Canadian Energy Research Institute

Greenhouse Gas Emissions Reductions in Canada through Electrification of Energy Services

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President&CEO
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CANADIAN ENERGY RESEARCH INSTITUTE

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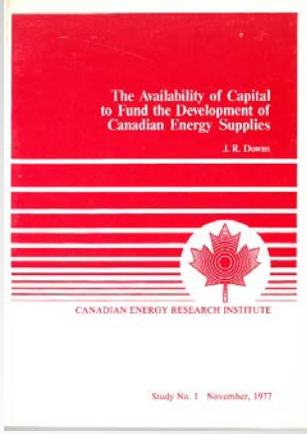
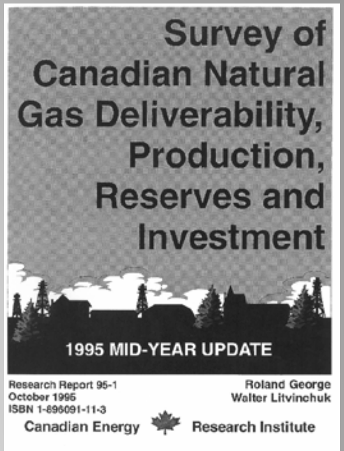
Canadian Energy Research Institute

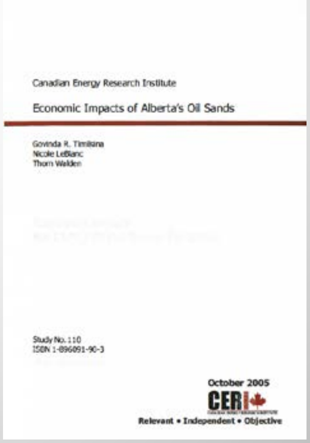
Overview

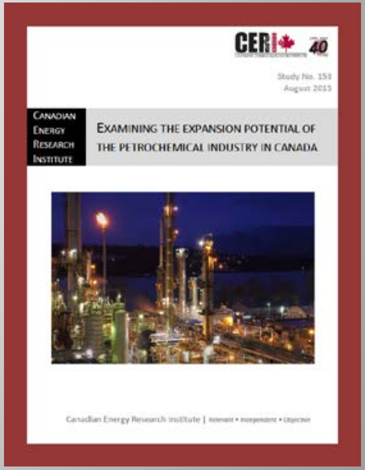
Founded in 1975, the Canadian Energy Research Institute (CERI) is an independent, non-profit research Institute specializing in the analysis of energy economics and related environmental policy issues in the energy production, transportation, and consumption sectors.

Our mission is to provide relevant, independent, and objective economic research of energy and environmental issues to benefit business, government, academia and the public.









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Introduction

- Electrification of end use energy services is seen as a "technology path" to economy wide GHG emissions resections
- Manage emissions in hundreds of point sources – not several thousands of distributed emitters (buildings, vehicles, etc.)
- Proven technology exists to decarbonize power generation
- Such an economy wide energy transition requires:
  - changing the existing infrastructure across all sectors of the economy (infrastructure inertia)
  - much larger electricity generation and transmission infrastructure than today

Objectives

- To assess economic and environmental impacts of electrifying energy end use services in Canada:
  - 10 provinces
  - 3 sectors: residential, commercial, passenger transportation
- We focus on energy end use services that can be electrified by utilizing commercially ready technologies or ones that can be commercialized within a decade or less

Main Research Questions

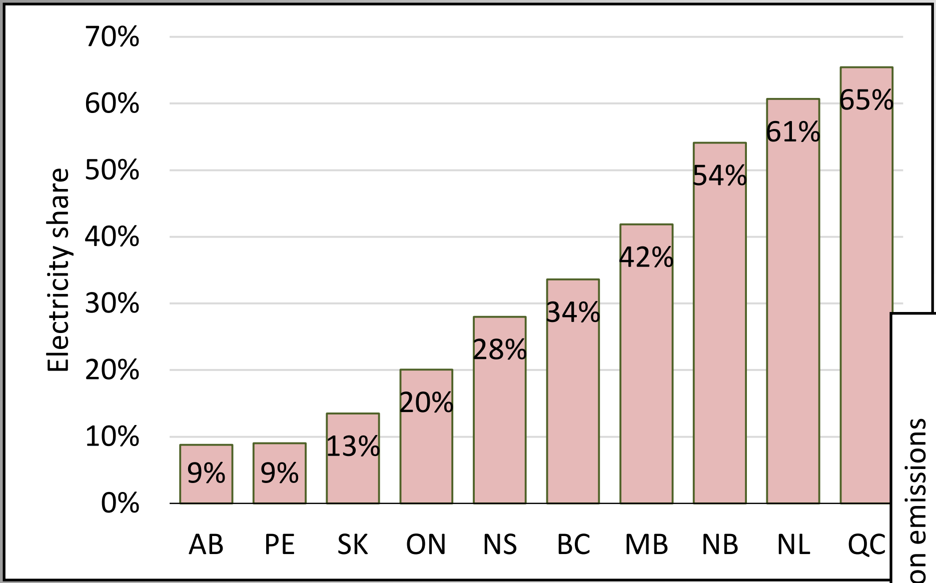
- Is it technically feasible?
  - With proven technologies
- What major transitions in the energy systems are required?
- What is the scale of emissions reductions that can be achieved through electrification of energy services?
- What would it cost?

