Mitigating Climate Change through Electrification - FINAL REPORT

Assessing the impact of provincial best practices on Canada's greenhouse gas emissions

SUBMITTED TO

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September 20, 2016

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Executive Summary

Electrification is an important action for reducing Canada's greenhouse gas emissions. Clean Energy Canada is interested in understanding the potential impact of national electrification efforts. In particular, what outcomes may be expected if leading provincial practices are applied across the country? This project seeks to answer this question using CIMS, a technologically-detailed energy-economy model of Canada.

What are the leading electrification policies in Canada today?

Clean Energy Canada identified a number of leading electrification policies that have been implemented or are proposed by provinces in Canada today, as summarized in Table 1. This study estimates the impact of these policies *if they were applied nationally across all of Canada*.

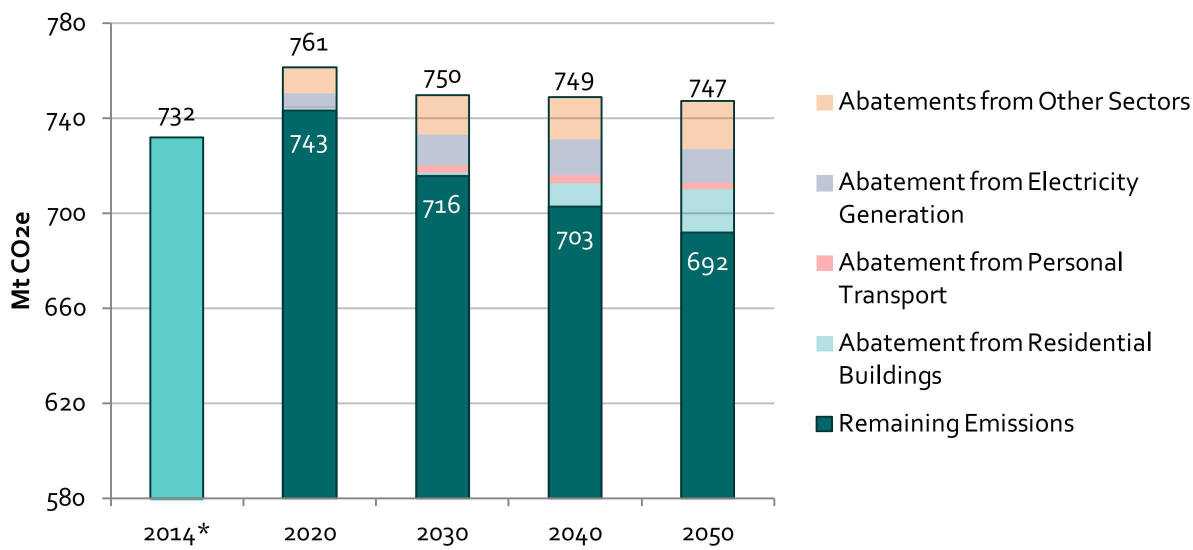
Table 1: Summary of leading provincial electrification policies

Sector	Policy	As implemented or proposed in
Personal transport	Zero Emission Vehicle (ZEV) mandate	Québec
	Financial incentives for PEVs	Ontario
Residential buildings	Net zero carbon building code	Ontario
	Financial incentives for net zero buildings	Québec & British Columbia
Electricity supply	Accelerated coal phase-out by 2030	Alberta
	Clean energy performance standard	British Columbia
Economy-wide	Carbon price	Alberta / British Columbia (price level) & Québec/Ontario (coverage)

What are the impacts of the electrification policies if they are implemented nationally?

If the leading provincial electrification policies were implemented across all of Canada, greenhouse gas emissions would be reduced by 34 Mt —from 750 Mt to 716 Mt—in 2030 (see Figure 1), thus closing 15% of the gap to Canada's 2030 target. The policies reduce greenhouse gas emissions by shifting energy consumption from fossil fuels towards electricity while at the same time ensuring that electricity generation comes from zero emission sources.

Figure 1: Canadian greenhouse gas emissions to 2050



* Source: Environment and Climate Change Canada. 2016. National Inventory Report.

What is the impact of each electrification policy?

