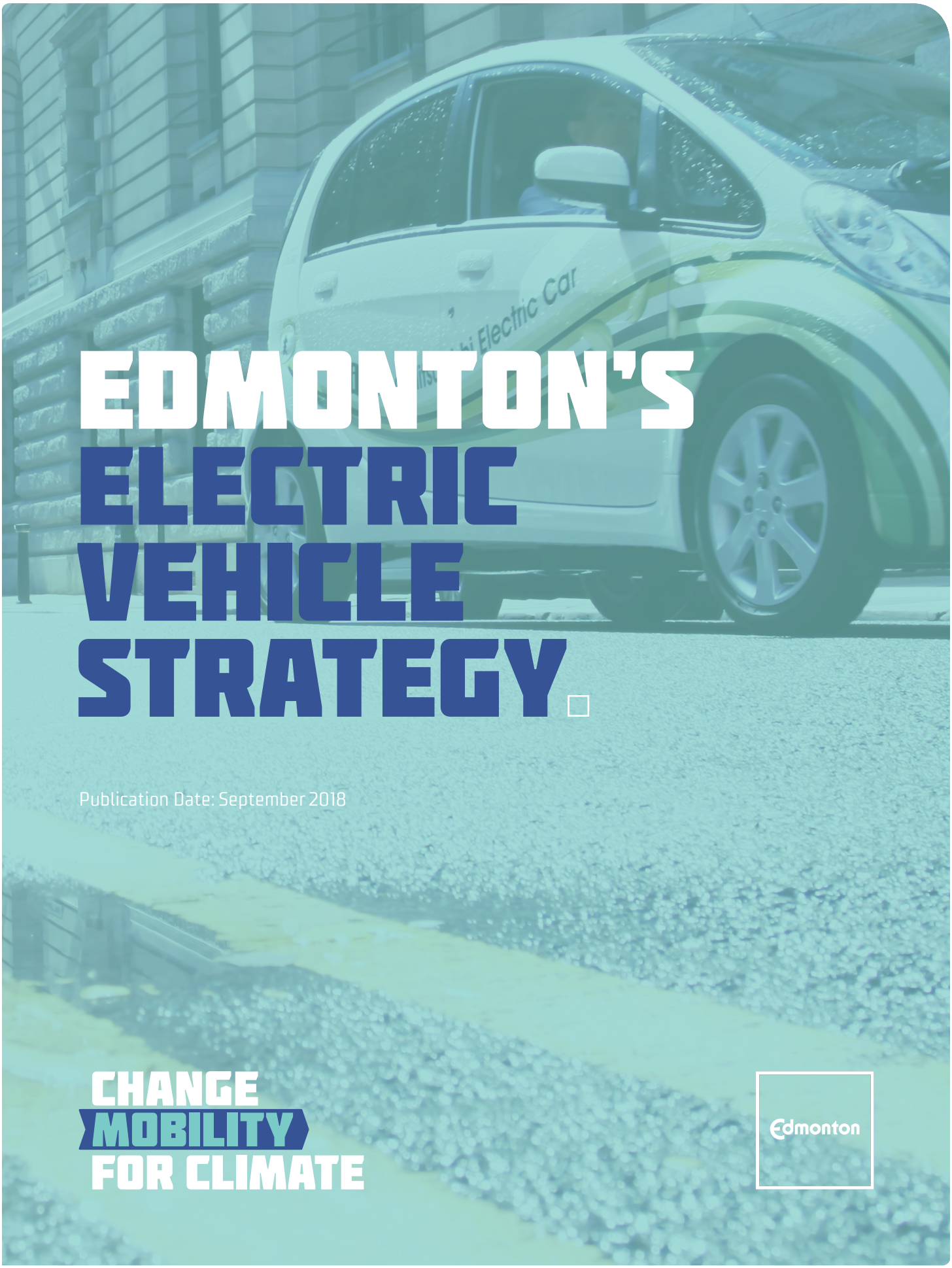
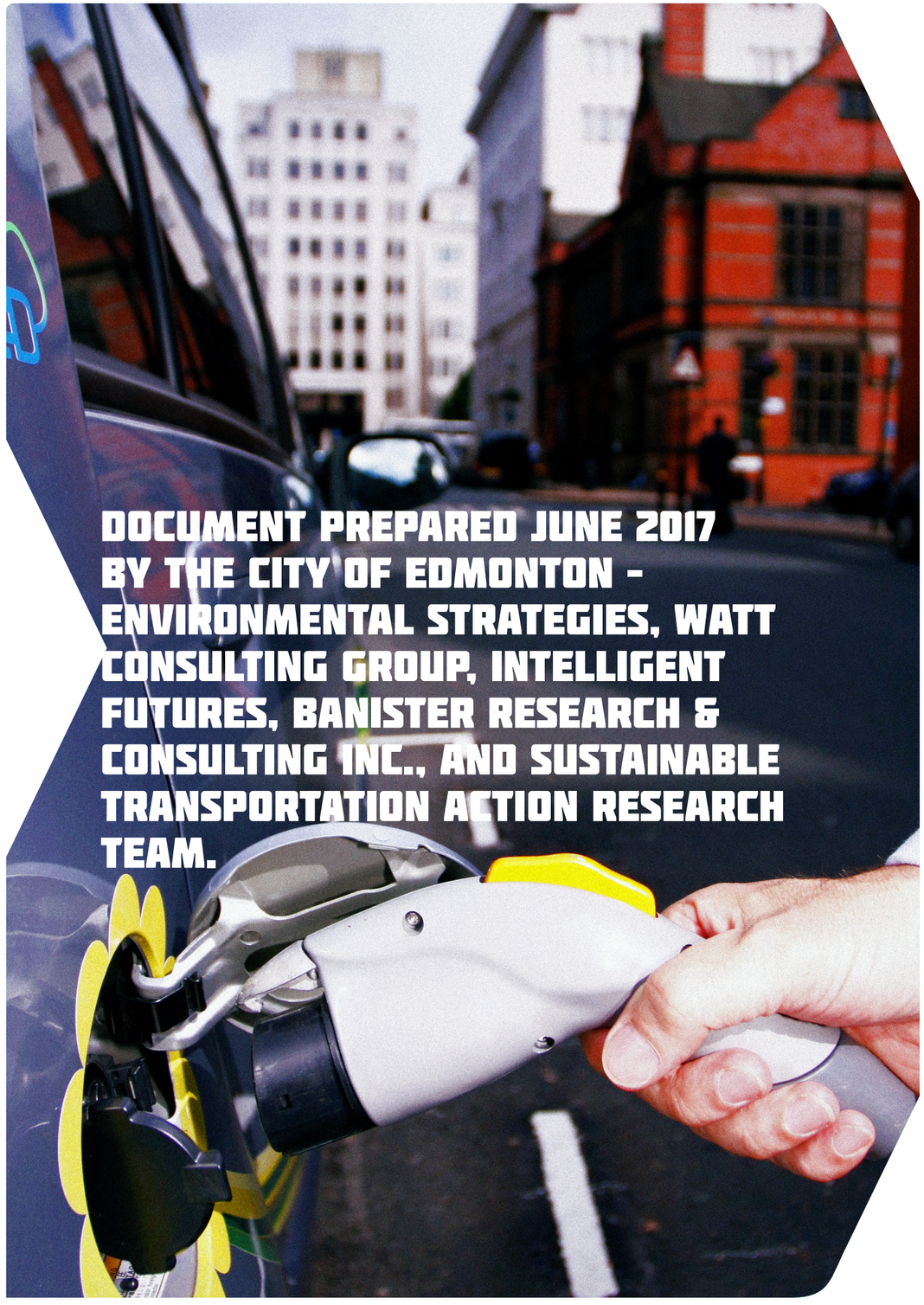


EDMONTON'S ELECTRIC VEHICLE STRATEGY.

Publication Date: September 2018

CHANGE MOBILITY FOR CLIMATE

Edmonton



DOCUMENT PREPARED JUNE 2017 BY THE CITY OF EDMONTON - ENVIRONMENTAL STRATEGIES, WATT CONSULTING GROUP, INTELLIGENT FUTURES, BANISTER RESEARCH & CONSULTING INC., AND SUSTAINABLE TRANSPORTATION ACTION RESEARCH TEAM.

CONTENTS

STRATEGY SUMMARY

Introduction

The City of Edmonton is committed to environmental preservation and sustainability through the City's guiding strategies. They identify an immediate and urgent need to reduce greenhouse gas (GHG) emissions to help mitigate the effects of climate change, reduce energy use, and improve air quality. Electric Vehicles (EVs) have an important role to play in supporting all three of these objectives by reducing the environmental impacts from personal transportation.

The City's continued goal is for public transportation and active transportation to be the preferred choice for more people - these are the most energy efficient mobility choices. Charging Up! Edmonton's Electric Vehicle Strategy envisions that those trips not displaced by mode shift will be completed using evs that take advantage of a greening electricity grid.

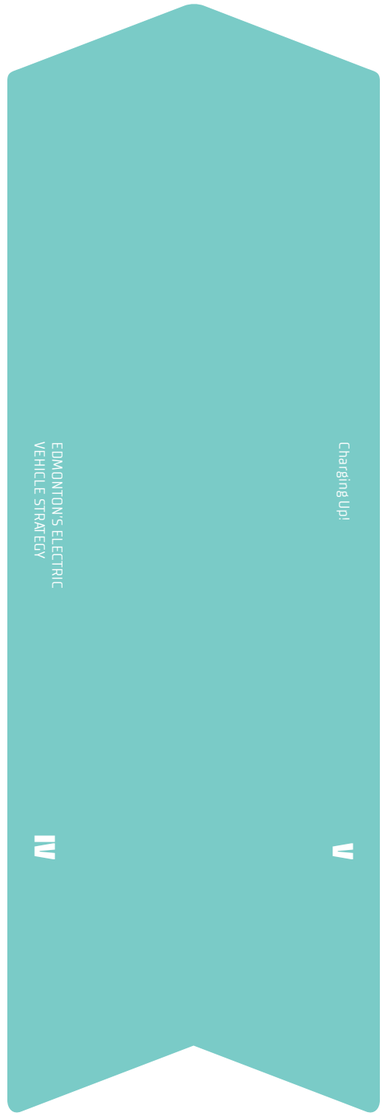
The goal of the Strategy is to identify strategic actions that will:

- advance Edmonton in becoming an EV-ready city
- drive an accelerated uptake of EVs in Edmonton
- create an environment in which EVs can thrive.

The scope of this strategy focuses on the plug-in variety of light duty EVs that use electricity (from an external charging source) to fuel the movement of the vehicle either in whole or in part. Specifically, this means light-duty plug-in hybrid electric vehicles (PHEV) and battery electric vehicles (BEV).

Electrification in transportation is already making its way into the City's operations through the purchase of electric buses, charging stations at City facilities and on right of way, and the introduction of some plug-in hybrid vehicles into the City fleet.

City of Edmonton
Charging Up!
Edmonton's Electric Vehicle Strategy



Edmonton's Electric Vehicle Strategy is the result of best practice research, extensive stakeholder engagement and market research in Edmonton. It represents a first step towards preparing Edmonton for evs – a rapidly changing and transformative technology. This strategy positions Edmonton among other forward-thinking cities preparing for this coming technology and enhances Edmonton's reputation as a city that welcomes innovation, talent and investment.

This five-year strategic plan identifies six opportunity areas and corresponding strategic actions that the City will take advantage of to become an EV-ready city, creating an environment where EVs thrive. These opportunity areas are:

- Education & Marketing
- Electric Vehicle Charging Infrastructure
- Incentives & Financial Tools
- Regulations
- City Leadership
- Collaboration, Partnerships & Advocacy

To measure the progress of the strategy, four key indicators with targets will be tracked. These are:

1. Edmontonians indicating they are knowledgeable about EVs

2. Number of EV charging stations

3. Edmontonians indicating that they would consider purchasing an EV

4. Number of EVs registered in Edmonton

Strategy Contents and Organization

Edmonton's Electric Vehicle Strategy is organized as follows.

