Assessing the Impact of Variations in Energy Rates and Carbon Price Projections on Low-Carbon Building System Designs in Canada

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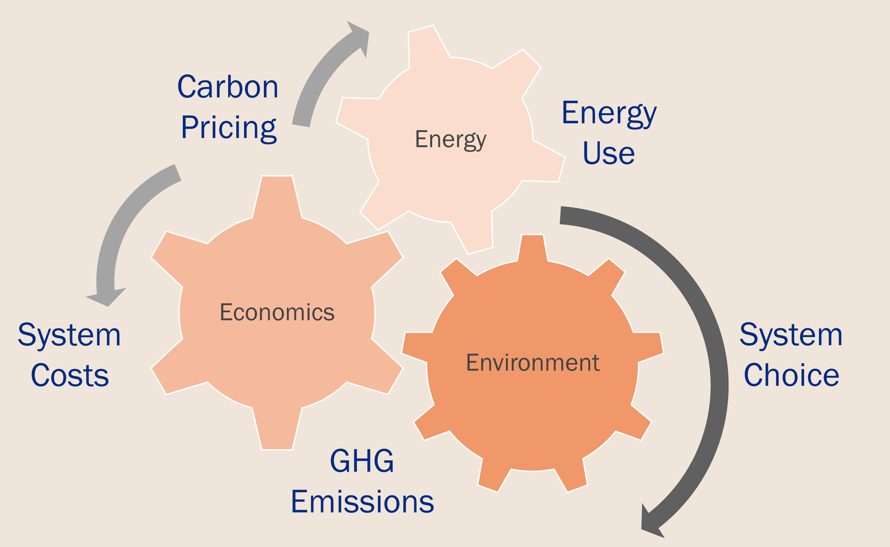
01 INTRODUCTION

Research Question: How different scenario-based projections of end-use energy rates and carbon pricing affect the financial feasibility of low-carbon building systems in Canada?

Achieving Canada's 2050 net-zero targets requires strategic choices in low-carbon building systems, with projections of natural gas (NG) and electricity rates, along with carbon pricing, playing a critical role in their financial feasibility analysis. Currently, most energy consultants and engineers assess the feasibility analysis of building design systems using current energy rates for NG and electricity with fixed annual escalation rates. Since electricity starts off more expensive than NG, using fixed annual escalation rates carries that cost gap forward. Even with carbon pricing added in, the gap remains the same even by 2050 as both fuels are assumed to rise at about the same pace. These inaccurate projections increase the risk of either overestimating or underestimating the financial viability of low-carbon design systems, leading to costly mistakes, either committing to investments that fail to deliver expected returns or missing opportunities for deeper emissions reductions. Hence, this research addresses how different Canadian institutional projection scenarios of NG and electricity end-use rates, as well as carbon pricing, impacts key building systems' performance metrics: energy costs, carbon costs, and greenhouse gas (GHG) emissions from 2025 to 2050. The research project is anchored by 3 dimensions: Energy, Environment, and Economics.



02 OBJECTIVE & PURPOSE

- Assess how energy rate and carbon pricing scenarios affect system costs, carbon costs, and GHG emissions.
- Compare outcomes of replacing business-as-usual (BAU) with high-efficiency (HE) systems across 3 provinces: Alberta, British Columbia, Ontario.
- Conduct a sensitivity analysis to test how changes in key assumptions influence retrofit feasibility.
- Explore organizational approaches to projecting energy rates in Canada.
- Highlight risks of relying on fixed escalation rates or a single projection source.
- Align with the United Nations Sustainable Development Goals (UN SDGs) SDG 7, SDG 11, SDG 13, to support sustainable, low-carbon cities and reach Canada's net-zero 2050 goal.

03 METHODOLOGY

Quantitative Analysis

Purpose: Compare and analyze total costs and GHG emissions of various low-carbon building system retrofits under 6 institutional scenarios across Alberta, British Columbia, and Ontario for the period 2025-2050. The low-carbon heating/cooling systems (HE 1 / HE 2) replaces BAU 1, and domestic hot water systems (HE 3 / HE 4) replaces BAU 2 in a 2-storey house.