Method

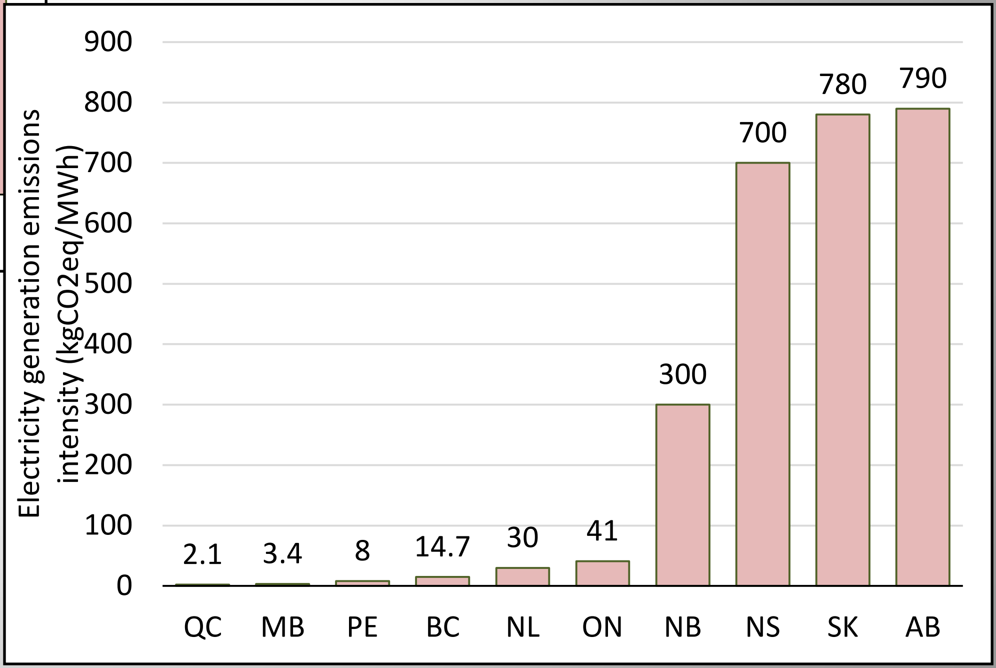
- A stock-rollover model that simulates physical infrastructure
- Annual time steps with equipment lifetimes: 2020-2050
- Simulate energy consumption at an aggregated level (housing stock, vehicle stock, etc.)
- Takes into account infrastructure inertia
- Build scenarios to explore emissions reduction options

Current Electricity use and emissions

Electricity Share of the Residential Sector Energy Mix in Canadian Provinces, 2014



GHG Emissions Intensity of Electricity Generation Mix of Canadian Provinces, 2014