- **Chapter 1** introduces the Strategy by outlining the rationale for having an EV strategy, an overview of the value case for electric vehicles, and how the EV strategy aligns with key initiatives of the City of Edmonton and the provincial and federal governments.
- **Chapter 2** describes the ways in which Edmonton is already progressing on environmental improvements in transportation, from purchasing electric buses for Edmonton Transit to installing EV charging stations at renovated libraries.
- **Chapter 3** provides a summary of global, national, provincial, and local trends in electric vehicle markets and ownership, as well as travel patterns in comparison to the capabilities of electric vehicles.
- **Chapter 4** presents the results of an environmental scan of best practices by municipalities in supporting the transition to electric vehicles.
- **Chapter 5** identifies key opportunities and challenges related to increased adoption of electric vehicles.
- **Chapter 6** provides a synthesized listing of opportunities and barriers from the perspectives of the general public, the private sector, and municipal government.
- **Chapter 7** identifies six key Opportunity Areas for accelerating electric vehicle ownership, along with a set of supporting Strategic Objectives. The opportunity areas can be aligned with the market transformation approach which is consistent with other aspects of the City's Energy Transition Strategy. Each opportunity area is accompanied by a number of supporting Strategic Objectives.
- **Chapter 8** introduces the Strategy implementation plan, which is documented under separate cover. The implementation plan consists primarily of a set of tactics, labelled Strategic Actions, which put into action the EV Strategic Objectives.
- **Chapter 9** concludes the strategy by introducing a set of key indicators and targets which will allow the success of the Strategy to be measured and monitored.

The six key opportunity areas identified in Chapter 7 are:

- *Education & Marketing*
- *Electric Vehicle Charging Infrastructure*
- *Incentives & Financial Tools*
- *Regulations*
- *City Leadership*
- *Collaboration, Partnerships & Advocacy*

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Edmonton's Electric Vehicle Strategy

Additional background on EVs is provide in five appendices to the Strategy:

- **Appendix A:** Electric Vehicles 101
- **Appendix B:** A Short History of Electric Vehicles
- **Appendix C:** Impacts of Cold Weather on EVs
- **Appendix D:** Best Practices from Leaders in EV Deployment
- **Appendix E:** Barriers to EV Adoption

Conclusion

Edmonton's Electric Vehicle Strategy sets important direction for the City of Edmonton on how it can achieve a future where electric vehicles are an integral part of the City's mobility network. The strategy has a five-year horizon, after which it will need to be revisited to ensure the strategy will reflect technological advancements, trends, market developments and best practices.

1.0

INTRODUCTION

Edmonton's Electric Vehicle Strategy is the result of best practice research, extensive stakeholder engagement and market research in Edmonton. It represents a first step towards preparing Edmonton for electric vehicles (EVs), a rapidly changing and transformative technology.

This strategy positions Edmonton among other forward-thinking cities preparing for this coming technology and enhances Edmonton's reputation as a city that welcomes innovation, talent and investment. This five-year strategic plan identifies opportunity areas that the City will take advantage of to become an EV-ready city, creating an environment where EVs can thrive.

1.1 WHY AN ELECTRIC VEHICLE STRATEGY?

The City of Edmonton is committed to energy resiliency through Edmonton's Community Energy Transition Strategy. This strategy identifies an immediate and urgent need to reduce greenhouse gas (GHG) emissions to help mitigate the effects of climate change, reduce energy use, and improve air quality. Electric vehicles (EVs) have an important role to play in supporting all three of these objectives by reducing the environmental impacts from personal transportation. Although the general trend toward more efficient vehicles over the years is encouraging, efficiency alone is insufficient to meet Edmonton's GHG and energy reduction goals.

The scope of this strategy focuses on the plug-in variety of light-duty EVs that use electricity (from an external charging source) to fuel the movement of the vehicle either in whole or in part. Specifically, this means light-duty plug-in hybrid electric vehicles (PHEV) and battery electric vehicles (BEV). For a detailed explanation of the different types of electric vehicles, see **Appendix A - Electric Vehicles 101**.

The topic of EVs is new to Edmonton and with that comes a relatively low level of public knowledge and familiarity with EVs and their associated benefits. Recognizing this, the strategy adopts a market transformation approach that applies education and awareness, capacity building, incentives and regulation efforts concurrently.

Edmonton's Electric Vehicle Strategy provides an evidence-based action-oriented 5-year strategic plan that will create a market-shift towards the purchase of EVs in Edmonton.

The goal of the Strategy is to identify strategic actions that will:

- advance Edmonton in becoming an EV-ready city
- drive an accelerated uptake of EVs in Edmonton
- create an environment in which EVs can thrive.

The strategic actions identified are ones that the City of Edmonton is well positioned as a municipality to implement, leveraging the City's ability to lead by example and act as a focal point for collaboration.

The City's current goals for the movement of people centre around mode shift where public transportation and active transportation become the preferred choice for more people. While the City has established clear goals to achieve sustainability in transportation, personal vehicle travel will likely continue to constitute a significant portion of the mode split for commuter and discretionary trips. For example, 76% of Edmontonians perceive that they will likely still need to own a car even if they take transit for most of their commute trips.[1] Edmonton's Electric Vehicle Strategy envisions that those personal trips not displaced by mode shift will be completed using EVs that take advantage of a greening grid. Encouraging the adoption of EVs is not anticipated to add to the total number of vehicles on the road. Market research completed for Edmonton's EV Strategy found that, if respondents purchased an EV, 65% would be replacing an existing vehicle while only 11% said it would be an additional vehicle for the household.[2]

The implementation of the Province's Alberta Climate Leadership plan makes the case for EVs even stronger. The plan would see all coal-fired electricity phased out by 2030 and sets a "30 by 30" renewable energy target where 30% of electricity used in Alberta will come from renewable sources such as solar, wind and hydro by 2030.[3] The Province also instituted a carbon levy which increases the cost of fossil fuels such as gasoline and diesel. In response to the Province's coal phase-out plan, TransAlta, one of Alberta's largest coal producers, approved a strategy to accelerate the decommissioning of its coal units. Transalta has committed to having those units converted to natural gas and renewables generation.[4]

"EVs of all types lie at the heart of future sustainable transport systems, alongside the optimisation of urban structures to reduce trip distances and shift mobility towards public transportation."

Source: Global EV Outlook 2016, International Energy Agency

City of Edmonton
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Edmonton's Electric Vehicle Strategy

Over the next decade, Alberta's electricity grid will become greener with an increase in renewable energy sources driving electricity generation. This is the right time for Edmonton to begin the planning needed to transition to EVs and take advantage of the opportunity to reduce the environmental impacts of personal vehicle travel.

It is clear that the environmental and economic benefits associated with purchasing and owning an EV today will only improve over time as Alberta's grid becomes cleaner and the cost of fossil fuels increases. Canadians replace their vehicles every 8 years on average, and vehicles remain in operation for just over 11 years.[5,6] As the electricity grid becomes cleaner, it will be important that Edmontonians begin the shift towards electric vehicles in order to take full advantage of reduced emissions over a vehicle's lifetime. If Edmonton is to benefit fully from a greener grid, it will need to start making the switch to EVs today.

Edmonton's Electric Vehicle Strategy sets important direction for the City of Edmonton on how it can achieve a future where electric vehicles are an integral part of the City's mobility network. The strategy has a five-year horizon, after which it will need to be updated. This ensures the strategy will reflect technological advancements, trends, market developments and best practices.

Through Alberta's Renewable Electricity Program, the government will add 5,000 megawatts of renewable electricity capacity by 2030 helping to achieve a target of 30% renewable energy as well as phasing out coal generation by that time. This provincial initiative can help strengthen the environmental benefits of EV adoption in Edmonton.

1.2 THE VALUE CASE FOR ELECTRIC VEHICLES

The electrification of Edmonton's transportation system holds great potential to reduce fossil fuel consumption and greenhouse gas emissions, while providing vehicle operating, maintenance and health cost savings, for individuals and the community, both today and in the future. The benefits associated with EVs align well the City's sustainability and liveability goals by contributing to cleaner air, reducing noise pollution, introducing resiliency into our transportation system, tapping into local renewable energy supplies, and supporting our local markets.

GHG and Energy Benefits to the Community Today

Some studies focus on the life cycle emissions of the fuels (source-to-wheels), while others also include the emissions associated with manufacturing and disposing of the vehicle components (cradle-to-grave). A study completed in 2015 by a research team at the University of Calgary found that the emissions of an EV in Alberta generates 1.24 tonnes of greenhouse gases less per year than a similar internal combustion engine (ICE) vehicle.[7] Another recent study determined that in the short-term, widespread adoption of EVs in Alberta has the potential to reduce fleet-average GHG emissions intensity by 37% relative to gasoline vehicles.[8] Yet a third study concluded that, over the cradle-to-grave life cycle of an EV (including its manufacturing, the manufacturing of the battery and its operation), battery electric vehicles realize a 51 to 53% reduction in GHG emissions compared to gasoline-powered cars.[9] These benefits are achieved even with an electricity grid as carbon-intense as Alberta's.

Some studies that have looked at the GHG benefits in the Alberta context have found less optimistic benefits for EVs in Alberta today. Although studies vary in their estimations of GHG savings from EVs in Alberta, there is little doubt that EVs will lead to considerable GHG savings over the next decade and in the long term. Edmonton must begin the shift today if those benefits are to be fully realized. It can take decades for a region to completely change from one dominant vehicle drivetrain to another—the vehicles bought today could still be on the road in 10 or more years.

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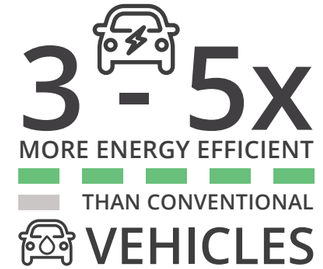
From an energy conservation perspective, EVs are unmatched when compared to conventional vehicles. Technologically, EVs are vastly more energy efficient than their gasoline-powered counterparts. EVs are particularly efficient in stop-and-go driving, typical of our urban city setting, owing in part to regenerative braking. EVs use 74 to 94% of the energy supplied to them to propel the vehicle, whereas only 14 to 30% of the energy consumed by a gas vehicle is used to propel the vehicle.[10]



GHG and Energy Benefits to the Community of Tomorrow

Long term GHG and energy savings accrued by EVs are substantial. An analytic tool created specifically to support the development of Edmonton's Electric Vehicle Strategy was used to calculate the long term impacts of EVs in Edmonton. Under the scenario where EV-supportive policies were implemented by all levels of government, including Edmonton's Electric Vehicle Strategy, to accelerate EV adoption, EVs could capture 5% of new car and SUV sales by 2025, rising to 32% by 2040.[11] **Table 1** details the life cycle savings that would be realized from EVs purchased between 2018 and 2035 as compared to the Business As Usual (BAU) scenario where EV uptake would be slower.

Table 1. *Estimated Life cycle GHG, Energy and Cost Benefits from EVs purchased between 2018 to 2035, EV Policy-Driven Scenario as Compared to Business as Usual*

GHG SAVINGS	600 kt CO2e (600,000 tonnes of greenhouse gases)
ENERGY SAVINGS	9,500 MJ
COST SAVINGS	$90 million

Table 1[12] shows how the increased EV sales, resulting from strong and supportive EV policies, can have a significant impact on GHGs emissions reduction over the next two decades as compared to the BAU scenario[13]. By 2040, EVs have the potential to reduce Edmonton's greenhouse emissions by 5% or 90,000 tonnes per year (compared to BAU) and could reduce energy consumption from transportation by 6% annually. These potential savings are from passenger cars and SUVs alone and do not include the possible savings of new pickup truck sales being captured by EVs. With EVs capturing an increasing portion of new car sales this would amount over 65,000 EVs on the road by 2040 in Edmonton, as compared to 25,000 EVs in a BAU scenario or 40,000 ICE vehicles avoided. In that scenario, the lifetime savings at the pump for Edmonton EV drivers is $90 million.

