

Charging Up: Policies to Spark Electric Vehicle Adoption in Metro Vancouver

by

Eric Allan Bing

B.Sc., University of British Columbia, 2014

Project Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Public Policy

in the

School of Public Policy

Faculty of Arts and Social Sciences

© Eric Allan Bing 2017

SIMON FRASER UNIVERSITY

Spring 2017

All rights reserved.

However, in accordance with the *Copyright Act of Canada*, this work may be reproduced, without authorization, under the conditions for Fair Dealing. Therefore, limited reproduction of this work for the purposes of private study, research, education, satire, parody, criticism, review and news reporting is likely to be in accordance with the law, particularly if cited appropriately.

Approval

Name: Eric Bing
Degree: Master of Public Policy
Title: Charging Up: Policies to Spark Electric Vehicle Adoption in Metro Vancouver

Examining Committee: **Chair:** Doug McArthur
Professor, School of Public Policy, SFU

Josh Gordon
Senior Supervisor
Assistant Professor

J. Rhys Kesselman
Supervisor
Professor

Benoit Laplante
Internal Examiner
Visiting Professor

Date Defended/Approved: March 28, 2017

Ethics Statement



The author, whose name appears on the title page of this work, has obtained, for the research described in this work, either:

- a. human research ethics approval from the Simon Fraser University Office of Research Ethics

or

- b. advance approval of the animal care protocol from the University Animal Care Committee of Simon Fraser University

or has conducted the research

- c. as a co-investigator, collaborator, or research assistant in a research project approved in advance.

A copy of the approval letter has been filed with the Theses Office of the University Library at the time of submission of this thesis or project.

The original application for approval and letter of approval are filed with the relevant offices. Inquiries may be directed to those authorities.

Simon Fraser University Library
Burnaby, British Columbia, Canada

Update Spring 2016

Abstract

Plug-in electric vehicles have the potential to significantly reduce greenhouse gas emissions in Metro Vancouver, but their adoption has been limited to date. This research paper examines the barriers to electric vehicle usage in Metro Vancouver, and analyzes several potential policy changes that could be made by the provincial government to encourage more people to purchase such vehicles. This analysis is based on a literature review, a jurisdictional scan, and interviews with experts and stakeholders. The policy options that are considered include a zero-emission vehicle mandate, building requirements for new residential developments, changes to strata legislation, and changes to utilities regulations.

Keywords: Electric vehicles; transportation; Vancouver; British Columbia; environment; climate change

To a clean energy future.

Acknowledgements

I would like to thank the School of Public Policy and my professors for the knowledge and skills they have helped me to develop throughout the past two years. In particular, I want to thank my supervisor Josh Gordon for his guidance and feedback throughout this project. I would also like to thank my family for their constant support. Finally, I want to thank my classmates for the encouragement and the laughs we shared while working our way through these projects, and throughout this program. All of you helped me to get here, and I truly appreciate it.

Table of Contents

Approval	ii
Ethics Statement	iii
Abstract	iv
Dedication	v
Acknowledgements	vi
Table of Contents	vii
List of Tables	ix
List of Figures	ix
List of Acronyms	x
Glossary	xi
Executive Summary	xii
Chapter 1. Introduction	1
Chapter 2. Background	4
2.1. Types of Electric Vehicles	4
2.2. Electric Vehicle Charging	5
2.3. Global Context for Electric Vehicles	6
2.4. Current Context for Electric Vehicles in Canada and BC	8
Chapter 3. Policy Landscape	11
3.1. Climate change and The Paris Agreement	11
3.2. Provincial Government Policies	13
3.3. Municipal Policies	15
3.4. Stakeholders	17
Chapter 4. Methodology	19
4.1. Data Description	19
4.2. Limitations	20
Chapter 5. Research Findings	21
5.1. Literature Review	21
5.1.1. Consumers	21
5.1.2. Barriers	22
5.1.3. Policies	25
5.2. Jurisdictional Scans	26
5.2.1. Norway	28
5.2.2. California	29
5.2.3. Quebec	30
5.3. Interviews	31
5.3.1. Barriers	32
5.3.2. Policies	33

5.3.3. Other Considerations	34
Chapter 6. Policy Options	35
6.1. Option 1: Zero-Emission Vehicle Mandate	36
6.2. Option 2: EV Charging Standards for New Residential Buildings	37
6.3. Option 3: Amend the Strata Property Act to have a “Right to Charge” Policy	38
6.4. Option 4: Exempt EV Charging Stations from the Utilities Commission Act	39
Chapter 7. Evaluation Framework.....	41
7.1. Policy Effectiveness	41
7.2. Budgetary Considerations	42
7.3. Ease of Implementation	43
7.4. Stakeholder Acceptance.....	43
Chapter 8. Evaluation of Policy Options	45
8.1. Option 1: Zero-Emission Vehicle Mandate	45
8.2. Option 2: EV Charging Standards for New Residential Buildings	49
8.3. Option 3: Amend the Strata Property Act to have a “Right to Charge” Policy	51
8.4. Option 4: Exempt EV Charging Stations from the Utilities Commission Act	53
Chapter 9. Policy Recommendations	56
Chapter 10. Conclusions and Further Considerations	58
References	59
Appendix A. Interview Participants	66
Appendix B. Table of Electric Vehicle Sales Data in Canada.....	67
Appendix C Policy Options Excluded from the Analysis	68

List of Tables

Table 1:	Electric vehicles sales in jurisdictions of interest.....	27
Table 2:	Policy Evaluation Framework	44
Table 3:	Summary of Evaluation of Policy Options	45

List of Figures

Figure 1:	Decreases in battery costs and improvements in battery energy density	7
Figure 2:	Electric vehicle market shares in Canadian provinces in 2016	8
Figure 3:	Yearly electric vehicle sales in BC, 2011-2016	9
Figure 4:	Electric vehicle market shares in 2016.....	27

List of Acronyms

BC	British Columbia
BEV	Battery Electric Vehicle
CCI	Community Charging Infrastructure
CEV	Clean Energy Vehicle
DC	Direct Current
EV	Electric Vehicle
GHG	Greenhouse Gas
GST	Goods and Services Tax
HOV	High Occupancy Vehicle
PHEV	Plug-in Hybrid Electric Vehicle
PST	Provincial Sales Tax
ZEV	Zero-Emission Vehicle

Glossary

Battery Electric Vehicle (BEV)	A type of vehicle that derives its power entirely from a battery, which is charged by plugging the vehicle into an external electricity source
Plug-in Hybrid Electric Vehicle (PHEV)	A type of vehicle that has a battery charged from external electricity sources, and also has an internal combustion engine fueled with gasoline or diesel
Electric Vehicle (EV)	A category of vehicles that includes both Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs)
Zero-Emission Vehicle (ZEV)	A category of vehicles that includes Battery Electric Vehicles (BEVs), Plug-in Hybrid Electric Vehicles (PHEVs), and other zero-emission technologies like Hydrogen Fuel Cell Vehicles

Executive Summary

Policy Problem

Climate change, driven by human-caused greenhouse gas emissions, poses a long-term threat to people around the world. As part of the global response to climate change, Canada pledged in the 2015 Paris Agreement to reduce its nationwide greenhouse gases by 30% by 2030, from 2005 levels. BC also has a provincial target of reducing emissions by 80% by 2050, and BC is a member of the International Zero-Emission Vehicle Alliance, which aims to ensure that all new vehicles sold in the members' jurisdictions after 2050 will be zero-emission.

Light-duty vehicles are responsible for 13% of greenhouse gas emissions in BC, and 31% of emissions in Metro Vancouver. Plug-in electric vehicles have the potential to significantly reduce greenhouse gas emissions in BC, particularly in Metro Vancouver, but their adoption has been limited to date. Only 1% of new vehicles sold in BC in 2016 were electric vehicles. However, the technology has rapidly improved over the past decade, so electric vehicles could grow to become a much larger share of the market in BC, particularly if the province implements policies to support them.

This report examines the barriers to electric vehicle usage in Metro Vancouver, and analyzes several potential policy changes that could be made by the BC provincial government to enable more people to purchase such vehicles.

Methodology

My research involved mixed methods of research. It began with a review of existing literature and reports about the local context for electric vehicles, electric vehicle adoption in general, and the barriers that limit it. I also conducted jurisdictional scans, exploring the policies that have been implemented in other jurisdictions like Norway, California, and Quebec. Finally, I conducted 11 interviews with experts, stakeholders, government officials, and other interested parties.

Research Findings

The main barriers to electric vehicle adoption include high upfront costs, limited access to charging infrastructure, concerns about range, a lack of availability, a lack of information and awareness, and resistance from dealerships. Within the issue of charging access, there are numerous challenges, including access in multi-unit residential buildings, access in public places, and the time needed to charge an electric vehicle.

BC's existing policies help to address some of these main barriers, but other barriers are not yet being sufficiently addressed. These include access to charging in multi-unit residential buildings, a lack of charging stations in public places, a lack of electric vehicle models available, and resistance from dealerships. For that reason, my report examines some new potential policies for addressing those barriers.

Policy Options and Recommendations

My analysis considers four policy options. The first option is to implement a zero-emission vehicle mandate, which would require that a certain percentage of new vehicles sold in BC each year must be either electric vehicles or other types of zero-emission vehicles (ZEVs), and the mandated percentage would increase over time.

The second option is the creation of provincial standards, requiring developers to provide EV charging infrastructure to a certain percentage of parking stalls in new residential developments. These could be voluntary additions to the BC Building Code, so that each municipality would have the option of whether to apply those requirements to new developments in their community.

The third option is for BC to amend the Strata Property Act, to include a "Right to Charge" policy. This would prevent strata organizations from unreasonably restricting residents from installing EV charging infrastructure in their own parking spots.

The fourth option is to provide electric vehicle charging stations with an exemption from being regulated under the Utilities Commission Act. The Act currently restricts organizations from re-selling electricity, unless they are a public utility or a municipality.

This poses a major barrier to the proliferation of publicly accessible charging stations, so exempting EV charging stations from those regulations would lift that barrier.

These four policy options are evaluated through a consistent set of criteria. These criteria are policy effectiveness in the short term, policy effectiveness in the long term, budgetary considerations, ease of implementation, and stakeholder acceptance.

This report recommends that the BC government should prioritize implementing a zero-emission vehicle mandate, and establishing opt-in building standards, requiring that a certain percentage of parking stalls in new developments must be equipped with EV charging infrastructure. In the long term, the BC government should also provide EV charging stations with an exemption from being regulated under the Utilities Commission Act. These policy changes would help to accelerate the transition towards electric vehicles in Metro Vancouver.

Chapter 1.

Introduction

In 2016, global average temperatures reached the highest levels ever recorded by humans, surpassing the highs set in 2014 and 2015 (NOAA, 2017). Carbon dioxide levels in the atmosphere continued their upward ascent, reaching record highs and remaining above the 400 parts-per-million milestone for the entire calendar year, for the first time in modern history (Schwartz, 2016). Meanwhile, new car sales in Canada also reached record highs in 2016. Automakers sold 1.95 million new vehicles in Canada (Global Automakers of Canada, 2017), most of which burn fossil fuels that create carbon dioxide emissions and contribute to global climate change.

Light duty vehicles are the largest source of greenhouse gas (GHG) emissions in Metro Vancouver at 31% (Metro Vancouver, 2013). Within the entire province of British Columbia (BC) they contribute 13% of emissions, while heavy duty vehicles contribute an additional 10% (BC Ministry of Environment, 2012). Thus in total, road transportation represents 23% of the province's emissions. The BC government has a provincial target of reducing its total GHG emissions by 80% by 2050, which will require dramatic reductions in many sectors. Reductions in the light duty vehicle sector may be easier than in many other sectors, due to technological and economic factors. These include the potential of electric vehicles as a clean alternative, as well as the shorter lifespans of cars and trucks, compared to buildings and factories, meaning that old technologies can be replaced more quickly. Therefore, efforts to reduce BC's emissions should include a focus on vehicles used for personal transportation. However, the adoption of electric vehicles or other zero-emission alternatives has been limited to date.

In 2016, electric vehicles held a market share of approximately 1% of new vehicle sales in BC. The International Energy Agency suggests that 40% of new passenger

vehicle sales worldwide should be electric by 2040, in order to limit global warming to two degrees Celsius (International Energy Agency, 2016), but researchers have projected that based on current policies, no Canadian province is on track for that (Axsen, Goldberg, & Melton, 2016).

Other modes of transportation, such as public transit and cycling, are also alternatives to gasoline-powered personal vehicles. However, while those modes of transportation have become more common in Metro Vancouver in recent decades, that shift has been slow and gradual. As of 2011, about 73% of personal trips within Metro Vancouver were by automobile, compared to 80% in 1985 (Translink, 2013a), and Translink's long term target is to reduce automobile usage to 50% of trips by 2045 (Translink, 2013b). This suggests that while increasing the region's levels of public transit ridership and cycling can and should be part of the solution in reducing pollution from automobiles, the automobile will remain a major mode of personal transportation in Metro Vancouver for decades to come. Therefore, making automobile usage less environmentally damaging will be essential, and increasing the usage of electric vehicles can be a key part of the solution.

This project explores the barriers that have limited the adoption of electric vehicles in Metro Vancouver, and examines the BC government's existing policies for incentivizing or enabling the usage of these vehicles, including both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). This report also analyzes new policies that the BC provincial government could potentially implement, which would address some of the barriers which existing policies cannot.

Chapter 2 provides background information about electric vehicles, including types of charging infrastructure, as well as the global and Canadian context for the increasing prominence of electric vehicles. Chapter 3 explores the current policy landscape around electric vehicles, including international climate change commitments, provincial government policies in BC, and municipal government policies within the Metro Vancouver region. Chapter 4 explains the methodology of my research. Chapter 5 outlines the findings of my research, including a literature review, jurisdictional scans, and interviews. Chapter 6 explains each of the four policy options that I consider in my analysis. Chapter

7 explains the evaluation criteria that I use to analyze each of my four policy options. Chapter 8 provides an analysis of the four policy options, explaining how each of them fits in the context of my evaluation criteria. Chapter 9 outlines my policy recommendations for the BC provincial government, based on my preceding analysis, and Chapter 10 provides my overall conclusions, final thoughts, and suggestions for future research.

Chapter 2.

Background

2.1. Types of Electric Vehicles

Electric vehicles have become the most promising alternative to conventional vehicles, which rely on an internal combustion engine. Electric vehicles have the potential to dramatically reduce the impacts of personal transportation on climate change, while still meeting people's transportation needs.

