Canada's Electric Vehicle Policy Report Card

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About START

Sustainable Transportation Action Research Team (START), in the Faculty of Environment at Simon Fraser University, focuses on supporting sustainable shifts in our transportation systems by conducting interdisciplinary research and engaging governments, industry, and communities. Our research approach integrates the best methods and perspectives available to integrate understanding from technology assessment, market acceptance, business strategy, and public policy.

START produces policy- and industry-relevant sustainable transportation research in three key aspects of transportation: vehicles and drivetrains, fuels and infrastructure, and mobility and travel demand. For each aspect, we produce comprehensive research to assess different transportation technologies, practices, and solutions according to technological feasibility, consumer and citizen acceptance, business and innovation strategy, and public policy.

Contents

Executive Summary

Plug-in electric vehicles (PEVs), which we refer to in this paper as electric vehicles, have the potential to significantly reduce greenhouse gas emissions from transportation. This includes pure battery electric vehicles (BEVs) that run on only electricity, and plug-in hybrids (PHEVs) that run on both electricity and gasoline.[1] With Canada's current electric grid, an electric vehicle could reduce emissions 45% to 98% compared to a conventional gasoline vehicle[2] [1]. These reductions will become even more substantial as provinces continue to move towards low-carbon sources of electricity.

GHG Emissions

45 to 98%

Around the globe, sales of electric vehicles vary significantly by region and country. Although no country has made a complete transition from conventional gasoline or diesel vehicles to electric vehicles, countries like Norway and the Netherlands are leading the way.

In Canada, the market for electric vehicles has been growing, but remains small. In 2015, electric vehicles made up about 1% of new vehicle sales in Canada. Research shows there is significant interest in electric vehicles among Canadian consumers, but potential consumers are constrained by a range of factors such as lack of awareness and limited electric vehicle model variety [1-3].

Research and real-world experience demonstrate that strong electric vehicle supportive policy can encourage sales. For example, **demand-focused policies** can directly support or encourage consumers to purchase electric vehicles by offering financial incentives or providing charging infrastructure. **Supply-focused policies** can encourage or require suppliers, such as auto manufacturers and dealerships, to develop and sell electric vehicles by specifying that a certain share of vehicles sold in a jurisdiction have zero tailpipe emissions or through support for research and development.

The objective of this report is to evaluate electric vehicle supportive policies in Canada. We frame our evaluation around the level of electric vehicle adoption likely needed to meet deep greenhouse gas reductions,[3] using the goal of 40% new vehicle sales or "market share" by 2040[4] [4].

Based on our evaluation we generate policy report cards for each province (see Provincial Report Cards, page 26). The Report Cards provide an overview of current and proposed policies in each province as well as the overall effectiveness of these policies.

Our approach

We evaluate the likely effectiveness of each Canadian province's electric vehicle supportive policies in three steps:

1. Identify electric vehicle supportive policies
2. Evaluate the effectiveness of each policy
3. Assign letter grades to each province

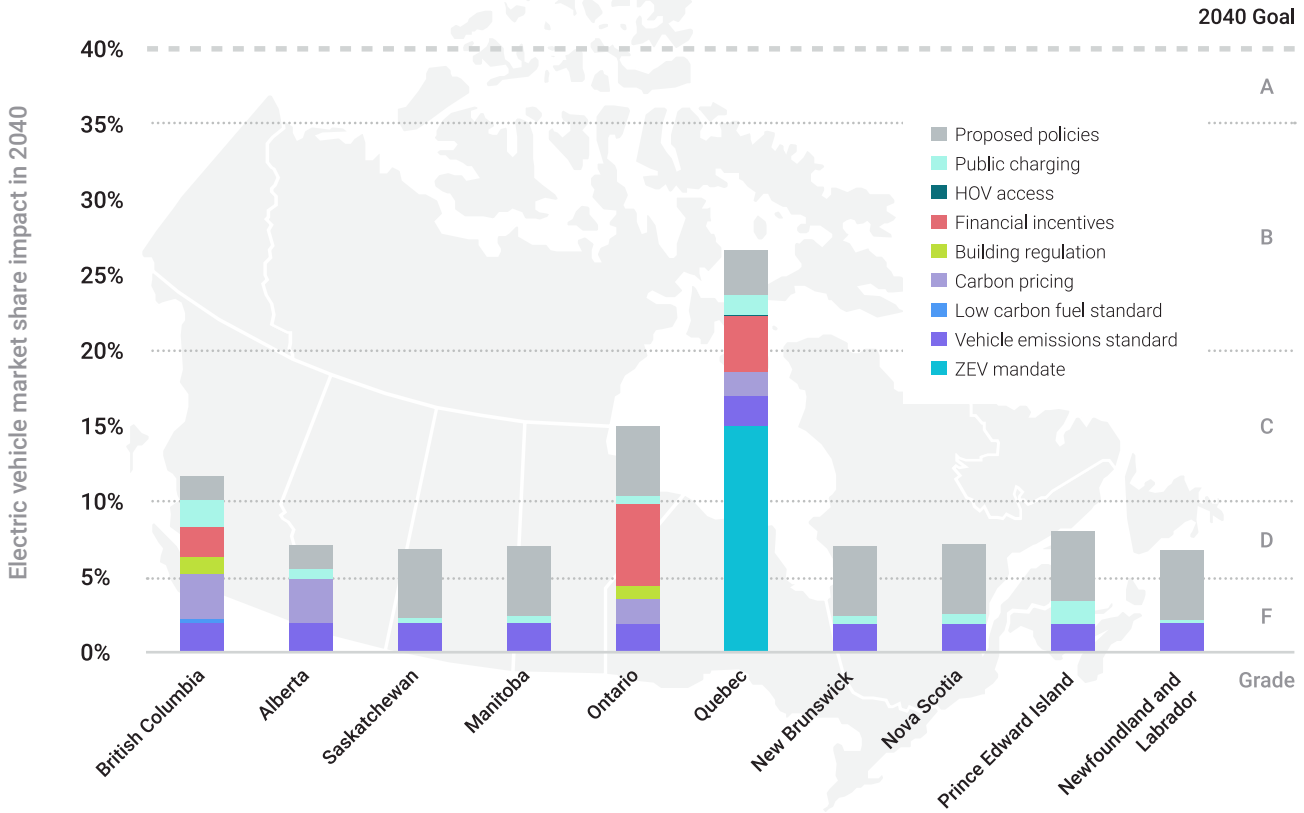
We focus on currently implemented and recently proposed electric vehicle supportive policies in Canada initiated by federal, provincial, and major municipal governments, as well as electric utilities. Our evaluation framework draws from research and literature to estimate the impact of each policy on electric vehicle market share in 2040, and has undergone peer-review.[5] Letter grades are assigned to each province based on their overall package of supportive policies — where "A" is excellent and "F" is unsatisfactory.

Key results

We identified 96 policies that directly or indirectly aim to increase electric vehicle sales in Canada. Of these policies, 8 have expired, 62 are active, and another 26 have been proposed (as of October 2016). The number of electric vehicle supportive policies implemented by each province varies from 0 to 32. The provinces with the largest number of policies are Quebec with 32, Ontario with 26, and British Columbia with 19 policies.

According to our evaluation, with the electric vehicle supportive policies currently in place, all Canadian provinces fall short of the 2040 policy goal of 40% market share (see Figure E–1). Six provinces receive an "F" because the policies currently in place are not likely to encourage electric vehicle market shares greater than 5% by 2040. Quebec, British Columbia, Ontario, and Alberta all receive "passing" grades. Quebec leads Canada with a grade of "B–" and an estimated 2040 new market share of 24% due to the recently passed Zero Emission Vehicle (ZEV) mandate. Policies in British Columbia, Ontario and Alberta are expected to have weaker impacts with electric vehicle market shares estimated to be no greater than 10% by 2040. British Columbia and Ontario each receive a "C–" while Alberta receives a slightly lower grade of "D."

Figure E–1:
Evaluation of current and proposed electric vehicle policies, by province



In terms of proposed policies, the proposed federal carbon pricing policy is anticipated to have a modest impact on 2040 market share: six provinces' grades increase to a "D," Quebec's grade increases to a "B," Ontario's grade increases to a "C" (with proposed provincial policies as well), and British Columbia's and Alberta's grades do not change (due to their existing carbon tax).

Canada as a nation receives an overall grade of "C–" for policies currently in place across Canada, and a "C" based on proposed policies.

Because no Canadian province receives an "A," we look to other countries and regions for examples of additional effective policies, specifically Norway and California (which both earn a "B" in our framework). When we apply policies similar to those implemented in Norway or California to each Canadian province, projected electric vehicle market shares increase to around 30% or more by 2040 in all provinces and raise grades to between "B" and "A." Our analysis demonstrates that Canadian provinces can substantially improve future electric vehicle market shares using policies that currently exist in other regions. Further, we highlight different policy pathways for Canadian provinces to improve future electric vehicle adoption — implementing strong demand-focused policies (like Norway), implementing strong supply-focused policies (like California) or, most effective of all, a combination of both.

Table E–1 summarizes the letter grades we assign to each province with the policies they currently have in place. It also includes our evaluation of what each province's grade would be if they implemented their proposed policies as well as policies similar to those implemented in Norway or California.

Table E–1: Electric vehicle policy grades by province

Province	Current policies*	Current + proposed*	Current + proposed* + "Norway-like"	Current + proposed* + "California-like"
Canada	**C–**	**C**	**B+**	**B+**
British Columbia	**C–**	**C–**	**B**	**B+**
Alberta	**D**	**D**	**B**	**B+**
Saskatchewan	**F**	**D**	**B**	**B+**
Manitoba	**F**	**D**	**B**	**B+**
Ontario	**C–**	**C**	**B**	**B+**
Quebec	**B–**	**B**	**A**	**B+**
New Brunswick	**F**	**D**	**B**	**B+**
Nova Scotia	**F**	**D**	**B**	**B+**
Prince Edward Island	**F**	**D**	**B**	**B+**
Newfoundland and Labrador	**F**	**D**	**B**	**B+**

* as of October 2016

Policy implications and recommendations

Canada's Electric Vehicle Policy Report Card is designed to be a tool for policymakers to assess the effectiveness of different policy packages. Based on our evaluation of supportive policies, we identify six key policy implications for Canada:

1. No Canadian province is currently on track to achieve an "A." More stringent policies are needed.

2. Based on our evaluation, the most effective policies include a Zero Emission Vehicle mandate (like California and Quebec), strong and long-duration financial incentives (like Norway and Ontario), and strong taxation on gasoline or carbon pricing.

3. Different combinations of stringent policy can be used to achieve an "A." Therefore, regions have some degree of flexibility in selecting the policies best suited for their jurisdiction.

4. The federal government could raise the grades of all provinces to "A's" and "B's" and position Canada as an international leader by implementing effective policies such as a ZEV mandate and strong purchase incentives, as well as continued strengthening of the recently proposed carbon pricing policy.

5. Municipal governments can also play a role in improving their province's grades by implementing policies such as building regulations and public charging infrastructure deployment, and supporting other effective policies at the federal and provincial levels.

6. As more is learned about the relationship between electric vehicle supportive policy and long-term electric vehicle sales, we plan to update our framework.

Introduction

Introduction

Over a quarter of Canada's total greenhouse gas emissions come from the transportation of goods and people [5], so deep reductions in greenhouse gas emissions from transportation are essential to meeting national and provincial climate reduction targets.

Plug-in electric vehicles (PEVs), which we refer to in this paper simply as electric vehicles, have the potential to significantly reduce greenhouse gas emissions. Electric vehicles include pure battery electric and plug-in hybrid vehicles (see boxes below for explanation).

With Canada's current electric grid, an electric vehicle could reduce emissions 45% to 98% compared to a conventional gasoline vehicle[6] [1]. These reductions will become even more substantial as provinces continue to move towards low-carbon sources of electricity.

BEVs

Battery electric vehicles (or BEVs) run on electricity only. They are charged by being plugged into an electric vehicle charger. Depending on the make and model, a BEV can travel anywhere from 100 to 500 kilometers with a full battery before needing to be charged. Examples of BEVs currently available in Canada include the Nissan Leaf, Mitsubishi i-MiEV, and Tesla Model S.

PHEVs

Plug-in hybrid electric vehicles (or PHEVs) can run on both electricity and gasoline. They can be charged with electricity by plugging into a charger and they can be fuelled with gasoline at the pump. Depending on the make and model, a PHEV can travel for the first 20 to 60 kilometers on electricity with a full battery and then run on a full tank of gasoline for 500 to 900 kilometers. Examples of PHEVs currently available in Canada include the Chevrolet Volt, Ford C-Max Energi, and Cadillac ELR.

Research indicates that widespread adoption of electric vehicles will likely be necessary to meet longer-term climate targets. For example, the International Energy Agency suggests that to limit global warming to 2 degrees Celsius, 40% of new passenger vehicle sales must be electric by 2040 [4]. Studies in Canada suggest that even greater electric vehicle adoption may be needed, perhaps reaching up to 80–90% of passenger vehicles sales by 2050, to meet national and provincial greenhouse gas targets [6, 7].

The global market

Around the globe, sales of electric vehicles vary significantly by region and country. Although no country has made a complete transition from conventional gasoline or diesel vehicles to electric vehicles, countries like Norway and the Netherlands are leading the way. In 2015, electric vehicles made up 22% of all new vehicle sales in Norway and 10% of new vehicle sales in the Netherlands. These relatively high sales numbers are likely the result of strong electric vehicle supportive policies that have been in place in those countries for over a decade [8-10]. In North America, the state of California has also demonstrated leadership with electric vehicle policy and sales. In 2015, electric vehicles represented around 3% of new vehicles sales in the state [11].

The Canadian market

The market for electric vehicles in Canada has been growing, but remains small. As of June 2016, over 20,000 electric vehicles had been sold in Canada, and in 2015, about 1% of new vehicles sales were electric vehicles [12, 13]. Sales of electric vehicles in Canada have largely been concentrated in Quebec, Ontario, and British Columbia — which account for over two-thirds of the Canadian population. As we describe in this

Table 1:
Market share and total sales of electric vehicles by province

Provinces	Electric vehicle new market share (2015)	Electric vehicles sold (2011–2016)*
Canada	0.9%	22,763
British Columbia	2.0%	4,190
Alberta	0.3%	537
Saskatchewan	0.1%	60
Manitoba	0.2%	125
Ontario	0.7%	7,248
Quebec	1.4%	10,503
New Brunswick	0.1%	87
Nova Scotia	0.1%	94
Prince Edward Island	0.0%	11
Newfoundland and Labrador	0.0%	15

Sources [12-14]
*Electric vehicle sales data as of June 2016.

Total sales versus percentage of sales or "market share"

To understand and compare sales of electric vehicles, it is important to distinguish between the total number of sales and the percentage of new vehicles sales. Total number of sales can be more reflective of the size of a region's population and vehicle sales market, while the percentage of sales is more reflective of electric vehicle success.

In this study we focus on the percentage of new vehicles sales in a region that are electric vehicles, or what is typically called "market share." We use forecasted electric vehicle market share in 2040, or the percentage of new vehicles sales in 2040 that are electric vehicles, as a metric to assess policy progress.

report, these three provinces also have relatively strong electric vehicle supportive policy compared to other Canadian provinces. Table 1 shows electric vehicle new markets share for each province in 2015, as well as total electric vehicles sold from 2011 to June 2016.

Research shows that there is significant interest in electric vehicles among Canadian consumers, but potential consumers are constrained by factors on both the demand and supply side [1-3]. On the **demand side**, consumer awareness is very low. For example, less than one-third of Canadian new car buyers understand which vehicle models are plug-in hybrid and which are pure battery electric [1]. Further, interest is higher for consumers with home-charging access, but one-third of Canadian new car buyers lack such access [15]. On the **supply side**, electric vehicles are currently available in only a few vehicle classes [14], and only a fraction of dealerships keep these models in stock [16, 17]. This means that otherwise informed consumers with home charging access might not buy an electric vehicle if they cannot find one available in a nearby dealership or in the vehicle class they want. Our research leads us to conclude that without the implementation of effective policy, these barriers will likely prevent sales from reaching more than 1 to 10% of the new vehicle market by 2030 [18].

Research and real-world experience demonstrate that strong electric vehicle supportive policy can encourage sales to approach the levels needed to meet long-term greenhouse gas targets. Research on the North American vehicle market suggests that strong policies that remove both demand side and supply side barriers can boost future electric vehicle market shares to 24–40% by 2030 [19-21]. Globally, we can see that the regions with the strongest electric vehicle supportive policies — Norway, the Netherlands, and the State of California — also have among the highest electric vehicle market shares. Canada's electric vehicle market share is likely to remain low unless similarly strong supportive policies are adopted.

This study

The objective of this report is to evaluate electric vehicle supportive policies presently in place in Canada. Specifically, we evaluate each province's potential to achieve significant electric vehicle adoption in the long-term. To make our evaluation accessible, we assign each province a letter grade based on their policies, where "A" is excellent and "F" is unsatisfactory.

We frame our policy evaluation around the level of electric vehicle adoption needed to achieve deep greenhouse gas reductions in Canada.[7] We use the goal of 40% new vehicle sales or market share by 2040 to define excellent electric vehicle policy progress or an "A."

Electric Vehicle Policies

Electric Vehicle Policies

A wide range of policies can stimulate uptake of electric vehicles. We call these "electric vehicle supportive policies" and they can be categorized as demand-focused or supply-focused. These policy categories line up with the demand side and supply side barriers we noted in the Introduction.

Demand-focused policies aim to support or encourage consumer demand for electric vehicles by, for example, offering financial incentives or providing charging infrastructure. Supply-focused policies encourage or require suppliers such as auto manufacturers and dealerships, to develop and sell electric vehicles by, for example, specifying that a certain share of vehicles sold in a jurisdiction have zero tailpipe emissions, or through support for research and development. Further examples of demand-focused and supply-focused policies include:

Demand-focused policies

1. **Financial incentives** reduce the cost of electric vehicles and charging infrastructure. The most common types of financial incentives for electric vehicles are subsidies, rebates, waived user fees, and tax exemptions.

2. **Non-financial incentives** offer other benefits to consumers including unrestricted access to lanes reserved for high-occupancy vehicles (HOV), and free parking.

3. **Public charging deployment** provides access to charging away from home. Many regional governments and utilities have invested in the deployment of public chargers and some also offer free charging.

4. **Carbon pricing** increases the price of fuels and activities that generate carbon emissions and make low-carbon electricity even cheaper than gasoline. For example, gasoline prices would increase roughly 7 cents per litre with a carbon price of $30/tonne.[8] The two main types of carbon pricing policies are carbon taxes and cap-and-trade programs.

5. **Building regulations** can make the installation of home charging cheaper and easier. This can include building codes or by-laws, which mandate a certain level of charging access in new buildings. Regulations can also require the installation of circuits to support electric vehicle charging, or result in "right-to-charge" bylaws that empower individuals to set up charging infrastructure in apartments, condos, and townhomes.

6. **Information campaigns** educate the public about electric vehicles and charging and include public-sponsored advertising, consumer outreach, informational websites, and vehicle labeling.

7. **Other demand-focused** policies include government investment in electric vehicles for public fleets and planning efforts related to electric vehicles.

