and the timeframes associated with achieving it are unclear at this time.

Employing a Fleet Approach:
Closely related to achieving cost competitiveness, employing a fleet approach to SMR deployment where the technology is largely standardized in design provides some cost certainty to investors. However, the industry may need to study global markets more closely prior to making any technology decisions to ensure it will be able to be competitive with respect to international market demands in the future.

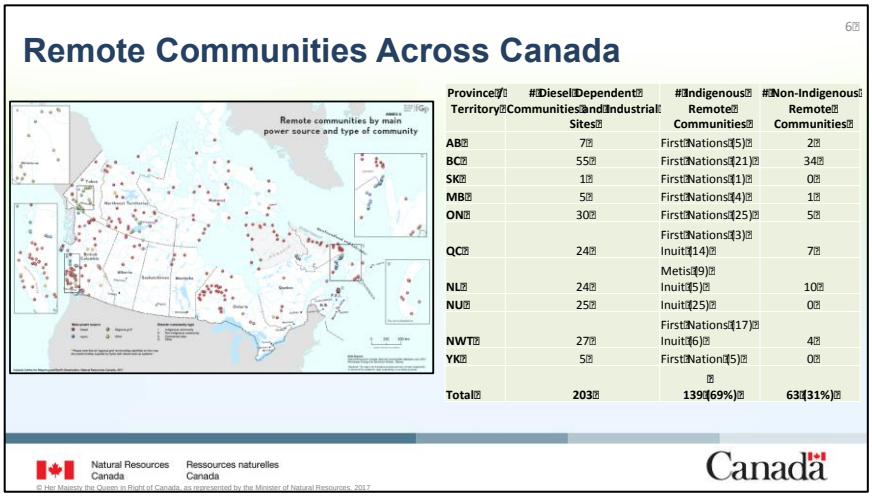
Ensuring Regulatory Certainty:
Canada will require a clear regulatory framework for SMRs based on top-tier/global standards that have consistent and predictable timeframes associated with its processes. Uncertainty in these timeframes can lead to additional costs and inefficiencies.

3.2 Off-Grid Applications/Markets

Prior to the roundtable discussion related to off-grid applications/markets, the presentations discussed under sub-section 2.3 Northern and Remote Communities were provided as well as a presentation from Julia Turner, Senior Policy Advisor, Nuclear Energy Directorate at NRCan, on the key data regarding remote communities in Canada, their current energy production sources, and a demonstration of NRCan/Indigenous Services Canada (ISC) *Remote Communities Energy Database.*

Overall, 203 remote communities[1] across ten provinces and territories rely on diesel for their power generation needs, of which 69% are Indigenous communities. Approximately, 70% of remote communities are currently served by provincial or territorial utilities. A number of Independent Power Producers (IPPs) are serving Indigenous communities in Ontario and British Columbia. Further, there has been an increasing role for Indigenous groups, communities, and regional development corporations in setting the direction for future energy generation for remote communities (e.g. Nunatsiavut Energy Security Plan, Makivik-FCNQ joint-venture, Watay Hydro Project).

[1] For the purposes of the SMR Roadmap the definition of a "remote community" is: 1) Any community not currently connected to the North American electrical grid nor to the piped natural gas network; and 2) Is a permanent or long-term (5 years or more) settlement with at least 10 dwellings.



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Remote Communities Across Canada

Province/ Territory	# Diesel Dependent Communities and Industrial Sites	# Indigenous Remote Communities	# Non-Indigenous Remote Communities
AB	7	First Nations (5)	2
BC	55	First Nations (21)	34
SK	1	First Nations (1)	0
MB	5	First Nations (4)	1
ON	30	First Nations (25)	5
QC	24	First Nations (3) Inuit (14)	7
NL	24	Metis (9) Inuit (5)	10
NU	25	Inuit (25)	0
NWT	27	First Nations (17) Inuit (6)	4
YK	5	First Nation (5)	0
Total	203	139 (69%)	63 (31%)

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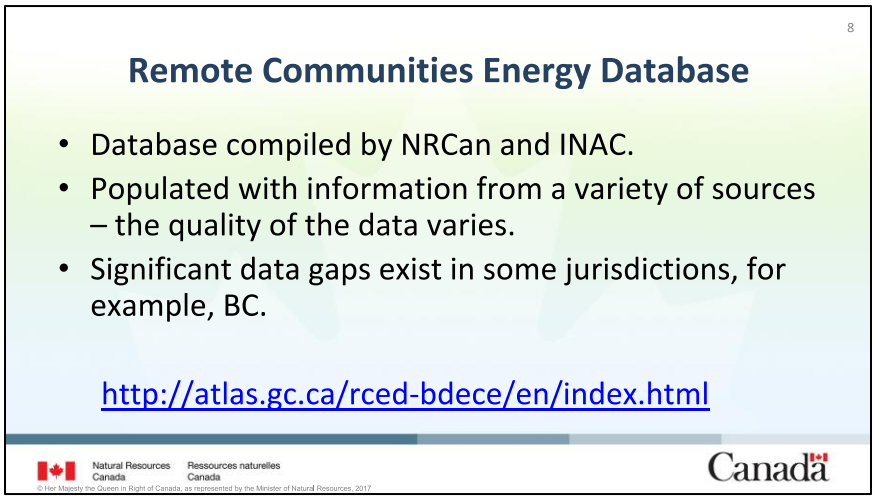