INSTITUTIONAL SCENARIOS

Canada Energy Regulator (CER): Global Net Zero (GNZ); Canada Net Zero (CNZ); Current Measures (CM)

Navius Research: Net Zero (NZ); Electrification Net Zero (ENZ); Current Measures (CM)

BUILDING SYSTEMS

Heating/Cooling:
- BAU 1: Packaged Air Conditioning Unit + NG fired furnace
- HE 1: Air-source heat pump (ASHP) + Electric Back Up
- HE 2: Air-source heat pump (ASHP) + NG Back Up

Domestic Hot Water:
- BAU 2: Efficient NG fired water heater
- HE 3: CO_2 HPWH, no back-up
- HE 4: R32 HPWH, variable-speed compressor, electric back-up

Background on Scenarios:
(Navius Research, 2023; Canada Energy Regulator, 2023)

- **GNZ:** Canada reaches net-zero by 2050 with ambitious global climate action.
- **CNZ:** Canada reaches net-zero by 2050 though strong domestic action despite slower global progress.
- **CM:** No new policies beyond 2023; Canada does not reach net-zero by 2050.
- **NZ:** Mirrors CER's GNZ & CNZ for direct comparison.
- **ENZ:** Electricity becomes cost-competitive and dominates across sectors, replacing NG and other fossil fuels.
- **RBK:** No new policies beyond March 2025; Canada does not reach net-zero by 2050.

Data was collected from publicly available sources and Introba to calculate the following variables:

Energy Cost ($/year) = Energy Consumption × Energy Rate

GHG Emissions (t CO_2e/year) = Energy Consumption × Emission Factor

Carbon Cost ($/year) = GHG Emissions × Carbon Price

Total System Cost ($/year) = Energy Cost + Carbon Cost + Capital Cost

Qualitative Analysis - Survey

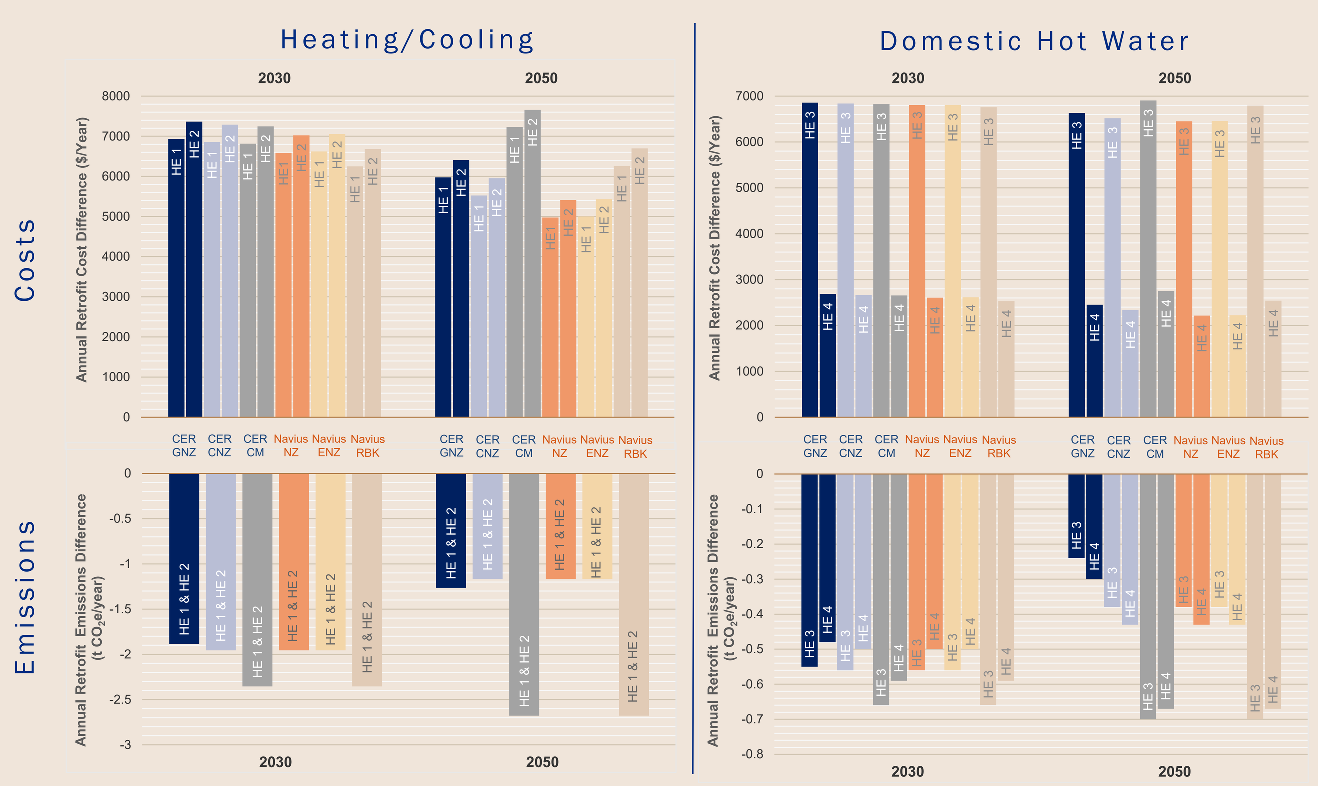
Purpose: To understand how companies project future energy rates and/or how they incorporate existing projections (e.g. from public reports) into their assessments.

