Canadian Nuclear Laboratories | Laboratoires Nucléaires Canadiens

Canadian Overview

Non-Electric Applications of Nuclear Heat Workshop Researchers panel

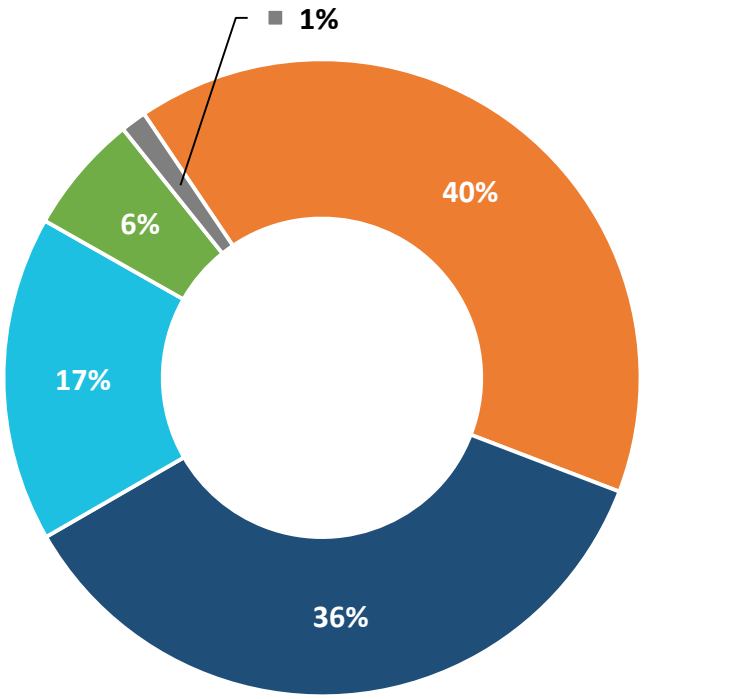
2022 October 03

Ali Siddiqui
Head of Directorate, Advanced Reactors
Canadian Nuclear Laboratories

Net-Zero Challenge

Reaching net zero is complex

- Large-scale electrification: requires significantly more electricity, as high as 2-3 times demand by 2050
- Transportation decarbonization: likely battery electric for light-duty vehicles, but hydrogen fuel cells are a good fit for large vehicles and/or high duty cycle applications, synthetic and clean fuels
- Industrial decarbonization: high temperature heat and hydrogen required in addition to electricity
- Time is short: Government of Canada has committed to net-zero by 2050, with a net-zero electricity grid by 2035
- No single technology can achieve our goals
- Success will require an “all options” approach, necessitating the use of hybrid energy systems



Data from Canada Energy Regulator: https://www.cer-rec.gc.ca/en/

Canada's Past Experience

- **Building Heat, 1980s**: WR-1 reactor and SLOWPOKE Energy System reactor in Whiteshell Labs, Manitoba
- **Bruce Heavy-Water Plant (BHWP), 1973-1998**: Steam was transported from the Bruce reactors to a co-located heavy water production plant in Ontario
- **Bruce Bulk Steam System (BBSS), 1972-2006**: steam used for building heat and through Bruce Energy Center supported a greenhouse; ethanol plant; plastic film production; alfalfa production; apple juice concentration plant and more

Canadian Landscape

Potential Applications

- Hydrogen
- Synthetic Fuels
- Mining
- Oil Sands
- Heavy Industry

Supporting Activities

- Hydrogen Strategy
- Advanced Reactors
  - SMR Action Plan
  - Utility Projects
  - SMR Developers
  - CNL

Hydrogen Strategy for Canada

Nuclear Working Group

- The Hydrogen Strategy identifies synergies with nuclear energy, as it can be used to produce low carbon intensity hydrogen via electrolysis or high temperature processes.
- The Nuclear Working Group has the following mandate
  - Foster coordination and collaboration among its stakeholder participants
  - Form recommendation in support of the implementation of the Hydrogen Strategy for Canada.
  - Leverage Canada's nuclear expertise to become leaders in hydrogen economy by improving non-emitting production technologies for hydrogen

