Government of Canada | Gouvernement du Canada

Small Modular Reactors (SMRs) in Canada

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Canada

Outline

1. **Context: A Canadian Perspective on Energy**
   - *Nuclear Energy in Canada*
2. **Canada's SMR Roadmap**
   - *Progress and Next Steps*
3. **Current Status**

A Canadian Perspective on Energy

Canada is a global energy leader with world-class assets and expertise…

Hydro
- 2nd largest hydro producer
- 59% of Canadian electricity

Energy efficiency
- Saved Canadians $38B in energy costs in 2015
- Avoided 95 Mt of GHG emissions

Crude oil
- 4th largest producer
- 3rd largest proved reserves

Environmental performance
- From 2000-2016, emissions per unit of energy decreased 13%
- Oil sands emissions per barrel have decreased 29% in the same period

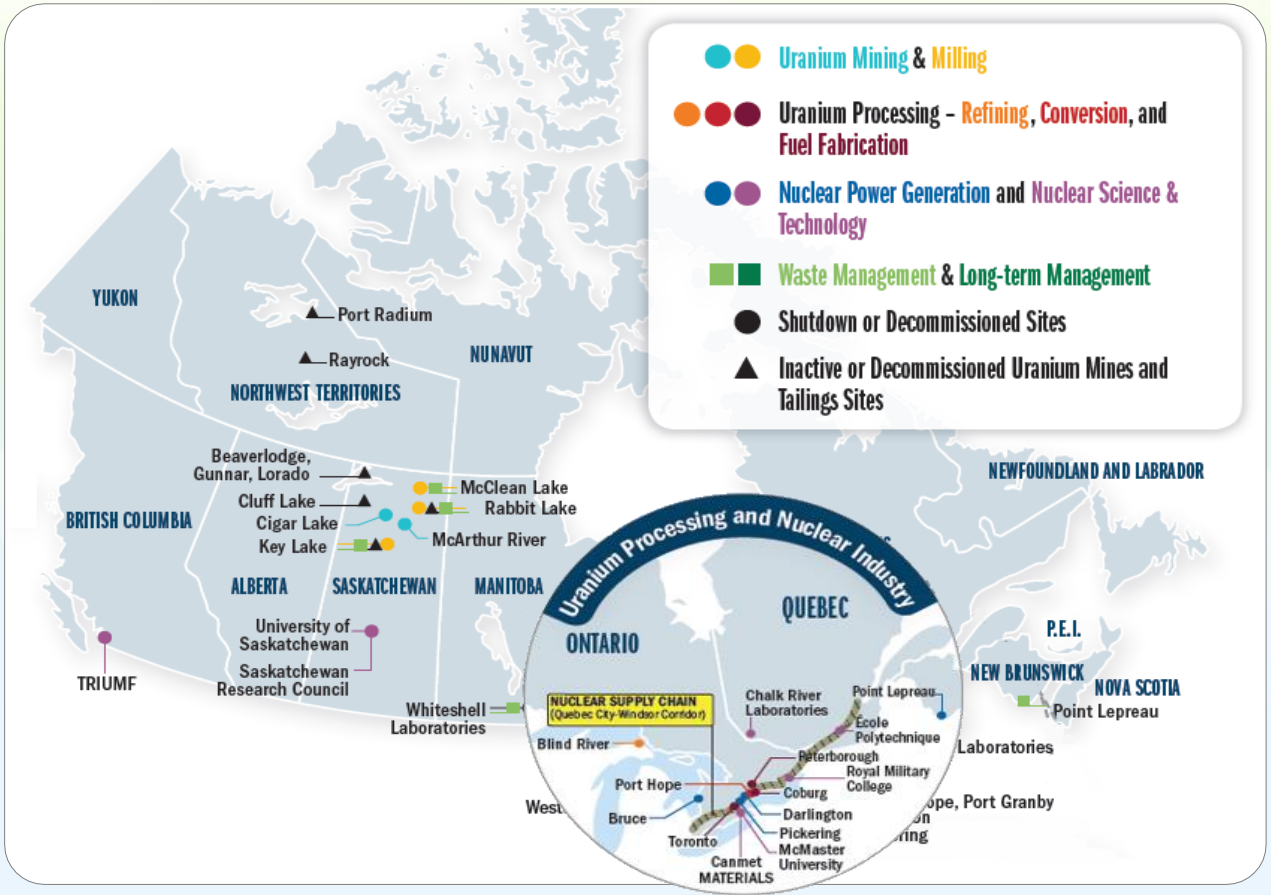
Natural gas
- 4th largest producer
- $7B net exports
- Cleanest LNG in the World