TARGET ORGANIZATIONS > Engineering, environmental, & sustainability firms, government bodies, research institutions, energy producers and distributors.

TARGET PARTICIPANTS > Analyzing, forecasting, or influencing future energy prices.

04 COSTS & EMISSIONS RESULTS

Example: Alberta



Analysis Across Provinces:

Heating/Cooling Systems

- Retrofit cost premiums highest in ON, then BC, lowest in AB.
- High ON electricity rates worsen heat pump cost disadvantage.
- AB's cheap NG favors BAU; BC's higher NG prices + lower electricity narrow the gap.

DHW Systems

- Cost pattern mirrors heating/cooling: ON highest gap, BC smaller, AB lowest.
- CO_2 ASHP approximately twice the cost of R32 ASHP due to high capital costs > financially uncompetitive without incentives.

Emissions Outcomes (Canada Energy Regulator, 2024; Lee et al, 2022)

- AB: largest near-term GHG reductions (carbon-intensive grid + strong policies).
- BC & ON: already clean grids, strong reductions even in modest scenarios.
- By 2050, only aggressive net-zero pathways deliver near-zero/net-negative emissions.
- Early adoption maximizes cumulative GHG cuts; delays reduce benefits.

05 SENSITIVITY ANALYSIS

Variables tested: Electricity (±10%), NG (±10%), Carbon price (±$30/t CO_2e)