Electric vehicle purchase incentive program

Ontario's **Electric Vehicle Purchase Incentive Program**, introduced in 2010, was the first electric vehicle incentive program in Canada. The program provided a rebate of up to $8,500 for the purchase or lease of new electric vehicles based on vehicle battery capacity. In 2016, Ontario revised the rebate so that purchasers of electric vehicles are eligible for a rebate ranging from $3,000 to $14,000 based on battery capacity, seating, and vehicle retail price (incentives are capped at $3,000 for vehicles priced over $75,000). In its recent Climate Change Action Plan the province extended this rebate to 2020.

Electric vehicle-ready building codes

The City of Vancouver was the first jurisdiction in North America to include requirements for electric vehicle charging in building bylaws. Introduced in 2008, the bylaw requires that all stalls in new one- and two-family homes, laneway houses, and secondary suites be equipped to support electric vehicle charging. The City also requires 20% of all parking stalls in newly developed multi-unit residential buildings be electric vehicle-ready. In 2013, Vancouver introduced a similar electric vehicle-ready standard for commercial buildings. The City is looking at opportunities to further expand access to home and workplace charging under the forthcoming EV Ecosystem Strategy (to be presented to City Council in November 2016).

Supply-focused policies

1 **Zero Emission Vehicle (ZEV)** mandates require auto manufacturers to sell a minimum percentage of electric or hydrogen fuel-cell vehicles. This encourages automakers to research, develop, and market a wider variety of models and potentially to lower sales prices as well.

2 **Research and Development (R&D) support** provides government funding for technology innovation and development related to electric vehicles. For example, R&D funds can support the development of batteries, electric drivetrain innovation, or electric vehicle demonstrations.

3 **Low-carbon fuel standards (LCFS)** require fuel suppliers to reduce the carbon intensity of the fuels they sell in a regulated region. An LCFS can support electric vehicle adoption because electricity is considered a low-carbon "fuel." A fuel supplier might be able to meet some or all of its LCFS requirement by purchasing credits from electric utilities that supply electricity to electric vehicles, creating an incentive for electric utilities to support electric vehicle deployment (e.g. by using revenue from credit sales to build more chargers or lower electricity rates for electric vehicle users).

4 **Vehicle emissions standards** specify a required maximum level of tailpipe emissions for each vehicle class. For example, emissions standards in Canada and the United States specify that new passenger cars cannot produce on average more than 98 grams of greenhouse gas emissions per kilometer across the full fleet by 2025. Because electric vehicles produce zero tailpipe emissions their sale can help automakers comply with this policy.

5 **Other supply-focused policies** include initiatives to develop local industries related to electric vehicles.

Policy spotlight

Bill 104: An Act to establish a ZEV mandate in Quebec

In June of 2016, Quebec's Minister of Sustainable Development, Environment and the Fight against Climate Change introduced a bill to establish a Zero Emission Vehicle (ZEV) mandate in Quebec [22]. The ZEV mandate requires major automakers to sell a minimum number of electric and hydrogen fuel-cell vehicles. The proposal was for a target of 15.5% of new vehicle sales as zero emissions by 2025, with provisions for automakers to generate and sell credits. This allows auto companies that sell more electric vehicles than needed for compliance to sell their extra credits to other auto companies. On October 26, 2016, the bill was adopted by the Quebec legislators, making it the first province in Canada to have a ZEV mandate.

Our Approach

Our Approach

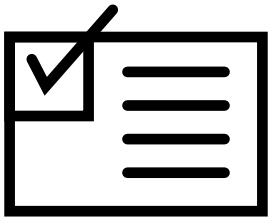
The wide variety of electric vehicle supportive policies makes it difficult to evaluate and compare their individual impacts. The Sustainable Transportation Action Research Team (START) developed a method to help policymakers and researchers in these efforts. Specifically, we evaluated the likely effectiveness of each province's electric vehicle supportive policies in three steps:

In this section, we provide a brief description of each step. Additional detail on the methods used to estimate individual policy impacts and uncertainty is discussed in Appendix B.[9]

1

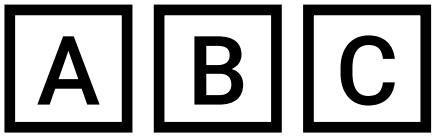
Identify electric vehicle supportive policies

2



Evaluate the effectiveness of each policy

3



Assign letter grades to each province (based on the effectiveness of their policies)

Step 1
Identify electric vehicle supportive policies

We focus on existing and recently proposed electric vehicle supportive policies (as of October 2016) in Canada initiated by federal, provincial, and major municipal governments, as well as electric utilities. We broadly define electric vehicle supportive policies as programs, initiatives, investments, incentives, or regulations that aim to directly or indirectly encourage electric vehicle adoption. For example, our framework includes purchase incentives that directly encourage electric vehicle adoption, as well as carbon taxes that indirectly encourage electric vehicle adoption by increasing the price of gasoline (relative to electricity).

We identified supportive policies through online searches of government, industry associations, and news websites. We then compiled these policies into a database that we shared with contacts in government, academia, and industry for verification. The final database can be considered reasonably comprehensive, although it is possible that some initiatives were overlooked.[10]

Step 2
Evaluate the effectiveness of each policy

Our evaluation framework considers eight types of policies:

- **Five demand-focused policies:** financial incentives (vehicle and charger subsidies), non-financial incentives (HOV lane access), public charging deployment, electric vehicle building regulations, and carbon pricing (carbon tax and cap-and-trade), and

- **Three supply-focused policies:** zero emission vehicle (ZEV) mandates, vehicle emissions standards, and low-carbon fuel standards.[11]

We evaluate each policy against a "policy benchmark" (Table 2). This benchmark reflects the maximum stringency (how strong the policy is) and duration (how long the policy is intended to be in place for) of a specific policy type that is likely to be politically acceptable in North America. We also draw on existing research to estimate the impact of each policy benchmark on electric vehicle market share in 2040 (see appendices A & B for literature review and detailed methodology). In some cases, policy benchmarks are based on actual policies implemented around the world, while other benchmarks are based on stronger policies indicated in the electric vehicle literature. To evaluate the impact of a policy, we compare the stringency and duration of that policy to its policy benchmark.[12] We assume that policies that are weaker or shorter duration than the benchmark will have less of an impact on market share.[13] For example, if a policy is half as strong as the benchmark (e.g. a $6,000 financial incentive rather than the $12,000 benchmark) or will be in place for half as long as the benchmark (e.g. 7.5 years rather than 15), we assume the impact of the policy is half that of the benchmark (e.g. 5% rather than 10%).

Step 3
Assign letter grades to each province

We evaluate the overall effectiveness of each province's policies according to only one goal: reaching an electric vehicle market share of 40% by 2040.[14] For a province to achieve an "A" they need to have policies in place that put them on track for an electric vehicle market share of 40% by 2040.

We assign letter grades to each province based on the overall impact of the electric vehicle supportive policies they have in place relative to our 2040 electric vehicle policy goal. We add up the estimated impacts of all evaluated electric vehicle supportive policies in each province to determine overall impact and then translate impacts into a letter grade (see Table 3). For example, if a province has three policies, each with an estimated market share impact of 3% in 2040, the overall impact of that province's policies would be a 9% market share by 2040, earning it a grade of "D." This calculation of policy impact is simplistic and does not account for potential interactions among policies, but it is nonetheless instructive as an indicator of long-term electric vehicle policy effectiveness.[15]

Based on our evaluation we generate policy report cards for each province. These report cards provide an overview of the current and proposed policies in each province, as well as the effectiveness of these policies (see Provincial Report Cards, page 26).

Table 2:
Electric vehicle policy benchmarks and potential market share impacts

Policy	Policy Benchmark (i.e. maximum stringency and duration)	Estimated 2040 electric vehicle market share impact*
Demand-focused policies		
Financial incentives	$12,000 per vehicle for 15 years.	**10%**
HOV lane access	100% of congested highways have HOV lane access for PEVs.	**1%**
Public charging deployment	One public charger for every two gas stations (sufficient charger density to equate with gasoline refueling).	**3%**
Building regulations	100% of population has level 2 home charging access.	**8%**
Carbon price	Carbon price on track to meet $150/tonne CO_2e by 2030.	**15%**
Supply-focused policies		
ZEV mandate	California's ZEV mandate (requiring 9 to 21% electric vehicle sales by 2025).	**15%**
Vehicle emissions standards	Vehicle emissions standards with electric vehicle credits reaching 98g CO_2e per km by 2025.	**2%**
Low carbon fuel standards	Low carbon fuel standard requiring a 10% reduction in carbon intensity by 2020, with electric vehicle credits.	**0.3%**

*We consider an uncertainty range of +/- 50% or other ranges based on literature where possible.

Table 3:
Grading scale[16]

Grade	Estimated market share in 2040	Policy performance
A	**35%+**	**Excellent performance:** Initiatives are likely to meet or exceed target
B	**20–35%**	**Moderate performance:** Initiatives are likely to boost the adoption of electric vehicles but not achieve target
C	**10–20%**	**Marginal performance:** Initiatives are likely to achieve somewhat limited adoption of electric vehicles
D	**5–10%**	**Poor performance:** Initiatives are likely to achieve very limited adoption of electric vehicles
F	**0–5%**	**Unsatisfactory performance:** Initiatives, if any, are likely to induce insubstantial adoption of electric vehicles

Study assumptions and limitations

Our policy evaluation framework is intended to be a helpful guide for policymakers, researchers, and other stakeholders to identify the types of policies that are likely to be effective in reaching provincial and national greenhouse gas targets. However, we acknowledge a number of assumptions and limitations:

1. Our overall framework considers only one goal: putting electric vehicles on track to make up 40% of new passenger vehicle sales by 2040 to achieve greenhouse gas emissions targets.

2. Our evaluation is limited to effectiveness in achieving this one goal. We do not consider other policy criteria, such as the economic efficiency, equity effects, administrative complexity, or political acceptability.

3. Our estimates of market share impacts are uncertain. Although we rely on the literature to guide our estimates, much more research in the field remains to be done. Further, no single jurisdiction has yet reached the goal of 40% electric vehicle sales, adding to the uncertainty in estimating what policies are need to get there. Appendix B identifies top priorities for future research to inform this policy evaluation framework.

4. Our framework assumes that the effectiveness of one policy is independent from the effectiveness of other policies. This assumption does not account for potential interactions among policies in a region. In some instances policies may be complementary to one another, while in other cases the implementation of one policy may reduce the incremental impact of another policy.

5. We do not evaluate all policies. Specifically, we do not include information campaigns, government fleet procurement, planning, local electric vehicle industry development programs, or R&D support because their long-term market share impacts are uncertain and likely to be small in magnitude.

6. We assume that a given policy will have similar impacts across different jurisdictions. In reality, electric vehicle supportive policies may have slightly different effects across provinces, but we anticipate that these differences will be minor.[17]

Evaluation Results

Evaluation Results

Electric vehicle supportive policies in Canada

We identified 96 policies that directly or indirectly aim to increase electric vehicle sales in Canada. Of these policies, 8 have expired, 62 are active, and another 26 have been proposed (as of October 2016). The vast majority of these policies (close to 80%) were initiated by provincial governments. The remaining policies were initiated by municipalities, transit authorities, and utilities; only five policies were initiated by the federal government (see Figure 1).

The number of electric vehicle supportive policies varies significantly by province (Figure 2). The provinces with the largest number of policies are Quebec with 32, Ontario with 26, and British Columbia with 19. Of the remaining provinces, five have implemented less than five policies each, while two provinces (Saskatchewan and Prince Edward Island) have zero electric vehicle supportive policies.

The majority of these policies are demand-focused.[18] The most common demand-focused policies are financial incentives (20), public charging deployment (15), and information campaigns (14). Financial incentives include subsidies for vehicle purchases (11), subsidies for home charger installations (7), and waiving user fees and free home charging (2).

Few provinces have implemented or proposed supply-focused policies. Aside from the federal vehicle

Figure 1: Electric vehicle supportive policies in Canada by policy type, status, and initiating authority

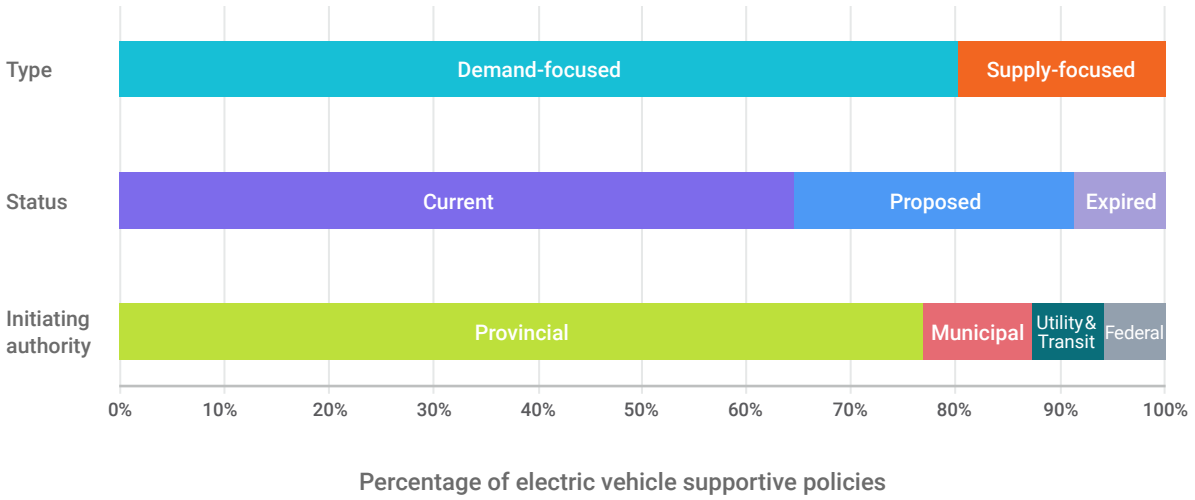
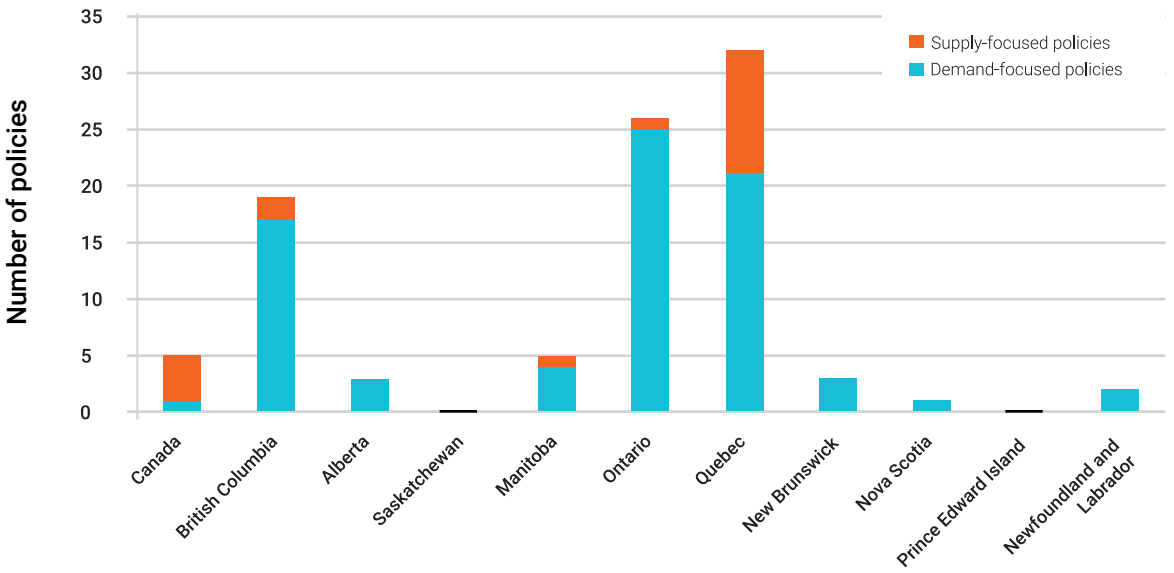


Figure 2: Number of demand-focused and supply-focused policies by province (includes expired, current, and proposed)



emissions standard, British Columbia's Low Carbon Fuel Standard and Quebec's ZEV mandate are the only significant supply-side policies identified. We also identified R&D policies and market development policies in several provinces. However, we do not evaluate these policies in this study.[19]

Policy evaluation and grades

Following our evaluation framework, we combine the market share impacts of individual policies and assign each province a letter grade based on its estimated 2040 electric vehicle market share. While our evaluation focuses on the effectiveness of policies currently in place in each province, we evaluate three additional policy scenarios. Specifically, we look at how a province's grade would change with the addition of:

1. proposed policies announced by provincial and federal governments,
2. proposed policies plus policies similar to those currently in place in Norway, and
3. proposed policies plus policies similar to those currently in place in California.

Table 4 summarizes the grades assigned to each province with policies currently in place, as well as with the additional policies. We describe each of these policy evaluations below.

Policies currently in place

All Canadian provinces fall short of the 2040 electric vehicle policy goal. Six provinces receive an "F" because the policies currently in place are not likely to encourage electric vehicle market shares greater than 5% by 2040. In these provinces, only two electric vehicle supportive policies are driving market share: the federal vehicle emissions standard and public

Table 4: Electric vehicle policy grades by province

Province	Current policies*	Current + proposed*	Current + proposed* + "Norway-like"	Current + proposed* + "California-like"
Canada	C–	C	B+	B+
British Columbia	C–	C–	B	B+
Alberta	D	D	B	B+
Saskatchewan	F	D	B	B+
Manitoba	F	D	B	B+
Ontario	C–	C	B	B+
Quebec	B–	B	A	B+
New Brunswick	F	D	B	B+
Nova Scotia	F	D	B	B+
Prince Edward Island	F	D	B	B+
Newfoundland and Labrador	F	D	B	B+

* as of October 2016

charger deployment. According to our evaluation framework, both policies are estimated to have minimal impact on 2040 market share.

Quebec, British Columbia, Ontario, and Alberta all receive grades better than an "F". Quebec leads Canada with a grade of "B–" and an estimated market share of 24% by 2040 due to the recently passed ZEV mandate. Policies in British Columbia, Ontario, and Alberta are expected to have lesser impacts with electric vehicle market shares estimated to be no greater than 10% by 2040. British Columbia and Ontario receive a "C–" while Alberta receives a slightly lower grade of "D." Driven primarily by provincial policies in Quebec, British Columbia, and Ontario, Canada as a whole receives a grade of "C–" based on policies currently in place.

Table 5 summarizes policy grades for each province as well as the estimated 2040 market share impacts of the electric vehicle supportive policies currently in place. Among the policies we evaluate, we attribute the highest market share impacts to the ZEV mandate in Quebec, followed by financial incentives in Ontario, Quebec, and British Columbia.

Quebec's ZEV mandate is estimated to have the most substantive impact on electric vehicle sales of any policy in Canada and is projected to boost electric vehicle market share in the province by 15%[20] Financial incentives have the second largest impact on 2040 market shares. Ontario's financial incentive is estimated to have a market share impact of 5% by 2040.[21] The impact of incentives is estimated to be slightly lower in Quebec 4% and British Columbia 2% due to lower incentive values and shorter announced durations.