Energy innovation
- $2.2B invested in energy RD&D
- 56,000 employed in clean energy
- 1st in G20 on potential for new clean tech start-ups

Nuclear
- 2nd in uranium production
- Tier 1 Nuclear Nation
- Own nuclear reactor technology (CANDU)

Renewables (e.g. wind, solar)
- 9th in wind power capacity
- 10-fold growth in solar capacity since 2010
- 8th in liquid biofuels

Canada's nuclear sector has a pan-Canadian footprint and complete supply chain



… and is a strategic asset for Canada.

For 60 years, Canada has leveraged its nuclear leadership for significant strategic, economic, and scientific benefit.

ECONOMIC

- **$6B** to the economy; **30,000 direct jobs**. **$26B investments** to refurbish Ontario's fleet.
- **$1.4B uranium exports** annually; powers **1 in 17 American homes**.
- 19 home-grown CANDU reactors for **15% of Canada's electricity** – 60% in ON, 33% in NB. **30 CANDU reactors** around the world – 5% of global installed capacity.

GEOPOLITICAL

- **Beachhead for strategic international engagement**: bilaterally (US, China, India) and multilaterally (International Atomic Energy Agency, Nuclear Energy Agency).
- **Leadership in nuclear energy innovation**, bolstered by $1.2B to revitalize Chalk River, gives us influence at **nuclear security tables**.

SOCIAL AND ENVIRONMENT

- **2nd largest source of non-emitting electricity in Canada**, offsetting 50M+ tonnes of CO_2.
- Waste management framework is **seen as the gold standard** internationally.

Canada's expertise and supply chain are world-class — *but what's next for nuclear in Canada?*

Markets are signalling demand for smaller, simpler, and "hybrid" nuclear technologies...

Artwork courtesy of Third Way

- Nuclear energy needed to meet climate change targets—IEA projects it **must double by 2040** to meet a 2 degree scenario.
- The **future of nuclear** is SMRs – smaller, simpler, safer and cheaper than full-scale nuclear power
- **New applications** for SMRs, such as load-following renewables, hybrid systems and energy parks
- **Fleet approach** – using the same design for several reactors – increases value proposition
- **Hybrid energy systems** integrate multiple energy sources to increase efficiency and allow for dynamic load-following
- **SMRs paired with variable renewables** could enable higher penetration of variables on a decentralized grid

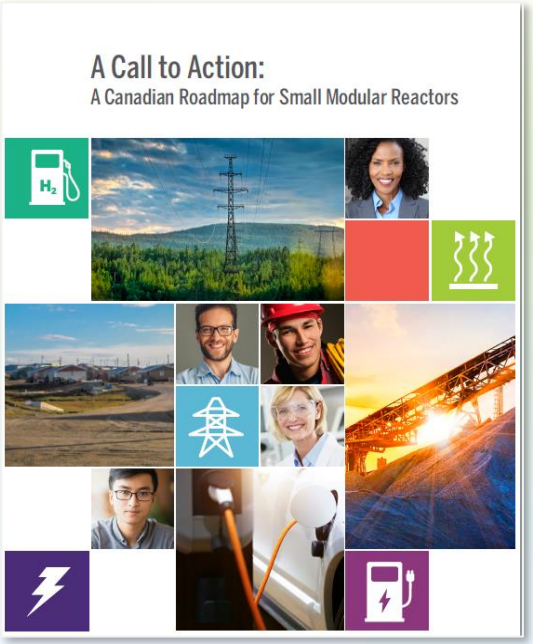
...and industry is innovating.

Canada's SMR Roadmap

The focal point for developing Canada's SMR policy framework

Canada's Small Modular Reactor Roadmap

SMRs as a source of safe, clean, affordable energy — opening opportunities for a resilient, low-carbon future and capturing benefits for Canada and Canadians.