A High EV Penetration Scenario was also tested, where there is massive market transformation within the next decade which could result from:

1. Implementation of strong and supportive EV policies at all levels of government;

2. Consumer preferences shifting towards highly energy efficient vehicles;

3. EV technology advancements and falling prices of EVs leading them to match the price of internal combustion engine vehicles;

4. Auto manufacturers introducing a host of new EV models into their line-ups, including pickup trucks.

In High Scenario, sales of EVs in Edmonton rise exponentially from the current state to an ambitious level of 20% of new vehicle sales in 2025, rising to 60% by 2040. **Table 2**[14] provides the estimated life cycle GHG, energy and cost savings in the High Scenario.

GHG SAVINGS	2,000 kt CO2e (2,000,000 tonnes of greenhouse gases)
ENERGY SAVINGS	36,000 MJ
COST SAVINGS	$360 million

Table 2. *Estimated Life cycle GHG, Energy and Cost Benefits from EVs Purchased between 2018 to 2035, High EV Penetration Scenario Compared to Business as Usual*

From this analysis, it is clear that the scale of GHG, energy and cost-saving benefits is largely dependent on how quickly EVs are adopted into the Edmonton vehicle fleet within next decade. The quicker EVs are adopted in the early years the more benefits will accrue over the long term (considering that a vehicle purchased today will likely remain in operation until 2028[15]). During that time, non-EVs will continue to use gasoline fuel even as the carbon intensity of the electricity grid is reduced substantially with coal being phased out by 2030. Put another way, every gasoline or diesel powered vehicle purchased today is a lost GHG emissions reduction and energy-savings opportunity for the future.

Additional Societal Benefits

Air quality: Chief among the benefits associated with EVs, and of particular importance to cities, is improved air quality owing to the absence of tailpipe emissions. Urban centres have high concentrations of vehicles responsible for an ever-growing number of daily trips. The most recent survey on travel behaviour in the City of Edmonton found that daily trips made by car have grown by nearly 670,000 over the past two decades, a nearly 40% increase in car trips. The most recent survey on travel behaviour in the City of Edmonton found that daily trips made by car have grown by nearly 670,000 over the past two decades, a nearly 40% increase in car trips.[16]

Gasoline and diesel powered vehicles are responsible for a host of air contaminants including particulate matter, hydrocarbon and methane emissions as well as oxides of nitrogen and sulphur. Air pollution from transportation is well established as adversely affecting human lung and cardiac health.[17]

A 2015 report prepared by the World Bank and the Institute for Health Metrics and Evaluation found that in 2010 alone, pollution from vehicles was the cause of 184,000 deaths globally[18]. In addition, the OECD estimates that in 2010, the economic cost of deaths from air pollution, attributable to road transportation, in OECD countries was $786 billion US.[19] More close to home, a report by Toronto Public Health found that traffic pollution gives rise to about 440 premature deaths per year in Toronto, noting that those deaths would not have occurred when they did without exposure to traffic-related air pollution.[20] The study also found that children and the elderly are particularly vulnerable.

Edmonton's strategy to accelerate the adoption of EVs is timely. Recently, the Clean Air Strategic Alliance commissioned the Non-Point Source Project Team to investigate and recommend strategies to mitigate impacts from air pollutants to the Edmonton region airshed in order to meet the Canadian Ambient Air Quality Standards (CAAQS).[21] The Ministry of Environment and Parks has tasked the project team with identifying strategies to mitigate impacts from non-point sources, such as on-road vehicles, that contribute to particulate matter and ozone in Alberta. The project team is in the process of developing recommendations that will include support for the adoption of low and zero emitting vehicles in Alberta. It is likely that municipalities will be asked to play a role in the implementation of any of the report's recommendations.

Reduced urban noise pollution: Traffic noise results from three main sources: tires, engines and wind passage. In an urban slow-traffic environment, engines are the primary contributors to traffic noise levels. In this context, EVs can have a great impact on reducing noise pollution, as they create virtually no engine noise.[22]

Energy Resiliency: Electricity is ubiquitous in our society. It is widely available, accessible (at home and work), reliable, and can be generated locally and in a number of ways, including from solar, wind, hydro and geothermal. By taking advantage of electricity as a fuel source, Edmonton can reap the benefit of introducing resiliency into the transportation system by decreasing reliance on one form of vehicle fuel.

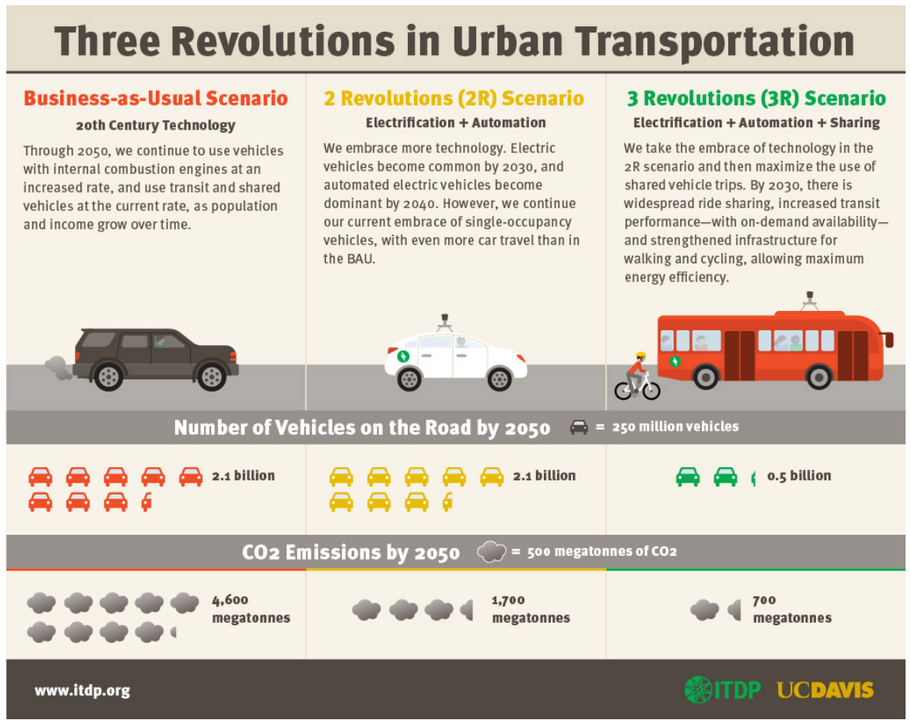
Benefits of Integrated EV and Automated vehicle technology: Early speculation is that the deployment of automated vehicles will likely be electric due to: relative ease of integrating automated and electric technology, more-stringent emissions regulations, and the lower cost of operations. Encouraging the adoption of EVs early on will help ensure Edmonton is keeping pace with this technology curve. This aligns well with the City's Smart Transportation Action Plan, which in part identifies how Edmonton can prepare for the integration of automated vehicles into Edmonton's mobility landscape to ensure it supports the City's sustainability and liveability goals.

The integration of EV and automated vehicles also promises GHG emission and energy savings. A recent report by the Institute for Transportation & Development Policy (ITDP) envisions revolutionary changes in mobility by considering the role of electrification, automation, and ride sharing. They developed their analysis using three main urban travel scenarios: a business-as-usual scenario, a technology-dominated 2 Revolutions scenario, and a technology + high shared-mobility 3 Revolutions scenario.[23]

Their analysis shows that the greatest benefits are incurred through a combination of electrification, automation, and multimodal shared vehicle trips. The infographic below provides a summary of their findings on a global scale.

A recent analysis conducted by the City assessed the city-wide benefits of various future carbon reduction measures. The analysis found that in a scenario of widespread adoption of non-EV automated vehicles that emissions would be considerably higher than if the vehicles were electric.

Three Revolutions in Urban Transportation. *An infographic by the Institute for Transportation and Development Policy & UC Davis. https://www.itdp.org/3rs-in-urban-transport/.*



Maintenance costs of EVs are lower as costs associated with oil changes, transmission fluid changes and maintenance of spark plugs and mufflers are eliminated.

Consumer Benefits

Reduced auto ownership costs: While EVs currently have a larger initial cost compared to conventional gasoline vehicles, the lower life cycle cost of EVs has the potential of easing the cost of vehicle ownership for Edmontonians. A life cycle cost study of midsize vehicles showed that EV owners could save about $13,000 over a 15-year period as compared to owning a gas vehicle.[24] Looking at the total cost of ownership, one study found that EVs can cost as much as $2,700 less per year to own and operate as compared to their gasoline vehicle counterpart.[25] The maintenance costs of EVs is much lower due to the lack of complex and numerous mechanical parts - costs associated with oil changes, transmission fluid changes and maintenance of spark plugs and mufflers, for example, are eliminated.

Falling battery prices means lower EV prices for consumers: Over time, the cost of EVs is expected to decline making them a more affordable option for Edmontonians. The higher cost of EVs is directly linked to the cost of the battery - which accounts for a third of the cost. Over the past five years there has been an exponential decrease in the cost of Lithium-ion batteries. This recent decrease in battery costs is a major factor that has helped to nudge the adoption of electric vehicles globally. The International Energy Agency reports that battery costs have been cut by a factor of four since 2008 and are projected to decrease further.[26]

A 2017 study found that the price of batteries fell by 77% from 2010 to 2016 (see **Figure 1**)[27] and also concluded that the cost of purchasing an EV will be lower than a gasoline car by 2025.[28] With overall EV ownership costs falling, the economic case to purchase an EV will make greater sense for Edmontonians as technology advances.

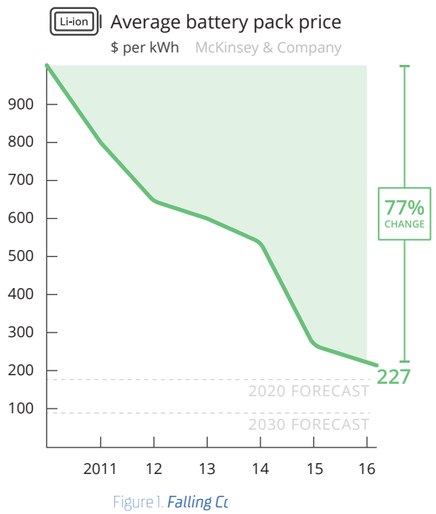


Figure 1. *Falling Cc*

Charging Up!

12

1.3 ALIGNMENT WITH CITY POLICY AND GOVERNMENT PLANS

Edmonton's planning and policy environment is strongly supportive of accelerating EV adoption. Relevant City plans that would support Edmonton moving towards greater EV adoption are discussed below.

The Way Ahead: City of Edmonton Strategic Plan

The Way Ahead captures City Council's Vision for Edmonton in 2040 and establishes six 10-year strategic goals to provide a clear focus for the future. City Council then established a set of corporate outcomes for the 10-year strategic goals, which outlines Council's priorities and describes how success is defined in achieving the goals.

"Edmonton is an environmentally sustainable and resilient city"

– The Way Ahead Corporate Outcome

Edmonton's Electric Vehicle Strategy directly supports the City of Edmonton's Corporate Outcome on sustainability and resiliency. This outcome is measured by [a] community GHG emissions and [b] ecological footprint. With lower emissions being generated from EVs, the adoption and acceleration of electric vehicles can propel the City towards achieving this corporate outcome.

Community Energy Transition Strategy

Edmonton's Community Energy Transition Strategy is a risk management strategy designed to make Edmonton an energy sustainable city.[29] By 2035, the strategy directs the City to achieve the following:

- Reduce greenhouse gas (GHG) emissions by 35%
- Reduce energy consumption by 25% per person
- Generate 10% of Edmonton's electricity locally

In support of these goals, *Edmonton's Community Energy Transition Strategy* calls for "increased electrification of Edmonton's transportation system with passenger vehicles, buses, light trucks and trains powered by clean electricity". The transportation sector in Edmonton accounts for 30% of GHG emissions – approximately 5 million tonnes annually – and 42% of energy used. This equivalent to the energy needs of Edmonton's residential and commercial buildings combined.

With 78% of all personal trips in Edmonton being made by a vehicle, there is strong case to advance the adoption of electric vehicles to help mitigate greenhouse emissions from the transportation sector. Encouraging Edmontonians to shift from gasoline and diesel-powered vehicles to electric vehicles will contribute to the City of Edmonton's transition to a low carbon, energy sustainable future.