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Remote Communities Energy Database

- Database compiled by NRCan and INAC.
- Populated with information from a variety of sources – the quality of the data varies.
- Significant data gaps exist in some jurisdictions, for example, BC.

http://atlas.gc.ca/rced-bdece/en/index.html

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Again, these presentations were intended for information purposes and to promote discussion in the subsequent roundtable. Attendees were then asked to remain at the same table as during the economic and financial considerations discussion to discuss the following question and report back to the larger group:

> **How have your answers changed (related to the most important economic matters) after considering the off-grid presentations?**

The following provides a summary of the results from these discussions. The results varied and included new challenges that will have to be addressed, as well as similar challenges as those identified during the economic and financial considerations but with new characteristics.

Expanding Regulatory Certainty to Include a Social License:
Regulatory certainty (i.e. standards, timeframes, costs) is still important for off-grid applications, but any regulatory framework for off-grid applications also needs to include community acceptance, or a "social license." Public engagement and education would need to be undertaken in potential SMR sites. Further, in many northern communities, traditional Inuit or First Nations knowledge should be requested and considered prior to any engagement or regulatory decision.

A key challenge is that in many northern and remote communities (particularly in Nunavut) there are public subsidies that significantly reduce energy costs. As a result, if SMR design and deployment achieved cost competitiveness, the community still may not acknowledge or realize the cost benefits relative to traditional fossil fuels. Further, climate change has had an impact on traditional activities in northern communities. However, the direct outputs of fossil fuel usage (e.g. smog) are not as apparent as in southern cities. Again, this lack of visible benefits in those communities may lead to a challenge in public acceptance of SMRs over traditional technologies. Engagement activities in these communities may require some creativity to position SMRs in an "attractive" light that clearly describes the long-term benefits of SMR technology.

Ensuring Capacity Exists:
In northern and remote communities, and in communities that are non-traditionally nuclear, there will be a need to establish sufficient capacity to build and operate the SMRs. This may require capacity development initiatives in order to ensure that the local labour force is able to provide the necessary skills. Undertaking capacity development initiatives in a community may also promote public acceptance. However, many existing reactors can be operated and maintained remotely, requiring little local intervention (i.e., skillsets). As such, jurisdictional requirements and quality of connectivity may contribute to the operational model and the extent that capacity development will be required.

Sharing Risk of FOAK:
The sharing of risk associated with the FOAK is still a concern, and should still be shared among the federal government, provinces, territories, and the private sector. However, the community (or communities) need to also be involved in the discussions around risk-sharing. As discussed above, energy costs (for current diesel-based technology) are heavily subsidized in many northern communities through the federal government. As such, it would be anticipated, or possibly even required, that the federal government assume a certain level of risk on behalf of these communities.

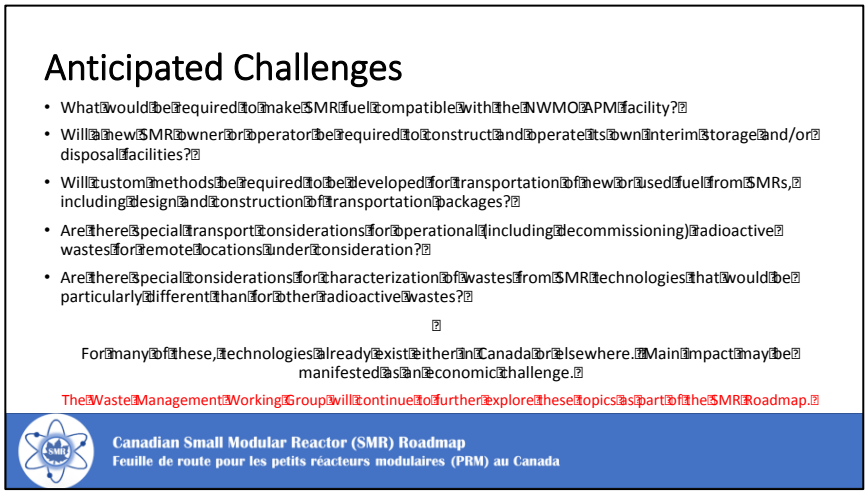
Achieving Cost Competitiveness:
Achieving cost competitiveness against competing technologies, particularly diesel, would still be a concern. However, placing SMRs in northern and remote communities would introduce additional costs associated with training, transportation, and waste management. Again, currently energy costs are heavily subsidized in many northern communities; this would need to be considered when planning for any SMR deployment in the north.