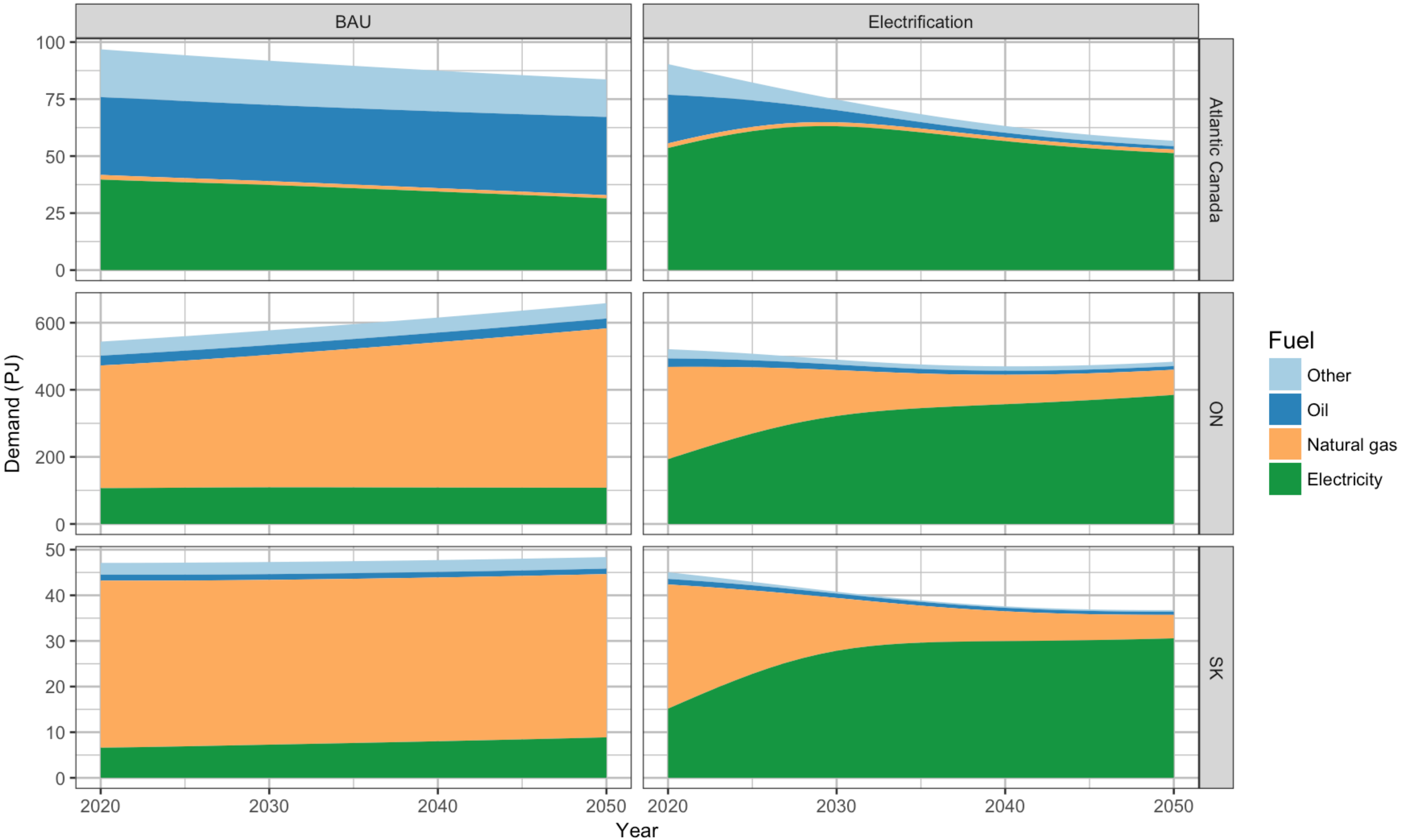
Methods: Scenarios

Demand side		Electricity supply scenarios		
		Business as usual scenario	High renewables	High renewables + NGCC-CCS
Demand side	Business as usual scenario	S0		
Demand side	Electrification scenario		S1	S2