Safety, Regulations, Code & Standards	Production Opportunities	Economics, Finance, Business Models, and Policy	Technology and Infrastructure

CNL's Role in Heavy Duty Transportation – Clean Fuels R&D

Rail fuel - hydrogen

- Fleet assessment; infrastructure design and planning; safety RCS; technology evaluation
- Projects: Hydrail feasibility study; safety RCS for Metrolinx & Transport Canada

Maritime fuel – hydrogen, biofuels, batteries and nuclear

- Fleet assessment tool; infrastructure design & planning; safety RCS; technology evaluation
- Projects: Transport Canada; Canadian Coast Guard

Sustainable aviation fuels – hydrogen + renewable carbon based

- Fleet and ground support equipment assessment; infrastructure design & planning; technology evaluation
- Projects: e-Syn jet fuel production technology

Need for Energy Analysis and Optimization Tools

Environment

- Reducing GHG emissions to meet the carbon neutral requirements to mitigate climate change
- Cutting emissions from fossil fuel to improve air quality

Energy

- Energy security
- Improving reliability and efficiency of energy systems
- Variability of renewable energy

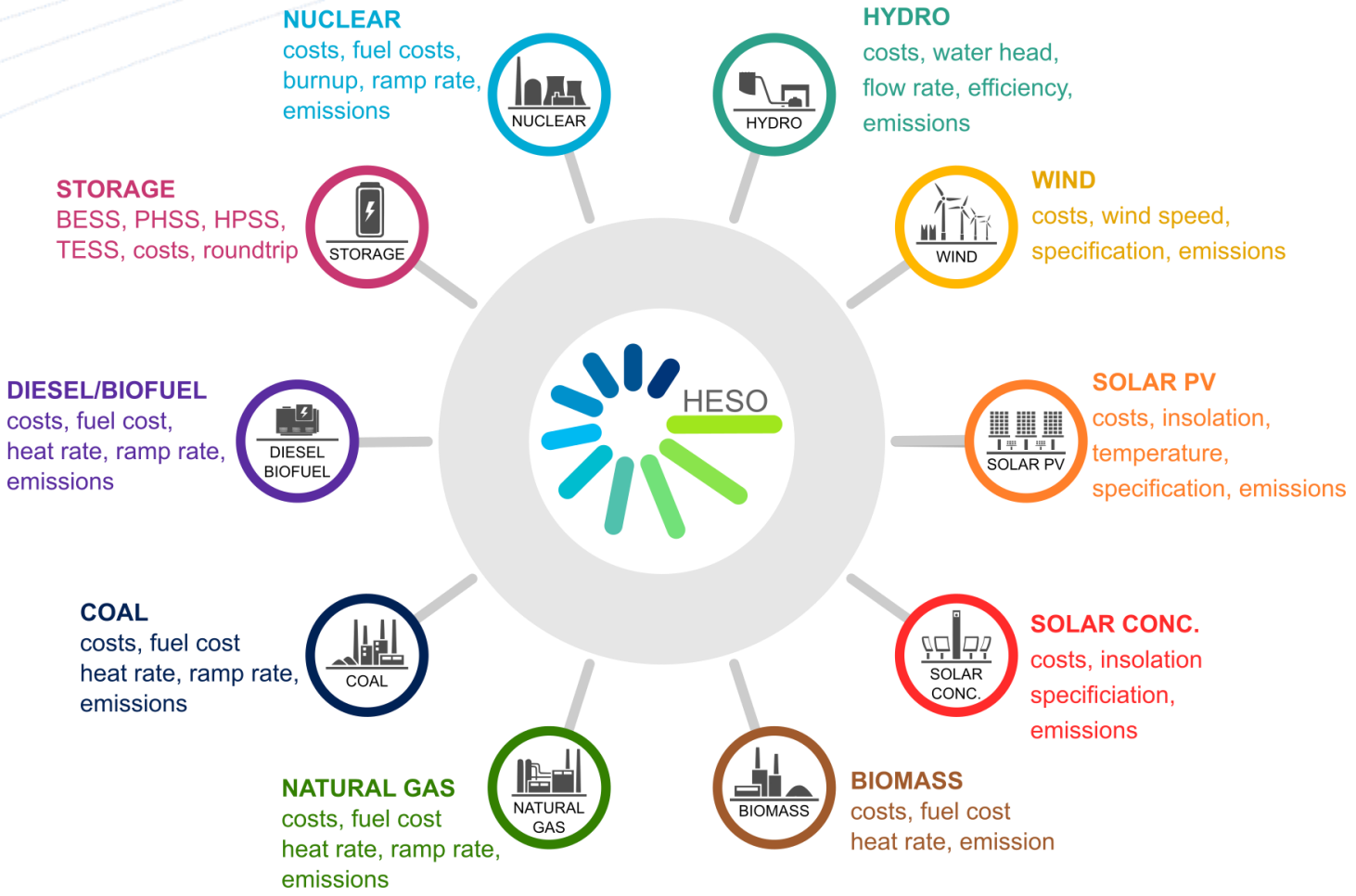
Economy

- Cost
- Increasing carbon tax
- Meeting increasing demand for green energy and technologies