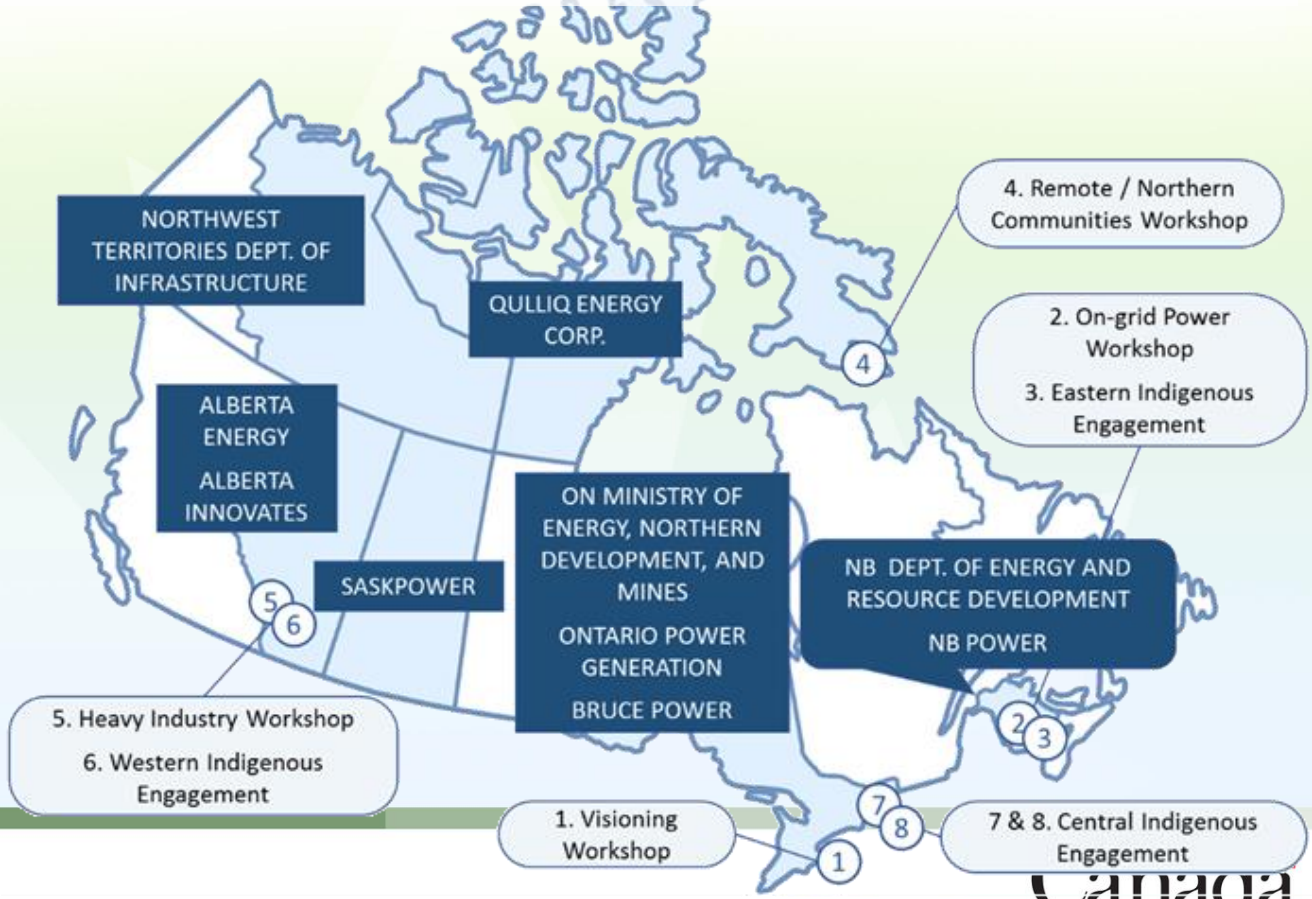


www.smrroadmap.ca

We took a national approach to engagement…

NRCan-convened, stakeholder-driven:

- ✓ **Nov 2017 – Sept 2018**
  - ➢ Extensive engagement
  - ➢ Analysis by experts
- ✓ **Collaborative, innovative leadership**
  - ➢ Provinces, Territories
  - ➢ Power Utilities
- ✓ **8 workshops across Canada**
  - ➢ 55 organizations
  - ➢ 10 sectors/subsectors
  - ➢ 180+ participants
- ✓ **5 expert working groups**
  - ➢ 18 organizations



…and an immense global SMR opportunity driven by climate change mitigation and energy security imperatives.