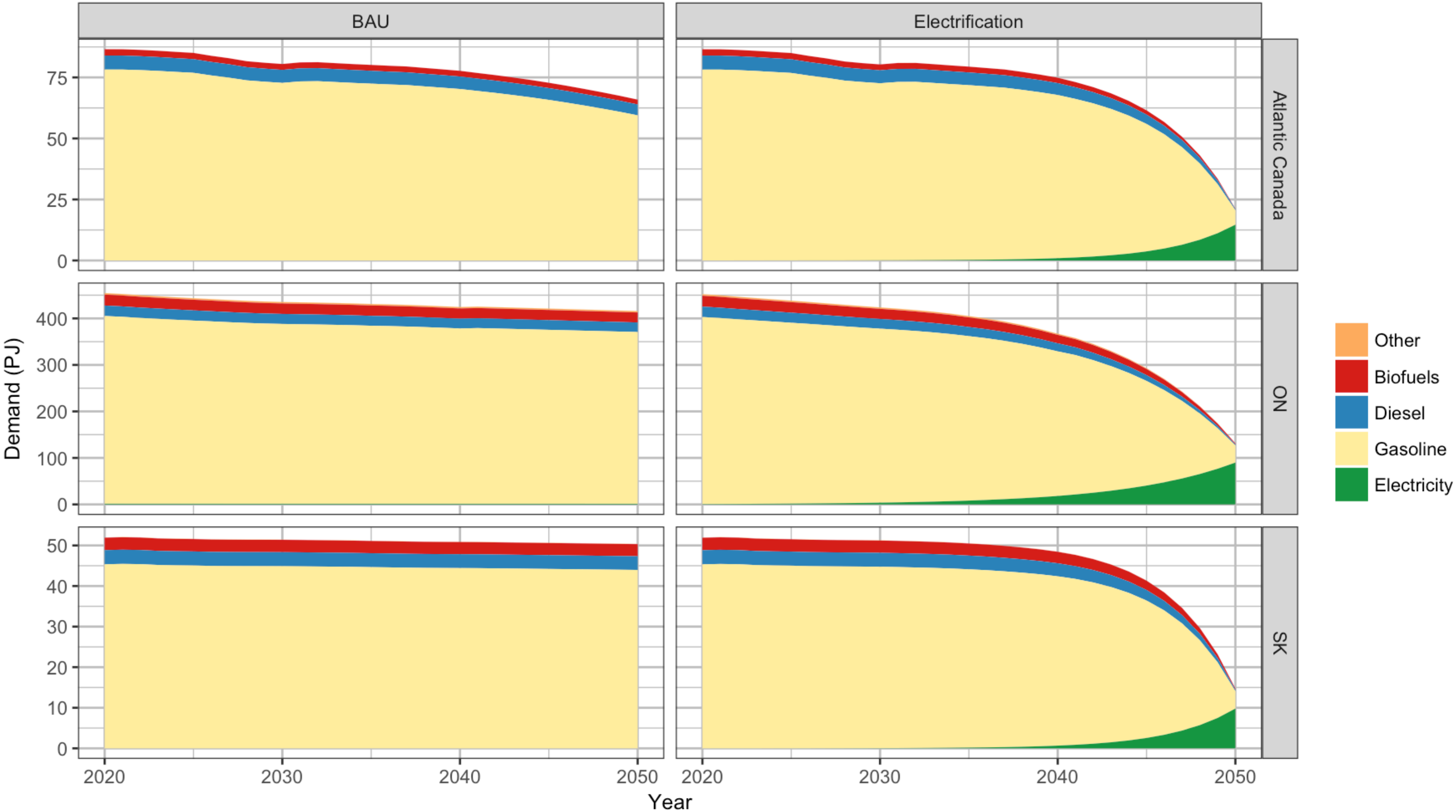
Note
- S2 renewable percentage is approximately 10% less than S1
- Different supply scenarios only for AB, SK, ON

