GREENHOUSE GAS EMISSIONS REDUCTIONS IN CANADA THROUGH ELECTRIFICATION OF ENERGY SERVICES

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Through Electrification of Energy Services

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Executive Summary

Mitigating climate change is one of the formidable challenges of our time. More than 190 nations – including Canada – have agreed and committed to take action to significantly reduce greenhouse gas (GHG) emissions to stabilize the global temperature at 1.5° C above pre-industrial levels. As announced by a joint federal-provincial declaration (Vancouver Declaration), Canada is to undertake efforts to reduce GHG emissions by 30 percent below 2005 levels by 2030. Canada's 2050 reduction targets are set at 80 percent below 2005 levels. Achieving these emissions reduction goals require transformational changes in the way we procure and consume energy.

Electricity as an energy carrier has a pivotal role in achieving economy-wide deeper emissions reductions. It is a highly versatile form of energy and converting electricity into end-use energy services can be done at high efficiencies. As such, an economy-wide transition from current energy end-use fuel mix to one dominated by electricity is an option to satisfy future energy demands, while achieving deep GHG gas emissions reductions. Through electrification, emissions can be moved from some millions of spatially dispersed sources such as vehicles and building sources to several hundred point sources (i.e., electric power generating units), making the emissions reduction more manageable. Furthermore, commercially proven technology exists – for example, wind, solar, tidal, geothermal and nuclear power – to produce electricity with zero GHG emissions. Transitioning to an energy system with electricity as the dominant end-use energy source requires changing the existing infrastructure stock – vehicle fleets, buildings, and equipment – across all sectors of the economy. Furthermore, it requires much larger electricity generation and transmission infrastructure than today. That would inevitably have significant economic impacts resulting from new investments, stranded assets, and changes to energy markets. As such, to set up a realistic technology and policy road map to deploy electrification as a climate change mitigation strategy, it is important to gain insights into those complicating factors through analyses that explicitly model those factors with sufficient spatial, sectoral, and temporal granularity.

The objective of this study is to provide such insights by assessing energy system, environmental, and economic implications of transforming energy end-use conversion technology mix into one dominated by electricity in the residential, commercial, and passenger road transportation sectors of the 10 Canadian provinces. The study does not include the three territories, the industrial sector, or the freight transportation sector. These are questions for further work.

We focus on energy end-use services that can be electrified by utilizing commercial or near to commercialization equipment. In the analysis, we focus on three key questions:

1. What major transitions in energy systems are required to electrify the end-use energy services of the residential, commercial, and passenger transportation sectors?
2. What level of emissions reductions can be achieved through electrification of energy services?
3. What would it cost?

In this analysis, we did not assess implications of electrifying industrial or freight transportation end-use energy demands. However, we estimated the total energy demand of those two sectors to make economy-wide energy and emissions estimates.

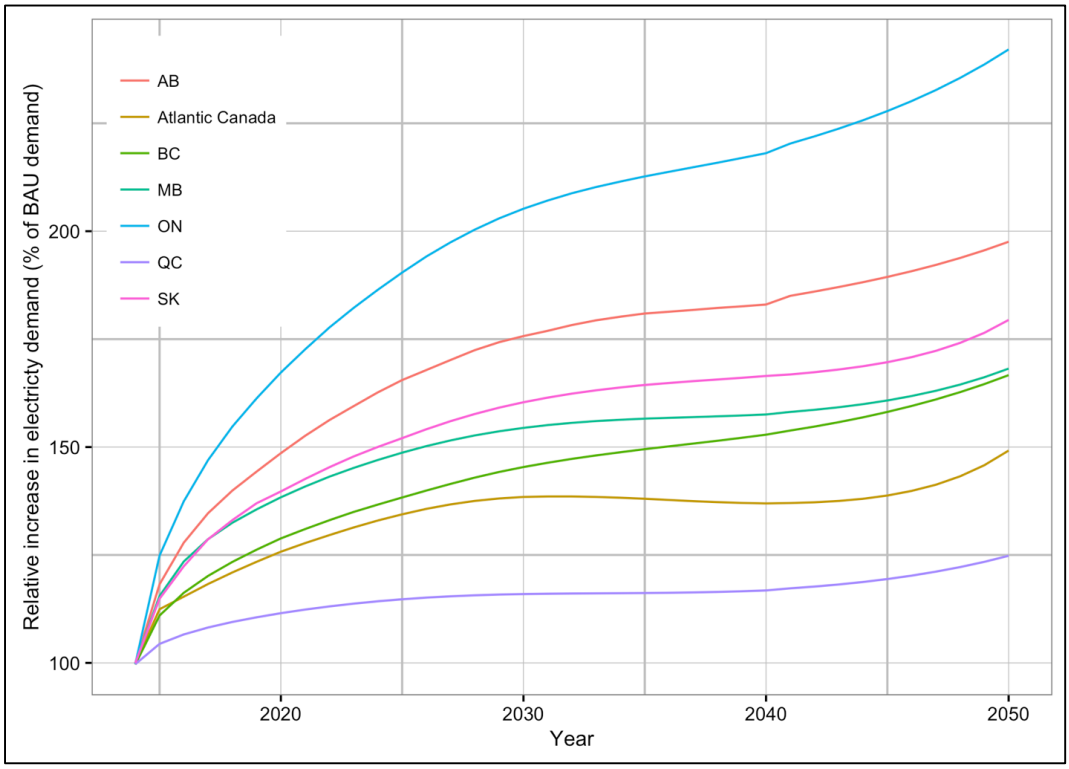
Our Business as Usual (BAU) scenario to 2050 shows that total energy demand in the residential sector grows from 5 percent (in Quebec) to almost 68 percent (in Alberta) depending on the province. In the Atlantic provinces, however, residential sector demand drops by 13 percent over the same period.