Alignment with Other Levels of Government

The federal government has also demonstrated its commitment to zero emission vehicles internationally. In 2017 Canada joined the global EV30@30 Campaign which sets a collective aspirational goal to reach 30% sales share for electric vehicles by 2030. The Canadian government has noted its current activities include developing a Zero Emission Vehicles Strategy; investing in electric charging infrastructure; developing enabling codes and standards; investing in research, development and demonstration of innovative technologies; and providing consumers with information and tools to inform their purchasing decisions.

In 2017, the federal government, in cooperation with provincial and territorial governments began developing a national strategy for zero emission vehicles. The strategy is slated to be completed in 2018 and included input from experts from industry, academia, non-profits, and some municipalities - including the City of Edmonton.

In addition, Alberta Transportation has undertaken a zero emission impact study to help "…deliver innovative strategies that the Department could implement to enable the transition to zero emissions vehicle or alternative carbon neutral technologies such as fuel cells…".

By developing a made-in-Edmonton EV strategy the City will be prepared to engage in meaningful discussions with other levels of government about how best to support EV adoption in Edmonton.

1.4 ENDNOTES

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2 *2017 City of Edmonton Electric Vehicle General Population Survey*. Banister Research and Consulting Inc. May 2017.

3 Government of Alberta. *Phasing out coal pollution*. Available online at: https://www.alberta.ca/climate-coal-electricity.aspx.

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6 IHS Markit. (2014). *Average Age of Vehicles on the Road Remains Steady at 11.4 years, According to IHS Automotive*. Available online at: http://news.ihsmarkit.com/press-release/automotive/average-age-vehicles-road-remains-steady-114-years-according-ihs-automotive.

7 Layzell, D., Straatman, B. (2016). *The Potential Impact of Electric Vehicles on Alberta's Energy System.* Available online at: http://www.cesarnet.ca/sites/default/files/pdf/CESAR-Scenarios-Potential-Impact-EVs.pdf.

8 Kamiya, G., and Axsen, J. (Under Review). *Modelling the GHG emissions intensity of plug-in electric vehicles using short-term and long term perspectives.* Submitted to Transportation Research Part D.

9 Nealer, R., Reichmuth, D., Anair, D. (2015). *Union of Concerned Scientists. Cleaner Cars from Cradle to Grave - How Electric Cars Beat Gasoline Cars on LIfetime Global Warming Emissions.* Available online at: http://www.ucsusa.org/sites/default/files/attach/2015/11/Cleaner-Cars-from-Cradle-to-Grave-full-report.pdf.

10 United States Department of Energy. *Where the Energy Goes webpage.* Available online at: https://www.fueleconomy.gov/feg/atv.shtml.

11 Not included is the percent of new pickup truck sales that are captured by EV as there are currently no EV pickup trucks on the market from which to obtain baseline data.

12 Discounted cost savings (in 2017 dollars) inclusive of electricity purchased to fuel an EV and avoided Carbon Levy on gasoline and diesel fuel purchases.

13 Even more ambitious EV sales targets might be feasible—for example, a modeling study based on the province of British Columbia demonstrated the potential for strong policy to induce EV new market share of 35-50% by 2030. [Wolinetz, M. and J. Axsen (2017). "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.].

14 Discounted cost savings (in 2017 dollars) inclusive of electricity purchased to fuel an EV and avoided Carbon Levy on gasoline and diesel fuel purchases.

15 IHS Markit. (2014). *Average Age of Vehicles on the Road Remains Steady at 11.4 years, According to IHS Automotive*. Available online at: http://news.ihsmarkit.com/press-release/automotive/average-age-vehicles-road-remains-steady-114-years-according-ihs-automotive

16 Health effects of transport-related air pollution /edited by Michal Krzyzanowski [et al.] http://www.euro.who.int/__data/assets/pdf_file/0006/74715/E86650.pdf.

17 Making Tracks, 2015 Edmonton and Region Ho usehold Travel Survey Summary Report, March 2018.

18 Global Road Safety Facility, The World Bank; Institute for Health Metrics and Evaluation. Transport for Health: *The Global Burden of Disease from Motorized Road Transport.* Seattle, WA: IHME; Washington, DC: The World Bank, 2014.

19 OECD (2014), *The Cost of Air Pollution: Health Impacts of Road Transport*, OECD Publishing. http://dx.doi.org/10.1787/9789264210448-en.

20 Toronto Public Health. *Air Pollution Burden of Illness from Traffic in Toronto – Problems and Solutions*. November 2007. Toronto, Canada.

21 The CAAQS are established with the goal of protecting human health and the environment and set the goals for maximum ambient concentrations of harmful air pollutants. Individual air zones in Alberta have been assigned different management levels, requiring that actions be taken to address identified and emerging air quality issues within the specified air zone. These actions will need to address the various types of anthropogenic sources present in Alberta, recognizing both point and non-point sources contribute to cumulative effects.

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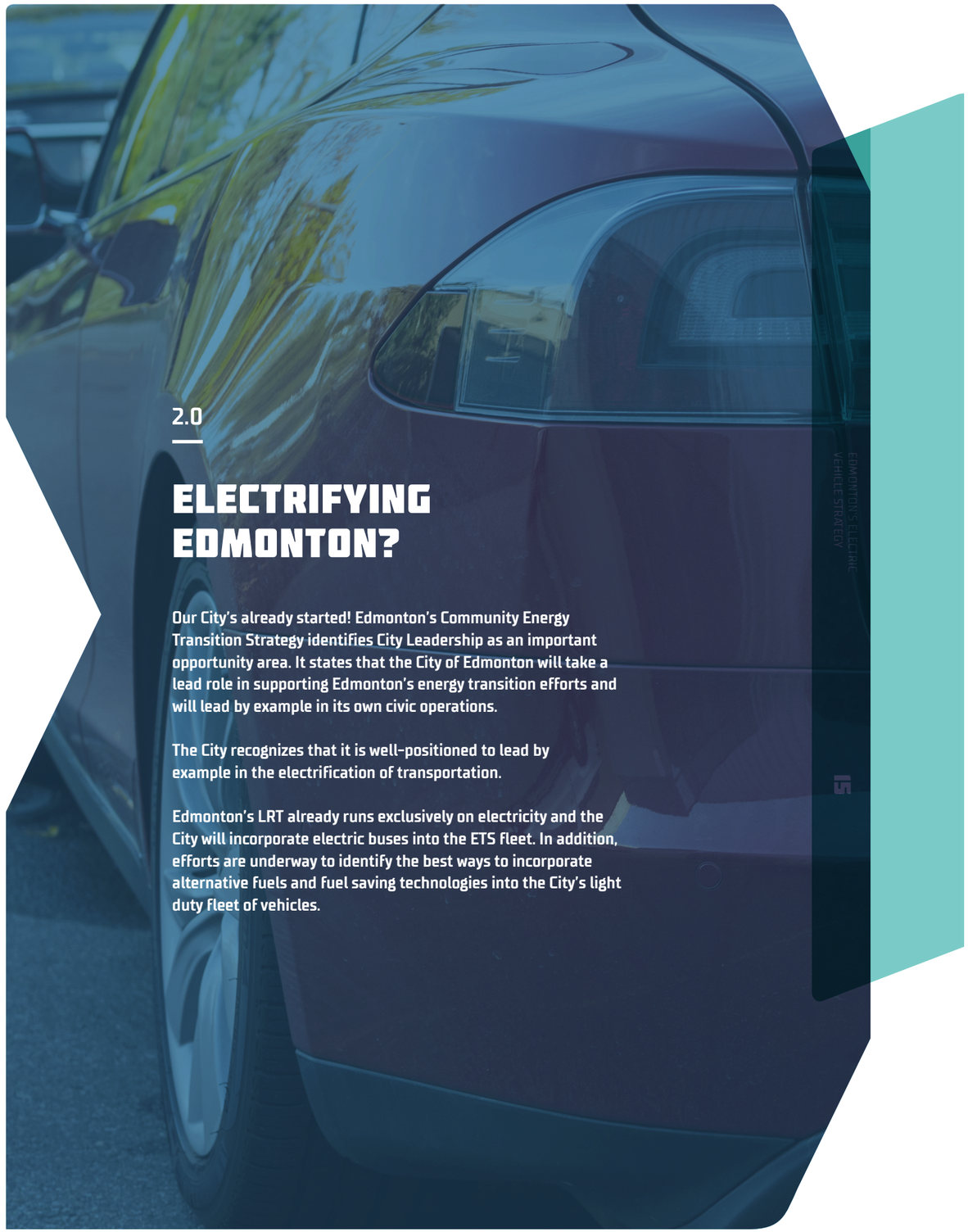


2.0

ELECTRIFYING EDMONTON?

Our City's already started! Edmonton's Community Energy Transition Strategy identifies City Leadership as an important opportunity area. It states that the City of Edmonton will take a lead role in supporting Edmonton's energy transition efforts and will lead by example in its own civic operations.

The City recognizes that it is well-positioned to lead by example in the electrification of transportation.

Edmonton's LRT already runs exclusively on electricity and the City will incorporate electric buses into the ETS fleet. In addition, efforts are underway to identify the best ways to incorporate alternative fuels and fuel saving technologies into the City's light duty fleet of vehicles.

EDMONTON TRANSIT SERVICE (ETS) ELECTRIC BUSES

Since 2014, ETS along with the City's Fleet and Facility Services have been working towards introducing battery-powered electric buses (e-bus) into its regular service fleet. This is part of the City's commitment to explore emerging technologies to create a more effective, efficient and ecologically responsible public transit service for Edmontonians.

The City's first test project was conducted between May and October of 2014, trialing two electric buses on Edmonton streets. In winter 2015/16, field trials showed that e-buses will operate effectively on Edmonton roads and throughout winter months.

In June 2016, Administration presented a report to City Council outlining the results of winter testing and a business case for an initial deployment of 40 e-buses. The analysis indicated that e-buses are a cost neutral alternative to diesel buses.

Based on present electricity generation in Alberta, it is estimated that an e-bus emits approximately 38 to 44 per cent less CO^2 emissions than its diesel counterpart. These benefits will continue to increase as the carbon intensity of Alberta's electricity grid declines.

The City will purchase up to 40 electric buses that Edmontonians will begin to see and ride in 2019. In addition, the City will conduct a thorough transit facility assessment that will provide the data needed to develop a long term strategy on electric buses. The City will also be monitoring the industry in relation to standardization and improvements in technology, both of which are developing at a rapid pace.

CITY SUSTAINABLE FLEET MANAGEMENT

The *City's Sustainable Fleet Management Plan* outlines opportunities, projects, and initiatives to support the City of Edmonton's corporate outcomes: "The City of Edmonton's operations are environmentally sustainable" and "Edmonton is an environmentally sustainable and resilient city."

Currently, City of Edmonton Fleet Services has implemented many measures to reduce the fleet's impact on GHG emissions, including:

- Actively identifying underutilized fleet for suggested relocation and/or removal from inventory.
- Right-sizing the fleet so that vehicles are the most efficient for operational needs.
- Providing the City with fleet product that comes from sustainable suppliers.
- Purchasing environmentally efficient options, such as start-stop technology and auxiliary power units, for gasoline and diesel powered vehicles as well as hybrid and battery electric vehicles.
- Equipping 1,700 vehicles with an Automated Fuel Metering System that collects data on idle times and amount of fuel used.
- Sharing fuel consumption data with personnel from the *Fuel$ense* training program, who teach City operators how to drive more efficiently to help reduce greenhouse gas emissions.
- Continuing research, trial, and implementation of alternative fuel options.
- Planning to purchase newly available plug-in hybrid conversion kits to test on the City's pickup trucks and vans.
- Issuing a tender for Light Duty Vehicles which will include a call for EVs, alternative fuels, and other new fuel saving technologies.

In 2017, Edmonton Police Service purchased its first plug-in hybrid EV to be used in non-enforcement applications. The City has also purchased a pick up truck that it plans to convert to plug-in hybrid vehicle using an XL Hybrid conversion to be used in City operations. The truck will be tested to inform future purchases and conversions.