Results

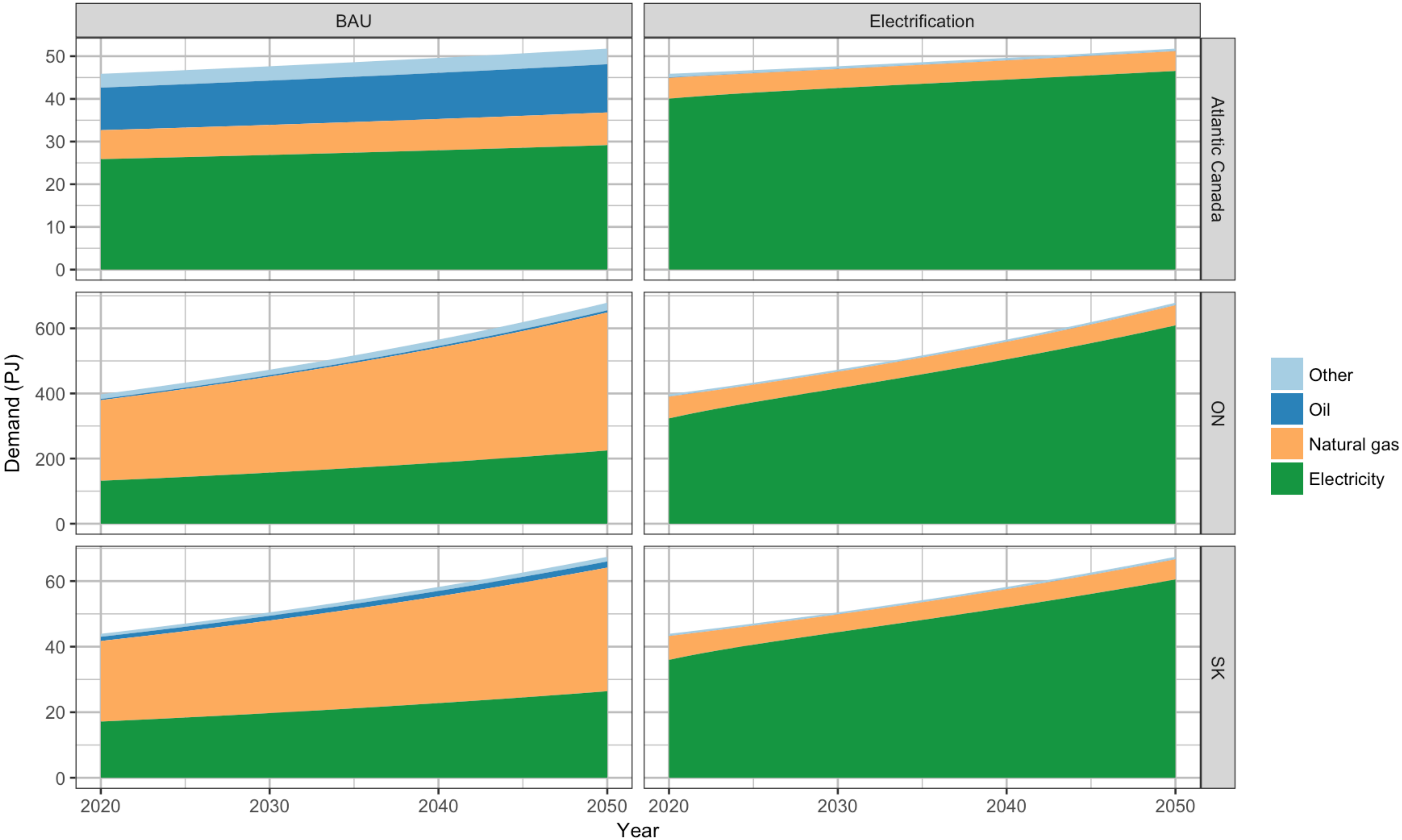
Residential Sector: Fuel demand



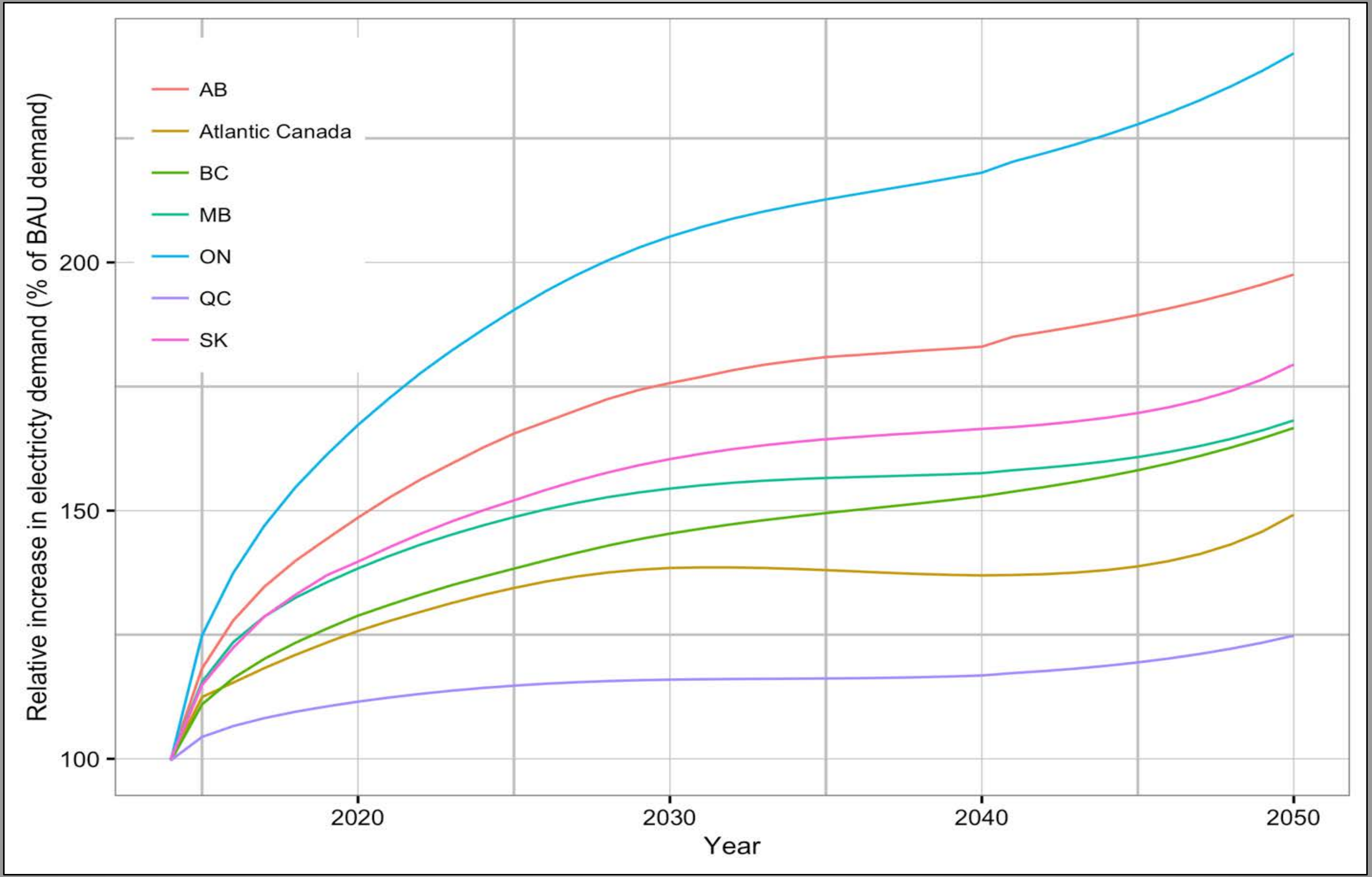
Road Passenger Transportation: Fuel demand