There are two main types of plug-in electric vehicles: battery electric vehicles and plug-in hybrid electric vehicles. Battery electric vehicles (BEVs) derive their power entirely from a battery, which is recharged by plugging it into an external electricity source like an electrical outlet or a charging station, thus they produce zero emissions. The most common BEVs in Canada are the Nissan Leaf and the Tesla Model S. The base model of the Nissan Leaf has a range of 172 km, and the Tesla Model S has a range of 401 km (McKinsey & Company, 2017). Currently, most BEVs have a range more similar to the Nissan Leaf.

Plug-in hybrid electric vehicles (PHEVs) have a battery that can be recharged from an external source, but also have an internal combustion engine that powers the vehicle after the battery is depleted, so PHEV owners can fuel their vehicles with both gasoline and electricity. They produce zero emissions in all-electric mode, but they do produce emissions when running off gasoline. The most common PHEV in Canada is the Chevrolet Volt, which has an electric range of 85 km, but an estimated total driving range of 676 km (Cobb, 2015).

These are both distinct from Hybrid Electric Vehicles, which rely on gas-electric hybrid motors, in order to achieve better fuel efficiency than conventional gas-powered vehicles. However, they do not plug into an external source, instead they only require gasoline as fuel. The US Department of Energy provides estimates of the annual emissions created by various types of vehicles in Vermont, which like BC, generates its

electricity almost entirely from clean sources. Based on those estimates, a conventional gasoline car produces about 5.2 tonnes of CO₂ emissions annually, a hybrid electric vehicle produces about 2.8 tonnes, a PHEV produces 1.5 tonnes, and a BEV produces none (“Emissions from Hybrid”, 2017). Thus, hybrid electric vehicles cannot achieve the same degree of emissions reductions, compared to PHEVs or BEVs, nor do they face the same challenges, in terms of plugging into an external electricity source. Therefore, hybrid electric vehicles are considered outside the focus of this project.

2.2. Electric Vehicle Charging

There are three main types of charging used for plug-in electric vehicles. Level 1 charging can come from a standard 120-volt outlet found in homes or businesses, and it is the slowest type. It is generally used for charging a vehicle overnight, and according to BC Hydro, 8 hours of charging would power a BEV for 40 km (BC Hydro, n.d.-a).

Level 2 charging is done from a 240-volt charging station, and it uses a level of power like that of an oven or a dryer. Most public charging stations are Level 2, and there are about 550 of them in BC, including 94 in the City of Vancouver (Government of British Columbia, 2015). Most public Level 2 charging stations are currently free to use. Many electric vehicle owners also choose to install a Level 2 charging station in their homes. BC Hydro says that between 1.2 and 2.4 hours of charging would power a BEV for 40km, and charging a depleted battery to full would take 4 to 6 hours (BC Hydro, n.d.-a).

Electricity that is used to charge an electric vehicle at home would be billed at regular residential rates, which are 9 cents per kilowatt-hour (kWh) up to a certain threshold, and then 13 cents per kWh once a household’s usage exceeds that threshold (BC Hydro, n.d.-b). According to BC Hydro, about two dollars’ worth of electricity would charge a Nissan Leaf enough to drive about 100 km, which is much cheaper than fueling a car with gasoline (BC Hydro, n.d.-a).

Direct current (DC) fast charger stations, also known as Level 3, use 480 volts, and BC Hydro says that they can charge a depleted battery to full in 30 minutes or less. These are not used in people’s homes, but there are 30 public DC fast charger stations in

BC, in addition to 8 Tesla Superchargers specifically for Tesla drivers. The 30 stations installed by BC Hydro charge user-fees of 35 cents per kWh of electricity (BC Hydro, n.d.-a). This is more expensive than residential rates, but still cheaper than fueling a car with gasoline. For example, the 2017 Chevrolet Bolt has a 60 kWh battery and its official range is 383 km, so fully charging it at a DC fast charger station would cost about twenty dollars.

2.3. Global Context for Electric Vehicles

Sales of electric vehicles have increased rapidly in recent years, largely due to improvements in battery technology which have made them more affordable and enabled them to have greater range. According to the International Energy Agency, battery costs in PHEVs (measured in USD/kWh) have fallen from \$1000/kWh in 2008, to approximately \$250/kWh in 2015 (International Energy Agency, 2016). A report from McKinsey & Company supports this, and says that in 2016, the battery costs were reduced to \$227/kWh, meaning that a 60 kWh battery costs about \$13,600. They estimate that once battery costs reach \$100/kWh, electric vehicles will be able to achieve “true price parity” with conventional vehicles, without incentives. They expect this to occur by 2025 or 2030, if not sooner (McKinsey & Company, 2017). Meanwhile, estimated battery energy density in PHEVs has increased more than threefold (see Figure 1), from less than 100 watt-hours (Wh) per litre (L) in 2008, to approximately 300 Wh/L in 2015 (International Energy Agency, 2016). This means that greater amounts of energy can be stored in a physically smaller battery, thus making it feasible for automakers to deploy batteries with more energy storage capacity, and create electric vehicles with greater range capabilities.

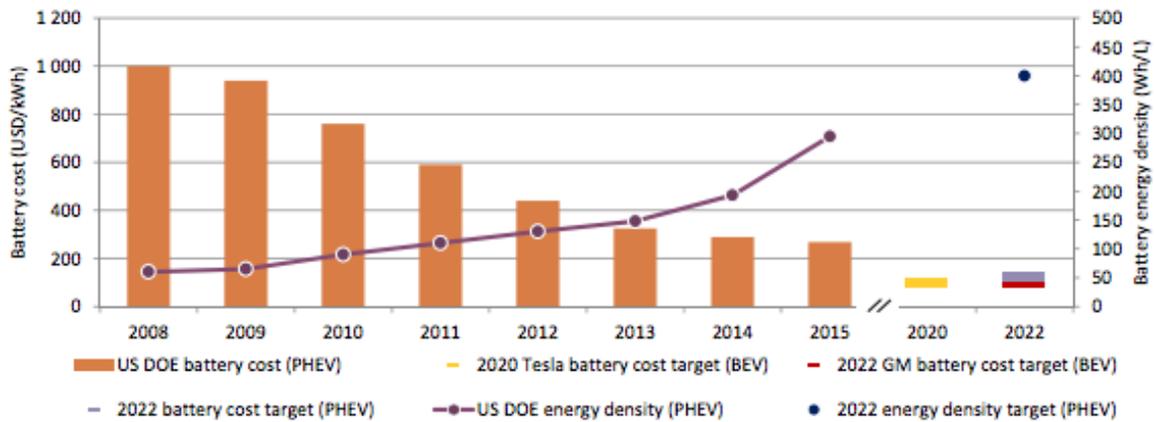


Figure 1: Decreases in battery costs and improvements in battery energy density

Source: International Energy Agency, 2016

With the rapid pace of technological improvements in recent years, the electric vehicle industry appears to have turned a corner, and is expected to grow rapidly over the coming decades. Global EV sales have been increasing rapidly since 2010, and over 700,000 new EVs were sold in 2016, bringing the total number of EVs on the roads to approximately 2 million (Cobb, 2017).

This represents great progress compared to negligible number of EVs on the roads prior to 2010, but the deployment of clean energy vehicles like EVs must reach much greater levels to mitigate climate change and limit its worst impacts. As of 2015, there were nearly 1 billion vehicles on the roads (International Energy Agency, 2016). The “Paris Declaration on Electro-Mobility and Climate Change & Call to Action” set a global deployment target of 100 million electric cars on the roads by 2030, up from 1 million in 2015 (UNFCCC, 2015). The International Agency suggests an even higher target of 140 million electric cars by 2030, and 900 million by 2050, to limit global warming to two degrees Celsius. To achieve those goals, electric cars would need to reach global sales targets of 20% by 2030 and 40% by 2040, and even higher ones in wealthier countries (International Energy Agency, 2016).

Considering the present dominance of internal combustion engine vehicles, most countries will need to rapidly increase their usage of electric vehicles, to achieve those targets. In 2015, the market share of electric vehicles among new vehicle sales exceeded

1% in only seven countries: Norway, the Netherlands, Sweden, Denmark, France, China, and the United Kingdom. The highest market shares were 23% in Norway and nearly 10% in the Netherlands (International Energy Agency, 2016). In Canada, electric vehicles are still a relatively small percentage of new motor vehicle sales, holding a market share below 1% (Klippenstein, 2017).

2.4. Current Context for Electric Vehicles in Canada and BC

From 2011 to 2016, over 27,000 EVs were sold in Canada, including over 10,500 in 2016 alone, and over 95% of Canada's electric vehicle sales have been in BC, Ontario, and Quebec (Klippenstein, 2017). Electric vehicles make up approximately 1% of new vehicles sold in BC and Quebec, but their market share is much lower in other Canadian provinces (see Figure 2).

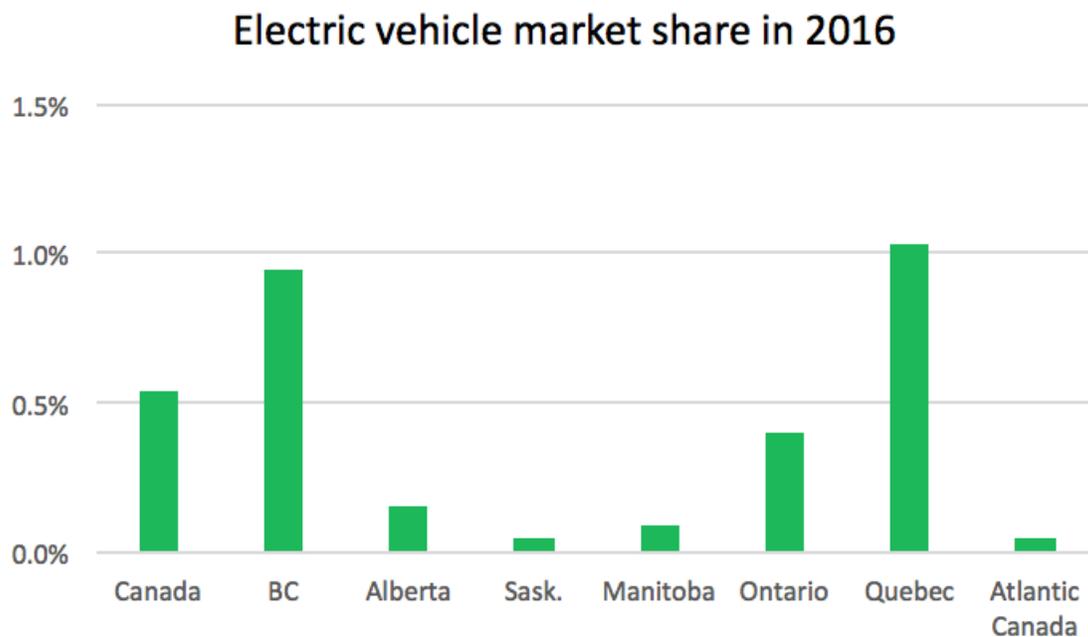


Figure 2: Electric vehicle market shares in Canadian provinces in 2016
Source: Klippenstein, 2017

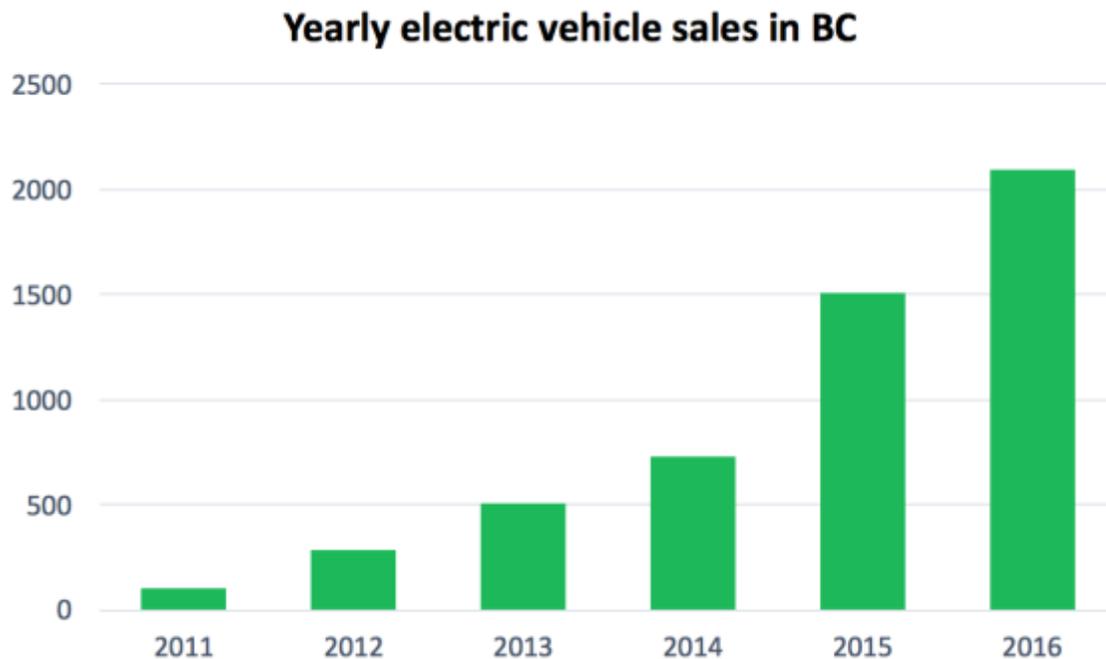


Figure 3: Yearly electric vehicle sales in BC, 2011-2016
 Source: Klippenstein, 2017

British Columbia has a variety of advantages that make it well-suited to lead the transition towards widespread adoption of electric vehicles in North America, particularly in Metro Vancouver.

One advantage is that about 98% of BC Hydro’s electricity comes from clean or renewable sources (BC Hydro, 2016), and electricity is more affordable in Vancouver than in most other North American cities (Hydro Québec, 2016). Meanwhile, Metro Vancouver’s gasoline is relatively expensive compared to other North American cities, due to various provincial and regional taxes. This increases the financial appeal of electric vehicles, and also means the environmental benefits are more significant than in places where electricity largely comes from fossil fuels. Another advantage is that the region is relatively geographically constrained, and winters are less cold than in most Canadian cities, which helps because batteries do not perform as well in cold temperatures. Researchers in Winnipeg found that at temperatures below -15°C the range of a battery electric vehicle can be reduced to approximately 30-35% of its baseline range at temperatures over 20°C,

while Transport Canada testing estimated a reduction down to 40-45% of the baseline range (Reyes, Parsons, & Hoemsen, 2016). Lastly, BC's population tends to be relatively environmentally conscious compared to other places in North America, and research indicates that people who are more environmentally conscious tend to be more inclined to buy electric vehicles (Krupa, Rizzo, Eppstein, Lanute, Gaalema, Lakkaraju, & Warrender, 2014). Thanks to these factors, BC has a great opportunity to reduce its GHG emissions by increasing the usage of electric vehicles and shifting away from gasoline-powered vehicles, as long as it can get the right policies in place.