Replace coal-fired power generation

- SMRs can further transition the power sector away from coal
- Even in a 2-degree scenario IEA projects 1100GWe
- Potential market **over $100B/year**

Remote island nations and off-grid communities

- Large potential in over 70k communities
- **$30B/year market**

Heat & power for mines

- SMRs powering of new mines between now and 2040 could yield total global value of **$3.5B/year market**

Steam for heavy industry

- Potentially **$12B per year global market**. Joint project from Idaho NL and NREL identified 850 facilities where SMRs could provide steam for US heavy industry.

Bottom Line: Estimated global value of $150B per year by 2040.

An SMR sub-sector is emerging in Canada, with an eye to a pan-Canadian domestic market…

Oil sands

- Steam for SAGD and electricity for upgrading at **96 facilities**
- 210 MWe average size for both heat and power demands
- 5% replacement by SMRs between 2030 and 2040 could **provide $350-450M in value annually**

High-temperature steam for heavy industry

- 85 heavy industry locations (e.g. chemicals, petroleum Refining)
- 25-50 MWe average size
- 5% replacement by SMRS between 2030 and 2040 could **provide $46M in value annually**

Remote communities and mines

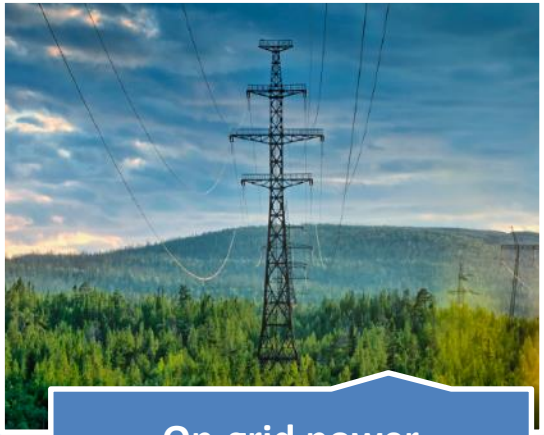
- 79 remote communities in Canada with energy needs > 1 MWe
- SMRs replacing costly diesel and heating oil could **reduce energy costs to the territorial government**
- **The high cost of energy from diesel is a barrier. SMRs could facilitate and enable new mining developments**
- 24 current and potential off-grid mines

Replacing conventional coal-fired power:

- 29 units in Canada at 17 facilities
- 343 MWe average size
- 10% replacement by SMRs between 2030 and 2040 could **provide $469M in value annually**

Bottom line: SMRs could conservatively yield **$5.3B in total value to Canada** between 2030 and 2040.

There are three distinct markets for SMRs in Canada and the global export market



On-grid power
(150 to 300 MWe)

On- and off-grid heavy industry (10 to 80 MWe)

Off-grid communities
(1 to 10 MWe)

We heard that SMRs are an innovation story with a range of potential benefits for Canada…

ECONOMIC

✓ **Thousands of jobs**	*…robust Canadian supply chain supporting high-skill labour force*
✓ **Centre of the export market**	*…Canadian power utilities leading the market as global SMR operators*
✓ **Cutting edge research**	*…CNL providing services as an international hub, helping to anchor the emerging high technology subsector in Canada*
✓ **Leadership in mining sector**	*…Canadian mining companies deploying SMRs in domestic operations, and leverage their networks to access export markets*

GEOPOLITICAL

✓**Policy expertise**	*…Canada as a Tier 1 SMR nation, with a strong international brand, strengthening Canada's position in international relations*
✓**Globally-recognized regulator**	*…CNSC as a standards-setter to influence international frameworks and enable export markets for technologies anchored in Canada*

SOCIAL AND ENVRIONMENT

✓**Reduce GHG emissions**	*…deployment of SMRs in Canada across several markets, displacing GHG emissions and increasing energy security*
✓**Regional growth**	*…Atlantic Canada leading on molten salt SMRs; Saskatchewan exporting uranium; Ontario providing advanced manufacturing to the world*
✓**Constructive partnerships**	*…Northern and Indigenous communities and SMR industry demonstrating engagement and partnership best practices*

Action now could lead to deployment and benefits for Canada by 2030.

…and several key themes emerged.