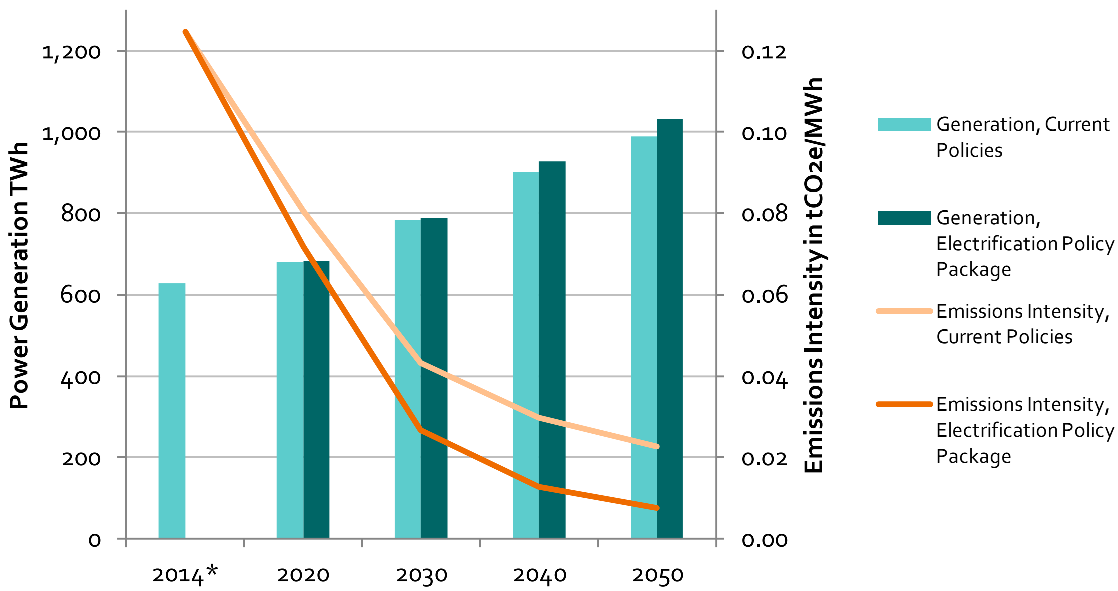
The impacts of each individual policy are summarized below:

- **Carbon price of $30/t (a reduction of 18.7 Mt annually in 2030).** This policy achieves the greatest abatement because it is the only policy to target more than one sector of the economy. Additionally, and like many other policies in this package, the carbon price can be strengthened over time to achieve even greater abatement.
- **Zero carbon residential building code taking effect in 2030 (3.6 Mt abatement annually in 2035 rising to 15.7 Mt abatement in 2050).** The building code requires new residential buildings to use zero carbon space heating after 2030, thus the associated reductions appear after this date.
- **Electricity supply policies (11.5 Mt annually in 2030).** By banning most fossil fuel-fired electricity generation unless equipped with carbon capture, these policies virtually decarbonizes Canada's electricity sector. These policies complements the other policies by ensuring that low carbon electricity is available to meet the demand from efforts to electrify end-uses.
- **ZEV mandate and personal transport incentives (2.5 Mt annually in 2030).** The ZEV mandate reduces emissions by requiring at least 12% of new passenger light duty vehicles sold in each province to be plug-in electric (PEV) by 2025. The transportation incentives apply to PEVs sold between 2017 and 2020. The incentives reduce emissions by 0.01 Mt in 2020.
- **Residential building incentives (0.8 Mt annually in 2030).** This policy reduces the cost of electric heat pumps and efficient building envelopes after 2016.

How do the policies impact Canada's electricity sector?

The electrification policies accelerate two key trends of Canada's electricity sector, as shown in Figure 2. First, demand for electricity rises more quickly as demand sectors switch from fossil fuels to electricity to comply with the electrification policies. Second, the electricity sector decarbonizes more quickly and more completely.

Figure 2: National electricity generation and emissions intensity



* Source: Environment and Climate Change Canada. 2015. National Inventory Report.

How does the policy package impact financial costs?

The electrification policies require investment in new capital stock, which is partially offset by lower energy expenditures in some sectors. The greatest required investment is in the electricity sector (an average of $2.8 billion/year or 4.6% above that which is required under Current Policies between 2021 and 2050).

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Contents

1. Introduction

Electrification is an important action for reducing Canada's greenhouse gas emissions, as highlighted in a recent report by Clean Energy Canada[1]. For example, recent analysis suggests that electrification—fuel switching to zero carbon electricity—could account for over one quarter of the abatement required to achieve deep decarbonization in Canada–a total of roughly 85 Mt in 2030 and 160 Mt in 2050[2].

Canadian provinces and territories are at various stages with respect to climate change mitigation planning and efforts to electrify greenhouse gas-emitting end uses. For example, Ontario recently released a Climate Change Action Plan that proposes several policies to encourage the electrification of transport and buildings. By contrast, some provinces have not implemented any policies to encourage electrification.

Clean Energy Canada is interested in understanding the potential impact of national electrification efforts. In particular, what outcomes may be expected if leading provincial practices were applied across the country? This project seeks to answer this question using CIMS, a technologically-detailed energy-economy model of Canada.

This report is structured so that each section answers a different question:

- **Section 2:** How are the impacts of electrification policies estimated?
- **Section 3:** What are the leading electrification policies in Canada today?
- **Section 4:** What are the impacts of the electrification policies?

[1] Clean Energy Canada. 2016. A Canadian Opportunity: Tackling Climate Change by switching to clean power.

[2] Bataille, C., Sawyer, D., Melton, N. 2015. Pathways to deep decarbonization in Canada.

2. How are the impacts of electrification policies estimated?

This analysis uses the CIMS energy-economy model to simulate how policies affect technology choices and how these choices impact future energy consumption, air emissions, and financial costs. The model has a detailed representation of technologies in all energy intensive sectors of the economy from the present to 2050 (i.e., buildings, transportation and industry).