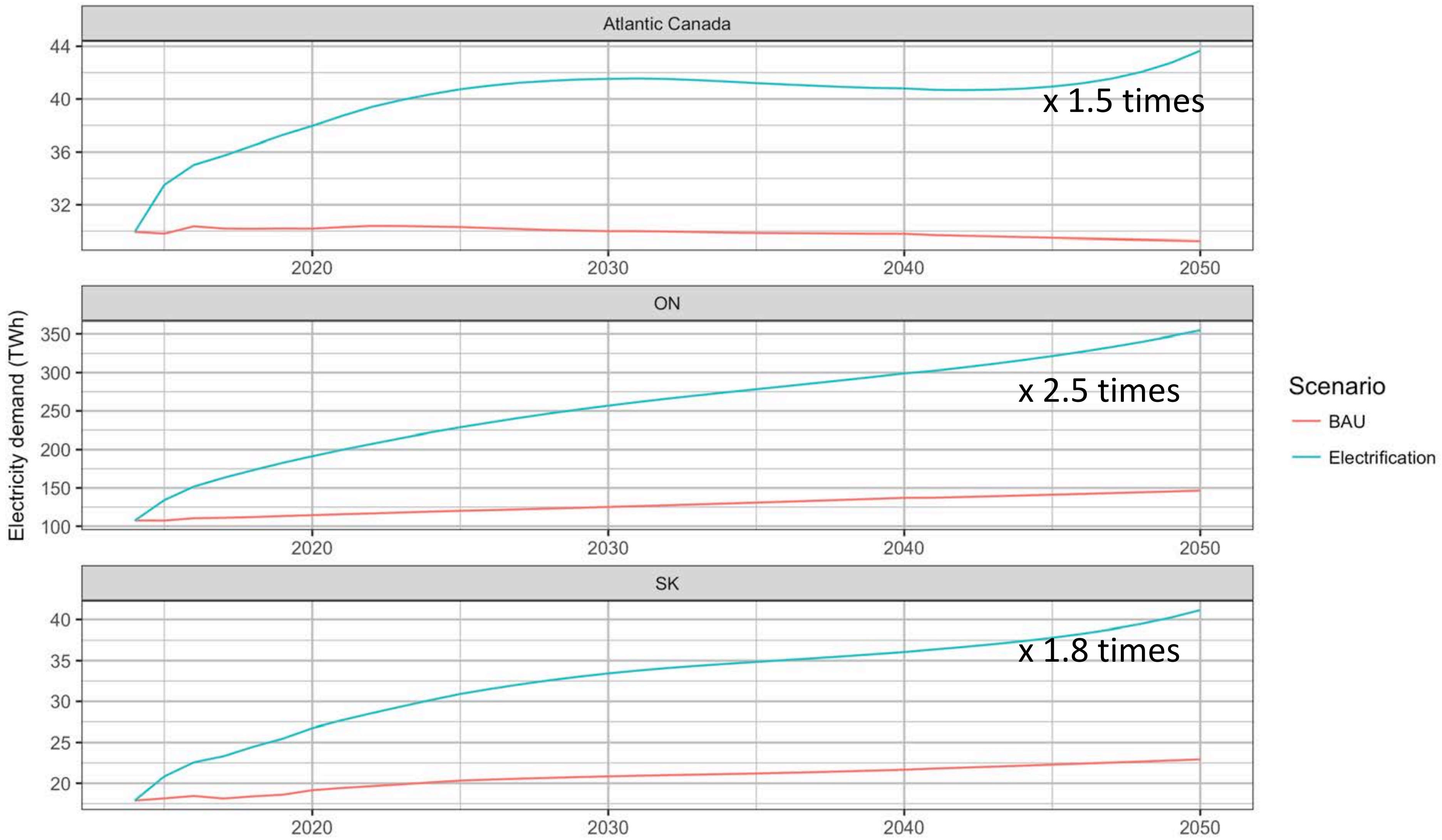
Commercial Sector: Fuel demand



Growth in Electricity Demand



Electricity Demand: Electrified Sectors



Efficiency Improvements - residential

Energy Intensity including direct fuel combustions and primary energy for electricity (GJ/household)					
Region	Year		BAU	Electrification	Reduction under electrification
Atlantic Canada	2030		85	73	14%
Atlantic Canada	2050		66	51	24%
Quebec	2030		83	74	11%
Quebec	2050		77	61	21%
Ontario	2030		91	85	7%
Ontario	2050		83	84	-1%
Manitoba	2030		81	73	10%
Manitoba	2050		75	57	24%
Saskatchewan	2030		96	100	-4%
Saskatchewan	2050		83	82	1%
Alberta	2030		117	123	-5%
Alberta	2050		133	126	5%
British Columbia	2030		57	56	3%
British Columbia	2050		58	57	0%