Science, Technology, and Innovation

- Canada could exploit a technologically-advanced niche

Economic Development and Competitiveness

- SMR innovation could be a driver of economic development and exports – *if the supply chain is anchored in Canada*
- Mining is a promising first market, in addition to on-grid

Global Leadership

- The target market is global – *starting with demo and deployment in Canada first*
- SMR demonstration would help capture first-mover advantages and anchor benefits for Canada

Community and Indigenous Engagement

- Some northern communities interested (others not); requested feasibility studies and holistic energy planning
- Indigenous priorities vary by region but include environmental stewardship, Indigenous ownership, and revenue sharing

Regulatory Frameworks

- Canada's regulatory framework is a competitive advantage
- Canada's legislative and regulatory frameworks are flexible enough to accommodate SMRs
- Some updates are recommended to improve efficiencies

Environment and Climate Change

- Potentially an important source of non-emitting heat and power—*especially for off-coal and off-diesel*
- Waste from SMRs can be accommodated within the existing framework, but will require some negotiation among owners

Bottom line: **Technology risks are manageable** with the right enabling frameworks and strategic partnerships to **achieve benefits to Canada**.

Conditions for Success

Beyond technical feasibility, there are six key conditions for success—and **Canada has what it will take to succeed:**

1. **Regulatory:** Independent regulator, open to innovation
2. **Sites:** Leadership in S&T and sites for demonstration
3. **Operators:** Experienced nuclear operators ready to partner
4. **Financing:** Mix of public and private financing
5. **Supply chain:** Full-spectrum supply chain ramped up
6. **Demand:** A strong brand internationally; favourable markets and economics; significant interest for mining

Canada is uniquely positioned to lead.

Canada's SMR Roadmap: *Final Report*

- ✓ **Final report was launched in November 2018**
  - ➢ At Canada's 1st International Conference on Generation IV and Small Reactors

- ✓ **With recommendations for concrete action by essential enabling partners across 4 pillars:**
  - ➢ **Pillar 1** – *Demonstration and Deployment*
  - ➢ **Pillar 2** – *Capacity, Engagement, and Public Confidence*
  - ➢ **Pillar 3** – *Policy, Legislation, and Regulations*
  - ➢ **Pillar 4** – *International Partnerships and Markets*

SMR projects are moving forward in Canada

- Projects that meet end-user needs are **ready to move forward** in Canada
- There are many technologies with **different risks and rewards**, across all three markets
- Canada is **well-positioned to lead** and capture value

11 working with the CNSC on pre-licensing vendor design reviews

1 application submitted

5+ working with CNL on its siting process

2+ working with NB Power

2+ working with OPG and Bruce Power

Applications submitted through ISED's Strategic Innovation Fund

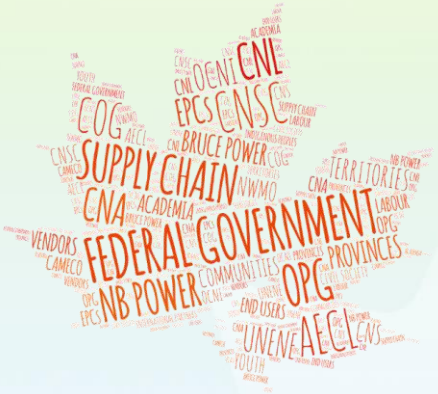
Team Canada is engaged

- **Candu Owners Group**
  - SMR Task - focused regulation gaps
  - SMR Vendor Participation Program
- **NEA –NEST SMR Project** - McMaster University
- **University of New Brunswick** – Centre for Nuclear Energy Research – SMR Cluster
- **Generation IV International Forum** – SMR Vendor Participation
- **Natural Science & Engineering Research Council of Canada**
  - Small Advanced Reactor Training Program (SMART)
- **MIRRACO – MOU with Bruce Power - Video**

We are taking action on key priorities for 2019…

- ✓ **Mining:** focused engagement with mining sector on end-user requirements, taking steps to foster strategic partnerships
- ✓ **Indigenous engagement**: preparing ongoing engagement strategies in partnership with Indigenous peoples
- ✓ **Global enabling frameworks**: active engagement and leadership in key fora (CEM, NEA, IAEA); validating size and pathways to global deployment
- ✓ **Strategic bilateral partnerships**: collaboration with other international leaders on SMRs (US, UK)
- ✓ **SMR demonstration:** project evaluation progressing across multiple markets (on-grid, off-grid, mining)

Effective partnerships are key to success



Domestic – *Team Canada*

- SMR Roadmap called for “Team Canada” to come together with concrete commitments for action
- Government of Canada committed to a team approach bringing together key enablers, leveraging respective roles, resources and responsibilities

Thank you!

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