Key inputs to the model include reference forecasts of energy prices and activity by sector, as well as technology parameters (e.g. cost, energy efficiency etc.). The model then simulates how capital stock is acquired, used to provide energy services (e.g. home heating, personal transportation, or electricity consumption), retrofitted and ultimately retired at the end of its useful life.

Technology choice decisions are based on financial costs as well as human behaviour. Specifically, CIMS accounts for how preferences for familiar technologies, perceived risks of new technologies, and heterogeneity of human choices will ultimately impact energy consumption and air emissions.

The analysis begins with a projection of Canada's energy-economy under **"Current Policy"**. This projection includes all substantive policies that have been currently implemented by the provincial and federal levels of government as of July 2016, as shown in Table 2. Energy prices are based on the National Energy Board's most recent forecast[3] while economic and demographic forecasts are similar to those used for the Deep Decarbonization Pathways Project[4]. We use CIMS to explore the impact of implementing several electrification policies, which are described next.

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[3] National Energy Board. 2016. Canada's Energy Future 2016: Energy Supply and Demand Projections to 2040.

[4] Carbon Management Canada. 2015. Pathways to Deep Decarbonization in Canada.

Table 2: Summary of current policies

Province	Policy	Leading electrification policy*
British Columbia	Carbon tax	
	Building code	
	Clean Energy Act	**Performance standard**
	Low Carbon Fuel Standard	
	Landfill Gas Regulation	
Alberta	Specified Gas Emitters Regulation	
	Carbon tax	**Carbon price:** $30 per tonne selected for stringency (price level)
	Ending coal pollution by 2030	**Accelerated coal phase-out**
	Renewable Fuels Standard Regulation	
	Renewable Portfolio Standard	
	Reducing methane emissions	
Saskatchewan	Boundary Dam Power Station CCS retrofit	
Manitoba	Building code	
	Biofuels Act – Renewable Fuel Standard	
	Biofuels Act – Biodiesel tax exemption	
Ontario	WCI Cap-and-trade	**Carbon price:** cap-and-trade selected for coverage
	Coal power phase out	
	Feed-in tariffs	
	Building Code	
	Landfill gas capture	
Québec	WCI Cap-and-trade	**Carbon price:** cap-and-trade selected for coverage
	Regulation respecting the landfilling and incineration of residual materials	
	Renewable Fuels Regulations	
Atlantic	Coal retirement (New Brunswick)	
	Renewable Portfolio Standard (Nova Scotia and New Brunswick)	
	Muskrat Falls (Newfoundland and Labrador)	
	Newfoundland and Labrador Building Code	

Province	Policy	Leading electrification policy*
Federal	Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations	
	Heavy-duty Vehicle and Engine Greenhouse Gas Emission Regulations	
	Reduction of Carbon Dioxide Emissions from Coal-Fired Generation of Electricity Regulations	
	Energy Efficiency Regulations	
	Renewable Fuels Regulation	
	ecoENERGY for Renewable Power	
	ecoENERGY for Buildings and Houses	

*Includes leading electrification policies that are currently implemented, but not those that are proposed. A full list of current and proposed leading electrification policies is summarized in the next section.

3. What are the leading electrification policies in Canada today?

Clean Energy Canada identified a number of leading electrification policies that have been implemented or are proposed by provinces in Canada, as summarized in Table 3. Along with co-signatories, Clean Energy Canada has previously recommended that some of these kinds of leading policies be applied nationally[5]. The present study estimates the impact of the identified leading electrification policies *if they were applied nationally across all of Canada*.

The policies are simulated both individually and together (as a **"Policy Package"**) to account for interactions among policies. This approach is important because the effect of the policy package is not necessarily equal to the sum of individual policy impacts. In some instances, policies complement each other and their impacts are additive, while in other cases the implementation of one policy may reduce the impact of another.

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[5] Clean Energy Canada. 2016. A Canadian Opportunity: Tackling Climate Change by switching to clean power.

Table 3: Summary of electrification policies

Sector	Policy	As implemented or proposed in	Description	Modeled implementation date
Personal transport				
	Zero Emission Vehicle (ZEV) mandate	Québec	This policy requires that auto automakers earn a minimum number of ZEV credits each year. We assume that it results in plug-in electric vehicles (PEVs) accounting for 12% of new light duty vehicles sold by 2025 (the mandate increases linearly from 0% in 2020). Additionally, we assume it is incremental to the federal emissions standards (i.e., manufacturers can't lower the average fuel economy of non-PEVs as a result of the policy).	2025
	Financial incentives for PEVs	Ontario	This policy includes incentives for PEVs between 2017 and 2020: (1) $15K per new PEV sold (including $14K purchase price subsidy and $1K home charging subsidy) and (2) free overnight charging (estimated at about $180 per vehicle per year[1]). After 2020, the incentives drop to zero.	2017-2020
Residential buildings				
	Net zero carbon building code	Ontario	This policy requires that new residential buildings meet near net- zero carbon standards after 2030. It is modeled by requiring new furnaces to emit zero direct greenhouse gas emissions.	2031
	Financial incentives for net zero buildings	Québec & British Columbia	Financial incentives are provided for electric heat pumps ($800[2]) and near net-zero carbon shells ($3,500[3]).	2017