Hybrid Energy System Analysis

Hybrid Energy System Optimization

Generating technologies and storage options

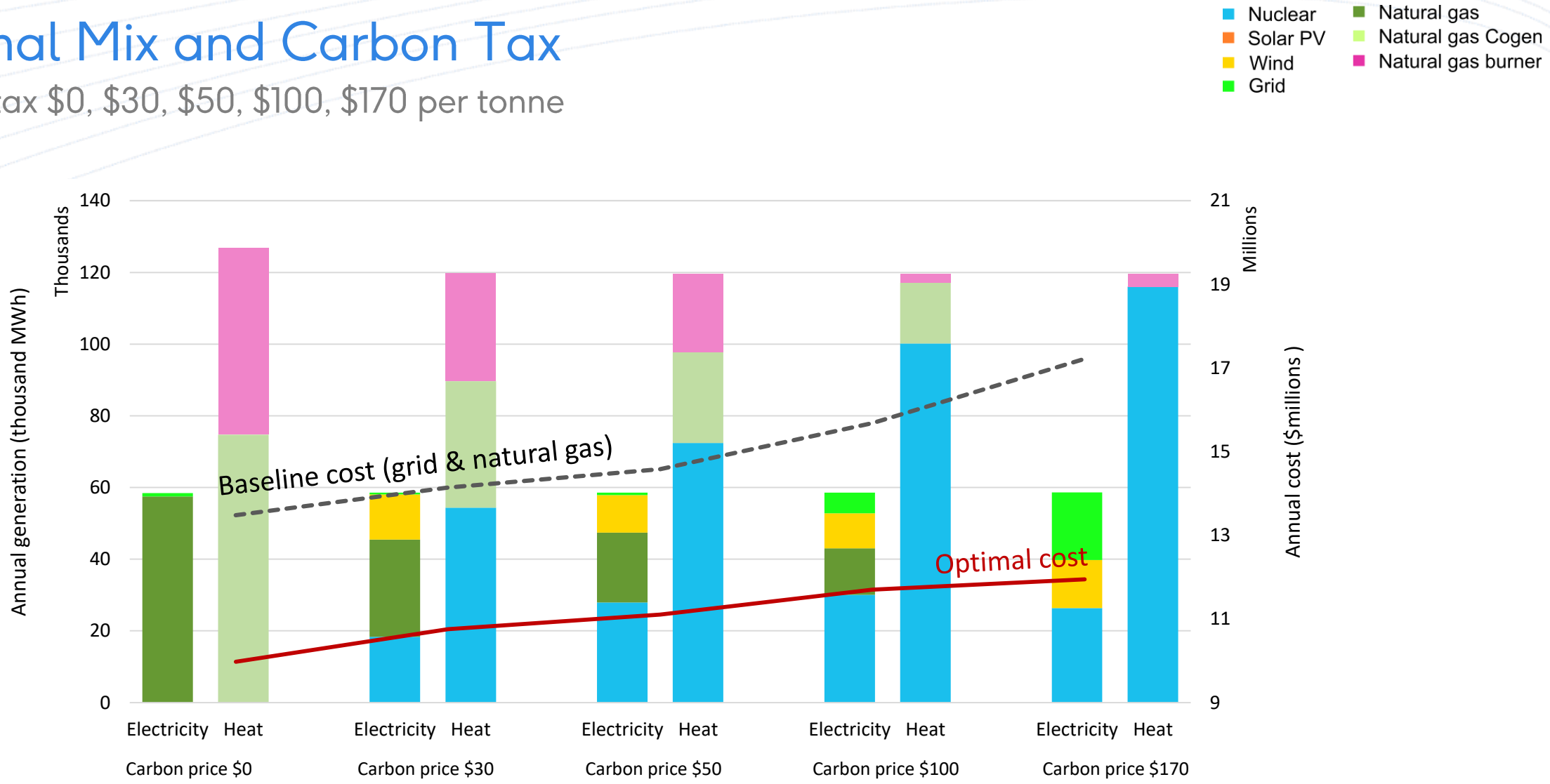


Key Features

- ✓ Multiple generating and storage technologies
- ✓ Ramp rates
- ✓ Nuclear technical constraints
- ✓ Maintenance schedules
- ✓ Three types of demands
  - Electricity
  - Heat
  - Hydrogen
- ✓ Hourly time step
- ✓ Life cycle GHG emissions
- ✓ Carbon tax (fossil fuels)
- ✓ Cogeneration
- ✓ Carbon capture and storage (CCS)
- ✓ On-grid and off-grid
- ✓ No installed capacity information required

Optimal Mix and Carbon Tax

Carbon tax $0, $30, $50, $100, $170 per tonne



Selected Feasibility Studies using HESO

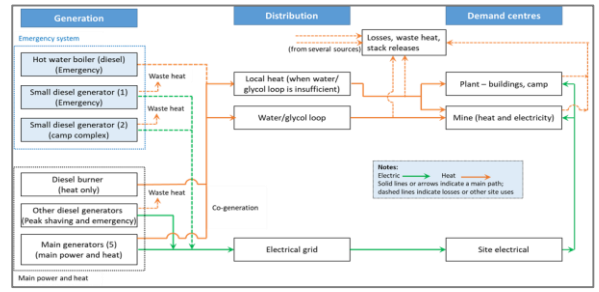
Small Modular Reactor (SMR) Economic Feasibility and Cost-Benefit Study for Remote Mining in the Canadian North

This research project identifies the specific electrical and thermal requirements of a representative mine site to evaluate the economic competitiveness of vSMR deployment under different scenarios.

ONTARIO POWER GENERATION

Canadian Nuclear Laboratories | Laboratoires Nucléaires Canadiens

mirarco MINING INNOVATION



Nuclear renewable hybrid energy system assessment through the thermal storage system

