

Improve the Understanding of Environmental Impacts and Waste of SMR Operations in Support of the Pan-Canadian SMR Roadmap Activities

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PROJECT

Knowledge Gaps

1. Potential new waste streams to Canadian jurisdictions
2. New radionuclides that are not well studied in Canadian ecosystems

Objectives

- Parameters for assessing ecological and human health risk from Small Modular Reactors (SMR) in the Canadian environment.
- Estimates of low- and intermediate-level waste (LILW) streams from SMR operation, fuel cycle and decommissioning
- Strategy for graphite waste
- SMR fuel processing and stabilization options

Alignment

Aligns with Government Priority to “Overcome the challenges of powering off-grid communities and contribute to CO2 emission reduction in Canada”

Stakeholders NRCan, CNSC, ECCC, Health Canada

ENVIRONMENTAL IMPACT STUDIES

Planning for Arctic Research (Year 1)

Planning for arctic field research in summer 2021 is underway, utilizing the results of Brinkmann and Rowan (2018) for aquatic ecosystems as a template for ecological risk and site selection. Preliminary field sites for 2021 are identified.

- Areas with high risk include southern Baffin Island, Ungava Bay and eastern Labrador. Areas with moderate risk include Baker Lake, Slave Lake (NWT) and Churchill (MN), with lower risk at Cambridge Bay and Wood Buffalo National Park.
- A draft research plan was submitted to the Nunavut Research Institute in June (milestone, June 2019). A final proposal to obtain a research license will be submitted following community approval (Iqaluit, Cambridge Bay and Baker Lake).
- Permits are not required for Churchill (Manitoba), Labrador, Ungava Bay and Wood Buffalo National Park.
- Slave Lake requires a research license from Northwest Territories.

WASTE STREAMS

Calculating N-activation Waste Streams (Year 1)

Neutron activation calculations to determine waste streams for five SMR technologies:

1. Integral Pressurized Water Reactor (iPWR)
2. High Temperature Gas-cooled Reactor (HTGR)
3. Molten Salt Reactor (MSR)
4. Lead-cooled Fast Reactor (LFR)
5. Sodium-cooled Fast Reactor (SFR)

N-activation Methodology:

Coupling neutron fluxes and spectra with neutron nuclear reactions and decay

1. Neutron fluxes and spectra SERPENT v.2: 3-D continuous-energy Monte Carlo particle transport code
2. Time-dependent isotope concentrations activities: ORIGEN (Oak Ridge Isotope Generation code) v2.2 on neutron transmutation, fission, and decay

Data collection for primary reactor components and physics models developed (shown in figures) for 4 of the 5 reactor types to be modelled.

Calculations have started to determine the waste inventory from neutron activation.

Graphite Waste Inventory

Graphite waste treatment technologies literature is being review to determine waste inventories, characteristics, and recycle technologies.

- 250,000 tons of i-graphite.
- Activation of atoms within the graphite structure include C-14, Cl-36 (long-lived) and H-3, Co-60 (short-lived). Activation of atoms deposited on the graphite surface will be C-14.
- There is potential for future re-use of graphite for for HTGR and Integral MSR.

FUEL DISPOSAL AND LIFE-CYCLE WASTE GENERATION

Review of fuel disposal and life-cycle waste (Year 1)

- Fuel disposal and life-cycle waste generation for SMR are being reviewed, including investigation of dry processing for research reactor fuels, spent fuel and high level waste disposal technologies and possible processing methods for spent fuel types.

HTGRb

- Direct storage of TRISO
- TRISO encapsulation in glass

MSRb,c

- Electro-metallurgical process for stabilization
- CNL Reactor Fuels
- Conversion of metal and carbide fuels to oxides

NEXT STEPS (Future Years)

Environmental Impact Studies

- Sample soil, plants and water utilized by wildlife and people in sub-Arctic and Arctic regions of Canada to assess soil to plant transfer of radionuclides
- Measure dispersion in coastal marine areas of the Canadian Arctic for radionuclide fate and transport models
- Develop regional approaches for evaluating ecological and human health risk in Canada from SMR deployment
- Identify resilient and vulnerable regions, ecosystems and pathways for various SMR types

Waste Streams

- Improve estimates of LILW generation for SMRs
- Assess LILW waste management challenges and disposal requirements in the Pan-Canadian framework, including development of a strategy for recycling graphite waste

Fuel Disposal and Life-Cycle Waste

- Research and review of spent fuel characteristics and disposal technologies. Collect and summarize lifecycle waste data.
- Identify possible processing methods and develop plans for future experimental work
- Initial research into methods for conversion of SMR spent fuel to suitable fuel form for disposal in Nuclear Waste Management Organization (NWMO) repository.