Sector	Policy	As implemented or proposed in	Description	Modeled implementation date
Electricity supply				
	Accelerated coal phase-out	Alberta	All coal-fired power plants cease operations by 2030 unless equipped with carbon capture.	2030
	Performance standard	British Columbia	This policy requires a minimum of 93% of electricity be provided by renewables or thermal plants equipped with carbon capture.	2021
Economy-wide				
	Carbon price	Alberta (price level) & Québec/Ontario (coverage)	A price of $30/t CO_2e (constant in real terms) is applied to all sources of combustion and process emissions.	2017

Notes:

1. Assuming an average annual distance of 15,000 km per PEV and 80% of charging completed overnight.
2. Based on BC Hydro's Heat Pump rebate.
3. Based on Quebec's RenoClimat initiative including incentives for roof, foundation, and exposed floor insulation as well as air tightness.

Electrification and low carbon fuel standards

British Columbia's low carbon fuel standard (LCFS) requires fuel suppliers to reduce the carbon intensity of fuels sold in the province by 15% by 2030. This policy may not seem like an electrification policy, but one option for compliance is for fuel suppliers to purchase credits from suppliers of electricity for PEVs. The Government of British Columbia estimates that its LCFS will reduce emissions by up to 3.4 Mt annually in 2030[6]. Using that estimate as a starting point, we can extrapolate that extending a similar policy across the country could reduce emissions by as much as 30.5 Mt, an increase of 798% relative to having the policy in British Columbia alone. Nevertheless, it should be noted that this policy is likely to overlap with other transport policies. For example, British Columbia reports that total emissions reductions from all transport policies in its Plan will be 3 Mt in 2050.

[6] British Columbia. 2016. Climate Leadership Plan. http://climate.gov.bc.ca/

4. What are the impacts of the electrification policies?

4.1. How does the policy package impact greenhouse gas emissions?

If the leading provincial electrification policies were implemented across all of Canada, greenhouse gas emissions would be reduced by 34 Mt (5.0%) in 2030 and 55 Mt (8.2%) in 2050, relative to a current policies scenario. Emissions abatement is concentrated in several sectors, as shown in Figure 3:

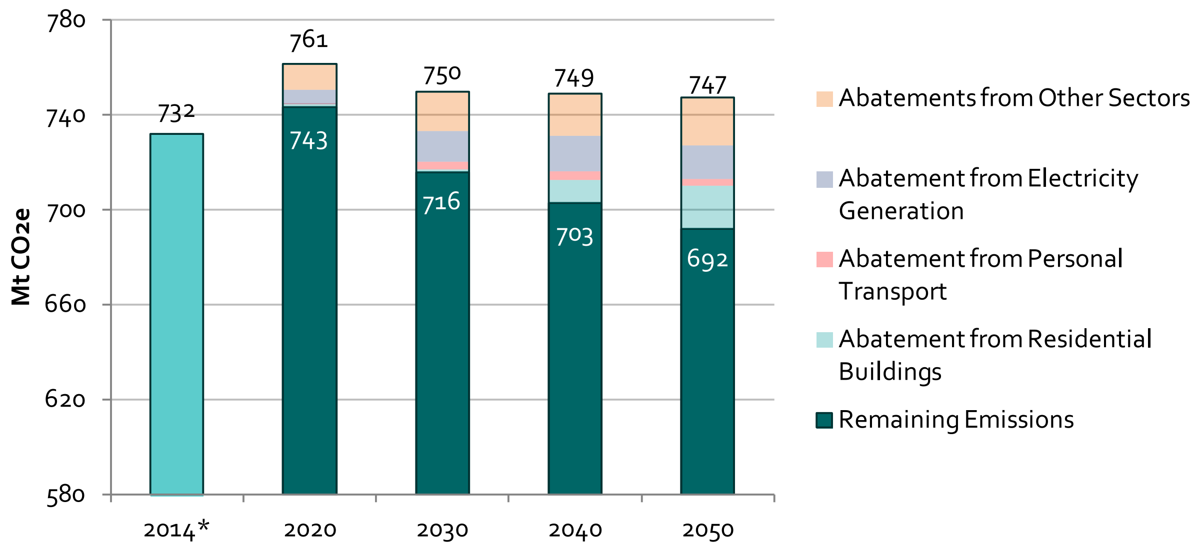
- **Residential buildings (1.2 Mt abatement in 2030 rising to 18.5 Mt abatement in 2050).** Emissions from residential buildings are reduced by over half from the Current Policy projection in 2050 due to net-zero carbon building regulations and the carbon price.