Policy	British Columbia	Alberta	Saskatchewan	Manitoba	Ontario	Quebec	New Brunswick	Nova Scotia	Prince Edward Island	Newfoundland and Labrador
Demand-focused policies										
Financial incentives	2%	-	-	-	5%	4%	-	-	-	-
HOV lane access	0.01%	0.5%	-	-	0.03%	0.03%	-	-	-	-
Public charging deployment	2%	-	0.3%	0.5%	0.5%	1%	0.5%	0.7%	2%	0.3%
Building regulations	1%	-	-	-	0.9%	-	-	-	-	-
Carbon price	3%	3%	-	-	2%	2%	-	-	-	-
Total demand-focused policies	8%	4%	0.3%	0.5%	8%	7%	0.5%	0.7%	2%	0.3%
Supply-focused policies										
ZEV mandate	-					15%				
Vehicle emissions standards	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
Low carbon fuel standards	0.3%									
Total supply-focused policies	2%	2%	2%	2%	2%	17%	2%	2%	2%	2%
Market share from all current policies										
2040 market share impact	10%	6%	2%	3%	10%	24%	3%	3%	4%	2%
Uncertainty low value	*5%*	*3%*	*1%*	*1%*	*5%*	*12%*	*1%*	*1%*	*2%*	*1%*
Uncertainty high value	*15%*	*8%*	*4%*	*4%*	*16%*	*28%*	*4%*	*4%*	*5%*	*3%*
Grades										
Current policies	C–	D	F	F	C–	B–	F	F	F	F

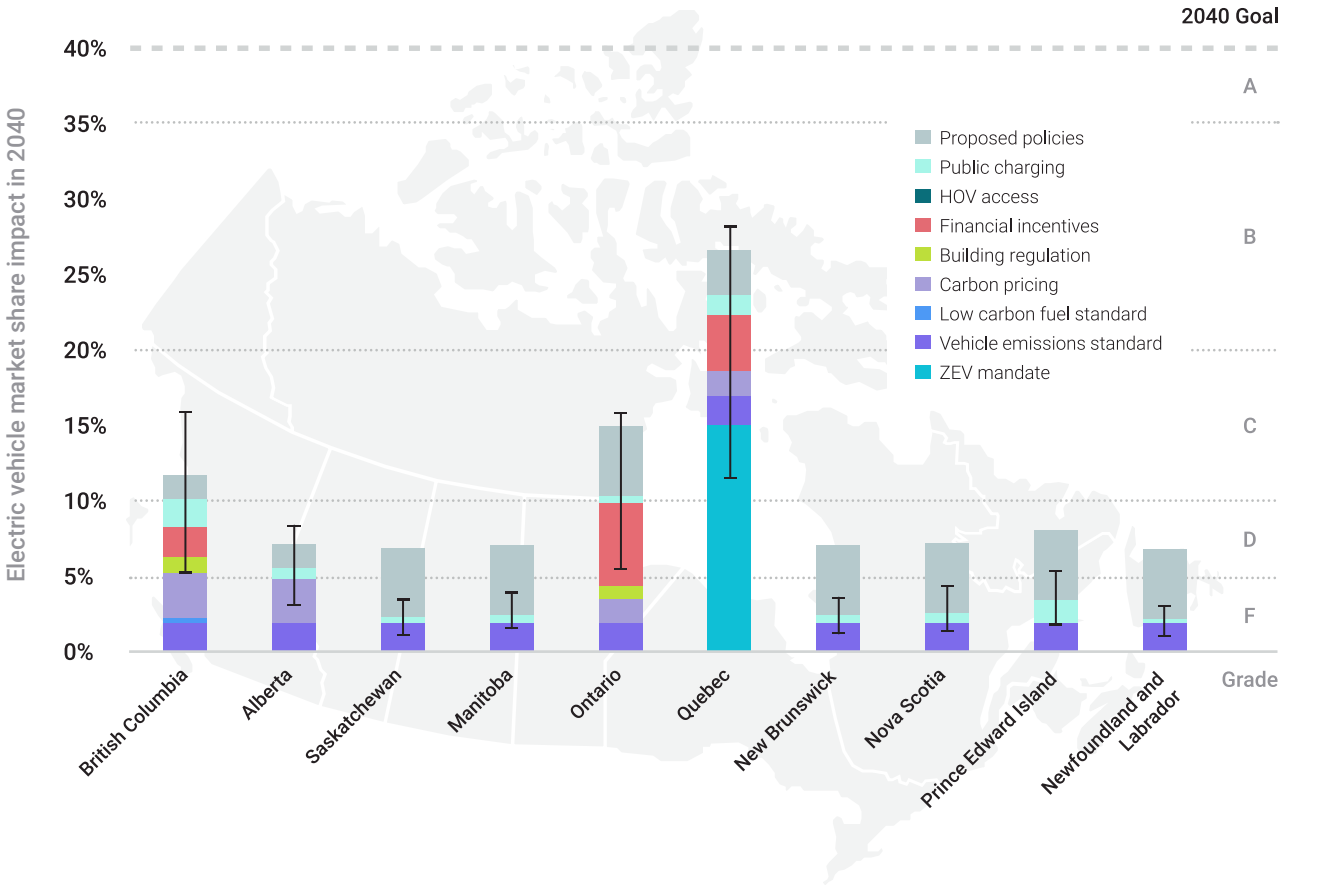
Table 5:
Evaluation of current electric vehicle policies and overall policy grades

Proposed policies

We also evaluate proposed electric vehicle supportive policies in each province. The most effective policy is the proposed federal carbon pricing policy ($10/tonne in 2018, rising to $50/tonne by 2022), which we estimate to have a market share impact of around 5% for provinces with no existing carbon pricing policy. The proposed federal policy increases all the provinces' grades. For six provinces, overall market shares more than doubles, increasing grades from an "F" to a "D." Ontario's grade increases to a "C" with the proposed federal policy and the proposed policies in its recent climate action plan, such as free overnight charging and electric vehicle-ready building codes. The impact of the proposed federal policy is smaller in British Columbia, Alberta and Quebec (2% to 3% market share) due to existing carbon pricing policies. Quebec's grade increases slightly to a "B" while British Columbia's and Alberta's grades do not change.[22]

Figure 3 depicts how proposed policies (grey bars) would increase grades and estimated electric vehicle market shares in 2040.

Figure 3: Evaluation of current and proposed electric vehicle policies, by province



Note: Bars reflect uncertainty ranges associated with estimated market shares.

Applying our policy report card framework to Norway and California

To see how our Canadian analysis compares with world leaders in electric vehicle policy and sales, we also apply our framework to Norway and California. Norway has followed a largely demand-focused approach that includes strong financial incentives for electric vehicles (along with financial disincentives for conventional vehicles) equivalent to up to a 50% reduction in the purchase price of new electric vehicles, as well as deployment of extensive public charging infrastructure networks [23]. In contrast, California has implemented a relatively modest set of demand-focused policies (such as electric vehicle purchase incentives, HOV lane access, and public charging deployment) but has also pioneered several supply-focused policies including a ZEV mandate — requiring automakers to sell a minimum number of electric or hydrogen fuel-cell vehicles in the state. According to our policy evaluation framework, both regions beat all Canadian provinces' grades. Norway's demand-focused policies are estimated to result in a 27% electric vehicle market share by 2040, earning it a "B." California's more supply-focused policy approach is estimated to result in a 29% electric vehicle market share by 2040, earning it a "B."

California- and Norway-like policies

We also evaluate what provinces' grades would be if they adopted similar policies to California and Norway, in addition to current and proposed policies (see box on the left). When we apply Norway-like and California-like policies to Canadian provinces, grades increase to between a "B" and "A" and market shares increase to near or above 30% by 2040 in all provinces (see Table 4). Although simplistic, this exercise demonstrates that Canadian provinces can substantially improve their grades using policies that currently exist in other regions. For example, we estimate that Quebec could achieve the 2040 policy goal (or an "A") by combining its ZEV mandate with Norway-like demand policies. Our analysis highlights a range of pathways for Canada and its provinces to improve future electric vehicle adoption:

1 Implementing strong demand-focused policies like Norway,

2 Implementing strong supply-focused policies like California, or

3 Implementing a combination of the two.

Policy Implications and Recommendations

Policy Implications and Recommendations

Canada's Electric Vehicle Policy Report Card is designed to be a tool for policymakers to assess the effectiveness of different policy packages. Based on our evaluation of supportive policies, we identify six key policy implications for Canada:

1 No Canadian province is currently on track to achieve the level of electric vehicle sales needed to meet long-term greenhouse gas reduction goals (i.e. no province earns an "A" grade). More stringent policies are needed.

2 Policymakers who want to achieve substantial electric vehicle sales in their region should draw lessons from existing policies in Canada and internationally. Based on our evaluation, the most effective policies include a Zero Emission Vehicle mandate (like those implemented in California and Quebec), strong and long-duration financial incentives (like those in place in Norway and Ontario), and strong taxation on gasoline or carbon pricing (like that in place in Norway).

3 Regions have some degree of flexibility in selecting stringent, effective policies. Both California and Norway are world leaders in electric vehicle policy and sales, yet California has followed more of a strong supply-focused policy strategy, and Norway has followed more of a strong demand-focused policy strategy. Different combinations of stringent policy can be used to achieve an "A" in our framework. For example, we estimate that Quebec could achieve an "A" by combining its ZEV mandate with Norway-like demand policies. Ultimately, policymakers will want to determine which effective policies are likely to achieve the right balance of economic efficiency, equity, and political acceptability in their region.

4 While we identify electric vehicle supportive policies at the national, provincial, and municipal level, the most effective policies currently in place are provincial. However, federal and municipal governments can have a positive effect on electric vehicle sales. The federal government, in particular, has the potential to implement all of the effective policies we identify in this report such as a ZEV mandate and strong purchase incentives, as well as continued strengthening of the recently proposed carbon pricing policy. In effect, the Canadian government could raise the grades of all provinces to "A's" and "B's" and position Canada as an international leader in electric vehicle policy.

5 Municipal governments can also play a role in improving their province's electric vehicle policy grades, both directly and indirectly. Directly, municipalities can implement policies such as building regulations and public charging infrastructure deployment. More indirectly, municipalities can collaborate with provincial and federal governments to support the implementation of the effective policies we identify above (provincial or federal level ZEV mandates, purchase incentives, and carbon pricing).

6 Our report identifies several limitations and simplifications in our method, including areas that need further research. As more is learned about the relationship between supportive policy and long-term electric vehicle sales, we plan to update our framework.

Provincial Report Cards

Provincial Report Cards

In this section we present electric vehicle policy report cards for each province. The report cards provide an overview of current and proposed policies in each province, as well as the grade each province receives based on our evaluation of these policies.

To go directly to a specific province, click on its flag:

British Columbia

C–

British Columbia receives a "C–" with its current policies. Despite the large number of policies (17 implemented and 2 proposed), the anticipated effect on long-term electric vehicle sales is modest. British Columbia could earn an "A" with additional effective policies.

Policy opportunity

British Columbia could achieve a "B" with a mix of implemented, proposed, and Norway-like policies, and a "B+" with a mix of implemented, proposed, and California-like policies. British Columbia could achieve an "A" with a mix of effective demand- and supply-focused policies. These could include the policies recommended by the Climate Action Leadership Team in October 2015: a ZEV mandate requiring that 30% of sales be zero emissions by 2030, a vehicle purchase tax based on carbon emissions, and a strengthening of the carbon tax. British Columbia's grade could also improve with the implementation of stronger and longer-duration financial incentives (such as those in Norway and Ontario). Municipal governments can also play a role in improving the province's policy grade by strengthening electric vehicle supportive building regulations.

Electric vehicle policy history

In 2008 the City of Vancouver introduced electric vehicle-ready building bylaws. In 2011 the Government of British Columbia launched its Clean Energy Vehicle Program, which provided incentives between $2,500–$5,000 for the purchase of electric vehicles, subsidies for electric vehicle charging infrastructure, support for fleet electrification, and investment in education and training. Since 2011, the province and several municipalities have introduced additional electric vehicle policies such as unrestricted high-occupancy vehicle (HOV) lane access, incentives for replacing older vehicles with electric vehicles, and public outreach campaigns.

Other electric vehicle supportive climate policies

British Columbia currently has the highest price on carbon emissions in Canada with a carbon tax of $30/tonne, and is the only jurisdiction in Canada to require a targeted reduction in carbon emissions from transportation fuels (known as the Low Carbon Fuel Standard).

Electric vehicles and chargers

In 2015, 2% of new vehicle sales were electric vehicles, and there were 168 public chargers per 1 million registered vehicles.[23]

Electric vehicle policy grade

Our evaluation of current policies assigns British Columbia a "C–" grade. The carbon tax and electric vehicle purchase incentive are likely to have the greatest impact on 2040 sales, but these policies are not likely to support an electric vehicle market share much higher than 10% by 2040.

Proposed policies

In its recent Climate Leadership Plan (August 2016) the province proposed strengthening two existing policies (Clean Energy Vehicle Program and the Low Carbon Fuel Standard), and two new electric vehicle supportive policies (electric vehicle supportive building regulations and incentives for electric vehicle development and research). Because the government has not yet provided details of these policies, we do not evaluate their effectiveness in this report. The proposed federal carbon pricing policy is anticipated to have a minimal impact on British Columbia due to the existing carbon tax, keeping its grade at "C–."

British Columbia's Electric Vehicle Policy Report Card

Overall Grade

C– 10% market share by 2040

Scenarios

Implemented + proposed policy	Implemented + proposed + "Norway-like" policy	Implemented + proposed + "California-like" policy
C– 12% market share by 2040	**B** 28% market share by 2040	**B+** 33% market share by 2040

Evaluated Policies

Implemented

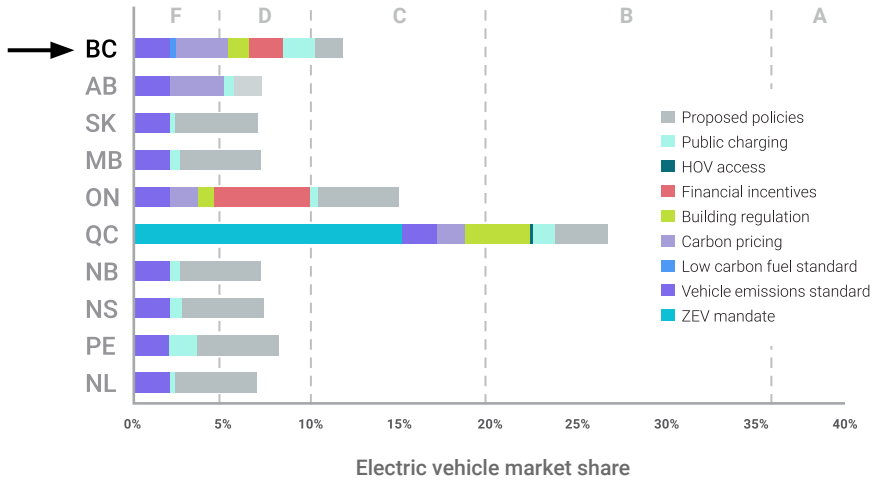
1. Federal vehicle emissions standard
2. Public charging infrastructure
3. Electric vehicle purchase and vehicle replacement incentive ($2,500 to $8,250 until 2018)
4. Carbon tax at $30/tonne
5. City of Vancouver electric vehicle ready building regulation
6. Low carbon fuel standard (10% reduction by 2020)
7. HOV lane access

Proposed

1. Federal carbon price ($10–$50/tonne, 2018–2022)

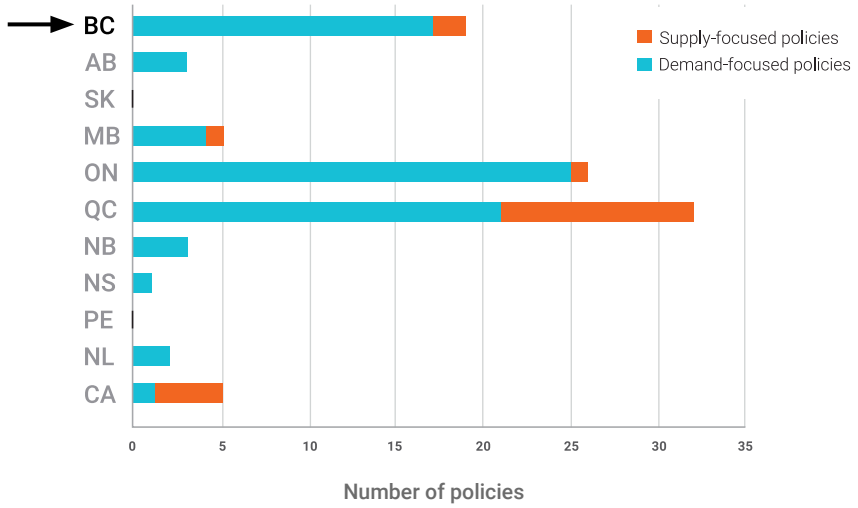
2040 market share with evaluated electric vehicle policies

(ranked based on current policy effectiveness)

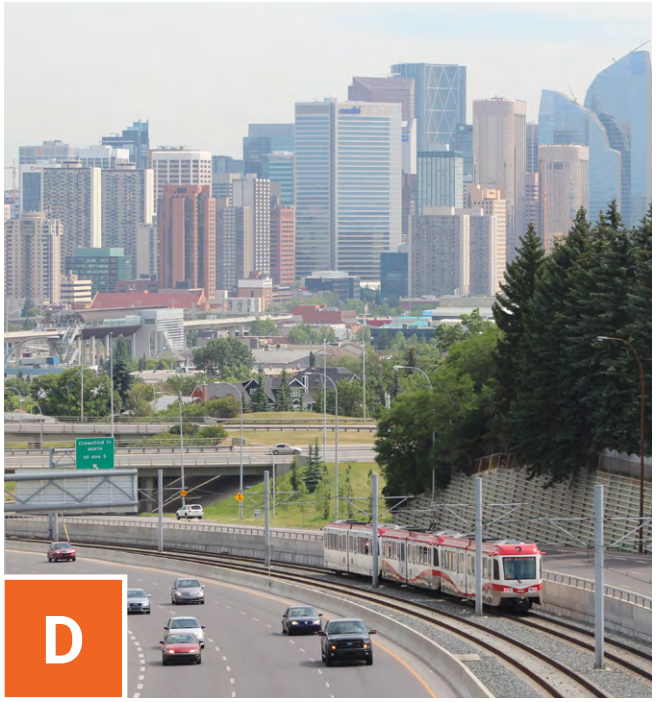


Total number of electric vehicle policies

(includes expired, current, and proposed policies)



Alberta



D

Alberta receives a “D” with its current policies and proposed policies. Alberta’s policies (3 implemented) are anticipated to have minimal effect on long-term electric vehicle sales. Alberta could earn an “A” with additional and effective electric vehicle supportive policies.