Chapter 3.

Policy Landscape

Constitutional authority over environmental protection is ambiguous, as the Canadian constitution does not explicitly allocate it to one level of government or another. Thus, environmental policies tend to be implemented by multiple levels of government, sometimes with significant overlap. Electric vehicles are one of these issues where multiple levels of government have taken relevant policy actions, but to date, provincial governments have been the main site of activity. For example, provinces like BC, Ontario, and Quebec offer rebates for the purchase of electric vehicles (Rivers, 2012). Other relevant issues, such as building codes and electricity regulation, are also mainly within provincial jurisdiction. The federal government's role on the issue of EVs has largely involved funding programs that support sustainable innovation. These include the Automotive Innovation Fund, which was introduced in 2008, and the Sustainable Development Tech Fund, which began in 2001.

3.1. Climate change and The Paris Agreement

Climate change, driven by human-caused GHG emissions, poses a long-term threat to people around the world, as well as many other species of animals and plants that inhabit this planet. The established science indicates that humanity must drastically reduce its greenhouse gas emissions over the upcoming decades, to prevent the worst effects of climate change. For that reason, over 190 countries attended the 2015 United Nations Climate Change Conference and negotiated the Paris Agreement, to reaffirm their commitment to reducing GHG emissions and trying to mitigate climate change.

Canada pledged in the 2015 Paris Agreement to reduce its nationwide greenhouse gases by 30% by 2030, from 2005 levels. Furthermore, BC has a provincial target of reducing its GHG emissions by 80% by 2050, and in 2015, BC became a member of the International Zero-Emission Vehicle Alliance, which seeks to ensure that all new

passenger vehicles in the members' jurisdictions will be zero-emission vehicles by no later than 2050 (BC Ministry of Environment, 2015).

In December 2016, Canada's First Ministers released the "Pan-Canadian Framework on Clean Growth and Climate Change", which outlines a plan for reducing Canada's GHG emissions and achieving clean growth. The report notes that 23% of Canada's emissions in 2014 were from the transportation sector, particularly passenger vehicles and freight trucks, and that more government action is needed to reduce emissions, including efforts to expand the number of zero-emission vehicles on the roads. The report notes that zero-emission vehicle technologies, including PHEVs, BEVs, and hydrogen fuel-cell vehicles, are "becoming increasingly affordable and viable, and governments can help accelerate these trends, including by investing in charging and fueling infrastructure." The report also says that "federal, provincial, and territorial governments will work with industry and other stakeholders to develop a Canada-wide strategy for zero-emission vehicles by 2018", and that they will work together to accelerate deployment of necessary infrastructure, such as electric-charging stations (Government of Canada, 2016).

In May 2015, the BC government established the BC Climate Leadership Team, bringing together leaders from the business, academic, and environmental communities, as well as First Nations and local governments. The team released a report in October 2015, outlining their climate change policy recommendations for BC. The report notes that BC has existing legislation for a zero-emission vehicle (ZEV) standard, also known as a ZEV mandate, but has yet to implement it. They recommend that this policy should be implemented, to establish targets for the sale of new light duty vehicles, such that 10% must be zero-emission vehicles by 2020, 22.5% by 2025, and 30% by 2030. They also recommend "establishing revenue neutral PST for all vehicles based on grams of CO₂ per km, similar to many European vehicle registration systems" (Climate Leadership Team, 2015).

In August 2016, after reviewing the BC Climate Leadership Team's recommendations, the BC government released its Climate Leadership Plan, which addresses some of the recommendations and omits others. The Climate Leadership Plan

does not include any mention of a ZEV mandate or an emissions-based PST. However, it does declare that BC's Clean Energy Vehicle program will expand to support new vehicle incentives, as well as education and economic development initiatives. The plan also says the BC government will support the development of charging stations across BC by "developing regulations to allow local governments to require new buildings to install adequate infrastructure for electric vehicle charging", and by "developing policies to facilitate installing electric vehicle charging stations in strata buildings and developments" (Government of British Columbia, 2016).

3.2. Provincial Government Policies

Electric vehicles are affected by policies from a variety of provincial government departments. The BC Ministries of Energy and Mines, Environment, Transportation, and Housing all have some responsibility for policies that affect EVs, and so do BC Hydro and the BC Utilities Commission. Here are some of the existing policies that affect electric vehicles:

HOV lane access

In 2016, the BC provincial government announced that electric vehicles would be allowed to travel in high occupancy vehicle (HOV) lanes, without having to meet the passenger requirements. Electric vehicle owners can now apply to the Ministry of Transportation to get a permit and decal for their electric vehicle, which allow them to drive in HOV lanes.

Clean Energy Vehicle Program

The BC government has a program called the Clean Energy Vehicle (CEV) Program, which "is intended to encourage and accelerate the adoption of CEVs in BC for their environmental and economic benefits" ("Clean Energy Vehicle Program", n.d.). The CEV Program was initially implemented in 2011 but Phase 1 expired on March 31, 2014, and was later renewed for Phase 2 which began on April 1, 2015. In February 2017, the BC government announced that they will invest \$40 million more into the CEV Program, so it is now expected to run until 2020, unless those funds are depleted sooner.

The CEV Program uses multiple approaches to promote electric vehicles and other clean energy vehicles, and one of these approaches is the CEVforBC™ vehicle incentive program. That program currently offers point-of-sale rebates of \$5000 for the purchase of a new BEV, as well as amounts varying between \$2500 and \$5000 for the purchase of a PHEV, depending on the model (“CEVforBC™ Vehicle Incentive Program”, n.d.).

There is a separate program in BC called SCRAP-IT, which is not part of the CEV Program, but it allows people who trade in an older vehicle to receive an additional \$6000 towards the purchase of an electric vehicle, thus EV buyers can potentially receive as much as \$11,000 of incentives in total. This incentive was increased in early 2017 from \$3000.

Another major component of the CEV Program is investments in charging infrastructure, including public DC fast charger stations, which provide Level 3 charging access and generally require the user to pay for the electricity. For Phase 1 of the program, 30 DC fast charger stations were installed along major highway corridors in BC, from 2012 to 2016. They now plan to install 20 more DC fast charger stations under Phase 2 of the program, which would bring the total to 50. In 2015, the Fraser Basin Council produced a “Gap Analysis” report which identifies priority routes for that next deployment of 20 DC fast charger stations. Some of these recommended locations for new stations are within Metro Vancouver, while others are on southern Vancouver Island or in the southern interior of BC, and they are intended to fill in key gaps in the existing network of 30 stations, while also extending it further (Fraser Basin Council, 2015).

Phase 1 of the program also supported the installation of 998 Level 2 charging stations, of which 550 were public stations funded through the Community Charging Infrastructure (CCI) Fund. The remaining 448 stations were installed in single residential buildings, multi-unit residential buildings, and commercial buildings (Government of British Columbia, 2015). It is worth noting that the CCI funding for public Level 2 stations ended in 2013, and is not included in Phase 2 of the CEV Program.

The CEV Program also partially funds a public outreach and awareness campaign called “Emotive”, which raises awareness about electric vehicles in BC. The campaign involves a partnership between numerous organizations, including the Province of BC,

Metro Vancouver, the Fraser Basin Council, and others, and its main approaches are social media, outreach at community events, and “ride-and-drives” (E. Hou, personal communication, Feb 21, 2017).

Carbon Tax and Gas Taxes

BC’s relatively high gasoline prices increase the appeal of electric vehicles, particularly in Metro Vancouver. The federal government charges a 10-cent excise tax and a 5% GST on gasoline sales anywhere in Canada (“Fuel Consumption Taxes in Canada”, 2016), but there are additional taxes on gasoline that are specific to BC and Metro Vancouver. BC has a \$30/tonne carbon tax which adds 6.67 cents to the price of each litre of gasoline. Metro Vancouver also has 17 cents in gas taxes dedicated to funding Translink, 6.75 cents dedicated to the BC Transportation Financing Authority, and 1.75 cents which go to general revenue for BC. In total the BC government levies 32.17 cents of taxes on each litre of gasoline sold in Metro Vancouver, compared to 26.17 cents in the Victoria area, and 22.67 cents in the rest of BC (BC Ministry of Finance, 2016). Consequently, Metro Vancouver tends to have among the highest gasoline prices in North America.

3.3. Municipal Policies

Municipal governments tend to be involved in the provision of public charging stations for electric vehicles in their communities. Typically these are Level 2 charging stations placed in publicly accessible locations, many of which were funded in part by the provincial CCI Fund, until that program ended in 2013. Some municipalities have also chosen to establish requirements for EV charging infrastructure in new building developments.

The City of Richmond has a policy, outlined in its 2041 Official Community Plan, requiring that in new multi-family residential developments, 20% of parking stalls must have a Level 1 outlet for EV charging, and an additional 25% of parking stalls must be constructed to accommodate the future installation of EV charging equipment (City of Richmond, 2012). The city is now considering options for improving or expanding upon

this policy, including revising it to accommodate Level 2 charging (City of Richmond, 2016).

The District of North Vancouver requires that for new multi-family residential developments, 20% of parking stalls must be EV-ready and wired for Level 1 charging, and there must be a conduit in place so that all stalls can later be wired for Level 1. They also require that in new commercial or industrial developments, approximately 10% of parking stalls must be EV-ready, wired for Level 2 charging (District of North Vancouver, 2014).

The City of Port Coquitlam is considering a policy to require new apartment buildings to have “rough-ins of Level 2 EV charging infrastructure” with “electrical outlets sited to be accessible to each parking spot allocated to residents” (City of Port Coquitlam, 2017).

Other municipalities, such as the City of Surrey or the City of Burnaby, do not yet have policies requiring EV charging in new housing developments. However Burnaby’s most recent “Community Energy and Emissions Plan” indicates that it will explore options for supporting the deployment of electric vehicles, including charging infrastructure in new developments (City of Burnaby, 2016).

The City of Vancouver is in a somewhat different situation than other municipalities in Metro Vancouver, because Vancouver is granted additional powers through the Vancouver Charter. The most notable difference in regards to electric vehicles is that Vancouver has its own building code, whereas other municipalities in BC are subject to the BC Building Code. Consequently, Vancouver established policies in this area before other municipalities were clear about whether they had the authority to do so.

In 2009, Vancouver passed a building bylaw requiring electric vehicle charging circuits in all new multi-unit residential buildings. In 2013, they updated this policy to require that the charging infrastructure requirements, which apply to 20% of parking spaces, must support Level 2 charging. Additionally, since 2013, they have required that all parking spots in one or two family homes must be have Level 2 charging circuits, as

well as 10% of parking stalls in new mixed-use and commercial buildings (City of Vancouver, 2016a).

In 2016, Vancouver released its “Electric Vehicle Ecosystem Strategy”. In this strategy, they suggest that increasing access to charging will lead to an expansion of the local electric vehicle market, which will lead to a better return on investment from public charging, and will ultimately lead to greater private-sector uptake of public charging infrastructure. The city estimates that there were about 1000 EVs in Vancouver in 2016, and they expect the city to have 30,000 by the mid-2020s, and 200,000 by 2050 (City of Vancouver, 2016b). The city’s goal is that by 2050, 25% of vehicles will be BEVs, 45% will be PHEVs, and 30% will be conventional hybrid vehicles (City of Vancouver, 2016a). Vancouver is currently considering a policy to require 50% of parking stalls to have Level 2 EV charging infrastructure (I. Neville, personal communication, Feb 7, 2017).

3.4. Stakeholders

Many organizations can be considered stakeholders in this topic. The Ministry of Energy and Mines is one, as they are responsible for the Clean Energy Vehicle program, and co-chair an initiative called Plug In BC, along with BC Hydro. BC Hydro and the BC Utilities Commission are relevant stakeholders, since electric vehicles have major implications for the electric market and electricity regulation. The topic could have implications for the BC Ministry of Transportation, whose role includes providing transportation infrastructure, and developing transportation policies. The topic is relevant to the BC Ministry of the Environment because increased electric vehicle usage could help BC to make progress towards its GHG emissions targets, and electric vehicles are mentioned in the BC Climate Leadership Plan.

For similar reasons, the topic is important to non-governmental organizations (NGOs) who do research or advocacy work on environmental issues. Municipal governments in Metro Vancouver are working to support electric vehicles, so provincial policies on the topic would be relevant to them. Electric vehicle owners have a stake in this topic, and in Metro Vancouver, they are represented by an organization called the Vancouver Electric Vehicle Association. The Condominium Home Owners’ Association of

BC are a stakeholder, and so is the development industry, since they are both affected by policies relating to housing. Finally, auto dealers and auto manufacturers are stakeholders because they are affected by policies that impact the market for vehicles, particularly supply-side policies.

Chapter 4.

Methodology

This study involved mixed methods of research. It began with a review of existing literature and reports about the local context for electric vehicles, electric vehicle adoption in general, and the barriers that limit it. I also conducted jurisdictional scans, exploring the policies that have been implemented in other jurisdictions like Norway, California, and Quebec. Finally, I conducted 11 interviews with experts, stakeholders and other interested parties, from a variety of organizations. Each type of research ultimately helped to inform my policy analysis.

4.1. Data Description

For data about electric vehicles sales in various jurisdictions, I relied mainly on a publicly available online database called “Canadian EV Sales”, maintained by Matthew Klippenstein. Klippenstein’s data for total automobile sales is from Statistics Canada, and his data for sales of EVs is based on vehicle registration data from IHS Auto. It is worth noting that his numbers for the sales of EVs are slightly lower than the actual total sales numbers, because according to a note on the spreadsheet, “IHS Auto data does not / cannot track Prius Plug-in, Ford C-Max or Fusion Energi, because it doesn't distinguish hybrids from plug-in hybrids” (Klippenstein, 2017). That said, comparisons to other data sources suggest this does not have a large impact on the data.

I prepared an interview guide for each of my interviews, and these varied depending on who I was speaking with. In general, some of the topic areas of discussion included:

- Relevant work that has been done by their organization, including involvement in policy development, program delivery, public outreach, advocacy, or research
- Current barriers to electric vehicle adoption
- Policies that are currently in place in BC

- Potential policies to increase electric vehicle adoption
- Their organization's perspective on current and potential policies
- Challenges associated with potential policies
- General thoughts about the transition towards electric vehicles

4.2. Limitations

One limitation of my project is that I gathered less information about certain topics than I would have liked. This is partly because to some extent, the policy focus of my analysis shifted away from certain policy ideas towards others during this project. Thus, I did not get the opportunity to hear as many perspectives as I would like, particularly regarding two housing-related policies included in my analysis.

Another limitation is that there could have been an overrepresentation of certain views in my qualitative interviews, due to the selection of people that I interviewed. The choices about who I interviewed were not random, nor were they intended to be, as they were often chosen because I wanted to hear the perspectives of people from particular organizations. My interviews also depended upon people's availability and openness to participating in this project, so it is possible that people who I did not interview could have offered very different opinions and perspectives.