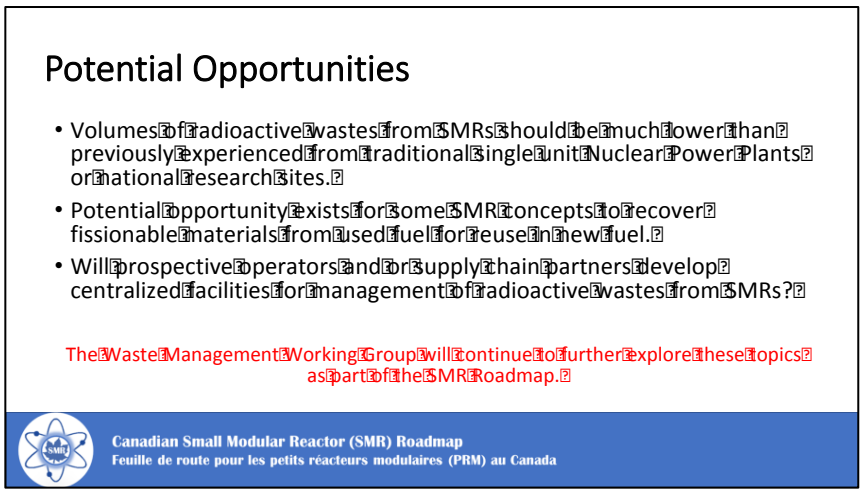
Further, the number of remote communities that are off-grid is decreasing (by being connected to the grid). This decreases the potential market size and could impact any cost advantages achieved through economies of series, particularly if a fleet approach to deployment is adopted.

3.3 Waste Management

Prior to the roundtable discussion related to waste management, Paul McClelland, Director of Waste Management and Technical Support from Atomic Energy of Canada Limited and the chair of the Waste Working Group provided a presentation on the current radioactive waste management landscape in Canada, the scale of radioactive waste, and anticipated challenges and opportunities for SMRs related to waste management.

In Canada, the federal government has the responsibility to develop policy, regulate, and oversee producers and owners to ensure that they comply with legal requirements, and that they meet their funding and operational responsibilities in accordance with approved waste disposal plans. Waste producers and owners are responsible, in accordance with the principle of "polluter pays", for the funding, organization, management, and operation of disposal and other facilities required for their wastes. This recognizes that arrangements may be different for nuclear fuel waste, low-level radioactive waste, and uranium mine and mill tailings.





Again, this presentation was intended for information purposes and to promote discussion in the subsequent roundtable. Attendees were then asked to discuss the following question (at their respective table) and report back to the larger group:

> **How does 1) the economic/financial issue and 2) the public engagement issue change once the waste considerations are solved (i.e. how, where)?**

The following provides a summary of the results from these discussions.

Increasing Investor Confidence:
In general, the waste costs are relatively small compared to the anticipated overall cost of SMR development and deployment. However, investors may raise concerns related to lingering waste and/or decommissioning costs. Although the waste from SMRs may be in a different form than traditional reactors and/or be managed in a different manner, the full lifecycle cost, including waste management, must be built into the overall cost from the outset. As such, solving waste management and decommissioning issues up front will introduce greater cost certainty, and increase investor confidence.

Easing Public Concerns:
Even with a waste solution technically solved, concerns from the public would continue to exist. Engagements would be required to improve public's understanding, and to alleviate any health and safety concerns. Any engagement would also need to involve describing the science and technology behind the solution, as well as a demonstration that the solution is viable, proven, and will not potentially lead to new issues in the future.

Establishing Transportation Webs:
A significant challenge for off-grid applications will be establishing the transportation methods and routes for fuel to, and waste from, the SMR. For many northern communities, transportation methods will have to involve water transport (i.e., sealift, barge), and access will be limited to certain periods of the year (typically June to October). Further, reactor operators in Canada have had little to no experience with water transport of waste.

Similarly, many remote communities are land locked and can only be accessed by a land vehicle in the winter via ice roads. As such, SMR operators may need use air transport for fuel/waste, and again, Canadian operators have had little experience using this type of transportation.