As end-use energy services are electrified under our electrification scenario, in most provinces electricity replaces natural gas as a residential heating fuel. In Atlantic Canada, electricity mainly displaces heating oil. The residential sector electricity demand across all provinces increases by 45 percent by 2030 and 66 percent in 2050. The exact increase depends on the region (highest in Alberta and lowest in Quebec). At the same time, combined natural gas demand drops by 48 percent by 2030 and 70 percent by 2050. Similarly, in the commercial sector, electricity displaces natural gas in most provinces and displace heating oil in Atlantic Canada.

In the passenger transportation sector, electricity displaces gasoline and diesel. Deployment of electric vehicles starts at a slow rate as it is constrained by full scale availability of electric vehicles.

Electrification will improve the efficiency of end-use energy conversions significantly. This is due to the higher efficiencies of electrical devices. We find that under electrification, energy intensity of household energy usage drops by up to 30 percent. More profound efficiency improvements are observed in the passenger transportation sector, where energy intensity falls by up to 71 percent.

Figure E.1: Relative Increase in Electricity Demand



Source: CERI

Figure E.1 shows the relative growth in electricity demand compared to the BAU scenario in all provinces. Ontario sees the highest relative electricity demand growth compared to BAU where, by 2050, the electricity demand is almost 2.5 times that of BAU. This is mainly due to the higher population and associated building and transportation energy demand. Ontario is followed by Alberta, where 2050 demand is 2 times that of BAU. The lowest demand growth is observed in Quebec and the Atlantic provinces. Quebec's 2050 electricity demand is only 20 percent higher than the BAU and this increase is driven predominantly by passenger transportation sector demand. The estimated cost of building and operating electric power systems under the electrification scenario is 1.5 to 3 times than the BAU scenario. The highest total electricity sector cost was observed in Ontario and the lowest in Quebec.

GHG emissions reductions from electrification of residential, commercial, and passenger transportation sectors over the analysis period (2020-2050) in all Canadian provinces are depicted in Table E.1.

Table E.1: GHG Emissions Reductions Achievable by Electrifying End-use Energy Demand of Residential, Commercial and Passenger Transportation Sectors of Canadian Provinces

	Emissions reduction (% of 2005 GHG emissions)		Cumulative emissions reductions in the period 2020-2050 (% of study BAU emissions) [i]	GHG emissions abatement cost ($/tCO2eq) [ii]
	In 2030	In 2050		
Atlantic Canada	7%	13%	16%	14
Quebec	9%	35%	11%	36
Ontario	14%	31%	20%	114
Manitoba	11%	24%	17%	8
Saskatchewan	8%	16%	13%	58
Alberta	6%	16%	8%	176
British Columbia	9%	16%	10%	13

[i] The business as usual (BAU) scenario assumes that end-use energy demands would be satisfied by current technology and fuel mix

[ii] Abatement cost is calculated based on cumulative emissions reduction in the period 2020-2050

Source: CERI

The exact level of achievable reductions varies by province (Table E.1). The GHG emissions reduction achievable in 2030 is 6 percent (in Alberta) to 14 percent (in Ontario) below 2005 levels. In 2050, the achievable GHG emissions reductions varies in the range of 16 percent (in Alberta) to 31 percent (in Ontario) below 2005 levels. Details of the sector results are shown in Table E.2.