Policy opportunity	Alberta could achieve a “B” with a mix of implemented, proposed, and Norway-like policies, and a “B+” with a mix of implemented, proposed, and California-like policies. Alberta could achieve an “A” with a mix of effective demand- and supply-focused policies. Both could include a ZEV mandate (like those implemented in California and Quebec), strong and long-duration financial incentives (such as those in Norway and Ontario), and strong pricing on gasoline or carbon (like in Norway). Municipal governments can also play a role in improving the province’s policy grade by strengthening electric vehicle supportive building regulations.
Electric vehicle policy history	Only three electric vehicle policies have been implemented in Alberta. Both policies were initiated at the municipal level and include investment in charging infrastructure at a government-owned building and pilot testing of electric vehicles in a municipal fleet.
Other electric vehicle supportive climate policies	Starting on January 1st 2017, a carbon tax (“the carbon levy”) will be applied to all combusted fuels. The tax will start at $20/tonne in 2017 and rise to $30/tonne in 2018.
Electric vehicles and chargers	In 2015, 0.3% of new vehicle sales were electric vehicles, and there were 20.6 public chargers per 1 million registered vehicles.[24]
Electric vehicle policy grade	Our evaluation of current policies assigns Alberta a grade of “D.” Current policies are not likely to support an electric vehicle market share much higher than 3% by 2040.
Proposed policies	The proposed federal carbon pricing policy is expected to have a modest impact (2%) on Alberta’s electric vehicle market share, as it overlaps with the Alberta Government’s carbon tax. The proposed federal carbon pricing policy does not change Alberta’s grade.

Alberta's Electric Vehicle Policy Report Card

Overall Grade

D — 6% market share by 2040

Scenarios

Implemented + proposed policy

D — 7% market share by 2040

Implemented + proposed + "Norway-like" policy

B — 27% market share by 2040

Implemented + proposed + "California-like" policy

B+ — 32% market share by 2040

Evaluated Policies

Implemented

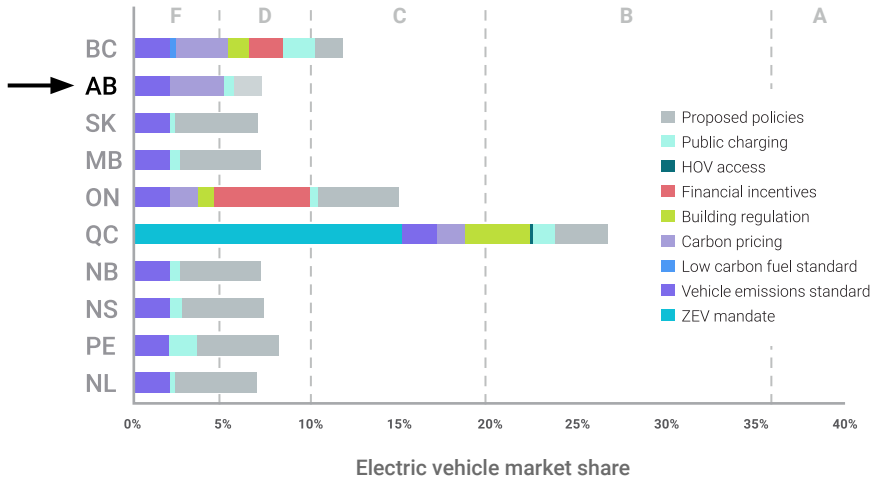
1. Federal vehicle emissions standard
2. Public charging infrastructure
3. Carbon tax ($20-30/tonne, 2017-2018)

Proposed

1. Federal carbon price ($10–$50/tonne, 2018–2022)

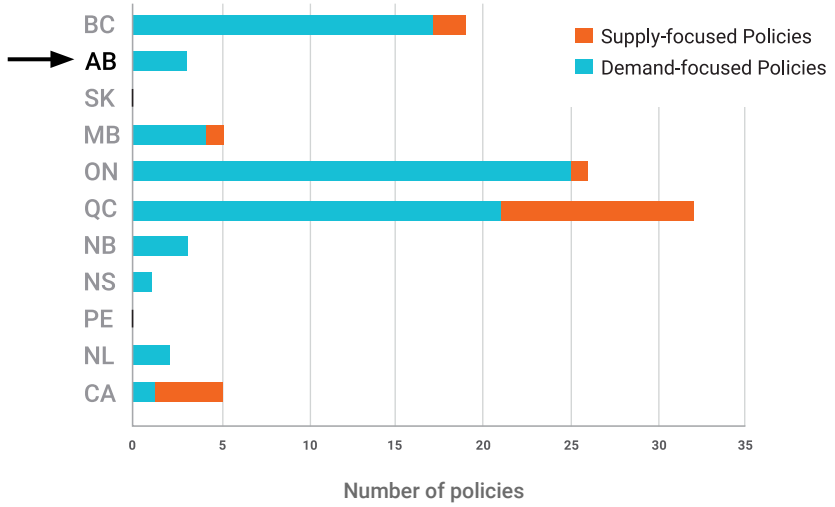
2040 market share with evaluated electric vehicle policies

(ranked based on current policy effectiveness)



Total number of electric vehicle policies

(includes expired, current, and proposed policies)



Saskatchewan

F

Saskatchewan receives an “F” with its current policies and a “D” with the proposed federal carbon pricing policy. With no policies implemented or proposed, long-term electric vehicle sales are anticipated to be minimal. Saskatchewan could earn an “A” with effective electric vehicle supportive policies.

Policy opportunity

Saskatchewan could achieve a “B” with a mix of implemented, proposed, and Norway-like policies, and a “B+” with a mix of implemented, proposed, and California-like policies. Saskatchewan could achieve an “A” with a mix of effective demand- and supply-focused policies. These could include a ZEV mandate (like those implemented in California and Quebec), strong and long-duration financial incentives (such as those in Norway and Ontario), and strong pricing on gasoline or carbon (like in Norway). Municipal governments can also play a role in improving the province’s policy grade by strengthening electric vehicle supportive building regulations.

Electric vehicle policy history

Saskatchewan has not implemented any electric vehicle policies.

Other electric vehicle supportive climate policies

Saskatchewan has no active climate policies that would encourage electric vehicle sales.

Electric vehicles and chargers

In 2015, 0.1% of new vehicle sales were electric vehicles and there were 29 public chargers per 1 million registered vehicles.[25]

Electric vehicle policy grade

Our evaluation of current policies assigns Saskatchewan a grade of “F.” Due to a lack of policy, its electric vehicle market share is not likely to be much higher than 2% by 2040.

Proposed policies

Aside from the proposed federal carbon pricing policy, which is expected to have a modest impact on its electric vehicle market share, Saskatchewan has no proposed electric vehicle supportive policies. The proposed federal carbon pricing policy would increase Saskatchewan’s grade to a “D”.

Saskatchewan's Electric Vehicle Policy Report Card

Overall Grade

F — 2% market share by 2040

Scenarios

Implemented + proposed policy

D — 7% market share by 2040

Implemented + proposed + "Norway-like" policy

B — 27% market share by 2040

Implemented + proposed + "California-like" policy

B+ — 32% market share by 2040

Evaluated Policies

Implemented

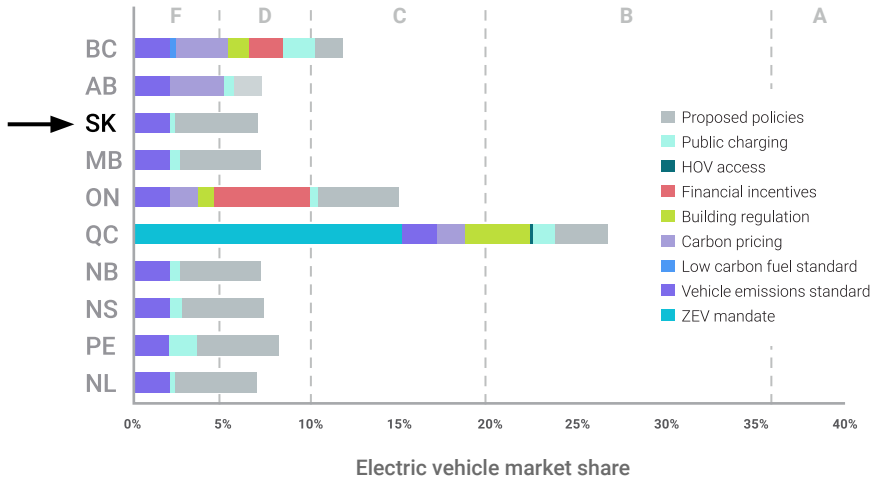
1. Federal vehicle emissions standard
2. Public charging infrastructure

Proposed

1. Federal carbon price ($10–$50/tonne, 2018–2022)

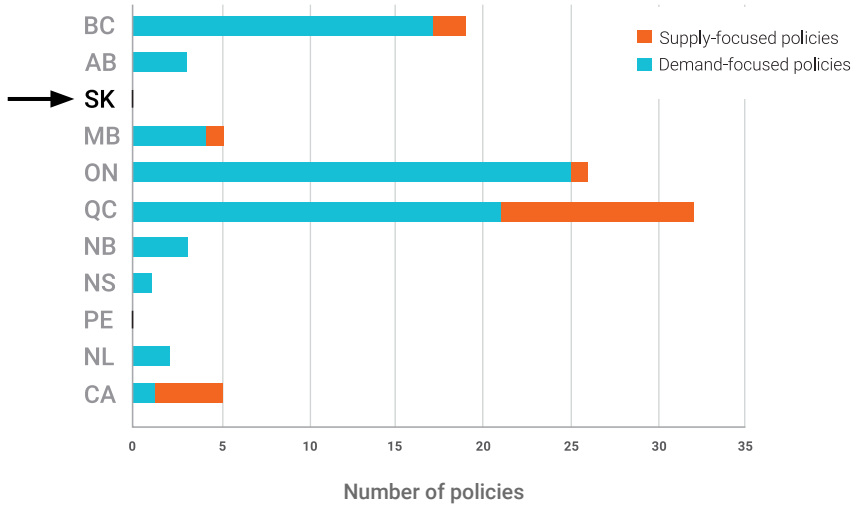
2040 market share with evaluated electric vehicle policies

(ranked based on current policy effectiveness)



Total number of electric vehicle policies

(includes expired, current, and proposed policies)



Manitoba

F

Manitoba receives an “F” with its current policies and a “D” with the proposed federal carbon pricing policy. Manitoba’s policies (5 implemented and 0 proposed) are anticipated to have a minimal effect on long-term electric vehicle sales. Manitoba could earn an “A” with additional and effective electric vehicle supportive policies.

Policy opportunity

Manitoba could achieve a “B+” with a mix of implemented, proposed, and Norway-like policies, and a “B” with a mix of implemented, proposed, and California-like policies. Manitoba could achieve an “A” with a mix of effective demand- and supply-focused policies. These could include a ZEV mandate (like those implemented in California and Quebec), strong and long-duration financial incentives (such as those in Norway and Ontario), and strong pricing on gasoline or carbon (like in Norway). Municipal governments can also play a role in improving the province’s policy grade by strengthening electric vehicle supportive building regulations.

Electric vehicle policy history

Electric vehicle policies in Manitoba focus on assessing and testing the suitability of electric vehicles in the region. In fact, in 2008 Manitoba became one of the first jurisdictions in North America to comprehensively test plug-in hybrid vehicles in cold weather. The Government of Manitoba has also collaborated with industry, government, academic, and utility partners to assess electric vehicle operation in Manitoba’s cold climate, and to launch a public education website in 2013 called Drive Electric Manitoba.

Other electric vehicle supportive climate policies

Manitoba has no active climate policies that would encourage electric vehicle sales.

Electric vehicles and chargers

In 2015, 0.2% of new vehicle sales were electric vehicles, and there were 49 public chargers per 1 million registered vehicles.[26]

Electric vehicle policy grade

Our evaluation of current policies assigns Manitoba a grade of “F.” Current policies are not likely to support an electric vehicle market share much higher than 3% by 2040.

Proposed policies

Manitoba has proposed a cap-and-trade program but has not specified the details of the program and we therefore do not evaluate its impact. Aside from the proposed federal carbon pricing policy, which is expected to have a modest impact on its electric vehicle market share, Manitoba has no proposed electric vehicle supportive policies. The proposed federal carbon pricing policy would increase Manitoba’s grade to a “D.”

Manitoba's Electric Vehicle Policy Report Card

Overall Grade

F — 3% market share by 2040

Scenarios

Implemented + proposed policy	Implemented + proposed + "Norway-like" policy	Implemented + proposed + "California-like" policy
D — 7% market share by 2040	**B+** — 32% market share by 2040	**B** — 27% market share by 2040

Evaluated Policies

Implemented

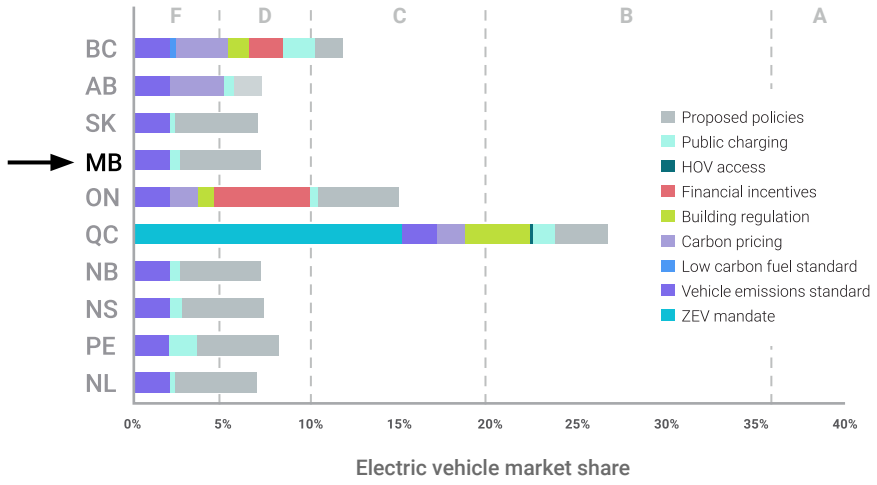
1. Federal vehicle emissions standard
2. Public charging infrastructure

Proposed

1. Federal carbon price ($10–$50/tonne, 2018–2022)

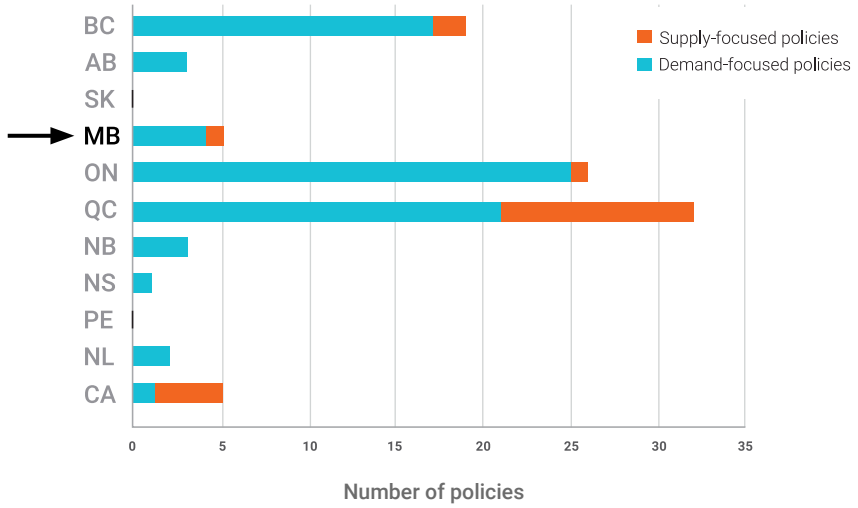
2040 market share with evaluated electric vehicle policies

(ranked based on current policy effectiveness)



Total number of electric vehicle policies

(includes expired, current, and proposed policies)



Ontario

C–

Ontario receives a "C–" with its current policies and a "C" with proposed policies. Despite the large number of policies (10 implemented and 16 proposed), the anticipated effect on long-term electric vehicle sales is modest. Ontario could earn an "A" with additional effective policies.

Policy opportunity

Ontario could achieve a "B" with a mix of implemented, proposed, and Norway-like policies, and a "B+" with a mix of implemented, proposed, and California-like policies. To achieve an "A," Ontario would need to implement the policies proposed in its Climate Change Action Plan along with a mix of additional effective demand- and supply-focused policies. These could include a ZEV mandate (like those implemented in California and Quebec) and stronger pricing on gasoline or carbon (like in Norway). Municipal governments can also play a role in improving the province's policy grade by strengthening electric vehicle supportive building regulations.

Electric vehicle policy history

In 2010, Ontario was the first province to offer incentives for electric vehicle purchases and to provide electric vehicle drivers with unrestricted access to high-occupancy vehicle (HOV) lanes. Since 2010, the Ontario Government and several municipalities have implemented a range of policies aimed at reducing electric vehicle costs, educating and engaging consumers, and electrifying public sector fleets. Between 2011 and 2015 the province also introduced six programs to support the installation of home and public charging infrastructure. More recently, the province increased its electric vehicle purchase incentive to provide between $3,000 to $14,000 per vehicle.

Other electric vehicle supportive climate policies

Ontario has established a cap-and-trade program to align with the Western Climate Initiative, which will put a price on carbon starting in 2017. In 2015, the price of carbon in the Western Climate Initiative was about $16/tonne.[27]

Electric vehicles and chargers

In 2015, 0.7% of new sales were electric vehicles, and there were 49 public chargers per 1 million registered vehicles.[27]

Electric vehicle policy grade

Our evaluation of current policies assigns Ontario a "C–" grade. The electric vehicle purchase incentive is likely to have the greatest impact on 2040 sales, but current policies are not likely to support an electric vehicle market share much higher than 9% by 2040.

Proposed policies

The Ontario Government's recent Climate Change Action Plan (June 2016) proposed several electric vehicle supportive policies, the most effective of which are: an electric vehicle-ready building requirement and free residential overnight charging. These policies, together with the federal government's proposed carbon pricing policy, would increase Ontario's grade to a "C."

Ontario's Electric Vehicle Policy Report Card

Overall Grade

C– 10% market share by 2040

Scenarios

Implemented + proposed policy	Implemented + proposed + "Norway-like" policy	Implemented + proposed + "California-like" policy
C 15% market share by 2040	**B** 29% market share by 2040	**B+** 34% market share by 2040

Evaluated Policies

Implemented

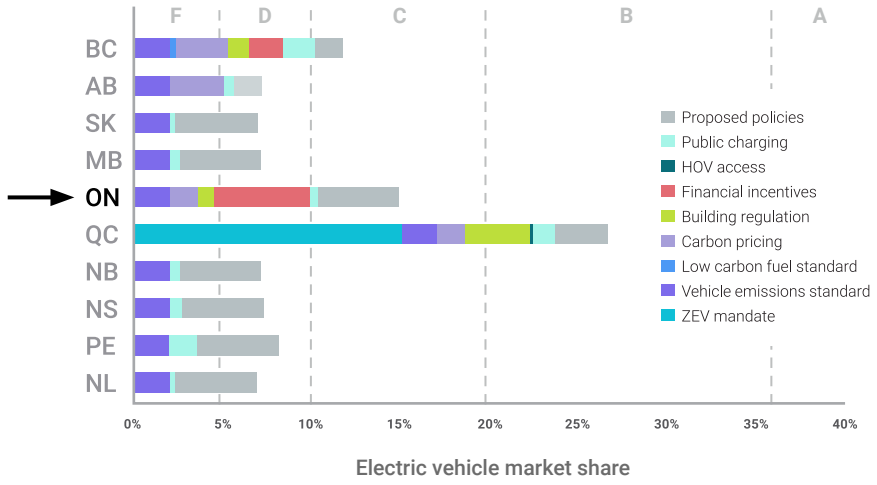
1. Federal vehicle emissions standard
2. Public charging infrastructure
3. City of Toronto electric vehicle ready building regulation
4. Electric vehicle purchase incentive ($3,000 to $14,000 until 2020)
5. HOV lane access
6. Cap-and-trade program

Proposed

1. Free overnight charging
2. Ontario-wide electric vehicle ready building regulation
3. Federal carbon price ($10-$50/tonne, 2018–2022)

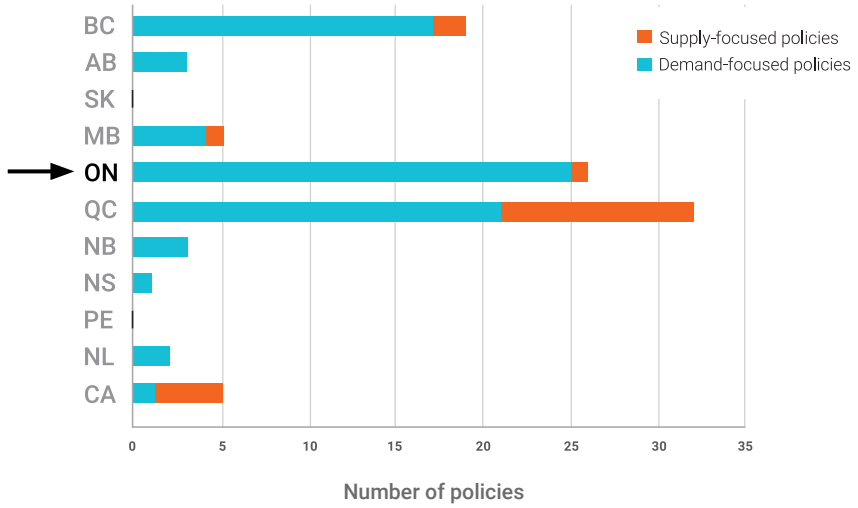
2040 market share with evaluated electric vehicle policies

(ranked based on current policy effectiveness)



Total number of electric vehicle policies

(includes expired, current, and proposed policies)



Quebec

B–

Quebec receives the highest grade in Canada with a "B–" for its current policies and a "B" with proposed policies. Of Quebec's current policies (32 in total), the recently passed ZEV mandate has the largest impact on long-term electric vehicle sales. Quebec could earn an "A" with additional effective policies.