- **Electricity generation (12.8 Mt abatement in 2030).** Emissions from electricity generation are reduced by roughly two thirds despite electricity generation increasing by over 64% in 2050. Abatement is caused by 1) the accelerated coal phase out that bans coal-fired electricity generation after 2030 unless equipped with carbon capture, and 2) the performance standard requiring that at least 93% of electricity generation in each province be generated by zero or near zero greenhouse gas emitting sources. Section 4.3 on page 12 describes the electricity sector impacts in greater detail.

- **Personal transport (3.3 Mt abatement in 2030).** Emissions from personal transport are reduced by 5% relative to the Current Policy projection in 2050. These reductions are due to the carbon price as well as the zero emission vehicle mandate requiring that at least 12% of light duty passenger vehicles sold in Canada are battery-electric by 2025.

- **Rest of the economy (16.4 Mt abatement in 2030).** Emissions across all sectors of the economy are reduced due to a carbon price of $30/t on combustion and process emissions.

Figure 3: Canadian greenhouse gas emissions to 2050



* Source: Environment and Climate Change Canada. 2016. National Inventory Report.

4.2. What are the interactive effects among individual policies?

Policies that decarbonize electricity generation complement policies that incentivize electrification in energy demand sectors. Table 4 quantifies the abatement achieved by each policy individually as well as the abatement achieved by the policy package (i.e., when all policies are enacted together). For most of the forecast period, the policy package achieves greater abatement than the sum of each individual policy's impact. This dynamic occurs because reducing emissions from electricity supply increases the abatement achieved by the other electrification policies.

Nevertheless, overlap does exist between some of the policies. First, the financial incentives overlap with regulatory mechanisms. For example, the subsidy on heat pumps doesn't achieve additional abatement after the regulations come into force requiring the use of electric space heating. In this instance, the impact of the financial incentive is to reduce the cost of compliance with the regulation rather than achieve additional abatement. The incentives do achieve abatement before the regulations come into effect. Second, the carbon price overlaps with the sector-specific regulatory policies. For example, the impact of the carbon price is reduced due to regulations requiring the use of zero emission space heating. However, the carbon price does apply to activities in the buildings and transport sectors not covered by regulations (e.g. water heating and bus travel), as well as sectors not covered by any regulations (e.g. freight transport, commercial buildings and industry). Therefore, the carbon price achieves some additional greenhouse gas reductions.

Table 4: Annual greenhouse gas abatement by policy

Policy	Abatement relative to Current Policies (Mt)[1]			
	2020	2030	2040	2050
Economy-Wide				
Carbon price	12.30	18.72	21.58	23.97
New Transport Policies				
ZEV mandate & EV purchase incentives	0.00	2.53	2.23	1.10
New Building Policies				
Net zero carbon building code in 2030	0.00	0.00	7.05	15.66
Building incentives	0.80	0.78	0.74	0.87
New Electricity Policies				
Electricity supply policies	5.08	11.54	12.80	12.34
Totals				
Policy Package Total	**18.12**	**33.77**	**46.19**	**55.43**
Total of Policies Implemented Individually	18.19	33.59	44.42	53.95
Policy Overlap[2]	0.07	-0.18	-1.77	-1.48

Notes:

1. Abatement is shown for all sectors (i.e., not just those affected by each policy).
2. A positive value for "policy overlap" indicates that abatement from the policy package is less than the sum of each individual policy's impacts (i.e., the policies have overlapping impacts). A negative value means that abatement from the policy package is greater than the sum of each individual policy's impacts (i.e., the policies complement each other).

The impacts of each individual policy are summarized below:

- **Carbon price (18.7 Mt abatement annually in 2030).** This policy achieves the greatest abatement because it is the only policy to target more than one sector of the economy. By covering all combustion and process emissions in Canada, this policy ensures that all abatement opportunities costing less than $30/t are undertaken.

- **Zero carbon residential building code (3.6 Mt abatement annually in 2035 rising to 15.7 Mt abatement in 2050).** The building code comes into effect after 2030. Due to the long life span of residential buildings, this policy will take time to decarbonize the building stock.

- **Electricity supply policies (11.5 Mt abatement annually in 2030).** By banning most fossil fuel-fired electricity generation unless equipped with carbon capture, these policies virtually decarbonizes Canada's electricity sector. As highlighted above, these policies complement the remainder of the policy package by ensuring that low carbon electricity is available to meet the demand from efforts to electrify end-uses.

- **ZEV mandate & transport incentives (2.5 Mt abatement annually in 2030).** The ZEV mandate reduces emissions by requiring at least 12% of new passenger light duty vehicles sold in each province are battery electric. Its impact declines after 2035 because PEVs achieve some market share without the policy (so the incremental effect of requiring 12% market share is reduced).

  The transport incentives apply to PEVs sold between 2017 and 2020. They increase the number of vehicles sold during this period, which reduces emissions over the course of their lifespan. This policy could also help increase PEV market share in the long-run by increasing consumer awareness about the technology, a dynamic which is included in the analysis (i.e., getting more people using PEVs increases the rate of adoption).