Chapter 5.

Research Findings

5.1. Literature Review

5.1.1. Consumers

Simon Fraser University researchers Axsen, Goldberg, and Bailey have conducted surveys of recent vehicle-buying households in BC, and they have identified some trends that differentiate electric vehicle “Pioneers” who have already bought one, compared to “Potential Early Mainstream buyers” who are interested but have not bought an EV yet. These surveys found that the “Pioneers” who already own an EV were likely to have higher income and education, were more likely to be multi-vehicle households, and were more likely to have charging access at home. They also found that “Pioneers” were significantly more likely to have high concern for the environment, and to engage in technology-oriented or environment-oriented lifestyles. They also found that “Pioneers” tended to prefer BEVs over PHEVs, but it was the other way around for “Potential Early Mainstream buyers” who tended to prefer PHEVs, once the two types of electric vehicles had been explained to them (Axsen, Goldberg, & Bailey, 2016).

An American research survey conducted by Krupa and others in 2011 explored consumer attitudes about PHEVs, and indicated that for most consumers, fuel savings are an important consideration that would help to motivate them to consider driving PHEVs instead of conventional vehicles. However upfront costs tend to be weighted more strongly than fuel costs; the survey found that on average, people were only willing to pay an average of \$1858 more upfront to save \$500/year in fuel costs (Krupa et al., 2014). Moreover, past research has indicated that consumers generally know little about their annual fuel costs, and do not think about them in a rational or calculated way, when purchasing a new vehicle. In fact, a survey of hybrid car buyers in 2004 and 2005 found that their decision to buy one tended to be more based more on general impressions and their symbolic meanings. They often felt good about having a more fuel-efficient car, but had rarely made any calculations or estimates about their costs or savings (Turrentine,

Kurani, & Heffner, 2007). This suggests that we cannot necessarily expect most consumers to properly account for potential fuel costs or savings when purchasing a new vehicle, as consumers may undervalue or fail to consider that benefit of electric vehicles.

Environmental attitudes seem to be a major factor that influences people's interest in electric vehicles. The 2011 survey conducted by Krupa and others found that only 55% of American consumers saw reducing GHG emissions as an important consideration in buying a PHEV over a conventional vehicle. However, those very concerned about climate change were 44 times more likely to consider buying one than those unconcerned about it. This survey also found that those with left-leaning political views were much more likely to consider buying an EV than those with right-leaning views (Krupa et al., 2014).

5.1.2. Barriers

Some of the key barriers preventing consumers from buying EVs include higher upfront prices, a lack of charging options, concerns about range, a lack of vehicle options available, a lack of awareness and information about EVs, and a lack of interest from dealerships.

Upfront Costs

In terms of upfront costs, the issue is that electric vehicles tend to cost more to purchase than similar gas-powered vehicles. Over the next decade the price gap is expected to narrow and then reach price parity (McKinsey & Company, 2017), but until then, the higher prices of electric vehicles are a barrier than limits public uptake.

Charging Infrastructure

Access to charging infrastructure is a barrier for many people. Previous research indicates that many households park a vehicle close to a charging outlet, but there are also many who do not. In 2007, a survey conducted by Axsen and Kurani found that about 52% of new car-buying households in the United States park a vehicle within 25 feet of a Level 1 electrical outlet. (Axsen & Kurani, 2012).

Recent surveys in BC, conducted by Axsen and his associates, have indicated that among “Pioneers” who own an EV, nearly all of them have Level 1 charging access at home, and 75% have installed a Level 2 charger. However, among “Mainstream” vehicle buyers, who do not own an EV, about two-thirds have access to Level 1 charging, and only 35% have the potential to install Level 2 charging. Most “Mainstream” respondents who park in a garage, driveway, or a carport have Level 1 access, but those who park on the street or in a parking lot usually do not (Axsen, Goldberg, Bailey, Kamiya, Langman, Cairns, Wolinetz, & Miele, 2015).

Those who cannot charge at home would have to rely on charging at work or at public charging stations, which for many people may not be feasible or convenient options. Most public charging stations are Level 2, which typically takes about 4 hours for a full charge. Currently it is very rare for people to buy an electric vehicle without having access to charging at home (S. Goldberg, personal communication, Feb 3, 2017). That said, this might change once Level 3 DC fast charger stations are more prevalent in people’s communities, as they could allow people to fully charge a vehicle in 30 minutes while having a coffee or a meal, for example.

Range Anxiety

A related barrier is that people have concerns about the range of electric vehicles, known colloquially as “range anxiety”. This is because Battery electric vehicles generally have a much shorter range than conventional gas-powered vehicles.

The other cause of these concerns is that gas stations are more common than EV charging stations, as well as being more visible and much more familiar to people. Additionally, filling a gas tank takes less than 5 minutes, compared to a few hours charging an EV at a Level 2 charging station, or approximately 30 minutes charging at a Level 3 station. These factors all contribute to people’s “range anxiety”, even beyond the actual concerns about the range of EVs themselves.

PHEVs are an alternative that addresses these concerns, but many people are not aware of their existence. However, when people have the concept explained to them, non-EV owners tend to prefer that option over pure battery electric vehicles (Axsen, et al.,

2015). So although the early-adopters of EVs tend to prefer BEVs, the next wave of electric vehicle buyers might prefer PHEVs. On the other hand, if more mass-market BEVs in the future have longer ranges, like the Chevrolet Bolt or the upcoming Tesla Model 3, then that may sufficiently address concerns about range anxiety, and interest in PHEVs could lessen.

Availability

Another barrier is the limited number of electric vehicle options available. Since the vast majority of new vehicles sold are gas-powered, there are relatively few models of electric vehicles being made, and as a result, many customers might not find a model matching their preferred style, size, and colour. This is particularly an issue for consumers who wish to buy a larger vehicle like a sport utility vehicle (SUV), a pick-up truck, or a minivan.

Information and Awareness

Another barrier is the public's lack of awareness, information, or familiarity with electric vehicles. Past research indicates that many members of the public are unfamiliar with how electric vehicles work, or what the experience of driving and charging one would be like. There also tends to be little awareness about public charging stations, as most British Columbians report having never seen any (Axsen, et al., 2015). Due to their unfamiliarity with them, people may regard electric vehicles as a riskier choice, compared to conventional vehicles, which they understand better and are much more familiar with.

Dealerships

That lack of information is exacerbated by other barriers involving the dealerships. Since electric vehicles are a relatively new technology, many car salespeople may lack knowledge about them or not be sufficiently helpful. In 2016, the Sierra Club did a study where volunteers inquired about electric vehicles at hundreds of auto dealerships in the United States, to identify ways in which dealers could be more successful at selling EVs. They found that 33% of salespeople did not mention the federal and state tax credits or rebates available, and 38% of salespeople did not mention any details about charging

(Lunetta, & Coplon-Newfield, 2016). Some dealerships may feel less inclined to prioritize them, since EVs tend to require less maintenance, and thus may be regarded as undermining a major source of their profits. The Sierra Club study found that at nearly half of dealerships, EVs were not displayed very prominently, and at 14% of dealerships, the EVs were insufficiently charged for a test drive (Lunetta, & Coplon-Newfield, 2016).

5.1.3. Policies

There are two broad categories of policies for electric vehicles: demand-focused policies, intended to increase consumers' interest in electric vehicles; and supply-focused policies, intended to incentivize vehicle suppliers to develop, market, and sell more electric vehicles.

A 2016 report called *Canada's Electric Vehicle Policy Report Card* suggests there are six main types of demand-focused policies: financial incentives, non-financial incentives, public charging deployment, carbon pricing, building regulations, and information campaigns. It also lists four main types of supply-focused policies: ZEV mandates, research and development (R&D) support, low-carbon fuel standards, and vehicle emissions standards. The report ranks BC as 3rd in Canada for its electric vehicle policies, and suggests that BC could improve by implementing a ZEV mandate, implementing a vehicle purchase tax based on carbon emissions, strengthening the carbon tax, or implementing stronger and longer duration incentives. It also suggests that BC municipalities could help by implementing EV-supportive building regulations (Axsen, Goldberg, & Melton, 2016).

A 2017 article suggests that for Canada to achieve high levels of EV adoption by 2030, supply-side policies should be implemented, in addition to demand-side policies. Using models based on surveys of BC consumers, it estimates that with no new policies, EV sales will reach a market share in the range of 1-10% by 2030. With strong demand-focused policies, such as continuing subsidies and increasing home charging access, EVs will achieve a market share of 17-28% by 2030. With strong demand-focused policies and strong supply-focused policies, they project a new market share of 38-49% by 2030. The

article highlights a ZEV mandate, low-carbon fuel standard and R&D subsidies as potential examples of supply-focused policies (Wolinetza & Axsen, 2017).

In terms of the demand side, some research suggests that perks like free parking or access to bus lanes can be an efficient and cost-effective way to incentivize EV adoption, compared to more expensive subsidies. On the other hand, those policy incentives can have negative side effects, which grow more significant over time, such as crowding in bus lanes, or increased overall automobile usage (Langbroek, Franklin, & Susilo, 2016).

A 2014 report from the World Wildlife Foundation examines Canada's progress towards increased electric vehicle usage, and recommends that provincial governments should maintain or introduce purchase incentives, increase the usage of EVs in their own fleets, update building codes and strata acts to establish guidelines for EV infrastructure in homes, encourage off-peak charging through pricing incentives and education, and consult with manufacturers to set actions for increasing the availability of EVs (WWF-Canada, 2014).

5.2. Jurisdictional Scans

In assessing BC's options for potential policy changes, it is helpful to consider the policies of some other jurisdictions: Norway, California, and Quebec. Norway currently leads the world with the highest market share for electric vehicles, California leads North America, and Quebec leads Canada. Thus, it is worth exploring the policies these jurisdictions are using to support electric vehicle adoption.

Electric vehicle market share in 2016

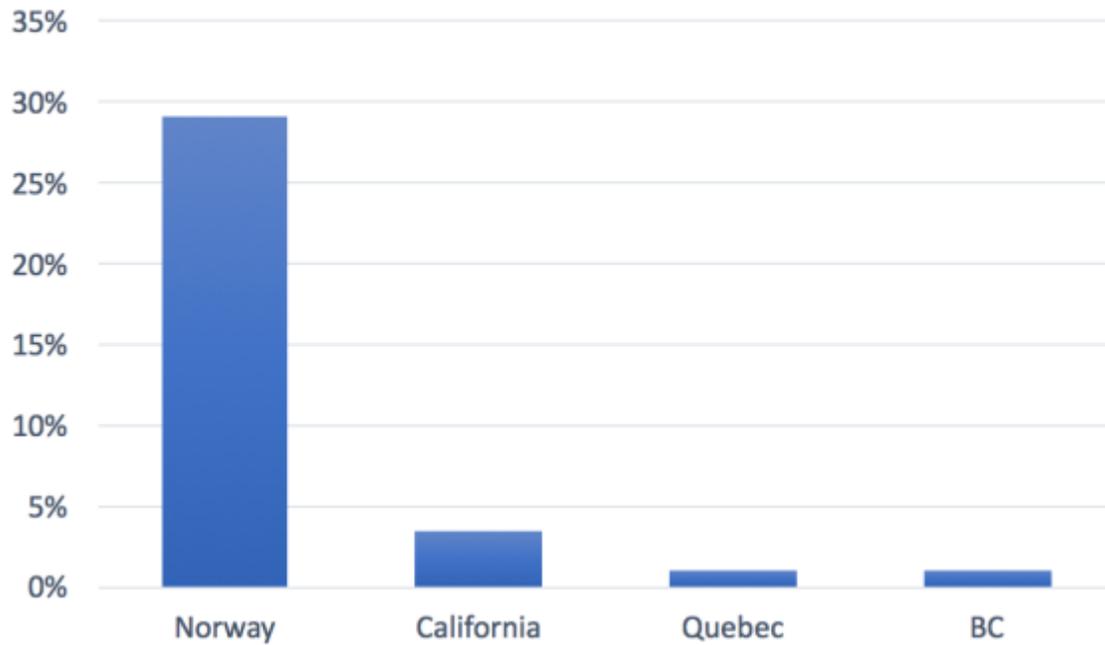


Figure 4: Electric vehicle market shares in 2016

Source: Frydenlund, 2017; Auto Outlook, Inc., 2017; and Klippenstein, 2017

Table 1: Electric vehicles sales in jurisdictions of interest

Jurisdiction	EV market share 2016	EV sales in 2016	Total vehicle sales in 2016
Norway	29.1%	44,800	154,603
California	3.5%	73,573	2,086,966
Quebec	1.03%	4794	464,671
BC	0.95%	2093	221,579

Source: Frydenlund, 2017; Auto Outlook, Inc., 2017; and Klippenstein, 2017

5.2.1. Norway

Norway has many similarities to BC, like its population of approximately 5 million, a somewhat similar climate, and the fact that its electricity is generated mostly from hydro. However, Norway is far ahead of BC in terms of electric vehicle adoption, and it currently leads the world in that regard. In 2015, about 23% of new vehicles sold in Norway were EVs (International Energy Agency, 2016), and in 2016 this increased even further to 29% (Frydenlund, 2017), compared to about 1% in BC (Klippenstein, 2017). As of December 2016, over 135,000 EVs have been sold in Norway (Cobb, 2017), and since it has approximately 2.6 million passenger vehicles in total (Figenbaum, 2016), this means that EVs now constitute over 5% of all vehicles on the roads in Norway.

Part of Norway's success is that they established strong policies incentivizing EVs between 1990 and 2009, before the major automakers began selling EVs in Norway. These included registration tax reductions, exemptions from the value-added tax, exemptions from paying for road tolls or ferries, free parking, and access to bus lanes. Since they were such a niche item at the time, there was little political resistance to these changes, so early lobbying efforts by electric vehicle advocates were very successful. Then around 2009 when major automakers began producing EVs, the favourable policies allowed EV sales to accelerate rapidly. Since then, Norway's Parliament has had broad political agreement on electric vehicle policies as part of their general climate policy (Figenbaum, 2016).

Analyses suggest that the value-added tax exemption, access to bus lanes, and free road tolls have been their strongest incentives, and that perks can have surprisingly strong psychological effects, despite smaller financial value than tax relief. Some of the incentives for BEVs were intended to last until 2017 or until 50,000 BEVs were on the road, which occurred in 2015, two years ahead of schedule. At that point, the government established a plan to phase out some of these incentives and tax exemptions, beginning in 2018 (Phillips, 2015).