Policy opportunity

Quebec could achieve a "A" with a mix of implemented, proposed, and Norway-like policies, and a "B+" with a mix of implemented, proposed, and California-like policies. To achieve an "A," Quebec would need to increase the stringency and duration of the proposed ZEV mandate to 30–40% of sales by 2040 or strengthen its demand-focused policies, such as stronger and longer-duration financial incentives (like those in Norway and Ontario), and stronger pricing on gasoline or carbon (like in Norway). Municipal governments can also play a role in improving the province's policy grade by strengthening electric vehicle supportive building regulations.

Electric vehicle policy history

In 2012, Quebec implemented electric vehicle incentives ranging from $500 to $8,000. Since then, the Government of Quebec and its municipal and utility partners have established several programs to improve availability and access to home, workplace, and public charging. Hydro Quebec has partnered with municipalities across Quebec to develop the largest charging network system in Canada, called Electric Circuit. Quebec also provides unrestricted high-occupancy vehicle (HOV) lane access to electric vehicle drivers and supports the electrification of public fleets. In 2015 Quebec released a Transportation Electrification Plan, which lays out a number of policies to stimulate electric vehicle sales, as well as technology innovation, market development, and education. Most recently (October 2016) the Quebec Government established a ZEV mandate, which is likely to require that 15.5% of all new passenger vehicles sold in the province be electric or hydrogen powered by 2025.

Other electric vehicle supportive climate policies

Quebec established a cap-and-trade program in 2013 and in doing so was the second province in Canada to put a price on carbon emissions. As of 2015, the price of carbon in Quebec was about $16/tonne.[28]

Electric vehicles and chargers

In 2015, 1.4% of new vehicle sales were electric vehicles, and there were 146 public chargers per 1 million registered vehicles.[29]

Electric vehicle policy grade

Our evaluation of current policies assigns Quebec a grade of "B–." The ZEV mandate is likely to have the greatest impact on 2040 sales and is anticipated to be the most effective policy in Canada. Combining this policy with Quebec's other high impact policies, notably the electric vehicle purchase incentive and cap-and-trade program, is likely to support an electric vehicle market of 24% by 2040.

Proposed policies

The federal government's proposed carbon pricing policy is anticipated to have a modest impact on its electric vehicle market share, increasing Quebec's grade to a "B".[30]

Quebec's Electric Vehicle Policy Report Card

Overall Grade

B– 24% market share by 2040

Scenarios

Implemented + proposed policy	Implemented + proposed + "Norway-like" policy	Implemented + proposed + "California-like" policy
B 27% market share by 2040	**A** 42% market share by 2040	**B+** 32% market share by 2040

Evaluated Policies

Implemented

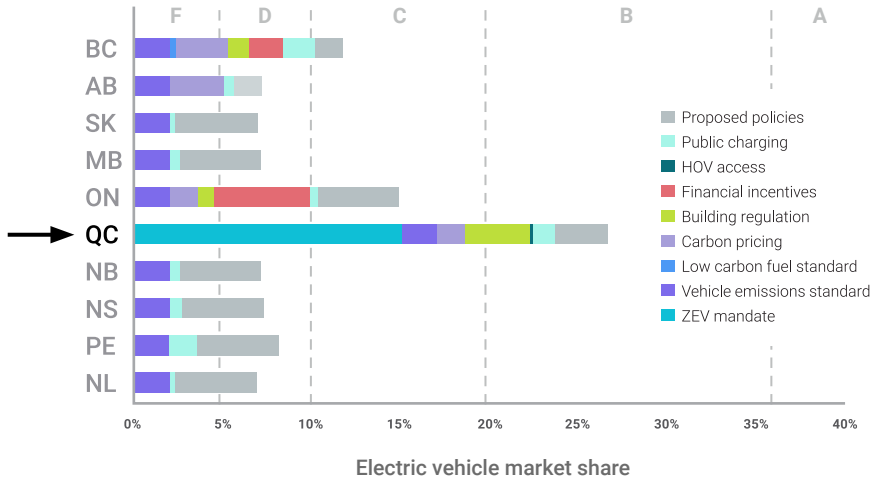
1. Federal vehicle emissions standard
2. Public charging infrastructure
3. Cap-and-trade program
4. Electric vehicle purchase incentive ($500 to $8,000 until 2020)
5. HOV lane access
6. ZEV mandate (15.5% of sales by 2025)

Proposed

1. Federal carbon price ($10–$50/tonne, 2018–2022)

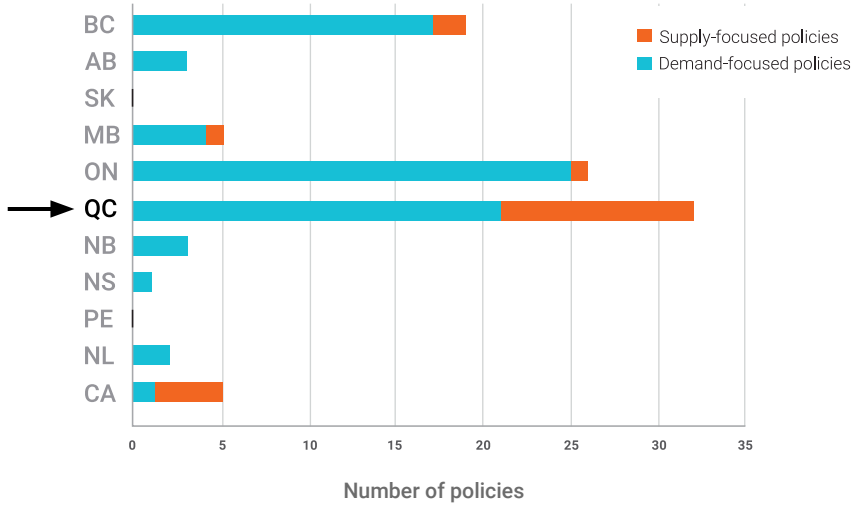
2040 market share with evaluated electric vehicle policies

(ranked based on current policy effectiveness)



Total number of electric vehicle policies

(includes expired, current, and proposed policies)



New Brunswick

F

New Brunswick receives an "F" with its current policies and a "D" with the proposed federal carbon pricing policy. New Brunswick's policies (3 implemented and 0 proposed), are anticipated to have a minimal effect on long-term electric vehicle sales. New Brunswick could earn an "A" with additional and effective electric vehicle supportive policies.

Policy opportunity

New Brunswick could achieve a "B" with a mix of implemented, proposed, and Norway-like policies, and a "B+" with a mix of implemented, proposed, and California-like policies. New Brunswick could achieve an "A" with a mix of effective demand- and supply-focused policies. These could include a ZEV mandate (like those implemented in California and Quebec), strong and long-duration financial incentives (such as those in Norway and Ontario), and strong pricing on gasoline or carbon (like in Norway). Municipal governments can also play a role in improving the province's policy grade by strengthening electric vehicle supportive building regulations.

Electric vehicle policy history

Electric vehicle policy in New Brunswick primarily focuses on outreach and education through the Shift Your Ride and Drive Electric New Brunswick initiatives, which provide public and municipal education about electric vehicles and their feasibility. As part of the Shift Your Ride initiative, NB Power offers assessments of electric vehicle suitability in public and private sector fleets. In addition, NB Power is offering free charging at its charging stations across the province.

Other electric vehicle supportive climate policies

New Brunswick has no active climate policies that would encourage electric vehicle sales.

Electric vehicles and chargers

In 2015, 0.1% of new vehicle sales were electric vehicles, and there were 71 public chargers per 1 million registered vehicles.[31]

Electric vehicle policy grade

Our evaluation of current policies assigns New Brunswick a grade of "F." Current policies are not likely to support an electric vehicle market share much higher than 3% by 2040.

Proposed policies

Aside from the proposed federal carbon pricing policy, which is expected to have a modest impact on its electric vehicle market share, New Brunswick has no proposed electric vehicle supportive policies. The proposed federal carbon pricing policy would increase New Brunswick's grade to a "D."

New Brunswick's Electric Vehicle Policy Report Card

Overall Grade

F — 3% market share by 2040

Scenarios

Implemented + proposed policy	Implemented + proposed + "Norway-like" policy	Implemented + proposed + "California-like" policy
D — 7% market share by 2040	**B** — 27% market share by 2040	**B+** — 32% market share by 2040

Evaluated Policies

Implemented

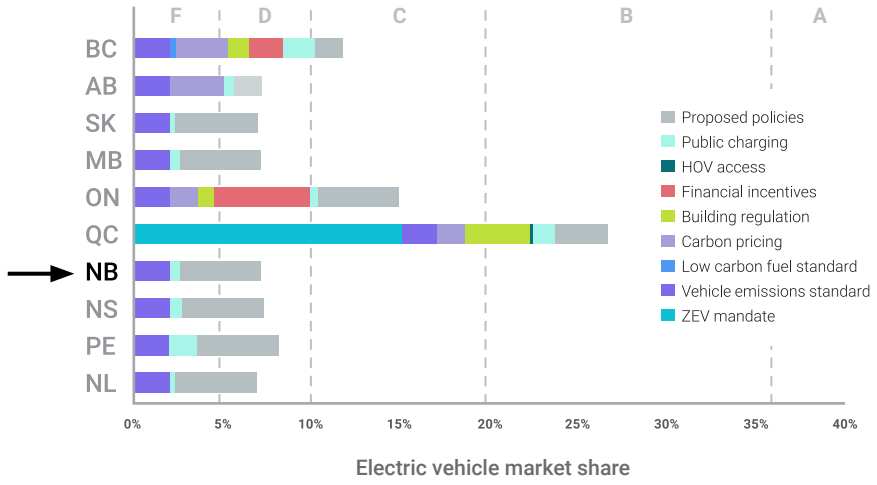
1. Federal vehicle emissions standard
2. Public charging infrastructure

Proposed

1. Federal carbon price ($10–$50/tonne, 2018–2022)

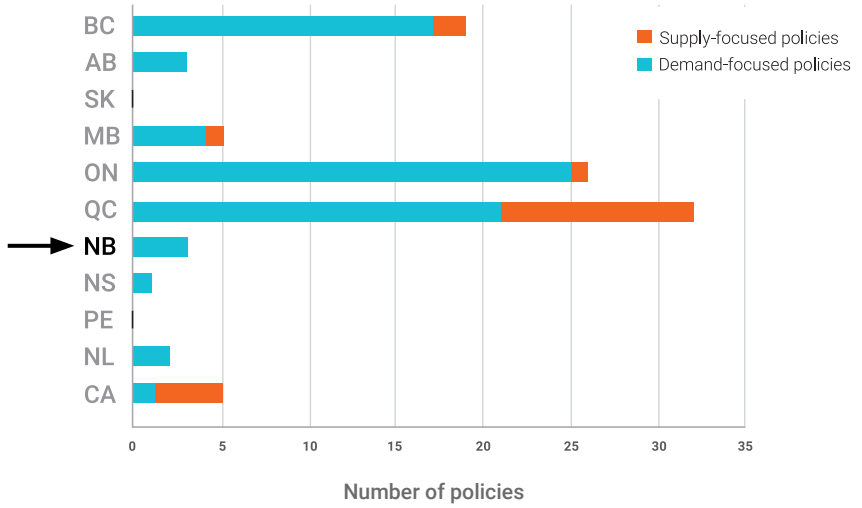
2040 market share with evaluated electric vehicle policies

(ranked based on current policy effectiveness)



Total number of electric vehicle policies

(includes expired, current, and proposed policies)



Nova Scotia

F

Nova Scotia receives an "F" with its current policies and a "D" with the proposed federal carbon pricing policy. Nova Scotia's policies (1 implemented and 0 proposed) are anticipated to have a minimal effect on long-term electric vehicle sales. Nova Scotia could earn an "A" with additional and effective electric vehicle supportive policies.

Policy opportunity

Nova Scotia could achieve a "B" with a mix of implemented, proposed, and Norway-like policies, and a "B+" with a mix of implemented, proposed, and California-like policies. Nova Scotia could achieve an "A" with a mix of effective demand- and supply-focused policies. These could include a ZEV mandate (like those implemented in California and Quebec), strong and long-duration financial incentives (such as those in Norway and Ontario), and strong pricing on gasoline or carbon (like in Norway). Municipal governments can also play a role in improving the province's policy grade by strengthening electric vehicle supportive building regulations.

Electric vehicle policy history

In 2011 NS Power initiated the ShareReady program to educate municipalities and businesses about electric vehicles by sharing 10 Nissan Leafs with 9 local organizations for 3 years.

Other electric vehicle supportive climate policies

Nova Scotia has no active climate policies that would encourage electric vehicle sales.

Electric vehicles and chargers

In 2015, 0.1% of new vehicle sales were electric vehicles, and there were 51 public chargers per 1 million registered vehicles.[32]

Electric vehicle policy grade

Our evaluation of current policies assigns Nova Scotia a grade of "F." Current policies are not likely to support an electric vehicle market share much higher than 3% by 2040.

Proposed policies

Aside from the proposed federal carbon pricing policy, which is expected to have a modest impact on its electric vehicle market share, Nova Scotia has no proposed electric vehicle supportive policies. The proposed Federal carbon pricing policy would increase Nova Scotia's grade to a "D."

Nova Scotia's Electric Vehicle Policy Report Card

Overall Grade

F — 3% market share by 2040

Scenarios

Implemented + proposed policy	Implemented + proposed + "Norway-like" policy	Implemented + proposed + "California-like" policy
D — 7% market share by 2040	**B** — 27% market share by 2040	**B+** — 32% market share by 2040

Evaluated Policies

Implemented

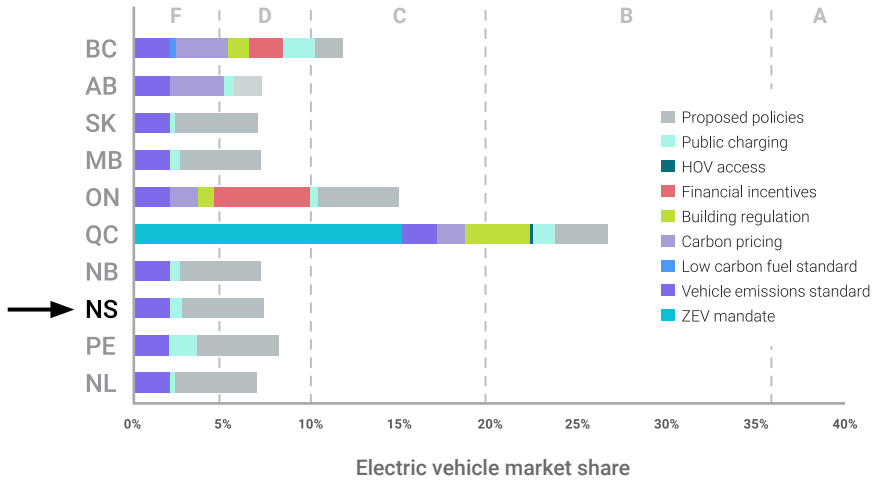
1. Federal vehicle emissions standard
2. Public charging infrastructure

Proposed

1. Federal carbon price ($10–$50/tonne, 2018–2022)

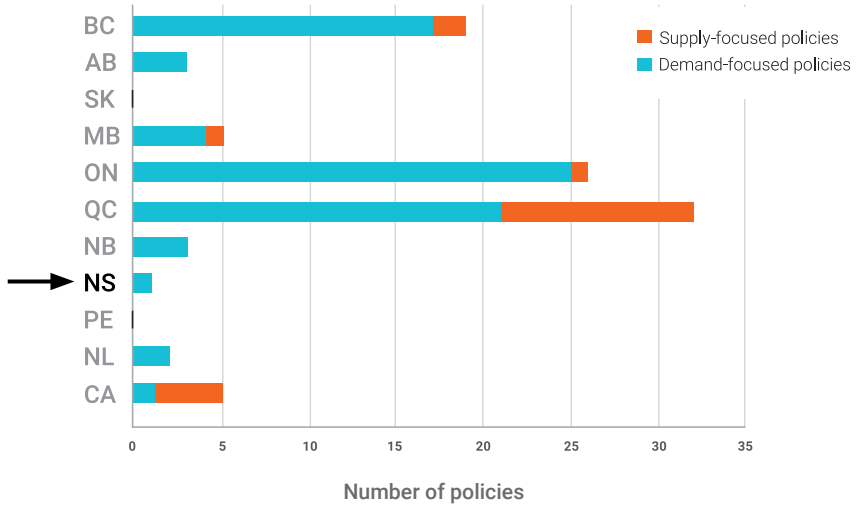
2040 market share with evaluated electric vehicle policies

(ranked based on current policy effectiveness)



Total number of electric vehicle policies

(includes expired, current, and proposed policies)



Prince Edward Island

F

Prince Edward Island receives an “F” with its current policies and a “D” with the proposed federal carbon pricing policy. With no policies implemented or proposed, long-term electric vehicle sales are anticipated to be minimal. Prince Edward Island could earn an “A” with effective electric vehicle supportive policies.

Policy opportunity

Prince Edward Island could achieve a “B” with a mix of implemented, proposed, and Norway-like policies, and a “B+” with a mix of implemented, proposed, and California-like policies. Prince Edward Island could achieve an “A” with a mix of effective demand- and supply-focused policies. These could include a ZEV mandate (like those implemented in California and Quebec), strong and long-duration financial incentives (such as those in Norway and Ontario), and strong pricing on gasoline or carbon (like in Norway). Municipal governments can also play a role in improving the province’s policy grade by strengthening electric vehicle supportive building regulations.