- **Residential building incentives (0.8 Mt abatement annually in 2030).** This policy reduces the cost of electric heat pumps and efficient building envelopes after 2016. The incentives increase the adoption of these technologies prior to the building code coming into force. After the building code comes into effect, the policy reduces the cost of complying with the building code.

4.3. What is the impact of scaling up provincial policies?

Implementing best practices nationally achieves greater abatement than if implementation is limited to certain provinces. Table 5 summarizes the impact of scaling-up provincial policies:

- "Provincial estimates" shows annual abatement associated with each policy being implemented only in the originating province (from public sources, where possible).
- "National application" shows the estimate of abatement if that policy is applied nationally.

Table 5: Scaling up from provincial to national policy

Policy	Province	Year of abatement estimate	Annual abatement (Mt CO_2e)		% increase in abatement
			Provincial estimate	National application	
Carbon price	British Columbia	2020	3[1]	12	310%
ZEV mandate	Québec	2025	0.1[2]	1.6	1,630%
EV purchase incentives	Ontario	2020	0.007[3]	0.01	43%
Net zero carbon building code in 2030	Ontario	2035	1.6[4]	3.6	121%
Building incentives	British Columbia/Quebec	2030	0.45[4]	0.78	131%

Notes:

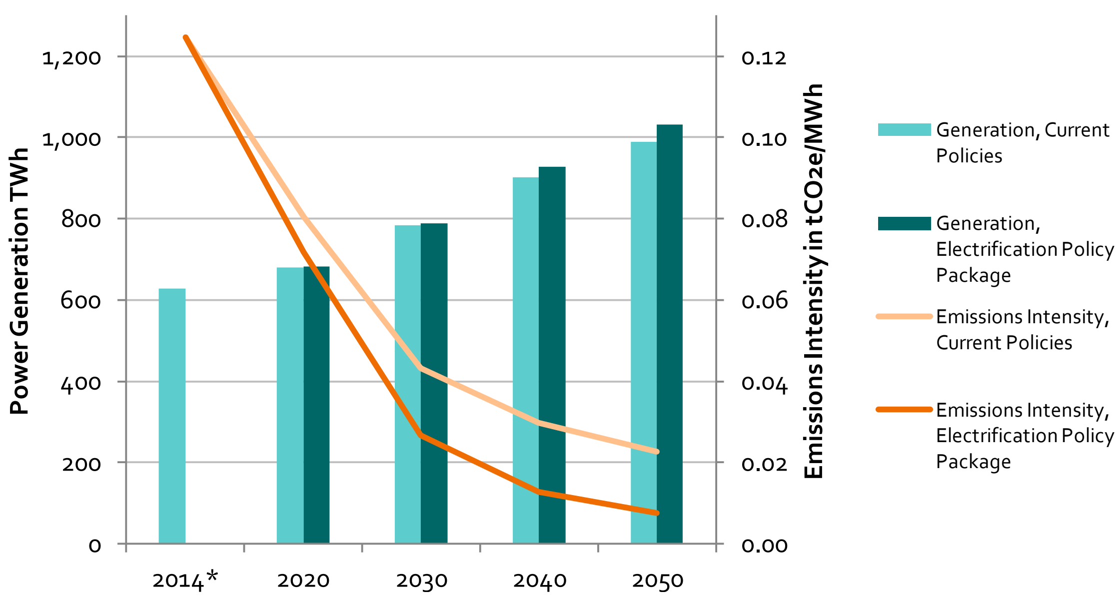
1. Although Alberta's proposed carbon price is higher than that of BC (it is designed to increase with inflation), since it is newer there are fewer estimates of policy impacts to draw from. British Columbia, 2008, Tax Reductions, Funded by a Revenue Neutral Carbon Tax, http://www.fin.gov.bc.ca/tbs/tp/climate/tax_cuts.htm
2. Québec, 2016, Analyse des avantages et des coûts d'un projet de norme sur les véhicules zéro émissions, Table 14, available from: www.mddelcc.gouv.qc.ca/changementsclimatiques/vze/analyse-avantages-couts.pdf
3. Ontario Climate Change Action Plan. Action 2 - Increase the Use of Electric Vehicles. Scaled abatement from Action 2 "Increase the use of electric vehicles" by funding spent on PEV incentives. Assumes similar $/t among policies. https://www.ontario.ca/page/climate-change-action-plan
4. Estimated based on this analysis.

4.4. How does the policy package impact Canada's electricity sector?

The policy package reduces greenhouse gas emissions by increasing the demand for electricity and ensuring that electricity generation comes from zero carbon sources. Electricity generation is projected to increase over the forecast period due to rising demand across many sectors of Canada's economy, as shown in Figure 4. Current federal and provincial policies are also expected to decrease the emissions intensity of electricity generation, from 0.125 t/MWh in 2014 to 0.023 t/MWh by 2050.