ELECTRIC VEHICLE CHARGERS AT CITY FACILITIES

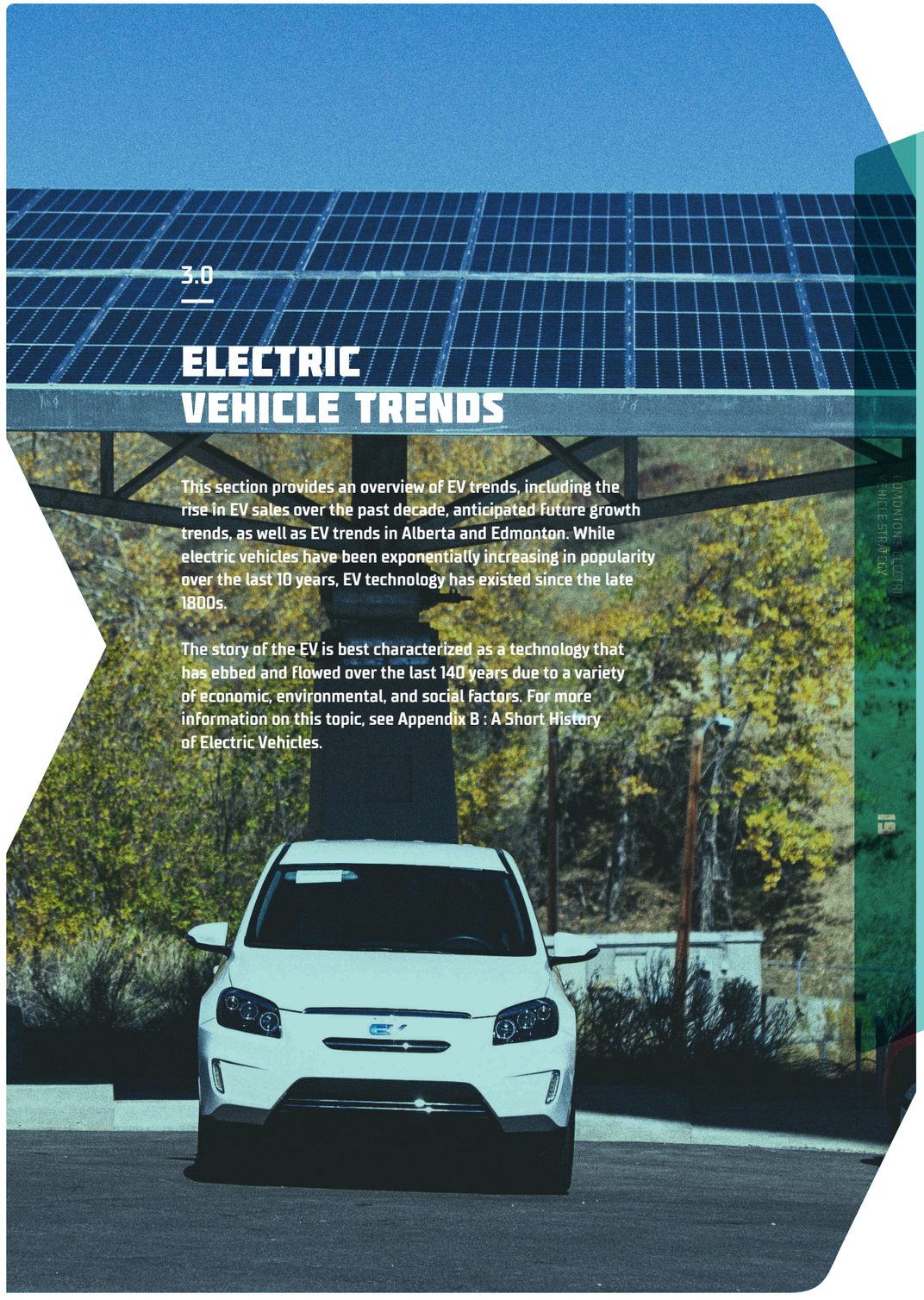
Since 2013, the City has integrated electric vehicle charging stations into the design and construction of some major facility renovation projects enabling them to achieve LEED building certification. The City currently operates four electric vehicle chargers at three library locations – Jasper Place Library, Mill Woods Library, and Calder Library. The Highlands Library branch has a 'rough-in' to accommodate the installation of an electric vehicle charging station at a future date.

In addition, new EV chargers are scheduled to be installed at four City locations by 2019 as part of major facility renovations. They include Capilano Branch Library, Fire Station 17, and Borden Park Outdoor Pool.

Top. *Jasper Place EPL EV Charging Station.*

Bottom. *Mill Woods EPL EV Charging Station.*

Credit. *Plugshare.com*



3.0

ELECTRIC VEHICLE TRENDS

This section provides an overview of EV trends, including the rise in EV sales over the past decade, anticipated future growth trends, as well as EV trends in Alberta and Edmonton. While electric vehicles have been exponentially increasing in popularity over the last 10 years, EV technology has existed since the late 1800s.

The story of the EV is best characterized as a technology that has ebbed and flowed over the last 140 years due to a variety of economic, environmental, and social factors. For more information on this topic, see Appendix B : A Short History of Electric Vehicles.

3.1 GLOBAL TRENDS

The global market for electric vehicles is on a growth trend. One of the most comprehensive sources is the International Energy Agency's (IEA) *Global EV Outlook 2017*.[1] The IEA reported that in 2016 the global electric car stock surpassed 2 million vehicles after crossing the 1 million threshold in 2015.[2] New registrations of EVs increased 60% between 2015 and 2016 with a record high 750 thousand sales worldwide in 2016.[3] The combination of aggressive climate targets coupled with some moderate policy support has provided impetus for auto manufacturers to commit to research and development. In turn, this has led to lower vehicle costs, extended vehicle range, and reduced consumer barriers in a number of countries. However, research on 30 years of "up and down" cycles for alternative fuels indicate that greater success for electric mobility hinges on a substantial increase of strong, durable policy support.[4]

While a number of countries have seen their EV markets grow over the past five years, a select few are leading the way.[5] In 2015, the percentage of new vehicle sales captured by EVs exceeded 1% in seven countries. Of particular note, EVs captured 10% of new vehicle sales in the Netherlands, a doubling over recent years; and Norway had the world's highest market share of EVs at 23%. Other nations also saw EV success in 2015 with year-over-year sales growth for EVs exceeding 75% in France, Germany, Korea, Norway, Sweden, the United Kingdom and India.

The two countries with the world's highest EV market share, the Netherlands and Norway, implemented a variety of measures that favour the EV market. For example, in the Netherlands, EV owners are assessed lower registration and circulation taxes. As well, they are given preferential access to portions of the bus lane network. Similarly, Norway has adopted a wider suite of demand-focused EV policies (that focus on the consumer rather than automakers or fuel supplier),[6] including incentives such as substantial reductions in the registration tax, an exemption from the value-added tax, waivers on road tolls and ferries, and access to bus lanes.[7]

ACHIEVED

1%

OF NEW VEHICLE SALES CAPTURED BY ELECTRIC VEHICLES

- Norway
- The Netherlands
- Sweden
- Denmark
- France
- United Kingdom
- China

As one exploration of the role of policy in EV sales, Sierzchula et al. (2014) collected and analyzed data from 30 countries over the course of 2012 to understand how policy, incentives, and charging infrastructure were correlated with EV adoption rates. Their sample included countries from Asia (China, Japan), Europe (Denmark, Finland, Ireland, Norway), and others such as the US and the UK. This exploratory research found that financial incentives, the availability of charging infrastructure per capita, and the presence of a local EV manufacturing facility were strongly associated with a country's EV market share.[8] These results provide one early perspective on what factors have been contributing to a growing global EV market share.

Increasing consumer demand, along with falling battery prices are helping create enthusiasm for EVs among automakers. For example, in early 2017, the Ford Motor Company announced that it will be introducing 13 electric vehicles to its model fleet by 2022, including an F-150 Hybrid, Mustang Hybrid, a plug-in hybrid Transit Custom van in Europe, and a fully electric SUV with an estimated range (ideal conditions) of 480 kilometres.[9] Tesla has indicated that they will be expanding their market offering, saying that they have a fully electric pickup truck in the early stages of development.

Other automakers such as Mercedes-Benz and BMW have signaled that EVs should account for up to 25 percent of their sales by 2025.[10] The Volkswagen Group is planning to invest in more EV technology with up to 30 EV models by 2020.[11] Volvo has also signaled a transition from a focus on diesel engines to EVs.[12] Bloomberg New Energy Finance predicts that by 2020 there will be over 120 different models of EV across the spectrum.[13] Though, caution must be taken in considering these forward-looking statements, as there are numerous examples of automakers making highly positive expectation statements for alternative-fuel technology that have not been fully realized.[14]

Another branch of research suggest that supply-focused policy has been playing an important role in supporting EV market growth—that is, policy that puts the onus on automakers to develop and supply EVs or other alternative fuel vehicles. The State of California has pioneered such policies, in particular when it first implemented the Zero-Emissions Vehicle (ZEV) mandate in 1990, which to this day is driving EV sales in different US states and cities. Research also suggest that California's ZEV mandate helped to support automaker breakthroughs in EV technology that later lead to EV success in other regions such as Norway.[15] Modeling studies also indicate that a similar ZEV mandate policy, like that recently implemented in Quebec, might be key to inducing a substantial PEV market transition in Canada.[16]

With stronger policy and the falling costs of EV batteries, experts predict that there will be 41 million electric vehicles on the road globally by 2040.

City of Edmonton
Charging Up!
Edmonton's Electric Vehicle Strategy

Global market trends show that EVs are becoming more widely adopted, though their continued success will be dependent on technological advancements, supportive policies, and incentives.

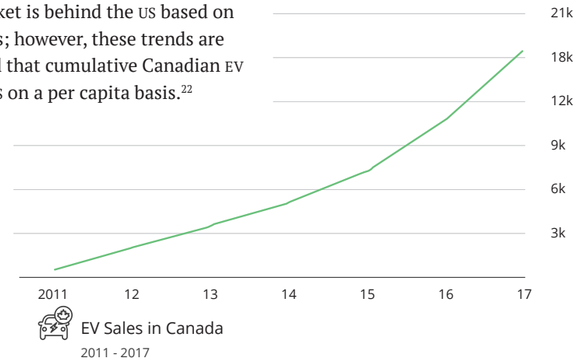
3.2 NATIONAL TRENDS

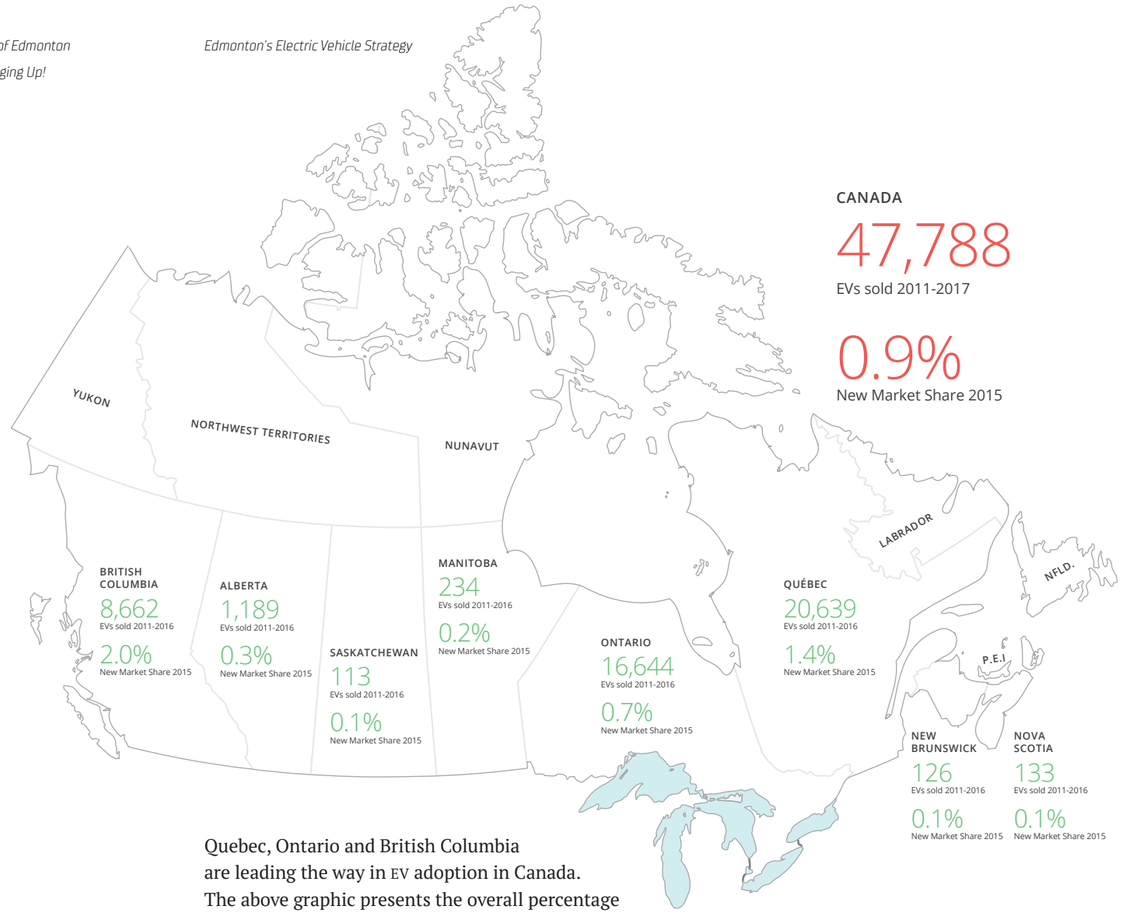
In Canada, the market for electric vehicles has been growing significantly since 2011 with sales increasing year-over-year (see **Figure 2**). From 2013 and 2017, approximately 45,000 electric vehicles have been sold nationally with more recent data indicating there were as many as 47,800 EVs on Canadian roads as of the end of 2017.[17]