Prior to 2009, Norway had very few public charging stations for EVs, but starting in 2009, the Norwegian government funded an initiative to build EV charging infrastructure nationwide, and the city of Oslo began a similar initiative. As a result, Norway now has

approximately ten times as many public charging stations as BC, which has helped to overcome people's concerns about "range anxiety" (Phillips, 2015).

One challenge Norway still faces is a lack of charging stations in apartment or condominium buildings. Although there is high interest in EVs from residents of those multi-family buildings in Norway, as of 2015, under 5% of building owners or strata councils in Norway had considered installing charging infrastructure (Phillips, 2015).

5.2.2. California

California currently leads North America in electric vehicle adoption, as 3.5% of new vehicle sales in 2016 were either PHEVs or BEVs (Auto Outlook, Inc., 2017). From 2010 to 2016, there were 265,274 EVs sold in California, which is approximately half of the total number sold in the United States, and Governor Jerry Brown has set a goal of getting 1.5 million zero-emission vehicles on California roads by 2025.

The United States federal government provides tax credits of \$2500 to \$7500 for the purchase of a new electric vehicle, and California provides additional rebates to electric vehicle buyers, which vary between \$0 and \$6500, depending on the household income of the buyer ("Electric Vehicles: Tax Credits and Other Incentives", n.d.).

California has a Zero-Emission Vehicle (ZEV) mandate, along with nine other states: Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Vermont. This policy will require automakers in those states to maintain ZEV credits equal to be 4.5% of all sales for 2018 vehicle models, and the requirement will increase to 22% by 2025. That said, many electric vehicles generate more than one credit for automakers, depending on their battery range, so the required ZEV credit percentage does not directly reflect the resulting market share for electric vehicle sales ("What is ZEV?", 2016). Credits can be sold from one company to another, and a higher number of sales in one state can make up for less sales in another state, which generally means that automakers and dealers can sell extra EVs in California to make up for lower sales elsewhere (I. Neville, personal communication, Feb 7, 2017).

California's building codes currently require that 3% of parking spaces must be designed to accommodate electric vehicles. Recently, the mayor of San Francisco introduced legislation to require all new residential and commercial buildings to be 100% "EV Ready", where 10% of parking spaces must be "turnkey ready" for EV charger installation, 10% must be "EV flexible" for potential charging and upgrades, and a conduit must run in the areas of the parking garage that are hardest to reach, to make the remaining 80% of parking spaces "EV capable" and avoid future cost barriers (San Francisco Office of the Mayor, 2017).

California has a "Right to Charge" policy for strata housing, which makes it illegal for stratas to impose conditions that prohibit or unreasonably restrict installation of charging infrastructure in an owner's designated parking space. However, the law does allow for certain conditions to be imposed, if the charging unit is installed in a common area. (California Plug-In Electric Vehicle Collaborative, 2013).

One difference between California and BC is that California has a more deregulated electricity market. This means that while in BC the resale of electricity is restricted by the BC Utilities Commission, this has not been a major impediment in California. That said, according to BC Hydro's Alec Tsang, the business case for private sector investment in charging stations there still remains weak (A. Tsang, personal communication, Feb 9, 2017).

5.2.3. Quebec

Quebec currently leads Canada in EV sales, both per capita and in absolute numbers. In 2016, nearly 5000 new electric vehicles were sold in Quebec, and they held a market share of more than 1% (Klippenstein, 2017).

In October 2015, the Quebec provincial government announced a plan called "Propulser le Québec par l'électricité" (or Propelling Quebec Forward with Electricity), intended to put 100,000 electric vehicles on the roads of Quebec by 2020. The plan included a continuation of the province's subsidies of up to \$8000 for electric vehicles, an

exemption from bridge tolls, access to reserved lanes, and more public charging stations (Meager, 2015). By the end of 2016, approximately 12,500 had been sold to date (Klippenstein, 2017).

In 2016, Quebec passed legislation to implement a ZEV mandate, meaning that in Quebec, automakers will have to maintain ZEV credits equal to 3.4% of all sales of 2018 vehicle models, and this will increase to 15.5% by 2025.

5.3. Interviews

In January and February of 2017, I conducted one-on-one interviews with a variety of experts, stakeholders, and other interested parties with relevant experience, to hear their perspectives on topics relating to electric vehicles in BC, and potential policies that could be implemented. These interviews were semi-structured, and the questions were tailored specifically to each interviewee, depending on their organization and their areas of knowledge. The interviews were typically between 30 and 60 minutes long.

I interviewed the following people:

- Don Chandler, Vancouver Electric Vehicle Association
- Rebecca Abernethy, formerly with the Fraser Valley Regional District
- Suzanne Goldberg, Simon Fraser University
- Ian Neville, City of Vancouver
- Alec Tsang, BC Hydro
- Blair Qualey, New Car Dealers Association of BC
- Nick Clark, BC Ministry of Energy and Mines
- Brendan McEwen, City of Richmond

- Government of BC employee [*name undisclosed*]
- Eve Hou, Metro Vancouver
- Kristine Bienert, BC Utilities Commission

Below I outline a few of the key themes and insights drawn from the interviews, and I also refer to the interviews throughout this report.

5.3.1. Barriers

- My interviews emphasized many of the barriers identified in the literature, such as upfront costs, concerns about range, a lack of home-charging access, and challenges involving availability of EVs, and the dealerships.
- Some of my interviewees had done consumer research or public outreach work, and they made it clear that many consumers lack information or knowledge about electric vehicles. Consumers also lacked experience or familiarity with them, and were did not know what it would be like to own an electric vehicle. Furthermore, many consumers are unaware of PHEVs, and many consumers were only aware of Teslas.
- Home-charging was emphasized as being very important for electric vehicle ownership, and thus people's lack of access to it poses a major challenge, particularly in multi-unit residential buildings.
- It was frequently mentioned that BC Utilities Commission regulations on the re-sale of electricity are a barrier to the installation of new charging infrastructure. Apart from municipalities, organizations generally cannot re-sell electricity without going through a significant regulatory process, which means they would be unable to recover the costs of providing electricity to a charging stations.

5.3.2. Policies

- The existing purchase rebates were highlighted as being valuable and helping to spur more people to buy electric vehicles. None of my interviewees suggested that it was not worth continuing, although it was seen as something that should eventually be phased out, once EVs are priced similarly to conventional vehicles.
- BC's public deployment of 30 DC fast charger stations was seen as a helpful initiative. An additional 20 stations are planned, but people suggested that the network should expand well beyond that, as they are a key infrastructure for supporting electric vehicles. Nick Clark from the BC Ministry of Energy and Mines suggested that public provision of fast charger stations would likely need to continue for longer than the purchase rebates, although both are important at present.
- Many of my interviewees emphasized that a Zero-Emission Vehicle Mandate would be a very effective way of overcoming some of the existing barriers, and spurring more adoption of EVs. However the New Car Dealers Association of BC is very opposed to it.
- To address a lack of access to home-charging, it was suggested that there should be requirements for charging infrastructure in new developments. Vancouver has had new building requirements for years, and more recently, some other municipalities have established such requirements as well. Apparently the BC government does not intend to update the BC Building Code to include EV charging infrastructure.
- A "Right to Charge" policy was emphasized as something that would make it easier for residents in strata buildings to install EV infrastructure, and interviewees noted that Hawaii and California have this type of policy.
- Numerous interviewees suggested that electric vehicle charging stations should be given a "class exemption" or "category exemption" from utilities regulations. Alec Tsang from BC Hydro suggested that they could be open to this in the long term, but want to proceed cautiously, and make sure all implications are considered in advance. Kristine Bienert from the BC Utilities Commission noted that they are a regulator and not a policy-making body, but outlined several possible ways that such a change could come about.

5.3.3. Other Considerations

- If all cars in BC were electric, it would increase BC's power load by 17-18%, so BC Hydro is not concerned about capacity at system-wide level, although there may be some challenges at the distribution level.
- Car dealerships make small profit margins of 1-3% on the sale of new vehicles. They get larger profit margins on the sale of used vehicles, and a lot of their profits come from maintenance and servicing. Some interviewees suggested that electric vehicles tend to require less maintenance work, and thus, some dealers are reluctant to sell them.

Chapter 6.

Policy Options

Clearly there are many different types of policies that can support increased usage of electric vehicles, and some are already in place in BC. The existing policies include carbon taxes and gas taxes, a Low Carbon Fuel Standard, HOV lane access, purchase incentive rebates, the Emotive awareness campaign, incentives for installing charging stations in multi-unit residential buildings, and funding of public DC fast charger stations.

These policies help to address some key barriers, and are important elements of a strategy to promote electric vehicle usage. However, there are other significant barriers which current policies do not address. For that reason, I have excluded those existing policies from my analysis, and have chosen to focus my policy analysis on new potential policies that could address some of the barriers which existing policies cannot. This does not mean that existing policies should not be expanded or modified, but simply that opportunities for doing so will not be the focus of this analysis.

My analysis explores four policy options, which BC's provincial government could implement to address some of the barriers to electric vehicle adoption. These policies are not mutually exclusive, so the government could implement any combination of them. They have arisen mainly from my interviews, as well as from jurisdictional scans.

In this chapter I will outline these four policy options, then the next chapter will outline the criteria that I use to evaluate those policy options, and then the following chapter will provide my evaluation of those options.

6.1. Option 1: Zero-Emission Vehicle Mandate

One option would be for BC to implement a Zero-Emission Vehicle (ZEV) mandate, also known as a ZEV standard. BC already has legislation on the books for a ZEV mandate, which was passed in May 2008 as part of the “GHG Gas Reduction (Vehicle Emissions Standards) Act” (Bill 39, 2008). A government news release at the time noted that the Act “provides B.C. with authority to require larger vehicle manufacturers to include a percentage (or set number) of zero-emission vehicles in their fleets per year... based on California’s approach” (BC Ministry of Environment, 2008). However, despite the passage of that legislation, the policy was never actually implemented.

If implemented, it would essentially require that a certain percentage of vehicles sold in BC each year must be electric vehicles or other types of zero-emission vehicles (ZEVs), and the mandated percentage would increase over time. Automakers would be required to earn a set percentage of ZEV credits, either through selling electric vehicles or other zero-emission vehicles, or by purchasing credits from other automakers who have a surplus of them. Similar policies are in place in California and nine other states in the US, and in 2016, Quebec passed legislation to implement a ZEV mandate there as well.

The intention of this policy would be to increase the amount and variety of electric vehicles produced by manufacturers and made available to consumers. It would also be intended to incentivize dealerships to make more efforts to sell electric vehicles.

For my analysis, this option would involve implementing BC’s existing legislation for a ZEV mandate, and setting a schedule of yearly ZEV targets, which would have to be met by automakers who sell vehicles in BC.

6.2. Option 2: EV Charging Standards for New Residential Buildings

Many people lack access to EV charging infrastructure at their home, which poses a major barrier to electric vehicle adoption. This is particularly a concern for those living in apartments or other types of multi-unit residential buildings, although there are also so-called “garage orphans” who live in single family homes but lack convenient access to an electricity source for their vehicle, particularly if they park on the street.

Existing apartment buildings and condominiums were not built with electric vehicles in mind, so most parking spaces do not have an electrical outlet nearby. Even when they do, residents are not always allowed to use them to charge their vehicle.

It is significantly more cost-effective to incorporate EV charging infrastructure into the initial construction of a building, rather than to add it later on. The City of Vancouver estimates that “retrofitting existing buildings with electrical supply that supports EV charging is approximately 2.5 times as expensive as installing the same equipment in a new building” (City of Vancouver, 2016a). For this reason, requiring EV charging infrastructure to be included in new multi-unit residential buildings could help to ensure that in the future, more people will be able to charge a vehicle at home, thus making EVs a feasible option for more people.

According to my interviews, the provincial government has told municipalities that they can set their own requirements for EV charging infrastructure in new developments, but legislation does not explicitly give them that authority, so some municipalities might still have concerns about whether such policies would withstand a potential legal challenge (B. McEwen, personal communication, Feb 21, 2017). Having a clearer provincial policy could alleviate concerns about that risk.

One way to achieve this would be to make additions to the BC Building Code requiring new residential developments, including multi-family buildings, to provide EV charging infrastructure to a certain percentage of parking stalls. This could be a mandatory part of the BC Building Code, or more likely, it could be a voluntary add-on, so that each

municipality would have the option of whether to apply those requirements to new developments in their community.

For my analysis, this option would involve creating voluntary additions to the BC Building Code, which each municipality in BC would have the choice of whether or not to adopt. These additions would require developers to provide EV charging infrastructure in new multi-family residential developments for a certain percentage of parking spaces, akin to what Richmond, Vancouver, and the District of North Vancouver currently do.

6.3. Option 3: Amend the Strata Property Act to have a “Right to Charge” Policy

For those living in strata housing, another possible barrier is that their strata council may be resistant or uncooperative in regards to electric vehicle charging, and might block them from installing a charging station. This could deter those living in strata buildings from considering an EV, and it can create problems for those who already own an EV, and lack the ability to charge at home.

To address this, the BC government could amend the Strata Property Act to include a “Right to Charge” policy, which would prevent strata organizations from unreasonably restricting the installation of EV charging infrastructure in a resident’s parking spot. This type of policy has been implemented in Hawaii and in California. In Hawaii the policy ensures that “any person may place an electric vehicle charging system on or near the parking stall of any multi-family residential dwelling or townhouse unit owned by that person”, provided they meet certain conditions (Plug In America, 2012). Similarly, California’s policy makes it illegal for stratas to impose any condition that “effectively prohibits or unreasonably restricts” the installation of an EV charging station in an owner’s designated parking space (California Plug-In Electric Vehicle Collaborative, 2013).

For my analysis, this option would involve amending the Strata Property Act to include a “Right to Charge” policy like Hawaii’s or California’s.

6.4. Option 4: Exempt EV Charging Stations from the Utilities Commission Act

Another barrier is a lack of publicly accessible charging infrastructure. The deployment of new public charging stations is complicated by the BC Utilities Commission, since under the Utilities Commission Act, the re-sale of electricity in BC is essentially prohibited except by public utilities. The Act provides exceptions allowing municipalities to sell power, and allowing landlords to sell power to their tenants, but otherwise organizations cannot charge fees for electricity, unless they go through the regulatory process of becoming a public utility or applying for an exemption (K. Bienert, personal communication, Feb 23, 2017). These processes can be onerous and present a significant deterrent for private businesses who would otherwise be interested in installing EV charging stations. Without the ability to charge user fees for electricity usage, they cannot recover the installation costs of a station, nor the operating and maintenance costs.

Another consequence of these regulations is that it becomes more difficult to find suitable locations to install publicly-funded DC fast charger stations. Currently they tend to be placed on municipally-owned property, in order to be allowed to charge user fees. However if BC Hydro could partner with private sector or non-profit organizations as hosts for these stations, it would open up more potential locations (R. Abernethy, personal communication, Jan 12, 2017).