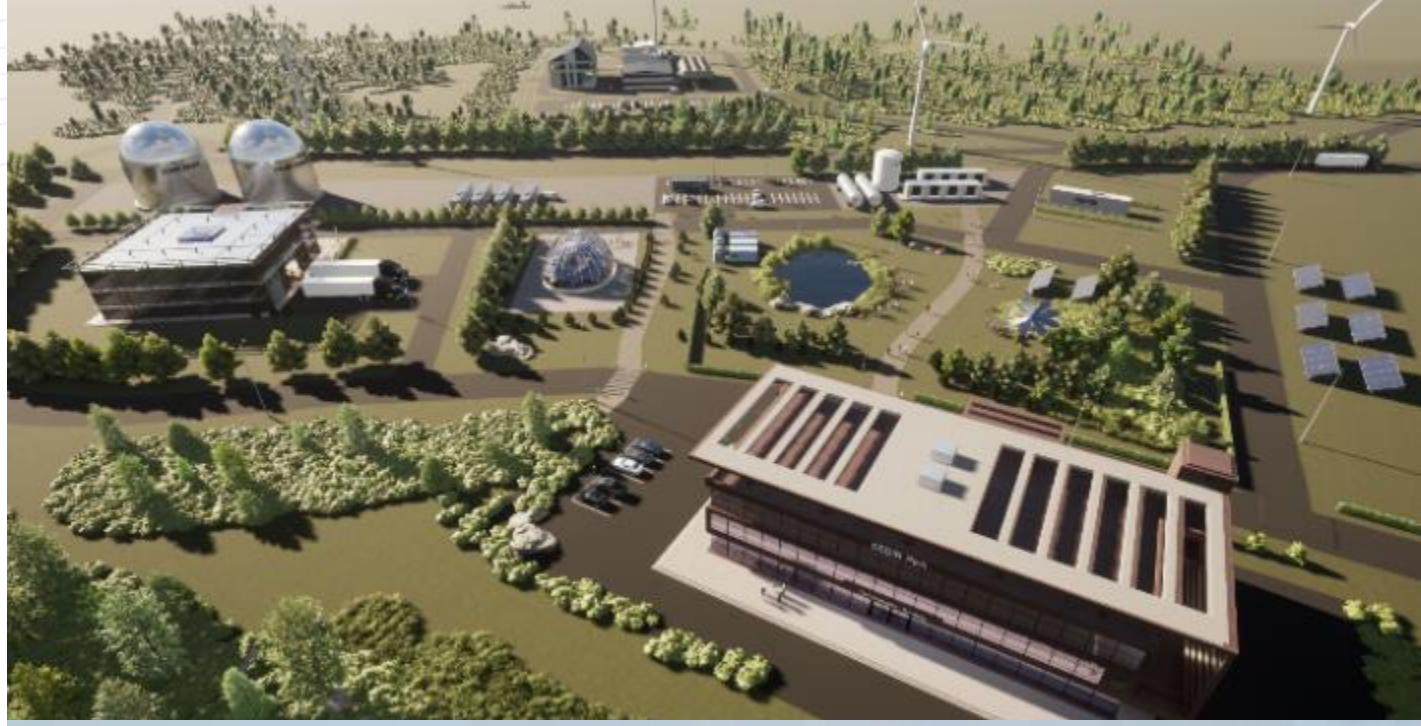
The studied hybrid energy system is composed of a small modular nuclear reactor (SMR), a concentrated solar tower (CST), and a thermal energy storage (TES) unit. The study indicated that an NR-HES is a promising low-carbon power generation system with the potential to meet the electricity and heat demand of remote communities.

Department of National Defense Emissions Reductions with SMRs

The study examines the feasibility of providing energy, both electrical and thermal from a SMR located at Chalk River Laboratories to achieve several goals for Base Petawawa, including reaching net-zero by 2050 in alignment with Canada's Climate Plan and reducing the Base's reliance on and use of diesel fuel. More specifically, Two SMR units could potentially generate enough clean energy to reduce the garrison's GHG emissions by 18-50% overall, supporting DND in meeting net-zero by 2050.

Clean Energy, Demonstration, Innovation & Research (CEDIR) Initiative

- Conducting research to pave the way for clean energy technologies
- Providing a demonstration platform for industry to test
- Evaluating how these technologies can work together



Thank you. Merci.

Canadian Nuclear Laboratories | Laboratoires Nucléaires Canadiens

www.cnl.ca/cedir

Ali Siddiqui
Head of Directorate
Advanced Reactors
Ali.Siddiqui@cnl.ca