Electric vehicle policy history

Prince Edward Island has no electric vehicle policies, but has the highest number of electric vehicle chargers per registered vehicle in Canada due to investment in electric vehicle charging stations.

Other electric vehicle supportive climate policies

Prince Edward Island has no active climate policies that would encourage electric vehicle sales.

Electric vehicles and chargers

In 2015, 0.03% of new vehicle sales were electric vehicles, and there were 260 public chargers per 1 million registered vehicles.[33]

Electric vehicle policy grade

Our evaluation of current policies assigns Prince Edward Island a grade of “F.” Due to a lack of electric vehicle policy, its electric vehicle market share is not likely to be much higher than 4% by 2040.

Proposed policies

Aside from the proposed federal carbon pricing policy, which is expected to have a modest impact on electric vehicle market share, Prince Edward Island has no proposed electric vehicle supportive policies. The proposed federal carbon pricing policy would increase Prince Edward Island’s grade to a “D.”

Prince Edward Island's Electric Vehicle Policy Report Card

Overall Grade

F — 4% market share by 2040

Scenarios

Implemented + proposed policy	Implemented + proposed + "Norway-like" policy	Implemented + proposed + "California-like" policy
D — 8% market share by 2040	**B** — 27% market share by 2040	**B+** — 32% market share by 2040

Evaluated Policies

Implemented

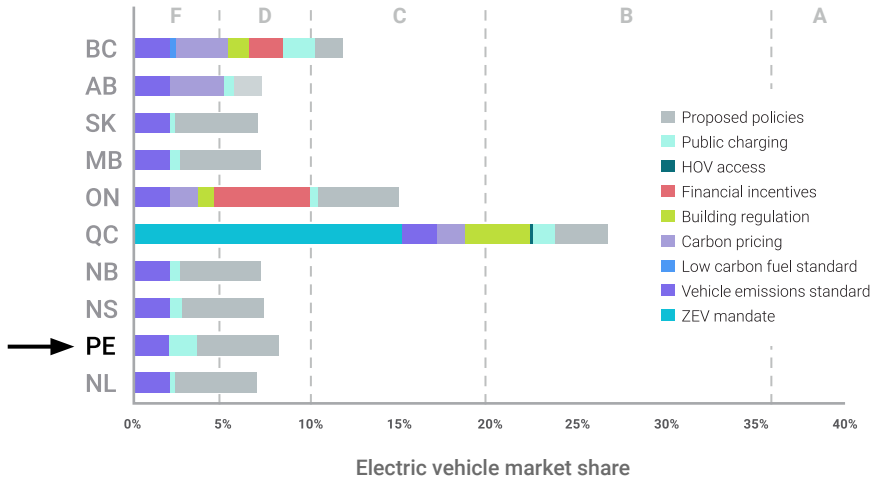
1. Federal vehicle emissions standard
2. Public charging infrastructure

Proposed

1. Federal carbon price ($10–$50/tonne, 2018–2022)

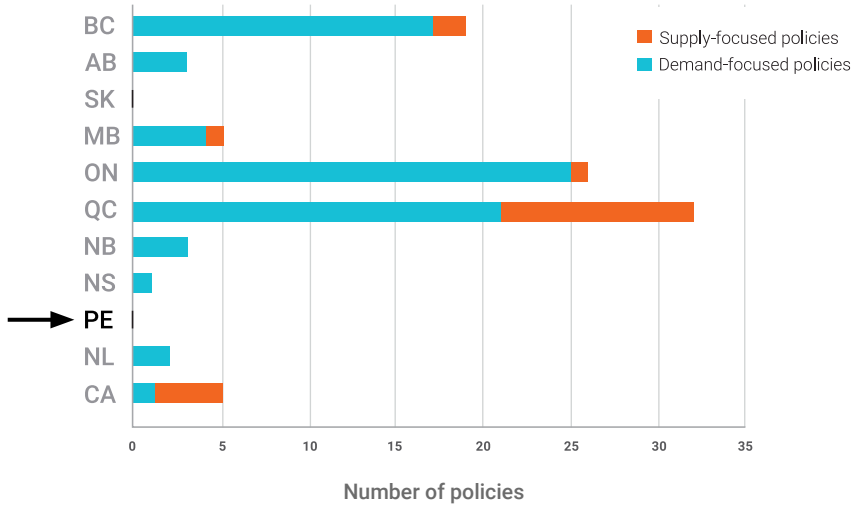
2040 market share with evaluated electric vehicle policies

(ranked based on current policy effectiveness)



Total number of electric vehicle policies

(includes expired, current, and proposed policies)



Newfoundland and Labrador

F

Newfoundland and Labrador receive an “F” with its current policies and a “D” with the proposed federal carbon pricing policy. Newfoundland and Labrador’s policies (2 implemented and 0 proposed) are anticipated to have a minimal effect on long-term electric vehicle sales. Newfoundland and Labrador could earn an “A” with additional and effective electric vehicle supportive policies.

Policy opportunity

Newfoundland and Labrador could achieve a “B” with a mix of implemented, proposed, and Norway-like policies, and a “B+” with a mix of implemented, proposed, and California-like policies. Newfoundland and Labrador could achieve an “A” with a mix of effective demand- and supply-focused policies. These could include a ZEV mandate (like those implemented in California and Quebec), strong and long-duration financial incentives (such as those in Norway and Ontario), and strong pricing on gasoline or carbon (like in Norway). Municipal governments can also play a role in improving the province’s policy grade by strengthening electric vehicle supportive building regulations.

Electric vehicle policy history

In 2015, the Newfoundland and Labrador Government allocated $52,000 to support the supply and installation of residential and commercial electric vehicle charging stations.

Other electric vehicle supportive climate policies

The Newfoundland and Labrador Government has a target for a minimum of 35% of its passenger vehicle fleet to be fuel-efficient.

Electric vehicles and chargers

In 2015, 0.03% of new vehicle sales were electric vehicles, and there were 28 public chargers per 1 million registered vehicles.[34]

Electric vehicle policy grade

Our evaluation of current policies assigns Newfoundland and Labrador a grade of “F.” Due to a lack of electric vehicle policy, its electric vehicle market share is not like to be much higher than 2% by 2040.

Proposed policies

Aside from the proposed federal carbon pricing policy, which is expected to have a modest impact on its electric vehicle market share, Newfoundland and Labrador has no proposed electric vehicle supportive policies. The proposed federal carbon pricing policy would increase Newfoundland and Labrador’s grade to a “D.”

Newfoundland and Labrador's Electric Vehicle Policy Report Card

Overall Grade

F — 2% market share by 2040

Scenarios

Implemented + proposed policy

D — 7% market share by 2040

Implemented + proposed + "Norway-like" policy

B — 27% market share by 2040

Implemented + proposed + "California-like" policy

B+ — 32% market share by 2040

Evaluated Policies

Implemented

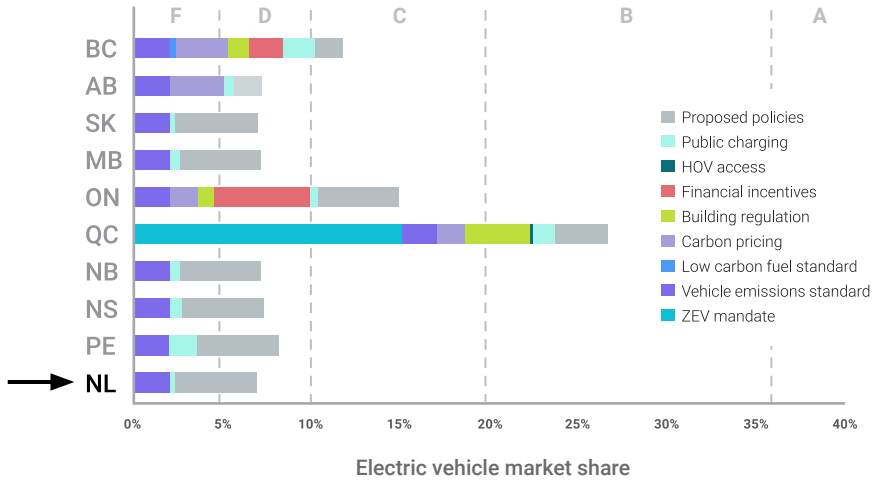
1. Federal vehicle emissions standard
2. Public charging infrastructure

Proposed

1. Federal carbon price ($10–$50/tonne, 2018–2022)

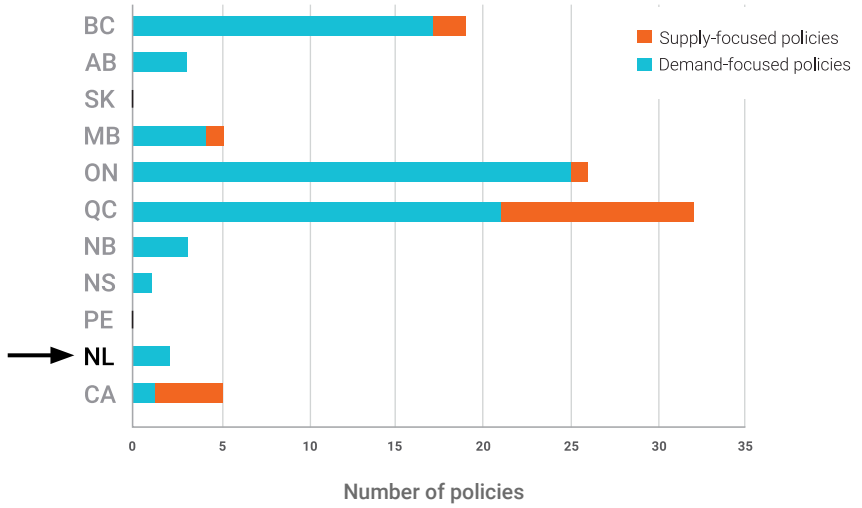
2040 market share with evaluated electric vehicle policies

(ranked based on current policy effectiveness)



Total number of electric vehicle policies

(includes expired, current, and proposed policies)



Notes

[1] In this report we focus on passenger vehicles, which for our purposes includes cars and light-duty trucks (not motorcycles, off-road vehicles or medium- or heavy-duty trucks).

[2] The range of values reflects differences in vehicle type (PHEV or BEV) and regional electric grids (higher or lower carbon electric grids).

[3] In line with several national and provincial targets, e.g. close to 80% reduction by 2050.

[4] In line with recommendations from the International Energy Agency, which suggest that to stabilize GHGs at 450ppm, 40% of vehicles will need to be electric by 2040.

[5] The method and evaluation framework used in this study were recently submitted to The U.S. National Academies Transportation Research Board (TRB) for peer-review. Reviewers have recommended the study for presentation at the 2017 TRB annual meeting in Washington DC.

[6] In this report we focus on passenger vehicles, which for our purposes includes cars and light-duty trucks (not motorcycles, off-road vehicles, or medium- or heavy-duty trucks).

[7] In line with several national and provincial targets, e.g. close to 80% reduction by 2050.

[8] Whereas electricity prices would not change in regions with low-carbon electricity sources.

[9] Our framework has recently undergone peer-review. The method and evaluation framework used in this study were recently submitted to the U.S. National Academies Transportation Research Board (TRB) for peer-review. Reviewers have recommended the study for presentation at the 2017 TRB annual meeting in Washington DC.

[10] If any substantial electric vehicle supportive policies were overlooked, please contact the authors of this report to assure that such policies are included in future versions of *Canada's Electric Vehicle Policy Report Card*.

[11] We do not evaluate information campaigns, government fleet procurement, local electric vehicle industry development programs, or R&D support because their impact on future electric vehicle adoption, by province, is particularly uncertain or small. For example, R&D support may contribute to electric vehicle technology development at a national or international level, but its direct impact on sales in one province is likely very small.

[12] In addition to stringency and duration, we also consider policy coverage. If a specific policy only applies to a subset of the region's population (e.g. to just one city in a province), we linearly scale the policy impacts.

[13] We assume that policy impact is proportional to stringency and duration.

[14] This goal is based on recommendations from national and international climate policy experts (e.g. International Energy Agency) on greenhouse gas reduction and electric vehicle adoption.

[15] Policy interactions might be particularly important between demand- and supply-focused policies. For example, an electric vehicle purchase incentive might help a region achieve the requirements of a ZEV mandate, and therefore its impact might not be completely additive to the ZEV mandate.

[16] Letter grades are largely based on the schemes used in most North American schools.

[17] Market research shows that potential electric vehicle demand is very similar across Canadian provinces, although preferences for types of electric vehicles do vary to some degree [1].

[18] See *Electric Vehicle Policies*, page 9, for a more detailed explanation and examples of demand-focused and supply-focused electric vehicle supportive policies.

[19] The potential impacts on electric vehicle market share from R&D support and market development policies are not estimated as part of this evaluation because their impacts are uncertain and likely small on a provincial level.

[20] Government communication suggests that the mandate target will be a ZEV market share of around 15.5% by 2025. We assume this strength of policy in our evaluation.

[21] Ontario's vehicle purchase incentive is up to $14,000 per vehicle.

[22] Although the Government of British Columbia noted several electric vehicle supportive policies in its recent climate action plan, these policies were not included in the evaluation as there was insufficient policy detail at the time of writing. Future versions of *Canada's Electric Vehicle Policy Report Card* will include these policies when details become available.

[23] Charger data includes the number of Level 2 and DC charging locations per 1 million registered vehicles, as of January 2016, as published by [25]; Sales data are from [26; 27].

[24] Charger data includes the number of Level 2 and DC charging locations per 1 million registered vehicles, as of January 2016, as published by [25]; Sales data are from [26; 27].

[25] Charger data includes the number of Level 2 and DC charging locations per 1 million registered vehicles, as of January 2016, as published by [25]; Sales data are from [26; 27].

[26] Charger data includes the number of Level 2 and DC charging locations per 1 million registered vehicles, as of January 2016, as published by [25]; Sales data are from [26; 27].

[27] Charger data includes the number of Level 2 and DC charging locations per 1 million registered vehicles, as of January 2016, as published by [25]; Sales data are from [26; 27].

[28] Based on the price floor for the WCI.

[29] Charger data includes the number of Level 2 and DC charging locations per 1 million registered vehicles, as of January 2016, as published by [25]; Sales data are from [26; 27].

[30] There are 7 additional proposed policies in Quebec (R&D and urban planning related policies). These policies were not included in the evaluation as their impact is uncertain or likely to be small.

[31] Charger data includes the number of Level 2 and DC charging locations per 1 million registered vehicles, as of January 2016, as published by [25]; Sales data are from [26; 27].

[32] Charger data includes the number of Level 2 and DC charging locations per 1 million registered vehicles, as of January 2016, as published by [25]; Sales data are from [26; 27].

[33] Charger data includes the number of Level 2 and DC charging locations per 1 million registered vehicles, as of January 2016, as published by [25]; Sales data are from [26; 27].

[34] Charger data includes the number of Level 2 and DC charging locations per 1 million registered vehicles, as of January 2016, as published by [25]; Sales data are from [26; 27].

References

1 Axsen, J., et al., *Electrifying Vehicles: Insights from the Canadian Plug-in Electric Vehicle Study*. 2015, Simon Fraser University: Vancouver, BC, Canada.

2 Ferguson, M., et al., *The Choice Between Plug-ins, Hybrids and the Status Quo: Evidence from A Canadian Stated Preference Analysis, in World Conference on Transport Research*. 2016, Elsevier: Shanghai.

3 *Electric Mobility Adoption and Prediction: Developing a strategic approach to enabling electric vehicle technology in the Cities of Calgary and Edmonton.* 2015, Pollution Probe.

4 IEA, *Energy and Climate Change: World Energy Outlook Special Report*. 2015, OECD/IEA: Paris.

5 *National Inventory Report*. 2016, Government of Canada.

6 Sykes, M., *Does a region need its own zero emission vehicle mandate, or can it free-ride off another? Modelling British Columbia and California*, in *Resource Environmental Management* 2016, Simon Fraser University: Burnaby, BC.

7 Bahn, O., et al., *Electrification of the Canadian road transportation sector: A 2050 outlook with TIMES-Canada*. Energy Policy, 2013. **62**: p. 593-606.

8 EAFO. *Country Summary*. 2016 [cited 2016 April 27]; Available from: http://www.eafo.eu/content/countries

9 Figenbaum, E., T. Assum, and M. Kolbenstved, *Electromobility in Norway - Experiences and opportunities*. Research in Transportation Economics, 2015. **50**: p. 29-38.

10 Mersky, A.C., et al., *Effectiveness of incentives on electric vehicle adoption in Norway*. Transportation Research Part D: Transport and Environment, 2016. **46**: p. 56-68.

11 *Electric vehicle registrations by core based statistical area*. 2015, IHS Automotive.

12 Klippenstein, M., *Canadian plug-in electric vehicle sales*. 2016: GreenCar Reports.

13 CANSIMS, *Table 079-0003 - New motor vehicle sales, Canada, provinces and territories, annual, S.* Canada, Editor. 2015.

14 Trochaniak, S., *Electric Vehicle Sales in Canada: March 2016 Update, in FleetCarma Blog*. 2016, FleetCarma.

15 Bailey, J., A. Miele, and J. Axsen, I*s awareness of public charging associated with consumer interest in plug-in electric vehicles?* Transportation Research Part D: Transport and Environment, 2015. **36**: p. 1-9.

16 Bauman, J., S. Hacikyan, and M. Stevens, *Ease of Purchasing EVs in Canada. 2015*, FleetCarma (prepared for Environment Canada). Available from: http://www.fleetcarma.com/ease-purchasing-ev-canada

17 Matthews, L., et al., *Do we have a car for you? Encouraging the uptake of electric vehicles at point of sale*. Energy Policy, 2017. **100**: p. 79-88.

18 Axsen, J. and M. Wolinetz, *How policy can build the plug-in electric vehicle market: Insights from the respondent-based preference and constraints (REPAC) model*. 2016, Simon Fraser University: Burnaby.

19 Lin, Z. and D. Greene, *Promoting the market for plug-in hybrid and battery electric vehicles: The role of recharge availability.* Transportation Research Record: Journal of the Transportation Research Board, 2011. **2252**: p. 49-56.

20 Sullivan, J., I. Salmeen, and C. Simon, *PHEV Marketplace Penetration: An Agent Based Simulation*. 2009, University of Michigan, Transportation Research Institute.

21 Tran, M., et al., *Simulating early adoption of alternative fuel vehicles for sustainability.* Technological Forecasting and Social Change, 2013. **80**(5): p. 865-875.

22 *Minister David Heurtel tables a bill to facilitate access by Quebecers to zero-emission vehicles.* 2016, Government of Quebec: Quebec.

23 Tietge, U., et al., *Comparison of leading electric vehicle policy and deployment in Europe.* 2016, ICCT.

24 Jin, L., S. Searle, and N. Lutsey, *Evaluation of State-Level U.S. Electric Vehicle Incentives* 2014.

25 ChargeHub. Public EV Charging Station Locations in Canada – Part 2 of 3. 2016.

26 Klippenstein, M. Canadian plug-in electric vehicle sales. GreenCar Reports, 2016.

27 Statistics Canada. Table 079-0003 — New motor vehicle sales, Canada, provinces and territories, annual. 2015.

Appendix A: Detailed Literature Review

Detailed Literature Review

As interest in electric vehicles has increased in recent years [1], so too has the number of studies assessing and comparing electric vehicle policy. We identify two broad types of electric vehicle policy studies:

i) those that compare electric vehicle initiatives among jurisdictions in present day (Table A1), or what can be called "short-term" evaluations, and
ii) those that use modeling to forecast the effects of electric vehicle policies in the "medium-term" (5-15 years) and "long term" (beyond 15 years).