To address these concerns, the BC government could provide a class exemption for EV charging stations from being regulated under the Utilities Commission Act, and according to Kristine Bienert from the BC Utilities Commission, there are several ways this change could be made (K. Bienert, personal communication, Feb 23, 2017). This would increase opportunities for providing publicly accessible EV charging infrastructure, both within communities and along routes used mainly for intercity travel.

For my analysis, this option would involve amending the Utilities Commission Act to provide a class exemption for electric vehicle charging stations, so that organizations could charge user fees for electricity from charging stations, without going through the regulatory process of becoming a public utility or acquiring an exemption.

Chapter 7.

Evaluation Framework

This chapter outlines the criteria and measures that I use to evaluate the policy options. Although the policy options are very different from one another, by using the same criteria and measures for each one, we can try to evaluate their relative trade-offs, in order to inform policy recommendations and next steps.

7.1. Policy Effectiveness

This criterion assesses the relative impact that a policy could have on the rates of electric vehicle adoption in Metro Vancouver. This can be difficult to estimate, given that the rates of EV adoption in any jurisdiction are the result of decisions made by many individuals, each motivated by a variety of social and economic factors, which make it challenging to isolate the impact of any one policy. For this analysis, assessments of a policy's potential effectiveness will consider the ways in which a policy could address key barriers to EV adoption, and will be based on educated predictions, informed by my research.

There are numerous avenues through which a policy might be effective at influencing people's likelihood of buying electric vehicles, like by increasing the affordability of purchasing or owning an EV, increasing the convenience of owning an EV, increasing the availability of EVs, or increasing people's awareness and familiarity with electric vehicles.

We expect most policies to have some lag time between their implementation and their impact on the public's adoption of electric vehicles. Most policies that could be decided upon in 2017 would have little impact on EV adoption in 2017 or 2018, but could have more significant impacts on EV adoption in 2022, 2027, or 2023, for example.

For this reason, I have chosen to separately assess the effectiveness of each policy on two timeframes: the short term, meaning 0-5 years from its implementation; and the long term, meaning over 5-15 years. Measuring effectiveness over two separate timeframes increases the weight placed upon this criterion, and this seems appropriate, since increasing electric vehicle adoption is the main objective of this research project.

A policy that receives a “low” ranking is expected to have a small impact on EV adoption in the relevant timeframe compared to the other policies, a “medium” ranking means it is expected to have a moderate impact, and a “high” ranking indicates that a policy is expected to have a very significant impact. For a rough sense of how effectiveness would be measured, we will say that in the short term, over the next 5 years, a policy increasing the market share of electric vehicles by more than 2% would be considered “high”. In the long term, over the next 15 years, an increase of greater than 5% would be considered “high”. For example, if electric vehicles would reach a market share of 20% over the next 15 years without a policy in place, but reach 26% with it in place, then that policy will be considered to have a “medium” impact.

7.2. Budgetary Considerations

This criterion is based on the financial resources required by the provincial government to implement a policy option. It can also take into account indirect impacts on government revenue.

A policy that receives a “low” ranking is expected to impose significant costs on the provincial government, a “medium” ranking means it has potential to impose significant costs on the government, and a “high” ranking indicates that a policy is not expected to result in any significant costs to the government.

7.3. Ease of Implementation

This criterion assesses the relative complexity of implementing and administering a policy. A “low” ranking indicates that a policy would be difficult or complex to implement, a “medium” ranking means it would be moderately complex, and a “high” ranking indicates that a policy would be relatively easy to implement.

7.4. Stakeholder Acceptance

There are a variety of stakeholders who could be affected by policies relating to electric vehicles. This criterion will assess the relative acceptance or resistance that can be expected, from stakeholders who would be affected by each policy. The relevant stakeholders may be different for each policy.

A “low” ranking indicates that stakeholders are expected to be very opposed to a policy, a “medium” ranking means that stakeholders may have some moderate concerns, and a “high” ranking indicates that there would be minimal opposition from stakeholders.

Table 2: Policy Evaluation Framework

Objective	Criteria	Measure
Policy Effectiveness: Short Term	How much would this policy increase the adoption of electric vehicles, over the next 5 years?	High if estimated EV market share increases by >2%; medium if it increases by 1-2%; low if it increases by 0-1%
Policy Effectiveness: Long Term	How much would this policy increase the adoption of electric vehicles, over the next 15 years?	High if estimated EV market share increases by >5%; medium if it increases by 2-5%; low if it increases by 0-2%
Budgetary Considerations	How much would this policy cost the provincial government?	High if it is not expected to impose significant costs; medium if it has potential to impose significant costs; low if it is expected to impose significant costs
Ease of Implementation	How complex would this policy be to administer?	High if relatively simple; medium if moderately complex; low if very complex
Stakeholder Acceptance	What would be the reaction of stakeholders who are directly affected?	High if there would be support or minimal opposition from stakeholders; medium if there would be some opposition; low if stakeholders would be strongly opposed

Chapter 8.

Evaluation of Policy Options

This section evaluates each of the four policy options, according to the criteria previously outlined, in order to demonstrate the trade-offs of each policy.

Table 3: Summary of Evaluation of Policy Options

Objective	Option 1	Option 2	Option 3	Option 4
Policy Effectiveness: Short Term	High (3)	Low (1)	Low (1)	Low (1)
Policy Effectiveness: Long Term	High (3)	Medium (2)	Medium (2)	High (3)
Budgetary Considerations	Medium (2)	High (3)	High (3)	High (3)
Ease of Implementation	Medium (2)	Medium (2)	Medium (2)	Low (1)
Stakeholder Acceptance	Low (1)	High (3)	Medium (2)	Medium (2)

8.1. Option 1: Zero-Emission Vehicle Mandate

Policy Effectiveness

Based on my research, this policy would be very effective at increasing electric vehicle adoption. Many of my interviewees emphasized a ZEV mandate as a key policy that is missing in BC, which would help to spur greater adoption of EVs, and this is supported by other research (Wolinetza & Axsen, 2017). BC already has some policies intended to address the demand-side, such as purchase incentives and programs to increase the availability of charging infrastructure, but there is very little on the supply-side, to encourage dealerships and manufacturers to offer more electric vehicles. On the surface this might seem like an issue that the markets should successfully resolve on their

own, as supply should grow to meet the demand. However, it is important to recognize that demand is not a naturally arising phenomenon, and auto manufacturers and dealerships can influence consumers' preferences through their advertising, their choices of which vehicles to display and promote, and the information they provide to customers.

This policy would help to address some key barriers which are not well-addressed by current policies, specifically a lack of electric vehicles available, and resistance from some dealerships. Surveys and public outreach have indicated that the lack of electric vehicles available is a key barrier to EV adoption. A ZEV mandate could result in more models of EVs being offered in BC, and more EVs being available at dealerships.

Studies have also indicated that there is significant room for improving the electric vehicle sales experience at dealerships. Salespeople at many car dealerships have limited knowledge about electric vehicles, and are unable to offer as much assistance as they would to someone buying a gas-powered vehicle. In many cases they also neglect to mention some of the benefits of electric vehicles, including the rebates available (Lunetta, & Coplon-Newfield, 2016). One potential reason for resistance from dealerships is that their business model relies largely on doing maintenance work on cars, which means that EVs pose a challenge, because they tend to require less maintenance, and thus result in less service revenue for dealerships. Furthermore, electric vehicles are a newer and less familiar technology, so selling one to a customer may take more time and require more explaining, compared to selling a conventional vehicle. Thus, many dealers may feel little incentive to promote them to customers who would otherwise buy a conventional vehicle.

Implementing a ZEV mandate would help to overcome resistance from dealerships, by giving them a strong incentive to promote and encourage the sale of electric vehicles. My interviews and the existing literature indicate that this policy would have a significant effect on electric vehicle adoption in both the short term and the long term, more so than any other potential policy under consideration, so it rates as "high" for effectiveness on both time frames.

Budgetary Considerations

This policy is not expected to incur any direct costs to the provincial government, besides the costs of administering the program. However there is potential for this policy to lead to a reduction in PST revenues, if it causes an overall reduction in car sales in BC. In a 2016 submission to the Quebec government, regarding their plans for a ZEV mandate, the Canadian Vehicle Manufacturers' Association (CVMA) argued that this would indeed be the result of the policy. The CVMA argued that "in order to attain the prescribed plug-in to non-plug-in vehicle sales ratio", car dealers would significantly reduce the number of conventional vehicles that they sell, resulting in less sales tax revenues for the provincial government (Canadian Vehicle Manufacturers' Association, 2016).

That said, this outcome is not certain to occur, as it would depend on the specifics for how the ZEV mandate was implemented, as well as whether car dealers and manufacturers were successful at increasing their sales of zero-emission vehicles. Based on surveys about recent car buyers in British Columbia, it appears that there is significant latent demand for electric vehicles in British Columbia (Axsen, et al., 2015), which could be realized through increased availability at dealerships, increased numbers of models, increased advertising, and greater sales efforts at the dealerships.

This policy has the potential to reduce government revenues, but it might not actually do so, thus it rates as "medium" for budgetary considerations.

Ease of Implementation

Legislation for this policy was already passed by BC's provincial legislature in 2008, but it was never implemented, so this reduces the amount of work needed to bring the policy into effect. Administering a ZEV mandate has the potential to be fairly complex, as it would be a significant new program, and would require coordination with automakers and dealers, to impose the new regulatory requirements. That said, in my interview with Nick Clark from the BC Ministry of Energy and Mines, he suggested that a ZEV mandate would not necessarily be overly complex to administer, depending on the specifics of how the policy was set up.

This policy rates as “medium” for ease of implementation.

Stakeholder Acceptance

This option would face significant resistance from stakeholders, particularly the auto retail industry and the auto manufacturers, who would be impacted by this type of regulatory approach. In my interview with Blair Qualey from the New Car Dealers Association of BC, he made it clear that their industry is very opposed to this type of policy, and prefers for policymakers to focus on the demand-side, not the supply-side. Furthermore, a newsletter from the New Car Dealers Association of BC indicates that they successfully lobbied against a ZEV mandate and organized a write-in campaign against the policy, when it was under consideration by the BC government, prior to the 2016 release of BC’s Climate Leadership Plan (New Car Dealers Association of BC, 2016).

I did not speak with anyone representing the auto manufacturing industry, but it is clear that they would also oppose this policy. In a written submission to the Quebec government, the Canadian Vehicle Manufacturers’ Association raised concerns about Quebec’s plans for a ZEV mandate, arguing that it would be costly to their industry, and that it should not be implemented. They also urge that if Quebec does proceed with a ZEV mandate, that policymakers should modify the policy to make it less burdensome for automakers (Canadian Vehicle Manufacturers’ Association, 2016).

This policy rates as “low” for stakeholder acceptance.

8.2. Option 2: EV Charging Standards for New Residential Buildings

Policy Effectiveness

This policy would have very little impact in the short term, because it only applies to new developments. No existing buildings would be affected, so the policy would have no immediate impact on anyone's access to EV charging infrastructure. Given the numerous steps involved in approving and constructing a new development, it would likely be a few years before developments covered by these regulations would finish construction. When residents finally move in, it will finally be the first point at which the policy improves residents' access to EV charging, but even then, it is unlikely that many of those residents will have immediate plans to buy a new car. Thus, in total, it would be at least a few years before new building requirements would have any effect on EV adoption, and so the policy's effectiveness in the short term is "low".

However, in the long term, this policy could ultimately affect a large number of residents. Metro Vancouver's growth plans focus on accommodating population growth primarily through densification, so there will be many new multi-family residential developments in the region. Having charging access at home is a key factor in people's decision of whether or not to buy an electric vehicle. Thus, this has the potential to be very effective and have a large impact. However, if these requirements are not adopted by many municipalities then its impacts will be less significant. It is also likely that in the absence of provincial guidance on this issue, many Metro Vancouver municipalities will implement their own policies, as some have already done. Therefore, if the provincial requirements are not much stronger than the requirements that Metro Vancouver municipalities would otherwise set, then the long-term impacts of the policy will be less significant. Taking these factors into account, this policy's long term effectiveness rates as "medium".

Budgetary Considerations

This policy would not be expected to impose any significant costs on the provincial government, as no direct expenditures would be necessary. It is worth noting that enforcement of building codes is carried out by local governments.

This policy rates as “high” on this criterion.

Ease of Implementation

This policy would be expected to be relatively easy for the provincial government to implement, particularly given that the enforcement of building codes is carried out by local governments. The main challenges would be determining the specifications of the requirements, which would require significant consultation with municipalities and the development industry.

This policy rates as “high” on this criterion.

Stakeholder Acceptance

There may be some resistance from building developers, whose building construction costs would increase if they were required to provide electrical infrastructure to accommodate EV charging in new residential developments. However, cost estimates from the City of Port Coquitlam suggest that the costs imposed by such a policy would not be too high, depending on the specifics. The City of Port Coquitlam estimates that in multi-unit residential buildings, creating “rough-ins” for Level 2 charging would cost \$200-\$1150 per parking space, which would equal about 0.17%-0.66% of total development costs, if required for all parking spaces. However to retrofit later on, the costs for “rough-ins” would be in the range of \$1500-\$16,000 per parking space (City of Port Coquitlam, 2017).

Furthermore, the approach of making this a voluntary addition to the building code would help to improve acceptance by stakeholders, since each municipal council could

decide whether or not the requirements were appropriate for their community. This seems reasonable given the geographic diversity of BC. The requirements might be appropriate within Metro Vancouver, but not so much in remote northern communities, for example, which are less likely to see widespread adoption of EVs any time soon.

In communities that did implement these standards, they would provide more policy uniformity and predictability for the development industry, which might make it simpler for them to plan projects, rather than facing a piecemeal mix of EV infrastructure requirements that vary from one municipality to the next.

This policy rates as “high” for stakeholder acceptance.

8.3. Option 3: Amend the Strata Property Act to have a “Right to Charge” Policy

Policy Effectiveness

In the short term, this policy’s effectiveness rates as “low”. It is unlikely to have much impact on EV adoption, since It is unlikely to be well-known among the public. It would mainly help strata residents who already own an electric vehicle or are very close to buying one, and are actively trying to install charging infrastructure, but have been blocked by their strata. It is not clear that there are a lot of people in this situation.

That said, it would remove a barrier that some EV owners or potential owners do face. In the longer term, it could have more impact on EV adoption, partly because it would normalize the process of installing electric vehicle infrastructure in a strata building. Another reason is that the infrastructure installed by the early adopters could help to reduce the costs of installing additional charging infrastructure, thus making it more feasible for other residents in their building to do so later.

In the long term, this policy’s effectiveness is expected to be “medium”.

Budgetary Considerations

This policy change would not be expected to result in any direct budgetary costs for the provincial government, so it rates as “high” on this criterion.