Efficiency Improvements - Transportation

Energy Intensity including direct fuel combustions and primary energy for electricity (MJ/Pkm)					
Region	Year		BAU	Electrification	Reduction under electrification
Atlantic Canada	2030		1.75	1.75	0.2%
Atlantic Canada	2050		1.73	0.68	60.8%
Quebec	2030		1.93	1.85	4.3%
Quebec	2050		1.96	0.65	66.8%
Ontario	2030		1.85	1.80	2.6%
Ontario	2050		1.85	0.92	50.1%
Manitoba	2030		2.24	2.19	2.1%
Manitoba	2050		2.19	0.67	69.6%
Saskatchewan	2030		2.05	2.04	0.3%
Saskatchewan	2050		2.05	0.90	56.1%
Alberta	2030		1.97	1.92	2.7%
Alberta	2050		1.97	0.79	59.9%
British Columbia	2030		1.92	1.84	4.3%
British Columbia	2050		1.92	0.74	61.6%

Emissions & Cost

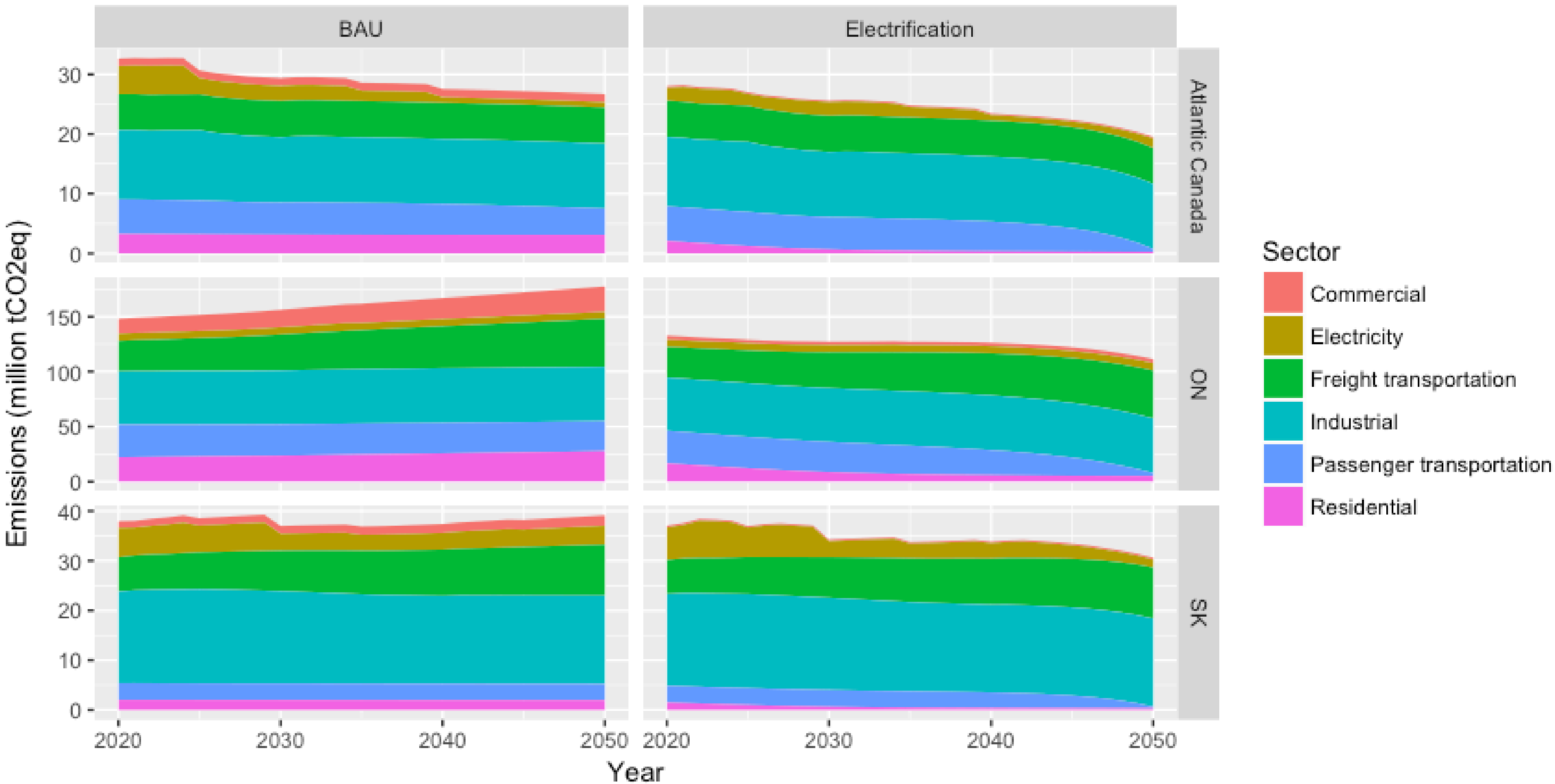
GHG Emissions relative to 2005 Benchmark