Table E.2: GHG Emissions and Relative Magnitude of Avoided Emissions by Sector

		Electrification (million tCO2eq)			Emissions reduction (% of 2005 provincial emissions)	
Region	**Sector**	**2020**	**2030**	**2050**	**2030**	**2050**
Alberta	Residential	7.6	3.9	2.4	3.6%	6.3%
	Commercial	1.8	1.3	1.4	2.6%	3.4%
	Passenger Transportation	7.5	8.2	0.9	0.1%	3.7%
	Freight Transportation	22.1	28.4	40.5	0.0%	0.0%
	Industrial	149.9	163.6	169.9	0.0%	0.0%
	Electricity	17.3	17.1	16.0	0.2%	1.3%
Atlantic Canada	Residential	2.1	0.7	0.3	4.4%	4.9%
	Commercial	0.3	0.3	0.3	1.8%	2.0%
	Passenger Transportation	5.8	5.4	0.4	0.0%	7.1%
	Freight Transportation	6.0	6.0	6.0	0.0%	0.0%
	Industrial	11.7	11.0	10.9	0.0%	0.0%
	Electricity	2.2	2.3	1.6	0.5%	-1.3%
British Columbia	Residential	3.9	2.3	1.5	4.8%	8.4%
	Commercial	0.8	0.6	0.5	3.4%	3.6%
	Passenger Transportation	7.8	7.7	0.8	0.6%	11.1%
	Freight Transportation	14.1	16.4	21.2	0.0%	0.0%
	Industrial	20.1	24.1	24.3	0.0%	0.0%
	Electricity	0.1	0.3	2.0	-0.3%	-2.9%
Manitoba	Residential	1.2	0.7	0.5	4.4%	6.9%
	Commercial	0.4	0.3	0.3	6.3%	7.6%
	Passenger Transportation	3.1	3.0	0.3	0.3%	13.3%
	Freight Transportation	3.2	3.7	4.7	0.0%	0.0%
	Industrial	4.9	4.8	4.9	0.0%	0.0%
	Electricity	0.2	0.2	1.0	-0.1%	-4.1%
Ontario	Residential	16.8	8.7	5.2	7.2%	10.8%
	Commercial	3.8	2.9	3.6	6.2%	9.2%
	Passenger Transportation	29.5	27.4	2.7	0.4%	11.6%
	Freight Transportation	27.9	32.6	43.3	0.0%	0.0%
	Industrial	48.4	49.0	49.8	0.0%	0.0%
	Electricity	6.5	6.5	7.0	0.0%	-0.2%
Quebec	Residential	4.5	2.5	1.7	3.4%	4.4%
	Commercial	1.6	1.3	1.5	4.5%	6.3%
	Passenger Transportation	26.1	23.9	2.4	1.4%	24.2%
	Freight Transportation	17.1	19.9	25.5	0.0%	0.0%
	Industrial	22.9	22.8	23.0	0.0%	0.0%
	Electricity	0.1	0.1	5.0	-0.1%	-5.5%
Saskatchewan	Residential	1.5	0.7	0.3	1.9%	2.4%
	Commercial	0.4	0.3	0.4	1.8%	2.5%
	Passenger Transportation	3.4	3.3	0.3	0.0%	4.2%
	Freight Transportation	6.8	8.1	10.2	0.0%	0.0%
	Industrial	18.4	18.6	17.7	0.0%	0.0%
	Electricity	6.5	3.2	1.6	0.2%	3.1%

Source: CERI

Although a considerable amount of emissions reductions is achieved by electrifying the residential, commercial and passenger transportation sectors, a larger amount of emissions would still be produced by industrial activities, and freight transportation. Mitigation actions are required in those sectors to achieve deeper emissions reductions.

Higher investment and operating costs will inevitably lead to higher average costs of electricity. We estimated the increase in average cost to be 16-77 percent in 2050 depending on the province. GHG emissions abatement cost of electrification is lower ($14-$38/tCO2eq) in Quebec, Manitoba, British Columbia and the Atlantic provinces. Abatement costs are higher in Alberta, Ontario, and Saskatchewan. It is well over $100/tCO2eq in Alberta and Ontario. Availability of natural gas-fired generation with carbon capture and storage leads to 8-18 percent lower abatement cost compared to an electricity supply without that technology in those three provinces.

Electrification of end-use energy services will make transformational changes in energy systems and will change the way we source and consume energy. However, the level of end-use energy services will remain unchanged. To achieve emissions reductions through electrification requires both transforming the end-use energy conversion infrastructure stock as well as decarbonizing the electricity supply. This requires coordinated efforts in policy, technology developments, and energy infrastructure deployments.