Ease of Implementation

This policy could be somewhat complicated to implement, due to the complexity of strata law. For example, California first passed legislation for this policy in 2011, but then revised it in 2012 with new legislation, clarifying that while residents cannot be prohibited from installing charging infrastructure in their own parking space, stratas can still impose restrictions on the use of common areas of parking lots (Swedelson, 2012).

This policy would require consultation with strata organizations, before passing the new legislation. The government would need to provide information and assistance to strata organizations to ensure they understand the implications of the legislation, to prevent legal disputes from arising later. The government could help stratas by providing sample by-laws, which strata organizations could use to clarify their new policies for installing EV charging stations, and replace the old by-laws that would now be void.

This policy rates as “medium” on this criterion.

Stakeholder Acceptance

There may be resistance from some strata organizations with concerns about the implications of a policy like this, who may be concerned that the installation or the subsequent electricity usage would impose costs on the strata. They may regard this policy as infringing on their strata’s autonomy and right to decide its own policies. For this reason, stakeholder acceptance for this policy is expected to be “medium”.

8.4. Option 4: Exempt EV Charging Stations from the Utilities Commission Act

Policy Effectiveness

In the short term, this policy would not be expected to have a significant impact on electric vehicle adoption, and rates as “low”. Numerous people I interviewed suggested that there is not yet a strong business case for private provision of charging stations, due to the relative scarcity of electric vehicles. Alec Tsang from BC Hydro raised the examples of California and Illinois, which he says have de-regulated electricity markets such that private businesses are allowed to charge tariffs for electricity from EV charging stations, but businesses there have not yet found it to be a viable venture. He speculated that it may be up to 10 years before there will be a sustainable business model for it, and that until then, charging stations will require government funding. The City of Vancouver is somewhat more optimistic, estimating that there will be a market large enough to support private sector investment in 5-7 years (City of Vancouver, 2016a).

One benefit this policy could offer in the short term is that it might become easier to find potential locations for the government-funded network of DC fast charger stations, since government and BC Hydro would be able to partner with private businesses to host public stations on their property. There is already one example of this in BC, as Bakerview EcoDairy farm applied and got an exemption from the BC Utilities Commission, allowing them to charge users fees at an EV charging station that they are hosting, in partnership with BC Hydro. A class exemption could open up more opportunities than the current situation, where they typically need to find municipally-owned properties to host stations.

In the long term, this policy change could have a significant impact on EV usage, by increasing the prevalence of EV charging stations, through enabling provision by private businesses. This would reduce people’s concerns about range anxiety and a lack of charging infrastructure, and it would make EV ownership more convenient, due to the ease of finding charging stations. This would also help to raise awareness and interest in

electric vehicles, as non-EV drivers would see charging stations more often in their daily lives. Eventually, for electric vehicles to take on a more commanding share of the personal vehicle market and meet more people's needs, publicly accessible EV charging infrastructure will need to become much more common, and this type of change to utility regulations will be needed. Allowing private sector businesses to sell electricity at EV charging stations will be very helpful in developing an network of Level 2 and 3 charging stations throughout Metro Vancouver, and also in providing charging stations along major highway routes around the rest of BC.

Thus, for long term effectiveness, this policy rates as "high".

Budgetary Considerations

No significant budgetary costs are anticipated, as this would be a regulatory change with no associated funding costs. On this criterion, this policy rates as "high".

Ease of Implementation

Based on my interviews, this policy would have a lot of potential implications that need to be considered and planned for, which increases the complexity. These include questions about the intended market structure, and possible issues with BC Hydro competing against private companies downstream of an electrical meter. There may also be questions about how to ensure accurate measuring of electricity at EV charging stations, to protect consumers.

The policy change itself might not be particularly complex to implement, depending on how they go about it. Furthermore, once implemented, this change would not be expected to pose an additional administrative burden. In fact, having a class exemption for EV charging stations could reduce regulatory work at the BC Utilities Commission, since future charging stations would not need to be regulated by them, and would not need to apply for exemptions from their regulations.

Given that this policy change involves multiple government organizations, and there are numerous regulatory issues to clear up in advance, this policy rates as “low” for ease of implementation.

Stakeholder Acceptance

Stakeholder acceptance is expected to be “medium”. Based on my interviews with officials from BC Hydro, the BC Ministry of Energy and Mines, and the BC Utilities Commission, it does not appear that there would be a lot of stakeholder opposition, except that BC Hydro prefers that this issue be handled cautiously for now.

In 2016, the BC Utilities Commission granted Bakerview EcoDairy, a non-profit agricultural organization in Abbotsford, with an exemption to Part 3 of the Utilities Commission Act, allowing it to sell electricity from a DC fast charger that was installed there. In submissions to that application process, BC Hydro expressed that it was not opposed to that exemption for Bakerview EcoDairy, but cautioned that it was too soon for a broader class exemption for EV charging infrastructure, saying that “there remain significant uncertainties regarding the appropriate market structure and regulatory framework going forward” (Loski, 2016). In my interview with Alec Tsang from BC Hydro, he suggested that while they prefer to move slowly and cautiously, BC Hydro is not fundamentally opposed to such a change and could be open to a class exemption down the road.

Otherwise, there are no obvious stakeholders for whom this policy would be a concern, and it is likely that many private businesses would favour this policy, in order to provide charging stations in the future.

Chapter 9.

Policy Recommendations

All four of these policies would help to increase EV adoption in Metro Vancouver, but a ZEV mandate should be a top priority. It has real trade-offs, including resistance from affected stakeholders like the auto dealers and manufacturers, but it would ultimately be the most effective new policy for boosting electric vehicle usage, in both the short and long term.

The other top priority should be establishing provincial standards for EV charging infrastructure in new multi-unit residential buildings. This policy could be voluntary, such that each municipality could choose whether it wishes to adopt these EV-related requirements as an addition to the BC Building Code. The policy should also not prevent municipalities from setting even stricter EV-charging requirements, if they wish to go beyond the provincial standards. This policy would not have any immediate impact on electric vehicle usage, since it would only affect future developments. That said, the lag time between this policy and its effects is inevitable, so it should be implemented as soon as possible, because the later that it is implemented, the later that its impacts will materialize.

Adding a “Right to Charge” policy to the Strata Property Act is not likely to have as much effect on electric vehicle adoption, compared to the other policies considered, so it does not need to be as high of a priority. That said, it would still be helpful to current and future EV owners who live in strata buildings, and should be implemented at some point.

Changing the Utilities Commission Act would ultimately be very useful, but it does not need to be the immediate priority. It is expected to have relatively little impact on EV usage in the short term, as there is not yet a strong business case for private companies to provide stations, due to the small number of EVs on the roads. However, in the long term, once more electric vehicles are on the roads, a policy change of this sort would be very impactful, because it could lead to a proliferation of publicly accessible charging stations provided by private businesses. Therefore, the BC government should certainly

explore its options for how to give EV charging stations a class exemption from the Utilities Commission Act, but this policy is less of an immediate priority than implementing a ZEV mandate or creating a voluntary set of EV-related additions to the building code.

For the ZEV mandate, many questions about its implementation will need to be considered. In which year should it take effect? How quickly should the requirements escalate? Should the program be integrated with Quebec's program, or should it be kept separate? Should vehicle manufacturers be provided with a bank of credits at the start of the program, to ease the transition? These questions will require further consideration and analysis, and consultation with stakeholders. It would also be helpful to study in detail the experience of California and other states, which have already implemented a policy like this.

For the additions to the building code, many specifics will need to be sorted out. What percentage of parking stalls should the requirements apply to? Should the requirements be for Level 1 charging, Level 2 charging, or a mix of each? How many of the parking spots should have charging infrastructure installed by the developer, and how many can simply have the preparatory work done to enable future installations?

Chapter 10.

Conclusions and Further Considerations

There are many angles of this topic that I did not get to explore in this research project. It would be useful to explore the potential for car-sharing services to utilize electric vehicles, particularly given that Vancouver is one of the top cities in North America for car sharing.

Another avenue for future work would be to explore the potential impacts of autonomous vehicles, since that type of technological change has the potential to dramatically reshape urban transportation systems, and could have implications for policies aimed at facilitating electric vehicles. For example, policies that require EV charging infrastructure in homes might become less useful in the long run, if society shifts away from personal ownership of vehicles, towards a vehicle-on-demand model.

My analysis focused on electric light duty motor vehicles, and did not explore issues relating to electric bicycles, or electric freight transportation. It also focused on enabling public adoption of electric vehicles, and did not explore issues related to incorporating EVs into corporate-owned or government-owned vehicle fleets.

Further research could explore the experiences of other jurisdictions in greater depth, by interviewing people involved in the policymaking process, to understand the challenges they had to overcome, whether those challenges were economic, political, administrative, or anything else. Future research could also investigate more specific questions about how these new policies should be implemented.

Finally, future research could explore the policy implications of emerging technologies or techniques relating to electric vehicles, such as roadside charging, wireless charging, or very high-voltage charging stations.

References

- Auto Outlook, Inc. (2017, February). *California Auto Outlook Volume 13, Number 1*. Retrieved March 15, 2017, from California New Car Dealers Association website: <http://www.cncda.org/CMS/Pubs/CA%20Auto%20Outlook%20Q%202016.pdf>
- Axsen, J., Goldberg, S., & Bailey, J. (2016). How might potential future plug-in electric vehicle buyers differ from current "Pioneer" owners? *Transportation Research Part D: Transport and Environment*, 47, 357-370. doi:10.1016/j.trd.2016.05.015
- Axsen, J., Goldberg, S., Bailey, J., Kamiya, G., Langman, B., Cairns, J., Wolinetz, M., & Miele, A. (2015). Electrifying Vehicles: Insights from the Canadian Plug-in Electric Vehicle Study. Retrieved March 15, 2017, from: [http://rem-main.rem.sfu.ca/papers/jaxsen/Electrifying_Vehicle_\(Early_Release\)-The_2015_Canadian_Plug-in_Electric_Vehicle_Study.pdf](http://rem-main.rem.sfu.ca/papers/jaxsen/Electrifying_Vehicle_(Early_Release)-The_2015_Canadian_Plug-in_Electric_Vehicle_Study.pdf)
- Axsen, J., Goldberg, S., & Melton, N. (2016, November). *Canada's Electric Vehicle Policy Report Card*. Retrieved March 15, 2017, from Sustainable Transportation Action Research Team website: <https://sfustart.files.wordpress.com/2016/11/canadas-electric-vehicle-policy-report-card.pdf>
- Axsen, J., & Kurani, K. S. (2012). Who can recharge a plug-in electric vehicle at home? *Transportation Research Part D: Transport and Environment*, 17(5), 349-353. doi:10.1016/j.trd.2012.03.001
- BC Hydro. (n.d.-a). How to charge an electric vehicle. Retrieved March 16, 2017, from <https://www.bchydro.com/powersmart/electric-vehicles/charging/how-to-charge.html>
- BC Hydro. (n.d.-b). Residential Rates. Retrieved April 22, 2017, from <https://www.bchydro.com/accounts-billing/rates-energy-use/electricity-rates/residential-rates.html>
- BC Hydro. (2016, April 22). *Earth Day news - B.C. records cleanest year in a decade for power production* [Press release]. Retrieved March 15, 2017, from: https://www.bchydro.com/news/press_centre/news_releases/2016/earth-day-news.html
- BC Ministry of Environment. (2012). *British Columbia Greenhouse Gas Inventory Report 2012*. Retrieved April 22, 2017, from: <http://www2.gov.bc.ca/assets/gov/environment/climate-change/data/provincial-inventory/2012/pir-2012-full-report.pdf>

- BC Ministry of Environment. (2008, April 29). *Legislation Introduced to Cut Vehicle Emissions* [Press release]. Retrieved March 15, 2017, from: https://archive.news.gov.bc.ca/releases/news_releases_2005-2009/2008ENV0049-000653.htm
- BC Ministry of Environment. (2015, December 10). *B.C. joins international alliance for zero-emission vehicles* [Press release]. Retrieved March 15, 2017, from: <https://news.gov.bc.ca/releases/2015ENV0081-002066>
- BC Ministry of Finance. (2016, August). *Bulletin MFT-CT 005: Tax Rates on Fuels*. Retrieved March 15, 2017 from: http://www.sbr.gov.bc.ca/documents_library/bulletins/mft-ct_005.pdf
- Bill 39: 2008 Greenhouse Gas Reduction (Vehicle Emissions Standards) Act.* (2008). 3rd Reading May 21, 2008, 38th Parliament, 4th session. Retrieved from the Legislative Assembly of British Columbia website: https://www.leg.bc.ca/pages/bclass-legacy.aspx#/content/legacy/web/38th4th/3rd_read/gov39-3.htm
- California Plug-In Electric Vehicle Collaborative (2013, November). *Plug-in Electric Vehicle Charging Plug-in Electric Vehicle Charging Infrastructure Guidelines for Infrastructure Guidelines for Multi-unit Dwellings*. Retrieved March 15, 2017, from: http://www.pevcollaborative.org/sites/all/themes/pev/files/docs/MUD_Guidelines4web.pdf
- Canadian Vehicle Manufacturers' Association. (2016, August 16). *CVMA Bill 104 Submission to Quebec National Assembly Committee*. Retrieved March 15, 2017, from: http://cvma.ca/en/downloads/QC_Bill_104_CVMA.pdf
- City of Burnaby. (2016, November 7). *Burnaby Community Energy and Emissions Plan*. Retrieved March 15, 2017 from: <https://www.burnaby.ca/Assets/city+services/policies+projects+and+initiatives/environment/Approved+CEEP.pdf>
- City of Port Coquitlam. (2017, January 27). *Report to Smart Growth Committee, Subject: Electric Vehicle Charging Infrastructure*. Retrieved March 15, 2017 from: [http://www.portcoquitlam.ca/Assets/\(SGC\)+Smart+Growth+Committee/2017-02-02+Smart+Growth+Committee+Agenda.pdf](http://www.portcoquitlam.ca/Assets/(SGC)+Smart+Growth+Committee/2017-02-02+Smart+Growth+Committee+Agenda.pdf)
- City of Richmond. (2012, November 19). *Official Community Plan (OCP) Schedule 1 of Bylaw 9000: 2041 OCP - Moving Towards Sustainability*. Retrieved March 15, 2017, from: http://www.richmond.ca/__shared/assets/OCP_9000_consolidation34181.pdf