The electrification policy package accelerates both of these trends. First, demand for electricity rises more quickly as demand sectors switch from fossil fuels to electricity to comply with the electrification policies. In the policy package, electricity generation reaches 1,031 TWh in 2050 (an increase of 4.4% relative to the Current Policy forecast). Second, the electricity sector decarbonizes more quickly and more completely, reaching 0.008 t/MWh in 2050. In the short-run (the early 2020s), most new electricity capacity is from renewable sources including hydro, wind and solar. Over the longer-term, fossil fuel plants with carbon capture could contribute to the low carbon electricity mix in provinces such as Alberta and Saskatchewan.

Figure 4: National electricity generation and emissions intensity



Could interprovincial electricity trade contribute to greenhouse gas abatement?

Interprovincial electricity trade has a large potential to reduce greenhouse gas emissions, but this potential has largely been unexamined in Canada. The cost of generating low carbon electricity varies among regions of Canada. Electricity trade could potentially allow for regions with lower costs to generate power for regions with higher costs. For example, the Trottier Energy Futures project determined that national abatement costs could be reduced by increasing inter-jurisdictional transfers of electricity, in particular from areas with hydro potential to neighbouring provinces[7].

In our view, interprovincial electricity trade requires unique modeling to be properly assessed. For this reason, this analysis does not explore the potential for electricity trade to contribute to greenhouse gas reductions. The electricity market is unique from virtually every other sector in Canada because it is the only sector in which hourly dynamics are essential to understanding how the system functions.

Several factors need to be specified on an hourly basis for any comprehensive electricity trade analysis, including:

- **The intermittency of renewable generation.** Resources such as wind and solar have capacity factors that vary significantly from hour to hour. Most simply, solar produces power during the day while wind produces power when the wind is blowing. Interprovincial trade provides an important opportunity to balance the system as a whole, but this balancing can only be understood at an hourly (or close to hourly) level.
- **Electricity consumption (i.e., load) in each province.** Electricity consumption varies on an hourly basis between regions, and this is one of the main justifications for electricity trade.

In addition to hourly dynamics, it is important to consider the following factors:

- **Provincial incentives to trade with the US.** For example, British Columbia's freshet (i.e., period of peak electricity production) coincides with high demand from California. During this period, British Columbia has an incentive to sell power to California.
- **Provincial policies for or against specific forms of electricity generation.** For example, British Columbia has committed to not relying on nuclear power.

[7] Trottier Energy Futures Project. 2016. Canada's Challenge & Opportunity.

4.5. How does the policy package impact financial costs?

The electrification policy package requires investment in new capital stock, which is partially offset by lower energy expenditures in some sectors. The impact of the policy package on financial costs varies depending on the sector, as shown in Figure 5 and Figure 6.

The greatest required investment is in the electricity sector (an average of $2.8 billion/year between 2021 and 2050). This investment is incremental to that which is required in the Current Policy scenario (i.e., to meet anticipated load growth while complying with existing policies and regulations). In total, electricity system costs (i.e., the capital, operating and fuel costs required to generate electricity) increase by 4.6% relative to the Current Policy scenario (see Figure 6). These costs vary from region to region, and hence the impacts on ratepayers' electricity bills will likewise be varied.

The passenger transport sector experiences a net financial benefit. Although plug-in electric vehicles are more costly to purchase, these costs are offset by lower energy and operating expenditures. For example, a driver in Ontario could save $14,400 in fuel costs by purchasing a Nissan Leaf instead of a Nissan Versa[8]. The net benefit depends on the extent to which battery technology (and cost) improves in the future. Additional financial benefits can be expected if the policies induce a shift toward smaller cars, which tend to be both cheaper to purchase and more efficient.

Energy costs increase in the residential sector because electricity is a more expensive fuel than natural gas over the time period of this analysis[9]. The building code allows both electric baseboards and electric heat pumps. The former have higher energy costs, while the latter have higher capital costs. The ideal choice of heating technology depends on building thermal efficiency, climate, electricity costs and possible future declines in heat pump cost and performance. In the case of retrofitting existing homes, the presence of existing ducting and the cost of thermal efficiency upgrades are also important factors.

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[8] Assuming 2016 model year operated for 15 years, 15,000km/year, $1.06/litre gasoline price and 8.7 cents/kWh off-peak electricity rate.