	In 2030	In 2050
Atlantic Canada	7%	13%
Quebec	9%	35%
Ontario	14%	31%
Manitoba	11%	24%
Saskatchewan	8%	16%
Alberta	6%	16%
British Columbia	9%	16%

Target - 2030 – 30% below benchmark
- 2050 – 80% below benchmark

GHG Emissions: All Demand Sectors

- Majority of demand side emissions are from non electrified sectors (i.e.. industrial, freight transportation)



What Would it Cost (in Saskatchewan)?

- By 2050, Under electrification scenario, electricity generation infrastructure is 1.8 times that of BAU scenario

Scenario	Demand side	Electricity supply	Cumulative cost of electricity[1] (billion 2014 CAD)	Cumulative GHG emissions[2] (million tCO_2eq)	Cost of avoided GHG emissions[3] (CAD/tCO_2eq)	Increase in average cost of electricity in 2050 (% of S0)
S0	Not electrify	BAU	23	1251		
S1	Electrify	High renewables	45	1084	65	29%
S2	Electrify	High renewables + GAS CCS	43	1088	58	31%

[1] Cumulative cost of adding new capacity and operating electricity infrastructure in the period of 2020-2050
[2] In the period of 2020-2050
[3] Calculated by taking into account capital cost of demand side mitigation measures and fuel cost savings.

What Would it Cost (in Ontario)?

- By 2050, Under electrification scenario, electricity generation infrastructure is 2.4 times that of BAU scenario

Scenario	Demand side	Electricity supply	Cumulative cost of electricity[1] (billion 2014 CAD)	Cumulative GHG emissions[2] (million tCO_2eq)	Cost of avoided GHG emissions[3] (CAD/tCO_2eq)	Increase in average cost of electricity in 2050 (% of S0)
S0	Not electrify	BAU	117	5144		
S1	Electrify	High renewables	366	4074	124	77%
S2	Electrify	High renewables + GAS CCS	352	4101	114	77%

[1] Cumulative cost of adding new capacity and operating electricity infrastructure in the period of 2020-2050

[2] In the period of 2020-2050

[3] Calculated by taking into account capital cost of demand side mitigation measures and fuel cost savings.

What Would it Cost (in Atlantic Canada)?

- By 2050, Under electrification scenario, electricity generation infrastructure is 1.5 times that of BAU scenario

Scenario	Demand side	Electricity supply	Cumulative cost of electricity[1] (billion 2014 CAD)	Cumulative GHG emissions[2] (million tCO2eq)	Cost of avoided GHG emissions[3] (CAD/tCO2eq)	Increase in average cost of electricity in 2050 (% of S0)
S0	Not electrify	BAU	29	909		
S1	Electrify	High renewables	54	764	14	48%
S2	Electrify	High renewables + GAS CCS	No change			

[1] Cumulative cost of adding new capacity and operating electricity infrastructure in the period of 2020-2050
[2] In the period of 2020-2050
[3] Calculated by taking into account capital cost of demand side mitigation measures and fuel cost savings.

Concluding Remarks

- Electrification provides a viable option to decarbonize residential, commercial, and passenger transportation sectors with current technologies
- Industrial sector remains the most significant contributor – we did not assess mitigation measures
- Electrification will profoundly transform the physical energy system
- Level of end-use energy services remains relatively unchanged

Concluding Remarks

- Viability of electrification as an emissions reduction measure depends largely on decarbonizing the power sector
  - Coal to standard gas transition is not sufficient
- Availability Gas CCS lowered the abatement cost and total cost in Saskatchewan and Alberta
- Deeper reductions require mitigation measures in the industrial sector, freight transportation and further decarburization of the electricity sector

Thank you for your time

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