- City of Richmond. (2016, December 12). *Report to Committee, Re: Electric Vehicle Charging Infrastructure in Private Developments*. Retrieved March 15, 2017, from:
http://www.richmond.ca/__shared/assets/_9_ElectricVehicleCharging_PrivateDev46263.pdf
- City of Vancouver. (2016a, November). *Vancouver's EV Ecosystem Strategy*. Retrieved March 15, 2017, from: <http://vancouver.ca/files/cov/EV-Ecosystem-Strategy.pdf>
- City of Vancouver. (2016b, November 16). *EV Ecosystem Strategy - Sustainability Group Report to Council*. Retrieved March 15, 2017, from:
<http://vancouver.ca/files/cov/ev-ecosystem-strategy-council-presentation.pdf>
- Clean Energy Vehicle Program. (n.d.). Retrieved March 19, 2017, from the Government of British Columbia website:
<http://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/transportation-energies/clean-transportation-policies-programs/clean-energy-vehicle-program>
- CEVforBC™ Vehicle Incentive Program. (n.d.). Retrieved March 19, 2017, from the Government of British Columbia website:
<http://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/transportation-energies/clean-transportation-policies-programs/clean-energy-vehicle-program/cev-for-bc>
- Climate Leadership Team. (2015, October 31). *Climate Leadership Team: Recommendations to Government*. Retrieved March 15, 2017, from:
http://engage.gov.bc.ca/app/uploads/sites/116/2015/11/CLT-recommendations-to-government_Final.pdf
- Cobb, J. (2017, January 17). *The World Just Bought Its Two-Millionth Plug-in Car*. Retrieved March 15, 2017, from Hybrid Cars website:
<http://www.hybridcars.com/the-world-just-bought-its-two-millionth-plug-in-car/>
- Cobb, J. (2015, August 4). *2016 Chevrolet Volt Rated For 53 Miles Electric Range*. Retrieved March 15, 2017, from Hybrid Cars website:
<http://www.hybridcars.com/2016-chevrolet-volt-rated-for-53-miles-electric-range/>
- District of North Vancouver. (2014, December 15). *Administrative and Operational Policy - Implementation of Electric Vehicle Charging Infrastructure with Development*. Retrieved March 15, 2017, from:
<https://www.dnv.org/sites/default/files/edocs/electric-vehicle-charging-infrastructure-policy.pdf>

- Electric Vehicles: Tax Credits and Other Incentives. (n.d.). Retrieved March 18, 2017, from the US Department of Energy website:
<https://energy.gov/eere/electricvehicles/electric-vehicles-tax-credits-and-other-incentives>
- Emissions from Hybrid and Plug-In Electric Vehicles. (2017). Retrieved April 27, 2017, from the U.S. Department of Energy website:
http://www.afdc.energy.gov/vehicles/electric_emissions.php
- Figenbaum, E. (2016). Perspectives on Norway's supercharged electric vehicle policy. *Environmental Innovation and Societal Transitions*.
doi:10.1016/j.eist.2016.11.002
- Firby, D. (2017, March 6). Why the future of cars is electric. *The Globe and Mail*. Retrieved March 15, 2017, from: <http://www.theglobeandmail.com/globe-drive/why-the-future-of-cars-is-electric/article34226779/>
- Fraser Basin Council. (2015, August 31). *A Gap Analysis For B.C.'s Electric Vehicle Direct Current Fast Charging Network*. Retrieved March 15, 2017, from Plug In BC website: http://pluginbc.ca/wp/wp-content/uploads/2015/10/BC-DCFC-Gap-Analysis-Report-FBC_Aug-2015.pdf
- Frydenlund, S. (2017, January 5). *Elbilsalget: Ned i fjor – venter ny vekst i år* [EV Sales: Down last year - awaiting new growth this year]. Retrieved March 15, 2017, from: <http://elbil.no/elbilsalget-ned-i-fjor-venter-ny-vekst-i-ar/>
- Fuel Consumption Taxes in Canada. (2016, November 16). Retrieved March 15, 2017, from the Natural Resources Canada website: <http://www.nrcan.gc.ca/energy/fuel-prices/18885>
- Ghoussoub, M. (2017, February 3). B.C. residents now have up to \$11K incentive to trade in a gas guzzler for an electric vehicle. Retrieved March 16, 2017, from: <http://www.cbc.ca/news/canada/british-columbia/b-c-residents-now-have-up-to-11k-incentive-to-trade-in-a-gas-guzzler-for-an-electric-vehicle-1.3965880>
- Global Automakers of Canada. (2017, January 4). *Canadian Auto Sales Set 4th Straight Record in 2016 Reaching 1.95 Million Units* [Press release]. Retrieved March 15, 2017, from: http://www.globalautomakers.ca/files/2016stats/dec2016_release%20.pdf
- Government of British Columbia. (2015, July 9). *British Columbia's Clean Energy Vehicle Program - Phase 1 Review*. Retrieved March 15, 2017, from: http://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/electricity-alternative-energy/transportation/cev_phase_1_review_final_2.pdf

- Government of British Columbia. (2016, August). *Climate Leadership Plan*. Retrieved March 15, 2017, from: https://climate.gov.bc.ca/wp-content/uploads/sites/13/2016/10/4030_CLP_Booklet_web.pdf
- Government of Canada. (2016). *The Pan-Canadian Framework on Clean Growth and Climate Change: Canada's Plan to Address Climate Change and Grow the Economy*. Retrieved March 15, 2017, from: http://publications.gc.ca/collections/collection_2017/eccc/En4-294-2016-eng.pdf
- Green, E. H., Skerlos, S. J., & Winebrake, J. J. (2014, February). Increasing electric vehicle policy efficiency and effectiveness by reducing mainstream market bias. *Energy Policy*, 65, 562-566. doi:10.1016/j.enpol.2013.10.024
- Hydro Québec. (2016). *Comparison of Electricity Prices in Major North American Cities*. Retrieved April 22, 2017, from: http://www.hydroquebec.com/publications/en/docs/comparaison-electricity-prices/comp_2016_en.pdf
- International Energy Agency. (2016). *Global EV Outlook 2016: Beyond 1 million electric cars*. Retrieved March 15, 2017, from: https://www.iea.org/publications/freepublications/publication/Global_EV_Outlook_2016.pdf
- Klippenstein, M. (2017). *Canadian EV Sales* [Online Spreadsheet]. Retrieved March 15, 2017, from: https://docs.google.com/spreadsheets/d/1dLFJwZVdvNLRpmZqPznIzz6PB9eHMe5b-bai_ddRsNg/edit#gid=5
- Krupa, J. S., Rizzo, D. M., Eppstein, M. J., Lanute, D. B., Gaalema, D. E., Lakkaraju, K., & Warrender, C. E. (2014). Analysis of a consumer survey on plug-in hybrid electric vehicles. *Transportation Research Part A: Policy and Practice*, 64, 14-31. doi:10.1016/j.tra.2014.02.019
- Langbroek, J. H., Franklin, J. P., & Susilo, Y. O. (2016, July). The effect of policy incentives on electric vehicle adoption. *Energy Policy*, 94, 94-103. doi:10.1016/j.enpol.2016.03.050
- Loski, T. (2016, February 5). *Bakerview EcoDairy Exemption Application Exhibit C1-3*. Retrieved March 19, 2017, from BC Utilities Commission website: http://www.bcuc.com/Documents/Proceedings/2016/DOC_45660_C1-3_BCH-Response-to-BCUC.pdf
- Lunetta, M., & Coplon-Newfield, G. (2016). Rev Up Electric Vehicles: Multi-State Study of the Electric Vehicle Shopping Experience. Retrieved March 16, 2017, from Sierra Club website: http://sierraclub.org/sites/www.sierraclub.org/files/uploads-wysiwig/1371%20Rev%20Up%20EVs%20Report_09_web%20FINAL.pdf

- McKinsey & Company. (2017, January). *Electrifying insights: How automakers can drive electrified vehicle sales and profitability*. Retrieved March 15, 2017, from: <http://www.mckinsey.com/industries/automotive-and-assembly/our-insights/electrifying-insights-how-automakers-can-drive-electrified-vehicle-sales-and-profitability>
- Meager, J. (2015, October 10). Quebec announces five-year car-electrification program. *Montreal Gazette*. Retrieved March 15, 2017, from: <http://montrealgazette.com/news/local-news/quebec-announces-five-year-car-electrification-program>
- Metro Vancouver. (2013). *Caring for the Air 2013 Report*. Retrieved March 15, 2017, from: http://www.metrovancouver.org/services/air-quality/AirQualityPublications/Caring_for_the_Air-MV2013.pdf
- New Car Dealers Association of BC. (2016). *Signals: November-December 2016*. Retrieved April 22, 2017, from: http://www.newcardealers.ca/wp-content/uploads/2015/05/Nov-Dec_2016_Signals_WebRes.pdf
- NOAA National Centers for Environmental Information. (2017, January). *State of the Climate: Global Analysis for Annual 2016*. Retrieved March 15, 2017, from: <http://www.ncdc.noaa.gov/sotc/global/201613>
- Ontario Ministry of Transportation. (2017, January). *Electric Vehicle Incentive Program (EVIP) Program Guide*. Retrieved March 15, 2017, from: [http://www.forms.ssb.gov.on.ca/mbs/ssb/forms/ssbforms.nsf/GetFileAttach/023-2096E~3/\\$File/2096E_Guide.pdf](http://www.forms.ssb.gov.on.ca/mbs/ssb/forms/ssbforms.nsf/GetFileAttach/023-2096E~3/$File/2096E_Guide.pdf)
- Phillips, L. (2015, October 26). *Norway's Electric Vehicle Revolution: Lessons for British Columbia* (Issue brief No. 43). Retrieved September 5, 2016, from Pacific Institute for Climate Solutions website: <http://deslibris.ca.proxy.lib.sfu.ca/ID/248993>
- Plug In America. (2012). *Hawaii EV Ready: Guidebook for Commercial Electric Vehicle Charging Station Installations*. Retrieved March 17, 2017 from Hawaii State Energy Office website: https://energy.hawaii.gov/wp-content/uploads/2011/09/updated-EV-Guidebook_FINAL_Sep-25_2012.pdf
- Reyes, J. R., Parsons, R. V., & Hoemsen, R. (2016). Winter Happens: The Effect of Ambient Temperature on the Travel Range of Electric Vehicles. *IEEE Transactions on Vehicular Technology*, 65(6), 4016-4022. doi:10.1109/tvt.2016.2544178
- Rivers, N. (2012, September 10). *Overlapping national and sub-national environmental policies: Climate change policy in Canada*. Unpublished manuscript, University of Ottawa. Retrieved March 15, 2017, from: <https://sites.google.com/site/nicholasrivers/home/research/files/overlap2012.pdf>

- San Francisco Office of the Mayor. (2017, February 28). *Mayor Lee and Supervisor Katy Tang Introduce Legislation Requiring All New Buildings to be 100% "Electric Vehicle Ready"* [Press Release]. Retrieved March 18, from: <http://sfmayor.org/article/mayor-lee-and-supervisor-katy-tang-introduce-legislation-requiring-all-new-buildings-be-100>
- Schwartz, J. (2016, October 3). A Milestone for Carbon Dioxide in the Atmosphere. *The New York Times*. Retrieved March 15, 2017, from: <http://www.nytimes.com/2016/10/04/science/atmospheric-carbon-dioxide-400-ppm.html>
- Swedelson, D.C. (2012, March 8). Governor Brown Signs SB 880 Dealing With Electric Vehicle Charging Stations. Retrieved March 18, 2017, from: http://www.hoalawblog.com/2012/03/governor_brown_signs_sb_880_de.html
- Translink. (2013a, June 12). *Regional Transportation Strategy Backgrounder #5: How and Why People Travel*. Retrieved March 15, 2017, from: http://www.translink.ca/~media/Documents/plans_and_projects/regional_transportation_strategy/Backgrounders/How_and_Why_People_Travel_Backgrounder.a shx
- Translink. (2013b, June 12). *Regional Transportation Strategy Backgrounder #1: Vision, Goals, and Targets*. Retrieved March 15, 2017, from: http://www.translink.ca/~media/Documents/plans_and_projects/regional_transportation_strategy/Backgrounders/Vision_Goals_and_Targets_Backgrounder.ashx
- Turrentine, T., Kurani, K., & Heffner, R. (2007). Fuel economy: What drives consumer choice? *Access*, 31, 14–19. Retrieved March 15, 2017, from: <http://escholarship.org/uc/item/6px5x20x#page-1>
- UNFCCC. (2015). *Paris Declaration on Electro-Mobility and Climate Change & Call to Action*. Retrieved March 15, 2017, from: <http://newsroom.unfccc.int/media/521376/paris-electro-mobility-declaration.pdf>
- What is ZEV? (2016, October 31). Retrieved from the Union of Concerned Scientists website: <http://www.ucsusa.org/clean-vehicles/california-and-western-states/what-is-zev>
- Wolinetz, M., & Axsen, J. (2017, April). How policy can build the plug-in electric vehicle market: Insights from the REspondent-based Preference And Constraints (REPAC) model. *Technological Forecasting and Social Change*, 117, 238-250. doi:10.1016/j.techfore.2016.11.022
- WWF-Canada. (2014, October). *Transportation rEvolution: Electric Vehicle Status Update 2014*. Retrieved March 15, 2017, from: http://awsassets.wwf.ca/downloads/wwf_ev_progress_update_report_2014_2.pdf

Appendix A.

Interview Participants

- Don Chandler, former President of the Vancouver Electric Vehicle Association
- Rebecca Abernethy, former Environmental Policy Analyst with the Fraser Valley Regional District
- Suzanne Goldberg, Director of Research and Outreach and an Adjunct Professor at Simon Fraser University's Sustainable Transportation and Research Team (START)
- Ian Neville, Climate Policy Analyst at the City of Vancouver
- Alec Tsang, Electric Vehicle Infrastructure Program Manager at BC Hydro
- Blair Qualey, President and CEO of the New Car Dealers Association of BC
- Nick Clark, Senior Policy Analyst at the Alternative Energy Unit of BC's Ministry of Energy and Mines
- Brendan McEwen, Sustainability Manager at the City of Richmond
- BC government employee [*name undisclosed*]
- Eve Hou, Air Quality Planner at Metro Vancouver
- Kristine Bienert, Director of Compliance at BC Utilities Commission

Appendix B.

Table of Electric Vehicle Sales Data in Canada

	EV market share in 2016	Number of EVs sold from 2011 to 2016
Canada	0.54%	27,366
BC	0.95%	5,208
Alberta	0.15%	700
Sask	0.05%	71
Manitoba	0.09%	151
Ontario	0.40%	8,579
Quebec	1.03%	12,459
Atlantic Canada	0.05%	190

Source: Klippenstein, 2017

Appendix C

Policy Options Excluded from the Analysis

- Carbon taxes or gas taxes
- Low Carbon Fuel Standard
- Driving-related perks or incentives
- Purchase rebates
- Information and awareness campaigns
- Rebates for EV charging retrofits
- Funding a network of DC fast charger stations along intercity routes