Most short-term studies (Table A1) start by summarizing and contrasting policy approaches among regions, but their overall aims differ. Studies have focused on electric vehicle adoption as the ultimate goal, rating jurisdictions by electric vehicle "readiness" [2, 3], and looking for associations between policy and current or recent electric vehicle sales in different jurisdictions [4–6]. Wesseling [7] followed a different angle, exploring the conditions that influence regional policy priorities and expenditures in Europe, which may hold more importance for assessing political acceptability rather than policy effectiveness.

These short-term studies tend to concentrate on demand-focused policies [8], including financial incentives, non-financial incentives, building codes, and direct government investment in refuelling infrastructure and informational campaigns. By contrast, supply-focused policies have received much less attention in electric vehicle policy studies. Examples of supply-focused policies include support for research and development, an explicit requirement for auto manufacturers to supply zero emission vehicles (e.g. ZEV mandate), fuel economy (litre/100 km) or CO_2 standards (g CO_2e/km) and low carbon fuel requirements (g Co_2e/litre). Of the seven electric vehicle policy studies identified in Table A1, three did not mention any supply-focused policies, two mentioned research and development subsidies, and two mentioned ZEV mandates. As noted above, supply-focused policies may be omitted in such studies because it is difficult to quantify their effectiveness.

A common theme of these studies is to develop metrics with which to compare groups of policies among regions. For example, monetizing non-financial incentives [4, 9], developing indices based on multiple criteria, [2] and determining government monetary expenditures on different types of initiatives [7]. Several studies make use of statistical analysis, for example, to test the relationship between the presence of incentives, charger deployment and electric vehicle market share in a given region, [4, 9] and to explore the relationship between various conditions and national initiative priorities [7]. While appealing, such statistical analyses are generally problematic given limitations in data points, omissions of long-term effects (e.g. where only a single year of sales data is used), multicollinearity among explanatory variables, and the potential for important explanatory variables to be omitted (e.g. automaker decisions to target marketing efforts at particular regions).

Table A1: Illustrative summary of short-term studies comparing electric vehicle initiatives among jurisdictions

Study citation	Study objective	Stated or implied goal of electric mobility	Regional unit of analysis	Demand-focused policies assessed?	Supply-focused policies assessed?	Non electric vehicle-specific initiatives considered?	Type of evaluation
Clark-Sutton et al (2016)	Rate cities in terms of electric vehicle "readiness"	Climate mitigation, energy security	U.S. cities [36]	Yes	None	Fuel cost environment	Historical comparison
Jin, Searle & Lutsey (2014)	Compare incentives and electric vehicle adoption across states	Climate mitigation, energy security	U.S. states [10]	Yes	None	No	Historical comparison and statistical analysis
Lutsey et al (2015)	Identify factors that increase electric vehicle adoption	Climate mitigation, local air pollution, energy security	U.S. cities [25]	Yes	ZEV mandate, low carbon fuel standard	Low carbon fuel standard	Historical comparison and statistical analysis
Mock & Yang (2014)	Analyze impact of financial incentives on electric vehicle adoption	Climate mitigation	Countries [11]	Yes (financial incentives only)	None	No	Historical comparison
RBSC (2010)	Rate cities in terms of electric vehicle "readiness"	Not clear	U.S. cities [50]	Yes	ZEV mandate	No	Historical comparison
Tietge et al (2016)	Identify policies to accelerate electric vehicle adoption	Climate mitigation, local air pollution, energy security	European countries [5] plus sub-national regions and cities	Yes	CO_2 standards, R&D incentives	CO_2 standards	Historical comparison
Wesseling (2016)	Explore conditions that influence policy expenditures	Sustainability transition	Countries [13]	Yes	R&D incentives	No	Historical comparison and statistical analysis
Present study	Evaluate progress toward decarbonizing light duty vehicles	Decarbonization of transport implied by climate mitigation targets	Canadian provinces [10]	Yes	ZEV mandate, CO_2 standards, low carbon fuel standard	Carbon pricing, CO_2 standards, low carbon fuel standard	Comparison of projected policy impacts

In contrast, the second category of policy study takes a longer-term approach to evaluating potential policy impacts, which typically requires some sort of modeling. Al-Alawi and Bradley [10] provide a summary of studies that explore the effects of electric vehicle policy on market share out to 2020 and as far as 2030, using constraints models (e.g.[11]), choice models (e.g.[12]) and agent-based models (e.g.[13]). To date, these studies also concentrate on demand-focused policies. Al-Alawi and Bradley [10] note that the lack of exploration of electric vehicle supply is an important limitation and that studies should account for the number and variety of electric vehicles available, given that size, comfort, style and brand can influence consumer interest [14]. Axsen et al. [15] provide one of the only "medium term" electric vehicle models that explicitly represents the supply side (simulating the effects of electric vehicle model variety and availability on market share to 2030).

Electric vehicle market share forecasts vary widely by model. Most models are generally highly sensitive to demand-focused policies, notably purchase subsidies and increased charger availability. As examples, electric vehicle subsidies in the range of US$5,000 are found to double or triple electric vehicle demand forecasts [11, 13, 16], or in one case to increase sales from 1% to 5% in 2020 and to 24% in 2040 [17]. In contrast, Eppstein et al. [18] estimated that a similar incentive has little impact if it is maintained for less than five years. A second common finding is a sensitivity of market share to charger access, where aggressive deployment of public and home charging infrastructure was found to double or even triple the rate of electric vehicle adoption in the U.S. from 2020 through to 2025 [19]. As noted by Al-Alawi and Bradley [10], these models tend to emphasize the effects of demand-focused policies. The supply side is not explicitly modeled, and in some cases electric vehicle supply is assumed to be complete (i.e., as if electric vehicles of all types were fully available in all makes and models).

One study by Axsen et al. [15] explores the effects of increasing electric vehicle supply on sales using the REspondent-Based Preference And Constraint (REPAC) Model. REPAC integrates a latent-class choice model estimated from a large survey of Canadian households, with a constraints model that represents limitations experienced by each respondent, including electric vehicle awareness, home recharge access and the variety and availability of electric vehicle models in that respondents' region. The authors find that even with strong demand-focused policy, electric vehicle new market share is not likely to exceed 12% by 2030 if there is not an increase in the availability and variety of electric vehicle models. With an increase in supply (moving from 20 models to over 50), 2030 sales could reach 30% new market share or more.

Canada's Electric Vehicle Policy Report Card aims to fill several gaps in the literature. First, we combine elements of both short- and long-term studies reviewed above and combine evidence from both sets of literature. We look at the policy context of specific jurisdictions in the present day, but consider the policy effects in the medium- and long-term in the context of deep greenhouse gas mitigation targets. Second, we develop an evaluation framework that provides explicit treatment of both demand-focused and supply-focused policies. While there is less literature to draw from to evaluate the effects of supply-focused policy, we feel it is important to include what could be a powerful policy lever. Lastly, our study compares electric vehicle initiatives across Canada — a country that has been the subject of relatively few studies. Distinguishing among regions in Canada is particularly important due to the substantial legislative authority granted to provinces and the heterogeneity of electric vehicle support among the provinces.

Appendix B: Methods

Methods

This appendix provides a more detailed summary of our electric vehicle policy evaluation framework, including our assumptions and methods, and the specific literature used to inform this framework.

Policy evaluation: New market share "points" and the "Electric Vehicle Policy Report Card"

As noted in this report, we evaluate electric vehicle-related policies in each province according to their ability to drive electric vehicle adoption, with the presumed goal of 40% new vehicle sales in 2040 based on the IEA [20]. Our framework considers eight categories of electric vehicle policies (Table B1), including demand-focused policies (financial and non-financial incentives, public (non-home) charging infrastructure deployment, electric vehicle-ready building codes, and policies that increase the cost of fossil fuels relative to electricity), and supply-focused policies relating to auto manufacturers and fuel providers (ZEV mandate, fuel economy standards and a low-carbon fuel standard). We do not evaluate other policies identified in the scan because the market share impact of some is likely small (e.g. voluntary programs) while the impact of others is particularly uncertain (e.g. research and development support).

For each policy type, we identify a "benchmark" stringency and duration based on a judgmental estimate of what might be the maximum politically acceptable level in North America. In some cases, policies of this stringency have already been implemented while in other cases policies are more stringent reflecting prices or targets indicated in the literature. Based on the available literature, we then estimate the effect of that benchmark stringency on the 2040 electric vehicle sales target we have assumed, in terms of new market share "points." That is, our evaluation framework translates a given policy (as currently implemented or announced) into new market share "points" in 2040. We represent uncertainty in these estimates by providing a range of potential impacts. Ideally this range is provided by the literature, but where it is not available we provide a range of plus or minus 50%.

For each policy identified in a region, we linearly scale its new market share points based on the magnitude (e.g. the size of the incentive) and the duration (e.g. how long the incentive is available). For example, an incentive of $5,000 per vehicle for 10 years would be estimated to have the same impact as an incentive of $10,000 per vehicle for 5 years — a simplistic assumption that can be improved in future versions of this framework. For each policy identified that applies only to a subset of the region's population (e.g. to just one city in a province), we likewise linearly scale the policy impacts based on that proportion. For example, an electric vehicle-ready building code applying to half a province's population is calculated as having half the potential market share impact compared to an equivalent policy applied to the entire population.

To estimate the total effect of a given region's portfolio of electric vehicle-related policies on 2040 market share, we sum up our estimated market share impacts for each individual policy. This summation is simplistic and does not account for potential interactions among policies. Such interactions might be particularly important between demand- and supply-focused policies, e.g. where an electric vehicle purchase incentive might help a region to achieve the requirements of its ZEV mandate (rather than the incentive being wholly additive to the ZEV mandate).

Table B1:
Summary of policy evaluation framework

Policy	Policy Benchmark (i.e. maximum stringency and duration)	Estimated 2040 electric vehicle market share impact*
Demand-focused policies		
Financial incentives	$12,000 per vehicle for 15 years.	**10%**
HOV lane access	100% of congested highways have HOV lane access for PEVs.	**1%**
Public charging deployment	One public charger for every two gas stations (sufficient charger density to equate with gasoline refueling).	**3%**
Building regulations	100% of population has level 2 home charging access.	**8%**
Carbon price	Carbon price on track to meet $150/tonne CO_2e by 2030.	**15%**
Supply-focused policies		
ZEV mandate	California's ZEV mandate (requiring 9 to 21% electric vehicle sales by 2025).	**15%**
Vehicle emissions standards	Vehicle emissions standards with electric vehicle credits reaching 98g CO_2e per km by 2025.	**2%**
Low carbon fuel standards	Low carbon fuel standard requiring a 10% reduction in carbon intensity by 2020, with electric vehicle credits.	**0.3%**

*We consider an uncertainty range of +/- 50% or other ranges based on literature where possible.

For each region, we assign a letter grade based on the sum of the market share percentage points a province receives across the full suite of policies in place (Table B2). The purpose of this grading scheme is to assign jurisdictions into one of five "letter grade" categories (analogous to grades commonly assigned to students in North America) reflecting policy effort:

i) likely to boost electric vehicle adoption enough to meet or exceed 2040 targets ("A"),
ii) likely to boost electric vehicle adoption, but not enough to achieve targets ("B"),
iii) likely to achieve relatively limited adoption of electric vehicles ("C" and "D"), and
iv) likely to induce only marginal adoption of electric vehicles ("F").

Table B2: Summary of evaluation grading scale

Grade	Estimated new electric vehicle market share in 2040	Description
A+ A A–	>45% 40–44.9% 35–39.9%	**Excellent performance:** electric vehicle initiatives are likely to meet or exceed target (35%+).
B+ B B–	30–34.9% 25–29.9% 20–24.9%	**Moderate performance:** electric vehicle initiatives are likely to boost the adoption of electric vehicles but not achieve target (20-35%).
C+ C C–	16.8–19.9% 13.4–16.7% 10–13.3%	**Marginal performance:** electric vehicle initiatives are likely to achieve relatively limited adoption of electric vehicles (10-20%).
D	5–9.9%	**Poor performance:** electric vehicle initiatives are likely to achieve relatively limited adoption of electric vehicles (5-10%).
F	0–4.9%	**Unsatisfactory:** electric vehicle initiatives, if any, are likely to induce only marginal adoption of electric vehicles (<5%).

The following subsections explain our methods of translating a given policy's stringency and duration into estimated contribution towards 2040 market share points.

Financial incentives

High levels of incentives are correlated with higher levels of electric vehicle market share among countries and U.S. states [4, 6, 9]. For example, Norway reached electric vehicle new market share levels of 22% in 2016 due to financial and non-financial incentives equal to up to half of average vehicle costs over 10 years [6]. Axsen et al. [15] find that the financial component of Norway's incentives applied to a Canadian context (totalling about $12,000 CAD per vehicle) might achieve a market share of roughly 10% within 15 years. Such a purchase incentive is comparable to the incentive recently announced by the province of Ontario. Several factors explain the lower level of impact as modeled in Canada relative to the experience of Norway, including a preference for larger vehicles that are more expensive to electrify [15].

For financial incentives, we set the benchmark at this level, i.e., $12,000 for 15 years yielding a market share impact of 10% as determined through analysis with the REPAC model, which is based on Axsen et al.'s [15] discrete choice model. This cited model also produces an uncertainty range of plus or minus five percentage points, ranging from 5% to 15% 2040 market share points. This range aligns with several other electric vehicle market share modeling studies (e.g. [11, 13], but is significantly lower than studies that have greater sensitivity to demand-focused policies (e.g. [12, 16]). Although financial incentives could be used to achieve greater levels of adoption, their financial sustainability over longer periods may be problematic. Even the assumed 15-year benchmark may be unrealistically optimistic. For example, 10 out of 14 previously implemented financial incentive programs for electric vehicles in Canada have lasted less than five years.

Non-financial incentives: Value of HOV lane access

We focus on HOV lane access because this is the only non-financial incentive identified in Canada. Jin et al [9] estimate the value of HOV lane access for a given city based on time saved according to the formula:

$$V_{HOV} = P_t \times C_c \times P_r \quad (1)$$

where V_{HOV} is the monetized value of HOV lane access for electric vehicles, P_t is the percentage of traffic alleviated by HOV access, C_c is the congestion cost, and P_r is the percent HOV relief, which accounts for the fact that only some congestion during an average commute occurs on highways and may thus be relieved by HOV lane access. The percentage of traffic alleviated by HOV access (P_t) is based on the share of congested highways that have HOV lanes for a given city. Following [9], we use Google maps to examine traffic at 8am on a weekday for Canadian cities that provide HOV lane access to electric vehicle owners. Major roads with orange or red markings are considered as important roads. We visually estimate the share of these roads that have HOV lanes, which we assume is representative of the percentage of traffic alleviated. We use values for congestion cost (C_c) based on Transport Canada data described in UTTF [21]. Finally, we assume a value of 50% for P_r based on Jin et al [9]. The resulting value of V_{HOV} for each city is weighted by proportion of the population that is likely influenced by the HOV lane access to determine a monetized value for the entire province. We translate this monetary value into a 2040 market share impact assuming the same relationship as between financial incentives and market share (i.e., $12,000 over 15 years yields 10%). We set $1,200 (1%) as the benchmark (Table B1) because this is the revealed value of HOV lane access in California, the U.S. state with the highest HOV lane benefit made available to electric vehicles [9].

This approach has several limitations. First, the

method for visually estimating P_t is imprecise. Future use of quantified spatial data could improve these estimates. Second, we assume a single value for P_r (percent HOV lane relief), whereas this value is likely to vary among cities. Third, the measure for congestion cost reported in [21] includes not only the monetary cost of wasted time and fuel, but also the environmental cost associated with additional carbon emissions.

Public charger rollout

We assign a monetary value to public charger availability based on a method established by Lin & Greene [19], estimating the cost a BEV owner would have to pay to rent a second vehicle for trips that exceed the range of his or her BEV. This cost would decrease given greater availability of public chargers, thereby creating a value of the charger network given by the formula

$$B_{rc} = B_{med} \times (N_{pc} \times N_g) \quad (2)$$

Where B_{rc} is the monetized benefit of range confidence for BEV owners, B_{med} is the benefit for the median driver under ideal charger availability, N_{pc} is the number of public chargers, and N_g is the number of gasoline stations. We determine a value of $3,800 for B_{med} based on an average daily rate of $22 across Canada (assuming a period of 10 years and a 7% discount rate) [22]. The number of charging stations by province (N_{pc}) is estimated by reviewing information from ChargeHub (2016), while the number of gasoline stations (N_g) is based on Statistics Canada [23]. We select a monetary value of $3,800 as the benchmark for this policy, because this is the value of a charging network that (from the simplified perspective of this method) alleviates range anxiety. This value is translated into a market share impact in a similar fashion as for financial incentives.

This approach has several limitations. First, it assumes that BEV drivers in Canada have similar characteristics as the U.S. drivers described by Lin and Greene [19]. Second, it assumes a single average rental car rate, whereas rental car rates may vary by province and over time. Third, it assumes that the benefit applies only to owners of BEVs, whereas some benefit may accrue to owners of PHEVs. We assume that the share of BEVs (relative to total electric vehicle sales) sold in Canada remains at its historic average of 37% [24], again an imprecision. Fourth, the direct comparison of public charging to gasoline stations is problematic because i) gas stations have quicker refuelling time and a different number of fuelling ports than the average public charging station and ii) the distribution of gasoline stations is unlikely to be an ideal distribution for public chargers. Finally, in addition to the specific challenges of this methodology, it yields results that contradict findings suggesting that public charger awareness might not be associated with electric vehicle purchase intention [25].

Building codes

Empirical research suggests that home charging could be considerably more important than public charging access [25]. Lin et al. [19] find that providing all U.S. households with Level 2 charging by 2025 increases demand for electric vehicles by between 5 and 10 percentage points of new market share. Axsen et al. [15] estimate discrete choice models with Canadian consumer data, finding that home access to Level 2 charging increases mainstream consumer willingness-to-pay for PHEVs by $1300, and for BEVs by $3300. In line with these findings, analysis with the REPAC model, based on Axsen et al.'s [15] discrete choice model, found that that lack of access to home charging in two Canadian provinces reduces unconstrained demand for electric vehicles by eight percentage points of new market share in 2030. We therefore set the benchmark for this policy as an electric vehicle-ready building code applying to an entire province, with a potential 2040 impact of eight new market share points. The ratio of the monetized value of the "benchmark" levels of home-charging and public-charging policies in (with home charging being about 2.5 times higher) is also similar to the those empirically estimated by Bailey et al. [25]. If a policy only applies to new buildings, we scale the market share impact by the proportion of average building age for which the policy is active, assuming an average building life span of 100 years.