From 2011 and 2016, approximately 23,000 electric vehicles have been sold nationally with more recent data indicating there were as many as 31,000 EVs on Canadian roads as of March 2017.[18, 19] In 2017 alone, the number of EV sales in Canada topped 18,000 compared to 11,000 in 2016.[20, 21] Anecdotally, there have been instances of affordable used EVs being brought into Alberta in increasing numbers, as they are becoming available from areas with financial incentives, such as BC, Ontario and the United States.

Compared to the approximately 570,000 EVs on the road in the United States, the Canadian EV market is behind the US based on overall sales and diversity of models; however, these trends are starting to change. One study found that cumulative Canadian EV adoption is about 30% that of the US on a per capita basis.[22]

Figure 2. *Electric vehicle sales in Canada 2011-2016* [21]





Quebec, Ontario and British Columbia are leading the way in EV adoption in Canada. The above graphic presents the overall percentage of sales (market share),[23] which is a strong indicator of their success, along with the total EV sales by province.[24] **Table 3** provides the total number of registered vehicles by province as of the end of 2016.[25]

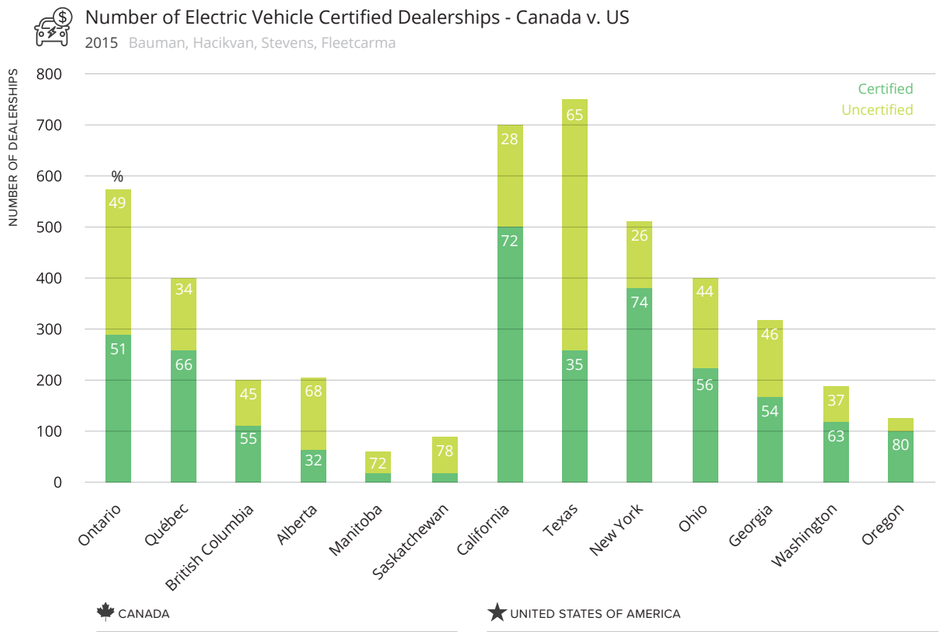
Within Canada, the product line of EVs available to consumers is continuing to grow. Most automakers today offer at least one hybrid or electric model to appeal to consumer preferences. There were 23 EV models on the Canadian market by the end of 2015, though the number continues to grow as consumer demand increases. [26] Although a variety of EV makes and models are available in Canada, the ability of Canadians to purchase EVs is constrained by the fact that many auto dealers are not certified to sell and service EVs. EV certification can be costly and difficult for dealerships to justify in the face of low EV demand. As shown in **Figure 3**, in Alberta only 32% of car dealerships are EV certified.

City of Edmonton *Edmonton's Electric Vehicle Strategy*
Charging Up!

Table 3. *Total Plug-In Vehicles by Province (as of December 31, 2016).*

PROVINCES	TOTAL NUMBER OF REGISTERED EV	% REGISTERED EV IN CANADA
Canada	29,270	100%
British Columbia	5,397	18.4%
Alberta	760	2.6%
Saskatchewan	79	0.3%
Manitoba	170	0.6%
Ontario	9,179	31.4%
Quebec	13,464	46.0%
New Brunswick	73	0.3%
Nova Scotia	106	0.4%
Prince Edward Island	13	0.04%
Newfoundland & Labrador	22	0.08%

Figure 3. *EV Certified Dealerships: Canada vs US* [26]

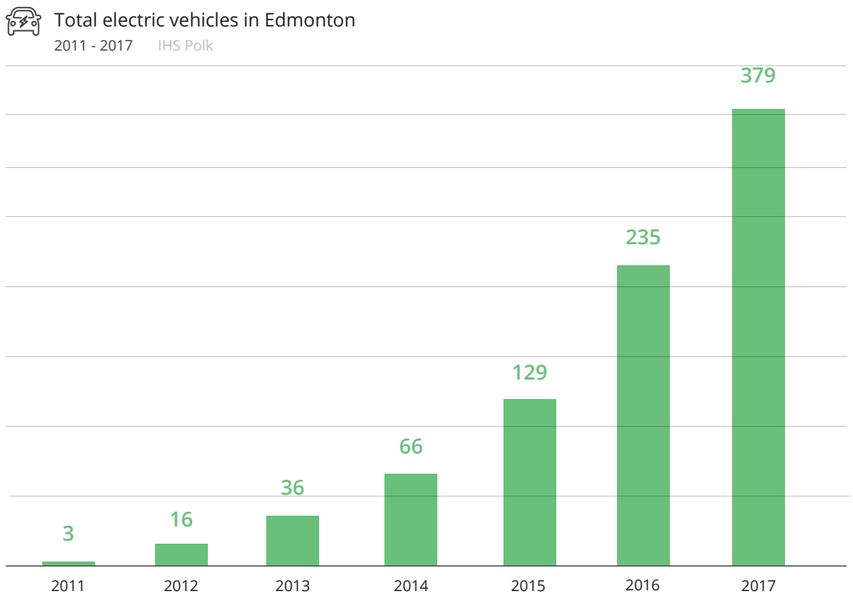


3.3 ALBERTA AND EDMONTON TRENDS

Alberta's EV market is relatively small. Data provided by IHS Polk shows that as of the end of 2017, only about 1,130 EVs were registered in Alberta. However, the numbers are growing - in the first three months of 2018, there were more battery electric vehicles registered in Alberta than in all of 2014.[27] Nevertheless, the most recent EV sales figures as of the end of 2016 from Quebec (13,500 vehicles), Ontario (9,200 vehicles), and British Columbia (5,400 vehicles) show a much stronger market share.[28] All three of these provinces have had EV-supportive policies in place for several years.

As shown in **Figure 4**,[29] as of the end of 2017 there were about 380 electric vehicles registered in the City of Edmonton - accounting for a third of the EVs in Alberta. The EVs on Edmonton roads today are evenly split between battery electric and plug-in hybrids representing about a dozen makes and models. The most common among them are the Tesla models, Chevrolet Volt, Volvo XC90, Porsche Cayenne, and the Nissan Leaf.

Figure 4. *Total Ele Registered in City*



Charging Up!

29

3.4 VEHICLE PURCHASING AND TRAVEL TRENDS

Motor vehicle sales data from Statistics Canada provide valuable information about the vehicle market in Alberta compared to the rest of Canada. The data show that over the past 15 years passenger cars have made up less of the new vehicle sales in Alberta. In 2000, passenger cars represented 37% of new vehicle sales, declining to 21% in 2015[30]. However, in contrast, truck[31] sales have seen an increase in new vehicle market share from 63% to 79% in the same timeframe. Nationally, trucks captured 63% of new vehicles sales in 2015.

Edmonton's vehicle landscape, like Alberta's, has been changing over the past decade from one characterized by passenger cars to one more dominated by light trucks, SUVs, crossovers, and vans. In 2016 there were 260,000 passenger cars registered in Edmonton as compared to 310,000 trucks, SUVs, crossovers and vans. **Figure 5** shows the trend in Edmonton vehicle registrations.[32]

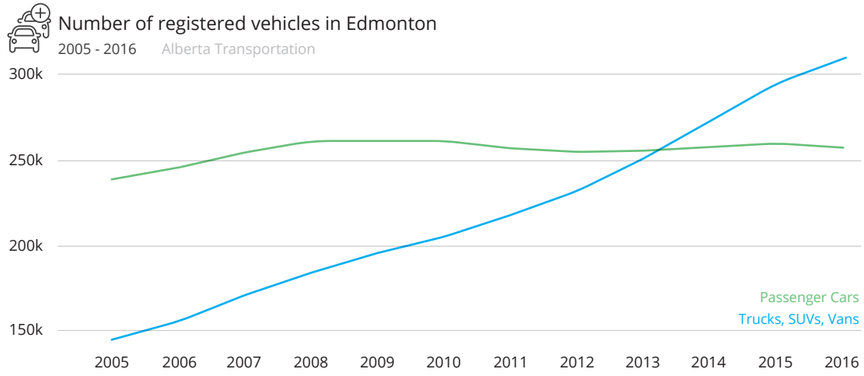


Figure 5. *Number of Registered Vehicles in Edmonton 2005-2016*

This could pose a barrier to EV adoption as there are currently few EV SUVs and vans and no EV pickup trucks available in the Alberta market. However, passenger cars representing 45% of registrations allows ample market space to increase EV sales. And, recently auto manufacturers have committed to adding a host of new SUV and pickup truck EVs to their line-ups that are expected to be available around 2020.

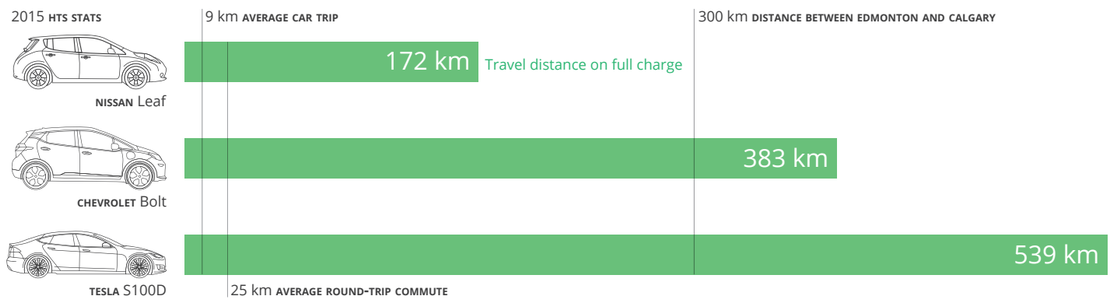
Regardless, there is a potential opportunity to begin a conversation with Edmontonians about factoring in vehicle right-sizing and fuel economy in vehicle purchasing decisions. Choosing a smaller vehicle, sized to accommodate typical rather than exceptional tasks, can lead to consumers considering the passenger vehicle category of car models, which currently offers greater EV options.