Province	System	Scenario	Year	Percentage Change in Retrofit Costs					
				Electricity Rates +10%	Electricity Rates -10%	Natural Gas Rates +10%	Natural Gas Rates -10%	Carbon Price +$30/t CO2e	Carbon Price -$30/t CO2e
ALBERTA	BAU 1 vs HE 1 (Heating/Cooling)	CM	2030	2.0%	-2.0%	-1.3%	-0.7%	-1.0%	1.0%
			2050	2.2%	-2.2%	-1.0%	-1.1%	-1.1%	1.1%
		GNZ	2030	1.9%	-1.9%	-1.1%	-0.8%	-0.8%	0.8%
			2050	2.2%	-2.2%	-2.9%	0.6%	-0.5%	0.5%
	BAU 2 vs HE 4 (DHW)	CM	2030	1.1%	-1.1%	-0.8%	-0.3%	-0.7%	0.7%
			2050	1.3%	-1.3%	-0.7%	-0.6%	-0.7%	0.7%
		GNZ	2030	1.1%	-1.1%	-0.7%	-0.4%	-0.5%	0.5%
			2050	1.2%	-1.2%	-1.7%	0.5%	0.6%	0.2%
BRITISH COLUMBIA	BAU 1 vs HE 1 (Heating/Cooling)	CM	2030	1.5%	-1.5%	-1.9%	0.3%	-1.1%	1.1%
			2050	1.6%	-1.6%	-1.6%	0.0%	-1.1%	1.1%
		GNZ	2030	1.5%	-1.5%	-1.7%	0.2%	-1.1%	1.1%
			2050	1.9%	-1.9%	-3.6%	1.7%	-0.4%	0.4%
	BAU 2 vs HE 4 (DHW)	CM	2030	0.8%	-0.8%	-1.1%	0.3%	-0.7%	0.7%
			2050	0.9%	-0.9%	-1.0%	0.1%	-0.7%	0.7%
		GNZ	2030	0.8%	-0.8%	-1.0%	0.2%	-0.7%	0.7%
			2050	1.0%	-1.0%	-2.1%	1.1%	-0.2%	0.2%
ONTARIO	BAU 1 vs HE 1 (Heating/Cooling)	CM	2030	1.6%	-1.6%	-1.8%	0.2%	-1.3%	1.3%
			2050	1.4%	-1.4%	-1.6%	0.1%	-1.3%	1.3%
		GNZ	2030	1.5%	-1.5%	-1.6%	0.1%	-1.0%	1.0%
			2050	1.7%	-1.7%	-3.5%	1.9%	-0.4%	0.4%
	BAU 2 vs HE 4 (DHW)	CM	2030	0.9%	-0.9%	-1.1%	0.2%	-0.8%	0.8%
			2050	0.8%	-0.8%	-1.0%	0.2%	-0.8%	0.8%
		GNZ	2030	0.8%	-0.8%	-1.0%	0.1%	-0.6%	0.6%
			2050	0.9%	-0.9%	-2.0%	1.2%	-0.2%	0.2%

Magnitude of effects:

- Electricity: symmetric impact (±10% shifts cost gaps equally up/down, +0.8% to +2.2%).
- NG: asymmetric impact (+10% raises retrofit costs more than -10% lowers them, -0.7% to -3.6%).
- Carbon price: muted effects (-0.2% to -1.3% cost gap)

System type:

- Heating/cooling retrofits more sensitive (approximately 1.5-2%).
- DHW retrofits less sensitive (<1%) since costs are dominated by capital costs, not energy costs.

Provincial variation:

- AB: most sensitive to electricity prices > higher projected rates & electrification demand.
- BC: more sensitive to NG prices > higher NG prices relative to cheap hydro electricity.
- ON: more sensitive to NG prices > stable/clean electricity supply means NG costs drive economics.

Scenario effect:

- Greater sensitivities under GNZ (high electrification, fast decarbonization).
- CM less sensitive to price fluctuations.

06 SURVEY RESULTS

Experience: 50% 'very' to 'fully' involved in projections with over 11 years of experience

Frequency of projection updates: monthly to every 3 years

Prominent Driver: Government policies and carbon pricing

Determining Carbon Prices: Government set prices and scenario-based projections of low/medium/high pathways

Biggest Uncertainty: Policy and regulatory changes, & market volatility

Canadian energy rate projections are influenced by a multiple forecasting approaches and range of factors and assumptions.

07 CONCLUSION & FUTURE RESEARCH

Feasibility of low-carbon retrofits depends strongly on institutional assumptions; small shifts in energy and carbon prices significantly alter outcomes.

High capital costs of low-carbon systems may remain a key barrier without incentives; deep reductions require aggressive net-zero pathways and early retrofits.

Assess and adopt multiple projection pathways for greater reliability; fixed escalation rates are unreliable.

Research helps building sector professionals assess retrofits against multiple plausible futures.

Accuracy of projections may shift widely due to global; uncertainty will always be part of energy planning.

- Analyze more institutional scenarios
- Extend analysis to additional provinces/territories
- Incorporate life-cycle costing (LCC)
- Test other low-carbon systems for different building types

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