Carbon pricing

A carbon price can be implanted via a carbon tax or cap-and-trade system. We base our benchmark on modeling of carbon pricing. Analysis for Canada suggests that a carbon price in excess of $100/tonne CO_2e is likely necessary to achieve federal targets for greenhouse gas abatement in 2030 [26]. More recent calculations by the authors based on the same modelling framework — the CIMS technology simulation model as described by [27, 28] — suggest that a carbon price of between $100 and $200 could increase demand for electric vehicles by 15 percentage points of new market share in 2040. Therefore, our benchmark for fuel cost environment is an implicit or explicit carbon price that is on a trajectory to meet at least $150/t by 2030.

Zero Emission Vehicle (ZEV) mandate

The most direct supply-focused policy is a ZEV mandate, which incentivizes auto manufacturers to invest in the innovation of electric vehicles and hydrogen fuel-cell vehicles (HFCVs), and to produce and actively market such vehicles in the regulated region. California's ZEV mandate requires automakers

to earn a minimum number of ZEV credits annually based on the number of vehicles they sell [29, 30]. Lutsey et al. [4] find that five of the seven U.S. cities with the highest electric vehicle sales in 2015 are in states that have adopted California's ZEV program. The authors also find that the six U.S. cities with the highest level of electric vehicle model availability in 2015 were in ZEV States — a factor that the authors found to be statistically associated with electric vehicle sales, controlling for the presence of other policies. The ultimate electric vehicle market share resulting from a ZEV mandate is dependent on the types of vehicles automotive firms develop, which could be some mix of PHEVs, BEVs and HCFVs. In the case of California's ZEV mandate (our benchmark policy), electric vehicle market shares could plausibly range from 9% to 21% of new vehicles sold in 2025 and be in compliance with the policy, assuming HFCVs are not developed in significant quantity. Although the impact of this policy could increase after 2025 due to declining capital costs (i.e., technology learning) such impacts are uncertain. Therefore, we take the conservative view and assume 2040 market share impacts are the same as projected impacts in 2025.

Fuel economy standards

The U.S. and Canada currently have Corporate Average Fuel Economy (CAFE) standards in place, requiring that new passenger and light commercial vehicles sold in Canada must meet fleet-wide greenhouse gas emission standards through the year 2025. Fleet requirements for passenger cars sold in 2025 are 98 g CO_2e/km, which is reduction of 35% from 2015 requirements [31]. As part of the current CAFE standards, BEV models are considered not to have any emissions, and only gasoline-based emissions are counted for PHEV models. Both vehicle models count as more than one conventional vehicle when calculating the weighted average fuel economy of a manufacturer (e.g. one BEV sold in 2017 counts as 2.5 cars, and one PHEV as 2.1 cars). The U.S. Environmental Protection Agency projects that electric vehicles need to make up about 2% of new vehicle market share in 2025 for fleet-wide CAFE compliance [32], which we take as the benchmark stringency for this policy. Adjusting this value for uncertainty of plus or minus 50% leads to a range of between 1% and 3%.

Low carbon fuel standards

A low-carbon fuel standard (LCFS) was first implemented in California in 2007 and similar policies have since been adopted by several other jurisdictions including the European Union and the Province of British Columbia [33]. The LCFS requires fuel suppliers to reduce the carbon intensity of fuels sold in a jurisdiction. One option for compliance in some jurisdictions (e.g. California and British Columbia) is for fuel suppliers to purchase credits from suppliers of electricity for electric vehicles. Yang [34] estimates the monetary value of such credits (as implemented in California) to be in the range of one to several hundred dollars per year per BEV, which in theory would be passed along to electric vehicle buyers as equivalent financial or non-financial incentives. Using the relationship between monetary value and market share points determined for financial incentives, we estimate the impact of this policy to be between 0.1% and 0.4%, with a mid-point of 0.3% ($300).

Limitations of this policy framework

In addition to the limitations of evaluating individual policies identified above, a number of limitations apply more broadly to the evaluation framework. First, policy impacts are uncertain. Although we have relied on literature to guide the evaluation where possible, much research into policy impacts remains to be done and no single jurisdiction has yet reached the benchmark target of 40% electric vehicle sales. Second, the framework deals with policies individually and doesn't account for interactions among them. In some instances policies may complement each other and their impacts are likely to be additive, while in other cases the implementation of one policy may reduce the incremental impact of another. Finally, we don't account for all policies. Specifically, we do not include research and development programs or informational campaigns because their impacts are particularly uncertain and difficult to quantify.

In addition, our framework assumes that the market share impacts of each policy type are identical across provinces. As one justification for this assumption, market research shows that potential electric vehicle demand is very similar across Canadian provinces, although preferences for types of electric vehicles do vary somewhat. Although regional differences in climate can affect electric vehicle performance, we point out that two global leaders in electric vehicle sales — California and Norway — have demonstrated success with electric vehicle policy and sales in both warmer and colder climates. While electric vehicle supportive policies may in reality have different effects across provinces, we anticipate that these differences will be minor.

Appendix C: Norway and California Policy Analysis

Norway and California Policy Analysis

We look to other countries for examples of effective electric vehicle supportive policies, such as those implemented in Norway and California, which each earn a "B" grade. For this reason, it is useful to assess what each province's grade would be if it added a set of policies similar to those in Norway and California (see Table C1). We call these the "Norway-like" and "California-like" policy packages.

The Norway-like policy package includes very strong financial incentives (worth over $27k CDN in the Norway context), carbon pricing (equivalent to $61 CDN/tonne), and extensive electric vehicle charger deployment [6]. The California-like policy package includes financial and non-financial incentives (worth over $14k CDN), carbon pricing (equivalent to $16 CDN/tonne based on current WCI prices), public charging deployment, the ZEV mandate, and a low-carbon fuel standard [35]. When adding these policy packages to each province, we consider only their incremental impact relative to the current active and proposed policies in each province.

In each policy case we add the projected incremental impact of Norway-like and California-like policies to the current and proposed policy portfolios of each province (see Table C1). For example, the impact of California's financial and non-financial incentives is 8% market share by 2040. When we apply the same policy to British Columbia, we estimate the incremental impact of this policy to be an additional 6% electric vehicle market share by 2040 because British Columbia's current financial incentives are estimated to result in a 2% market share by 2040. On the other hand, when we apply this policy to Saskatchewan, we estimate the incremental impact to be equivalent to the impact in California — 8% electric vehicle market share — because Saskatchewan does not currently have any financial incentives implemented.

Not surprisingly, when we apply Norway-like and California-like policies to each Canadian province, projected electric vehicle market shares increase to near or above 30% by 2040 in all regions, raising grades to between a "B" and an "A." With Norway-like policies we estimate that all provinces would reach a market share between 27% and 42% and a grade of "B", "B+" or "A." With California-like policies we estimate that all provinces would reach a market share between 32% and 34%, and a grade of "B+." Regions that already have substantial electric vehicle supportive policies in place or proposed would receive higher grades. Although simplistic, this exercise demonstrates that Canadian provinces can substantially improve their grades using policies that currently exist in other countries.

Table C1:
Evaluated policy impact of Norway's and California's electric vehicle-supportive policies

Policy Impact and Value*	Norway	California
Financial and non-financial incentives		
Market impact	15%	8%
Value of incentives	$27,735	$14,956
ZEV mandate		
Market impact	-	15%
Target		15% by 2025
LCFS		
Market impact	-	0.3%
Target		-10% by 2020
Carbon tax $/tonne		
Market impact	6%	2%
Target $/tonne	$61.07	$15.80
Public charging		
Market impact	3%	2%
Stations per 1,000 vehicles	2.4	0.22
Vehicle emission standard		
Market Impact	2%	2%
gGHG/km	89	96
Electric vehicle-ready building codes		
Market Impact	-	0.2%
Electric vehicle-ready building codes % population		Covering 12%
Total market share impact	**27%**	**29%**
Grade	**B**	**B**

* All dollar values are in CAD.

Appendix D: Result Tables

Table D1:
Summary of initiatives (expired, current, and proposed) by type and province

Policy	Canada	British Columbia	Alberta	Saskatchewan	Manitoba	Ontario	Quebec	New Brunswick	Nova Scotia	Prince Edward Island	Newfoundland and Labrador	Total
Demand-side policies												
Financial incentives	-	7	-	-	-	7	5	-	-	-	1	**20**
HOV lane access	-	1	-	-	-	1	1	-	-	-	-	**3**
Public charging deployment	-	3	1	-	-	6	4	1	-	-	-	**15**
Building regulations	-	2	-	-	-	4	-	-	-	-	-	**6**
Standards & planning	1	-	-	-	-	1	3	-	-	-	-	**5**
Carbon Price	1	1	1	-	-	1	1	-	-	-	-	**4**
Other demand-focused policies*	-	3	1	-	3	5	8	2	1	-	1	**24**
Total demand-focused policies	1	17	3	-	3	25	22	3	1	-	2	**77**
Supply-side policy												
ZEV mandate	-	-	-	-	-	-	1	-	-	-	-	**1**
Vehicle emissions standards	1	-	-	-	-	-	-	-	-	-	-	**1**
Low Carbon Fuel standards	-	1	-	-	-	-	-	-	-	-	-	**1**
Other supply-focused policies**	2	1	-	-	2	1	9	-	-	-	-	**15**
Total supply-focused policies	3	2	-	-	2	1	10	-	-	-	-	**18**
All policies												
Total	**5**	**19**	**3**	**-**	**5**	**26**	**32**	**3**	**1**	**-**	**2**	**95**

* Includes information campaigns [14] and fleet procurement [10];
**Includes R&D [11] and market development programs

Table D2:
Summary of current initiatives by type and province

Policy	Canada	British Columbia	Alberta	Saskatchewan	Manitoba	Ontario	Quebec	New Brunswick	Nova Scotia	Prince Edward Island	Newfoundland and Labrador	Total
Demand-side policies												
Financial incentives	-	5	-	-	-	2	5	-	-	-	-	**12**
HOV lane access	-	1	-	-	-	1	1	-	-	-	-	**3**
Public charging deployment	-	2	-	-	-	3	4	1	-	-	-	**10**
Building regulations	-	1	-	-	-	1	-	-	-	-	-	**2**
Standards & planning	1	-	-	-	-	-	-	-	-	-	-	**1**
Carbon Price	-	1	1	-	-	1	1	-	-	-	-	**2**
Other demand-focused policies*	-	3	1	-	2	1	8	2	-	-	1	**18**
Total demand-focused policies	1	13	2	-	2	9	19	3	-	-	1	**48**
Supply-side policy												
ZEV mandate	-	-	-	-	-	-	1	-	-	-	-	**-**
Vehicle emissions standards	1	-	-	-	-	-	-	-	-	-	-	**1**
Low Carbon Fuel standards	-	1	-	-	-	-	-	-	-	-	-	**1**
Other supply-focused policies**	2	-	-	-	2	-	5	-	-	-	-	**9**
Total supply-focused policies	3	2	-	-	2	-	5	-	-	-	-	**11**
All policies												
Total	**4**	**14**	**2**	**-**	**4**	**9**	**25**	**3**	**-**	**-**	**1**	**59**

* Includes information campaigns [14] and fleet procurement [10];
**Includes R&D [11] and market development programs

Table D3:
Summary of proposed initiatives by type and province

Policy	Canada	British Columbia	Alberta	Saskatchewan	Manitoba	Ontario	Quebec	New Brunswick	Nova Scotia	Prince Edward Island	Newfoundland and Labrador	Total
Demand-side policies												
Financial incentives	-	-	-	-	-	5	-	-	-	-	-	**4**
HOV lane access	-	-	-	-	-	-	-	-	-	-	-	**-**
Public charging deployment	-	-	-	-	-	2	-	-	-	-	-	**2**
Building regulations	-	1	-	-	-	3	-	-	-	-	-	**4**
Standards & planning	-	-	-	-	-	1	3	-	-	-	-	**4**
Carbon Price	1	-	-	-	-	-	-	-	-	-	-	**4**
Other demand-focused policies*	-	-	-	-	-	4	-	-	-	-	-	**4**
Total demand-focused policies	1	1	-	-	-	15	3	-	-	-	-	**22**
Supply-side policy												
ZEV mandate	-	-	-	-	-	-	-	-	-	-	-	**1**
Vehicle emissions standards	-	-	-	-	-	-	-	-	-	-	-	**-**
Low Carbon Fuel standards	-	-	-	-	-	-	-	-	-	-	-	**-**
Other supply-focused policies**	-	1	-	-	-	-	4	-	-	-	-	**6**
Total supply-focused policies	-	1	-	-	-	-	5	-	-	-	-	**7**
All policies												
Total	**1**	**2**	-	-	-	**9**	**7**	-	-	-	-	**29**

* Includes information campaigns [14] and fleet procurement [10];
**Includes R&D [11] and market development programs

Appendices References

1 Melton, N., J. Axsen, and D. Sperling. Moving beyond alternative fuel hype to decarbonize transportation. *Nature Energy*, Vol. 1, No. 3, 2016.

2 Clark-Sutton, K., S. Siddiki, S. Carley, C. Wanner, J. Rupp, and J. D. Graham. Plug-in electric vehicle readiness: Rating cities in the United States. *Electricity Journal*, Vol. 29, No. 1, 2016, pp. 30–40.

3 Roland Berger Strategy Consultants. *PEV readiness study.* 2010.

4 Lutsey, N., S. Searle, S. Chambliss, and A. Bandivadekar. *Assessment of leading electric vehicle promotion activities in United States cities*. Washington DC, USA, 2015.

5 Mock, P., and Z. Yang. *Driving electrification a global comparison of fiscal incentive policy for electric vehicles*. 2014.

6 Tietge, U., P. Mock, N. Lutsey, and A. Campestrini. *Comparison of leading electric vehicle policy and deployment in Europe*. 2016.

7 Wesseling, J. H. Explaining variance in national electric vehicle policies. *Environmental Innovation and Societal Transitions*, 2016.

8 Greene, D., and J. Shuguang. *Policies for Promoting Low-Emission Vehicles and Fuels: Lessons from Recent Analyses*. Knoxville, 2016.

9 Jin, L., S. Searle, and N. Lutsey. *Evaluation of state-level U.S. electric vehicle incentives*. 2014.

10 Al-Alawi, B. M., and T. H. Bradley. Review of hybrid, plug-in hybrid, and electric vehicle market modeling Studies. *Renewable and Sustainable Energy Reviews*, Vol. 21, 2013, pp. 190–203.

11 Lopes, M. M., F. Moura, and L. M. Martinez. A rule-based approach for determining the plausible universe of electric vehicle buyers in the Lisbon Metropolitan Area. *Transportation Research Part A: Policy and Practice,* Vol. 59, 2014, pp. 22–36.

12 Tran, M., D. Banister, J. D. K. Bishop, and M. D. McCulloch. Simulating early adoption of alternative fuel vehicles for sustainability. *Technological Forecasting and Social Change*, Vol. 80, No. 5, 2013, pp. 865–875.

13 Gnann, T., P. Plötz, A. Kühn, and M. Wietschel. Modelling market diffusion of electric vehicles with real world driving data – German market and policy options. *Transportation Research Part A: Policy and Practice*, Vol. 77, 2015, pp. 95–112.

14 Choo, S., and P. L. Mokhtarian. What type of vehicle do people drive? The role of attitude and lifestyle in influencing vehicle type choice. *Transportation Research Part A: Policy and Practice*, Vol. 38, No. 3, 2004, pp. 201–222.

15 Axsen, J., S. Goldberg, J. Bailey, G. Kamiya, B. Langman, J. Cairns, M. Wolinetz, and A. Miele. *Electrifying Vehicles: Insights from the Canadian Plug-in Electric Vehicle Study.* Vancouver, Canada, 2015.

16 Shafiei, E., H. Thorkelsson, E. I. Ásgeirsson, B. Davidsdottir, M. Raberto, and H. Stefansson. An agent-based modeling approach to predict the evolution of market share of electric vehicles: A case study from Iceland. *Technological Forecasting and Social Change*, Vol. 79, No. 9, 2012, pp. 1638–1653.

17 Sullivan, J. L., I. T. Salmeen, and C. P. Simon. *PHEV Marketplace Penetration An Agent Based Simulation*. 2009.

18 Eppstein, M. J., D. K. Grover, J. S. Marshall, and D. M. Rizzo. An agent-based model to study market penetration of plug-in hybrid electric vehicles. *Energy Policy*, Vol. 39, No. 6, 2011, pp. 3789–3802.

19 Lin, Z., and D. L. Greene. Promoting the Market for Plug-In Hybrid and Battery Electric Vehicles: Role of Recharge Availability. T*ransportation Research Record: Journal of the Transportation Research Board*, No. 2252, 2011, pp. 49–56.

20 International Energy Agency (IEA). *World Energy Outlook Special Report 2015: Energy and Climate Change.* 2015.

21 Urban Transportation Task Force (UTTF). *The High Cost of Congestion in Canadian Cities*. 2012.

22 Kayak. Car Rental Prices. https://www.ca.kayak.com/. Accessed May 6, 2016.

23 Statistics Canada. Table 551-0005 - *Canadian business patterns, location counts, employment size and North American Industry Classification System (NAICS), national industries, by Canada and provinces, December 2013, semi-annual*. 2013.

24 Klippenstein, M. *Canadian EV Sales Data*. 2016.

25 Bailey, J., A. Miele, and J. Axsen. Is awareness of public charging associated with consumer interest in plug-in electric vehicles? *Transportation Research Part D: Transport and Environment*, Vol. 36, 2015, pp. 1–9.

26 National Round Table on the Environment and Economy. *Reality Check: The State of Climate Progress in Canada*. 2012.

27 Bataille, C., M. Jaccard, J. Nyboer, and N. Rivers. Towards General Equilibrium in a Technology-Rich Model with Empirically Estimated Behavioral Parameters. *The Energy Journal*, Vol. 27, No. Special Issue on Hybrid Modeling of Energy- Environment Policies: Reconciling Bottom-up and Top-Down, 2006, pp. 93–112.

28 Jaccard, M. Combining Top Down and Bottom Up in Energy Economy Models. In *International Handbook on the Economics of Energy* (J. Evans and L. C. Hunt, eds.), Edward Elgar, Northampton, pp. 311–331.

29 Sykes, M. *Does a region need its own zero emission vehicle mandate, or can it free-ride off another? Modelling British Columbia and California*. Sustainable Transportation Action Research Team, Simon Fraser University, 2016.

30 Sperling, D., and D. Gordon. *Two Billion Cars: Driving Toward Sustainability*. Oxford University Press, 2009.

31 Government of Canada. SOR/2014-204 to 225 and SI/2014-76 to 77 and 79 to 80 : Regulations Amending the Passenger Automobile and Light Truck Greenhouse Gas Regulations (2017-2025). *Canadian Gazette Part II*, Vol. 148, No. 21, 2014, p. 2368 to 2536.

32 US Environmental Protection Agency (US EPA). *Regulatory Impact Analysis: Final Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards*. 2012.

33 Rhodes, E., J. Axsen, and M. Jaccard. Gauging citizen support for a low carbon fuel standard. *Energy Policy*, Vol. 79, 2015, pp. 104–114.

34 Yang, C. Fuel electricity and plug-in electric vehicles in a low carbon fuel standard. *Energy Policy*, Vol. 56, 2013, pp. 51–62.

35 Lutsey, N., S. Searle, S. Chambliss, and A. Bandivadekar. *Assessment of leading electric vehicle promotion activities in United States cities*. Washington, 2015.

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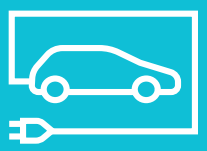

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