This trend in larger sized vehicles could also be due in part to Edmonton having historically enjoyed some of the lowest gas prices in the country. This trend could change with greater global and local emphasis on lowering greenhouse gas emissions. For example, as of January 1, 2017 the Alberta Government introduced a carbon levy on fossil fuel purchases which added 4.5 cents per litre for gasoline and 5.3 cents per litre for diesel. However, due to the incremental nature of the increases in fossil fuel costs via carbon levies and taxes, consumer behavior may not be significantly impacted. Nevertheless, by moving towards electrification in transportation this could shield Edmontonians to some degree from price volatility and supply uncertainty in the oil market.

Edmontonians' Trip Distances – Will they work with EVs?

Potential EV buyers often cite a concern over the limited range of electric vehicles, commonly termed "range anxiety", as one of the key barriers to owning an EV. This potentially applies for battery electric vehicles (BEV) moreso than plug-in hybrid electric vehicles (PHEV), which have both a gasoline engine and electric motor.

Even for BEVs, for most trips, range anxiety is more a perception than a reality. Data from Edmonton's Household Travel Survey (HTS)[33] sheds light on the average vehicle travel distances travelled in Edmonton and suggests that range anxiety would not be an issue for most daily trips made by Edmontonians. The 2015 HTS reported the following statistics:



The 2015 HTS reported that the average car trip in Edmonton is 9.4 km while the average round trip commute is 25.6 km - well within the range of electric vehicles on the market today.[34]

A valid concern is the less-frequent long-distance trip taken outside of Edmonton by vehicle. However, this obstacle has been overcome in other jurisdictions through a coordinated effort among various levels of government and the private sector to deploy fast charging networks outside of urban areas.

In addition, new BEV models are continuing to see improvements in their battery range. In ideal conditions, the Chevy Bolt and Tesla Model S 100D, for example, can travel up to 383 km and 539 km on a single charge, respectively.[35,36]

Research has shown that that EV range is reduced in cold weather situations due to increased power consumption for cabin heating and decreased battery efficiency, leading to an overall decrease in vehicle range by up to 50%.[37,38] **Appendix C - Researched Impacts of Cold Weather on EVs** provides a more in-depth discussion of how Edmonton's climate and EVs may interact.

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4.0

BEST PRACTICES

Edmonton does not have to reinvent the wheel to realize success with its Electric Vehicle Strategy; cities from around the world have successfully achieved high EV market share by adopting a combination of policies, incentives, and technical actions.

A 2015 report by the International Council on Clean Transportation (ICCT) analyzed the actions that are impacting electric vehicle deployment in the 25 most populated US metropolitan areas.[1] The study looked at both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs).

4.1 ACTIONS TOWARDS ELECTRIC VEHICLES

The 2015 study by the ICCT catalogued a number of actions that promote EVs at the federal, state, city, and utility level. For the purposes of Edmonton's Electric Vehicle Strategy, only the city-level actions are summarized below:

"A few cities alone aren't recasting the strategy of carmakers, but rather, decisions made by cities illustrate a mega-trend toward cleaner vehicles that manufacturers will have to incorporate in their strategy."[2]

– Emmanuel Bulle, Fitch Ratings' European manufacturing team

SUBSIDIES & INCENTIVES

- **VEHICLE PURCHASE SUBSIDY**
  Several cities offer financial incentives, ranging from $400–$2,500 for EV vehicle purchases or leases.

- **PARKING BENEFITS**
  Some local parking authorities provide designated parking for EVs.

- **CARPOOL LANE ACCESS**
  Some cities allow EVs to use carpool lanes as part of a strategy to promote greater EV adoption.

CHARGING STATIONS:

- **CITY-OWNED PUBLIC CHARGERS**
  18 of the 25 cities in the study have installed charging station equipment in different parts of their cities. Many of the stations are partially funded by federal or state funding and are made free for public use.

- **EV-READY REGULATIONS**
  As part of an effort to support charging infrastructure in the long term, some cities have included provisions in their city regulations to ensure that new buildings include or are prepared for electric vehicle charging equipment installation.

- **STREAMLINED EV CHARGERING PERMITTING PROCESS**
  A number of cities have made efforts to minimize issues related to the permitting for the installation of EV charging equipment. The intention is to streamline the permitting process for residential and commercial charging infrastructure.

CORPORATE ACTIONS

- **MUNICIPAL FLEET PURCHASING**
  15 of the 25 cities studied have some form of purchasing grants or incentives supporting increased EV deployment in city fleets.

- **LOCAL ELECTRIC VEHICLE STRATEGY**
  16 of the 25 cities in their sample have strategic plans that chart a path to increase EV adoption in their respective cities.

Thirty cities including New York and Chicago have recently jointly asked automakers for the cost and feasibility of providing 114,000 electric vehicles, including police cruisers, street sweepers and trash haulers.

The City of Los Angeles is coordinating the effort with full backing from Mayor Eric Garcetti. That would be comparable to about 72 percent of total U.S. plug-in sales in 2016.[3]

EDUCATION & OUTREACH

- **WEBSITE AND OTHER INFORMATIONAL MATERIALS**
  Several cities have informational, educational, and outreach activities to help promote EVs. This includes general information about EVs, links to external sources, and information about charging stations on their city websites.

- **OUTREACH AND EDUCATION EVENTS**
  Some cities have contributed to community-organized events to help promote greater understanding of EVs and the models available to consumers.

- **CARSHARING PROGRAM LINKS**
  Several cities are seeing EV deployment in their car sharing networks. This is helping to increase EV sales and also increases awareness, exposure, and level of comfort with EV use among prospective consumers.

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Table 4 summarizes the various EV promotion actions and where they have been adopted in select North American cities.[4] The table only includes a sample of cities that were studied by ICCT. Cities were selected based on one of the following criteria: [a] geographic diversity, [b] mix of electricity grids, and [c] comparable population size to Edmonton.

	MUNICIPAL LEVEL ACTION										
METRO AREA	VEHICLE PURCHASE SUBSIDY	PARKING BENEFIT	CARPOOL LANE (HOV) ACCESS	MUNICIPALLY-OWNED PUBLIC CHARGERS	EV-READY BUILDING CODE	STREAMLINED EVSE PERMITTING PROCESS	MUNICIPAL FLEET PURCHASING	ELECTRIC VEHICLE STRATEGY	CITY WEBSITE OR INFO MATERIALS	OUTREACH OR EDUCATION EVENTS	CARSHARING PROGRAM LINK
Boston		•		•			•		•	•	
Atlanta			•			•		•	•	•	
Denver	•	•	•	•					•	•	
Houston							•	•	•		•
Montréal*				•			•	•	•		
Portland OR				•		•	•	•	•		•
Riverside CA	•		•	•			•	•	•		
San Francisco			•	•	•		•	•	•	•	•
Seattle				•		•	•	•	•		
Vancouver*				•	•				•	•	•

Table 4. *Electric Vehicle Promotion Actions at the City Level*

• indicates electric vehicle action in place as of 2014.

*Montréal and Vancouver are not part of the ICCT study but have been included in the table as examples of Canadian cities with strong EV deployment actions.

The ICCT report included results from a statistical analysis that shows the link between EV promotion actions, incentives, charging infrastructure, model availability and EV uptake. Their model included actions from various jurisdictions including city governments, state governments, and utilities.

The statistical model organized all of the EV factors into three categories: [a] chargers per capita, [b] monetized EV benefits, and [c] EV models available. All three of these categories were found to have a statistically significant relationship with EV share across the 25 metropolitan areas.

The findings are summarized as follows:

- *Chargers per capita*: the number of public chargers per capita is a significant factor in a city's EV share. Public charging infrastructure can help alleviate range anxiety, extend the functional range of an EV, offer an economic incentive when the electricity is provided for free, and demonstrate support from municipalities and businesses.

- *Monetized EV benefits*: the model found state fiscal incentives and carpool lane access to be strong drivers for increased EV shares across the metropolitan areas. In addition, parking benefits, EV charging equipment subsidies and preferential rates for home charging[5] were found to be significant predictors for increasing EV shares. For EVs, their model found a strong statistical relationship between the number of monetized actions and EV share, which might be explained by consumers' preferences for a diversity of incentives.

- *EV model availability*: the availability of EV models was found to be a strong predictor in EV shares across the metropolitan areas. Some cities have up to 22 EV models available, representing a broad choice of sizes, styles, prices, and manufacturing companies from which a customer might choose. Note that vehicle model availability is strongly linked to the presence of a ZEV mandate , as discussed earlier—in other words, a ZEV mandate provides a strong incentive for automakers to make a wider variety of EVs available for sale in the regulated region.

The ICCT report provides some evidence on what factors are associated with higher EV uptake. **Appendix D - Highlighted Best Practices from Leaders in EV Deployment** provides more in-depth examples of cities, provinces, and countries leading the way in EV deployment.

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4.2 ENDNOTES

1 Lutsey, N., Searle., Chambliss, S., Bandivadekar, A. (2015). *Assessment of Leading Electric Vehicle Promotion Activities in United States Cities*. Available online at: http://www.theicct.org/leading-us-city-electric-vehicle-activities

2 Bloomberg Tecnology News. *No matter what Trump does, big cities pressing for cleaner cars*. Available at: https://www.bloomberg.com/news/articles/2017-05-17/paris-london-lead-urban-charge-for-cleaner-cars-as-trump-balks

3 Bloomberg Technology News. *Cities Shop for $10 Billion of Electric Cars to Defy Trump*. Available online at: https://www.bloomberg.com/news/articles/2017-03-14/cities-shop-for-10-billion-of-electric-vehicles-to-defy-trump

4 This table has been modified from Lutsey et al. (2015).

5 Some utilities offer preferential rates for customers who own EVs. This could be offered in the form of discounted rates for EV charging and/or time-of-use rates, which allow charging at much lower cost during off-peak hours.

5.0

IDENTIFYING OPPORTUNITIES AND BARRIERS

As part of the development of Edmonton's Electric Vehicle Strategy, multiple components of stakeholder engagement and market research were undertaken. Additional detail and specifics of these components are documented under separate cover [Compendium of Stakeholder Engagement & Market Research].

5.1 STAKEHOLDER CONSULTATION

In order to identify the barriers and opportunities to EV adoption in Edmonton, extensive stakeholder consultation was undertaken. The consultation involved [1] workshops with a diverse group of stakeholders, and [2] the collection of key insights gathered via focused one-on-one interviews and questionnaires.

Stakeholder Workshops

In March 2017, two workshops were held with 76 participants representing a total of thirty-five stakeholder organizations. A diversity of perspectives was offered by academics, advocates,utilities, EV owners and businesses, City staff, and other businesses. The stakeholders that participated in the workshops are listed below.

Attendance

Alberta Motor Association
ATCO
Capital Region Board
Centre for Citizen Experience
City of Calgary
City of Edmonton
Downtown Business Association of Edmonton
ECO Charge
Edmonton Catholic School District
Edmonton Federation of Community Leagues
Edmonton International Airport
Edmonton Police Service
Edmonton Public School Board
Electric Vehicle Association of Alberta
Enmax Energy
EnSeg
Epcor Energy
Government of Alberta
Growing Greener
Koch Ford Lincoln
Jewish Senior Citizen's Centre
John's Design and Drafting
Kuby Energy
Motor Dealers Association of Alberta
Pembina Institute
Pogo Carshare
Solar Energy Society
Solutions 105
City of Spruce Grove
City of St. Albert
Strathcona County
Strathcona Place 55+ Centre
University of Alberta
Waterloo Ford Lincoln
YRLess NRG Charging Lanes

From the City of Edmonton, the following business areas were represented:

- Building and Land Management
- Edmonton Transit Service
- Fleet and Facility Services
- Transportation Strategies (City Planning)
- Community Standards
- Integrated Strategic Development (Citizen Services)
- Facility Planning and Design
- Electrical Maintenance
- Engineering Services
- Community and Recreation Facilities
- Safety Codes Permits and Inspections
- Parking Services

The workshops included a technical overview and presentation of initial findings from compiled best practices and the current EV situation in Edmonton. Brainstorming activities examined barriers to increased EV adoption, and potential actions to address the barriers. Potential actions were examined with regard to level of effort and magnitude of impact.