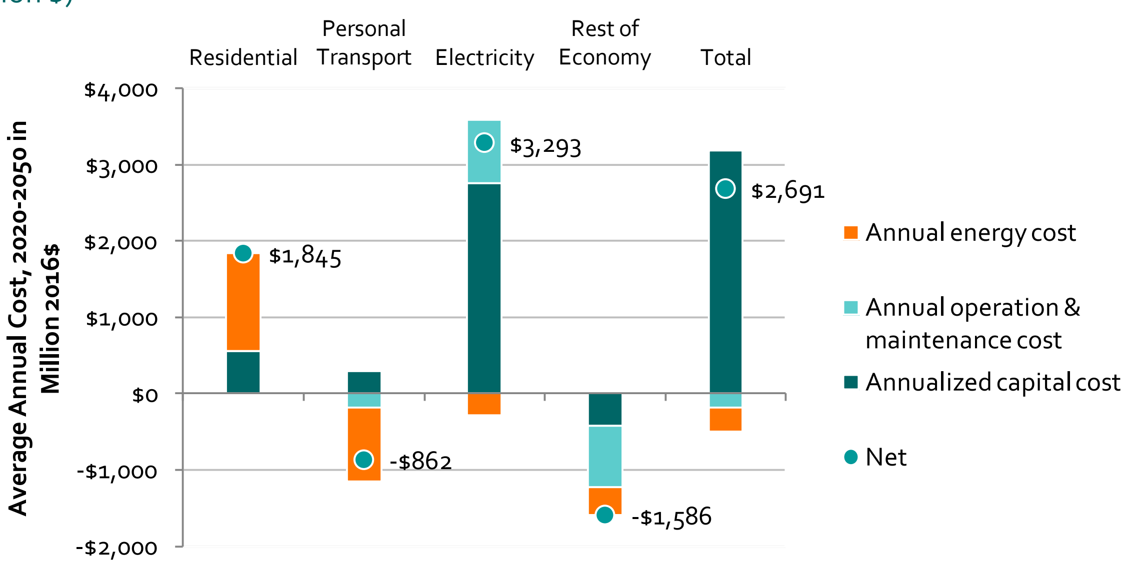
[9] As mentioned in Section 2 "How are the impacts of electrification policies estimated?", this analysis uses the National Energy Board's 2016 projection of natural gas prices. In this projection, the price for natural gas (measured at Henry Hub) gradually increases to USD $4.55/MMbtu by 2040. The future price for natural gas is uncertain, but is expected to remain below the price of electricity in all Canadian jurisdictions over the forecast period.

Between 2031 and 2050, average annual financial costs increase by $97 per household due to the policy.

The rest of the economy is impacted by the carbon price on combustion and process emissions. Total financial costs decrease for several reasons:

- Production of refined petroleum products and natural gas decreases due to lower demand in Canada caused by the electrification policies. Another important driver of fossil fuel production in Canada is demand for these energy commodities in the rest of the world. Therefore, the level of climate action undertaken in other jurisdictions is likely to influence this export demand.
- A greater share of freight is transported by rail instead of truck, which is less emissions intensive and also less costly (per tonne-kilometre travelled).
- The carbon price induces a small decrease in sector activity across industry. These impacts depend on how carbon revenue is redistributed. A carbon pricing policy can be designed to address competitiveness concerns.

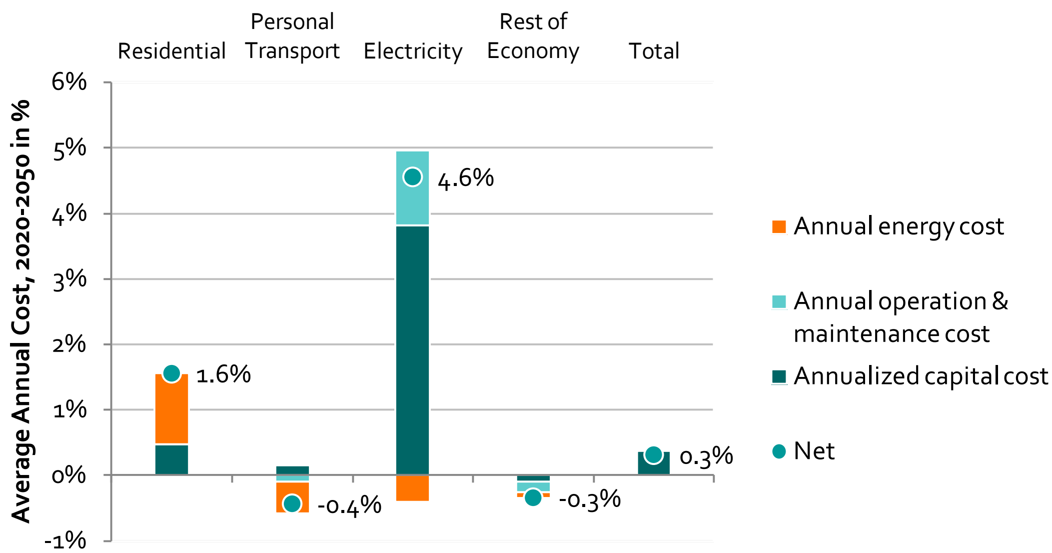
Figure 5: Average change in annual financial costs from reference case, 2021-2050 (million $)



Notes:

1. Excludes emissions cost (e.g. carbon price payments) because these costs can be returned to the economy through revenue recycling.
2. The data shown here reflect direct financial costs only. Additional costs would be associated with macroeconomic impacts (e.g. changes in demand for commodities, competitiveness impacts).

Figure 6: Average change in annual financial costs from reference case, 2021-2050 (%)



Notes:

1. Excludes emissions cost (e.g. carbon price payments) because these costs can be returned to the economy through revenue recycling.
2. The data shown here reflect direct financial costs only. Additional costs would be associated with macroeconomic impacts (e.g. changes in demand for commodities, competitiveness impacts).