Engaging the Public Residing Along the Transportation Route:
Engaging community members to alleviate concerns presents its own challenges, but it is relatively straightforward to identify and directly engage with the individuals in those communities. It is much more difficult to identify and have a dialogue with the public who reside along the transportation routes that will be used to supply fuel and remove waste. Further, as SMRs become more widely deployed, those transportation routes will increase in number and reach.

4. Concluding Remarks

Although attendees were not asked to specifically formulate a visioning statement, this was discussed during plenary sessions at the conclusion of the roundtable discussions. It was generally acknowledged that the group had the following vision statement for the SMR Roadmap, along with requirements to support the visioning statement:

Potential Vision Statement for the SMR Roadmap

SMR technology deployed in the future that is providing clean technology to northern and remote communities, and in on-grid and heavy industries applications.

Requirements to support the potential visioning statement include:

1. Risks related to FOAK needs to be shared among public (federal, provincial, and municipal) and private sectors.
2. Costs associated with any SMR technical solution are competitive relative to its competition (specifically natural gas and diesel).
3. Certainty in regulatory processes, standards, timeframes, and costs.
4. Engagement and education of the public to ease concerns and obtain a "social license."

Throughout the Visioning Session, a number of other themes or conclusions were brought forward by attendees that were flagged as items that should be considered by the Roadmap Secretariat as the project progresses. At a macro-level:

1. The proposed structure for the next 3 workshops is sound (on-grid, heavy industry, off-grid).
2. The Roadmap must present a complete, successful "macro-economic business case" for SMRs to gain support.
3. Successful engagement of Indigenous peoples is important and must be integrated fully and early in the process. Building onto pre-existing relationships will strengthen this.
4. The Visioning Workshop revealed that there are many different viewpoints to consider when framing the future of SMRs in Canada. There are no self-evident directions and solutions, and there is much dialogue needed to understand and balance the various inputs.

At a micro-level:

1. Participants in a workshop setting are essential for identifying, discussing, and aligning different views and considerations.
2. Input from the Working Groups will be an important enabler for the workshops.
3. It will be important to get a critical mass of the "right" participants at the subsequent three Roadmap workshops.

Appendix A: List of Presenters at the Visioning Session

The following provides a list of topics presented and presenters at the Visioning Session.

The Federal Government Perspective and an Introduction to the SMR Roadmap:

- Diane Cameron, Director, Nuclear Energy Division, Natural Resources Canada

The Status of Small Modular Reactors:

- Bronwyn Hyland, Program Manager of Small Modular and Advanced Reactor Technologies, Canadian Nuclear Laboratories and the co-chair of the Technology Working Group

On-Grid Applications/Markets:

- Paul Thompson, Deputy Chief Nuclear Officer, NB Power
- Iain Harry, Senior Business Advisor, Generation Asset Management and Planning, SaskPower
- Jeff Lehman, Vice President, New Nuclear Development, Ontario Power Generation
- Maury Burton, Manager, Nuclear Regulatory Affairs, Bruce Power

Heavy Industry Applications/Markets:

- Vic Pakalnis, President and CEO, Mirarco Mining Innovation
- Babatunde Olateju, Manager, Carbon Capture and Utilization, Alberta Innovates
- Colin Alie, Manager, Greenhouse Gas and Water, Enterprise Technology, Suncor

Off-Grid Applications/Markets:

- Bruno Pereira, President and Chief Executive Officer, Qulliq Energy Corporation
- Bert Rose, Acting Chair, Qulliq Energy Corporation

Economic and Finance Considerations of SMRs:

- Nicolle Butcher, Vice-President, Strategy and Acquisitions, Ontario Power Generation and chair of the SMR Economics and Finance Working Group

Canada's Remote Communities and Power Production/Distribution in those Communities:

- Julia Turner, Senior Policy Advisory, Nuclear Energy Directorate, Natural Resources Canada

Waste Management Considerations for SMRs:

- Paul McClelland, Director of Waste Management and Technical Support, Atomic Energy of Canada Limited and the chair of the Waste Working Group

Appendix B: List of Attendees at the Visioning Session

Appendix C: List of Steering Committee Organizations

The following organizations are represented on the SMR Roadmap Steering Committee:

- New Brunswick Power
- New Brunswick Department of Energy and Resource Development
- Qulliq Energy Corporation
- Ontario Ministry of Energy
- Ontario Power Generation
- Bruce Power
- SaskPower
- Northwest Territories Department of Infrastructure
- Alberta Ministry of Energy
- Alberta Innovates
- Non-voting: Atomic Energy of Canada Ltd.
- Non-voting: Natural Resources Canada

The Steering Committee is also served by the following non-voting co-chairs:

- Diane Cameron, Director, Nuclear Energy Division, Natural Resources Canada
- Phil Carr, Roadmap Facilitator, Strategic Review Group/Canadian Nuclear Association