Barriers to EV adoption identified in the stakeholder workshops have been well documented in research and through consumer preference surveys. A detailed summary of the most common barriers to EV adoption are provided in **Appendix E - Researched Barriers to EV Adoption.**

Focused Stakeholder Interviews

In order to obtain a more in-depth perspective on the issues surrounding EVs and EV charging, the City engaged a variety of stakeholders in focused interviews. Those interviewed represented a wide cross-section of stakeholders that influence the EV realm. Examples include retail outlets that had or were planning to install EV charging infrastructure, a developer actively pursuing the inclusion of EV car share into their condo developments, an electric service provider that installs home and commercial EV chargers as well as the Province, utility companies and auto dealerships.

The interviews yielded key insights into the stakeholders' current and future thinking on EVs and the impact to their current and future business. Participants were also asked for their advice on how the City of Edmonton could achieve greater EV adoption.

"It is exciting that EVs utilization is considered in the sustainable development of Edmonton, and our government will create an environment for electric vehicles thriving."

Community representative, Edmonton EV Strategy Workshop

Organizations that participated in the interviews are listed below.

- Alberta Transportation
- Atco Electric
- Edmonton Motor Dealers Association
- Enmax
- Epcor
- Capital Power
- Ikea
- Kuby Energy
- Motor Dealers Association of Alberta
- Pogo Car Share
- Simons Department Store
- Technical Strategies Consulting
- Urban Development Institute
- WestOak Development

Electric Vehicle Association of Alberta Workshop & Questionnaire

The City of Edmonton partnered with the Electric Vehicle Association of Alberta (EVAA) to host an "EVening with EV Owners" workshop. Attendees were asked to provide their unique insights as EV owners on the questions of barriers to purchasing, maintaining, and operating EVs in Edmonton today as well as what can be done to overcome the barriers and encourage more Edmontonians to purchase EVs.

In addition, the City conducted an online survey of current EV owners and potential owners, via the EVAA network. The survey gathered information about the brands and ages of EVs owned by the respondents, where they were purchased (or would be planned to purchase), and other related aspects such as home charging facilities, and costs of ownership.

Survey of Building Owners and Managers

Arising from involvement in stakeholder engagement, the Building Owners & Managers Association of Edmonton (BOMA) facilitated an email survey of its membership. BOMA acts as a voice for the commercial real estate industry, with over 100 members.

The survey garnered 24 responses, gathering information about parking management, perceptions of the business value of electric vehicle charging infrastructure as well as desired actions, if any, on the part of the City to incent the installation of EV chargers in buildings. Approximately one quarter of the respondents reported having already installed EV charging stations at one or more of their parking facilities.

Testimonials from Edmonton EV Owners included the following:

"Reliability has been unparalleled. The car feels like a tank that never fails regardless of weather conditions. No hassle operation, there is almost nothing to maintain this saves time, money and worry. It is difficult to put a price on the value of never going to a gas station."

"I love not having to go to the gas station during the summer and having a nice quiet and peaceful drive."

"Once you transition to an EV, there is no going back to ICE [internal combustion engine vehicle]. Would you give up your smart phone for a rotary wall phone?"

"A great investment for all my local driving needs. A fantastic winter car, too."

"It was great to see the City reaching out to its citizens as part of a well planned effort to be informed. The techniques for obtaining information were inspiring and highly effective."

Gathering Insights from EV-Leading Municipalities

Three North American cities, deemed to be leaders in EV deployment, were interviewed to collect information about their respective public EV charging station networks. The three cities included the City of Montreal, City of Vancouver, and the City of Portland.

The cities were asked ten questions which included the ratio of Level 2 and Level 3[1] chargers within their city boundary, the overall utilization of the charging stations, involvement from the private sector and/or utilities, and whether EV users are charged a fee for usage. Ultimately, the interviews endeavored to understand the overall value of publicly available charging stations for accelerating EV adoption in each of the respective cities. The salient findings from the interviews were incorporated into development of the **EV Charging Station Pilot Project** documented under separate cover.

5.2 MARKET RESEARCH

Edmonton Insight Community Survey

The Edmonton Insight Community[2] is an online citizen panel that reflects Edmonton's diversity, and serves the city by providing feedback on City policies, initiatives and issues. Members complete surveys and participate in discussion forums on a wide variety of topics at least twice a month. The Edmonton Insight Community is open to all residents of Edmonton, and those who own property in Edmonton, over the age of 15.

900 participants completed the survey on electric vehicles; the objectives of the survey were to assess awareness of electric vehicles, ownership status or likelihood to purchase an EV, barriers to purchasing an EV, and potential benefits of owning an EV.

The survey results assisted in initial direction-setting for the EV Strategy and were also used to compare with previous EV survey research conducted in Edmonton and elsewhere. In addition, the detailed survey results include sub-segment analysis that may be helpful in developing marketing or education outreach for EV Strategy implementation.

Survey of Edmontonians

A telephone survey was conducted in April 2017, to obtain a statistically-reliable sample of the views of Edmontonians regarding EVs. The random sample of 600 households was distributed evenly across the twelve wards of Edmonton, and evenly split between male and female respondents.

The telephone survey included questions such as the degree of knowledge about EVs, perceived barriers, possible mitigations, and the perceived impact of potential strategic actions to overcome barriers and increase probability of EV purchasing or leasing choices.

5.3 SYNTHESIS OF BARRIERS AND OPPORTUNITIES

The product of the consultations and market research was the formulation of themes around barriers and opportunities for EV adoption in Edmonton. The tables on the following pages outline those themes that emerged from the consultations, categorized by the influencing group.

Thoughts from Edmonton Insight Community EV Survey respondents

"I hope we go down this route both for the environment as well as staying up with the current trends all over the world. We do not need to fall behind on this great opportunity."

"As much as I'd like to say that environmental concerns will drive to purchasing an electric vehicle, the choice will ultimately come down to economics."

GENERAL PUBLIC

Barriers

- Lack of knowledge and familiarity of EVs.
- Upfront cost of EV and the lack of incentives.
- Range anxiety and lack of charging stations.
- Lack of vehicle options.
- Lack of charging stations in condos and apartments.
- Perceived as incompatible with winter weather.
- Lack of car dealer initiative/service.
- Currently few people would consider purchasing an EV.

Solutions

- Public opinion and comfort with EVs is improved when presented with opportunities to talk with EV owners, experience EVs and by seeing more charging stations in the public realm.
- Environmental and financial benefits of EVs are appealing.
- Coupling EVs with a renewable energy supply is appealing.
- Improving opportunities for charging at home and in public places has a highly positive impact on EV purchasing decisions.

PRIVATE SECTOR

Barriers

- Lack of current EV demand from the public makes it difficult to provide variety of product.
- A lack of demand coupled with low electricity prices makes a poor business case for the private sector to get involved in public EV charging deployment.
- A barrier to installing Level 3 charging is the unknown operating costs and possibly very high demand charges.
- Lack of knowledge around current and anticipated EVs on the road.
- Lack of knowledge about capital and operating costs of EV charging stations as well as vendors who can supply the equipment.

Solutions

- Sustainability is increasingly valued in a competitive market.
- Acknowledgement that EVs are an emerging technology and will eventually become the norm – the unknown is when.
- An openness to partnering with the City on initiatives of mutual benefit.
- Open to working with the City and leveraging collective purchasing power.
- Corporate tax incentives for 'green' action are welcomed over subsidies.

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GOVERNMENT

Barriers

- Potential lack of funds to fully implement plans.
- Perceived interference by government in natural market forces.
- Perception of public dollars being used to benefit a few.
- Perception of government as being suppliers of vehicle 'fuel'.
- Potential lack of funds to deploy Level 3 fast chargers due to high capital and operating costs.

Opportunities

- Leading by example through implementation of EVs in fleets.
- Ability to leverage bylaws and regulations.
- Far-reaching ability to communicate with the broader public.
- Cities are a natural focal point for collaboration among governments, private sector, utilities, and advocates.
- The City as a broker of trusted information and financial leveraging when it comes to increased deployment of EV charging in Edmonton.
- Ability to leverage purchasing power.
- Cities can deploy publicly accessible Level 2 charging stations on city-owned property to help create public awareness, encourage uptake of EVs, and alleviate range anxiety among EV users.

5.4 ENDNOTES

1 See Appendix A for definitions of the various types of charging equipment.

2 For more information about the Edmonton Insight Community, see online: https://www.edmonton.ca/programs_services/public_engagement/edmonton-insight-community.aspx

6.0

OPPORTUNITY AREAS & STRATEGIC OBJECTIVES

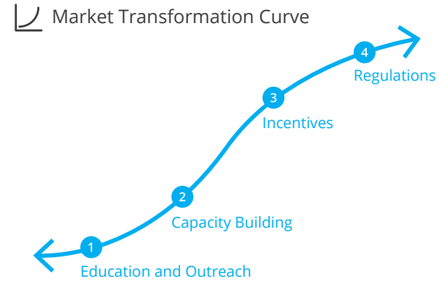
The City of Edmonton has an opportunity to accelerate electric vehicle ownership through six opportunity areas. Opportunity areas include strategic objectives – providing direction on where the City could pursue its efforts – along with strategic actions that identify how the City could achieve a meaningful outcome.

6.1 MARKET TRANSFORMATION APPROACH

The City's *Community Energy Transition Strategy* provides a strong foundation to help shift Edmontonians to an electric vehicle future. The strategy specifically calls for "increased electrification of Edmonton's transportation system with passenger vehicles, buses, light trucks and trains powered by clean electricity" to help achieve Edmonton's GHG and energy reduction goals.[1]

Strategic Action 5 of the *Community Energy Transition Strategy* directs the City to "apply a market transformation approach to achieve the changes that are needed to become an energy sustainable city."

The four stages of the market transformation curve provide a useful framework for the Edmonton's EV strategy by identifying the necessary steps to achieve greater EV adoption. Each stage is briefly described below as it relates to EV technology. Edmonton's *Community Energy Transition Strategy*[2] recommends that the market transformation approach be applied to energy transition initiatives, including those related to EVs.



It is important to note that when applying the market transformation curve to EV adoption, the stages will not necessarily be applied sequentially but rather concurrently. Applied in this way, the market transformation elements would become mutually reinforcing rather than linear. For example it could be beneficial to have regulations instituted ahead of, or concurrent with education programs to ensure that as interest and excitement are built around EVs that the infrastructure to support the shift is in place.

Stage 1 (Education & Outreach)
The market transformation begins with a segment of the population understanding and seeing the value of particular opportunities (e.g., electric vehicles, green buildings). Education and outreach help build awareness and consequently may contribute to higher demand for the opportunity. This first stage begins to establish the market.

Stage 2 (Capacity Building)
Because of the lack of knowledge, experience and familiarity of EVs in Edmonton, there will be a fairly steep learning curves. Not only does this apply to consumers but to those that supply and service EVs. Currently very few auto dealerships in the Edmonton-area are licensed by the their respective auto manufacturers to sell and service EVs. Likewise there is a limited number of companies in Edmonton that have experience in installing EV charging equipment - either for home or commercial uses. Critical to the advancement of EVs will be sufficient time, information and experience to understand the technology.

Stage 3 (Incentives)
Emerging technologies like EVs bring uncertainty to both suppliers and consumers. Consumers might take a cautious approach to buying new technologies and instead decide to wait-and-see. Similarly, suppliers of emerging technologies are cautious about entering markets where demand for emerging products is uncertain and/or volatile. In these early-market situations, incentives are often needed to help reduce the risks to early adopters and suppliers.

Stage 4 (Regulations)
At this stage, the market for the technology has matured and therefore, incentives may no longer be necessary. In addition, awareness, community support and demand exist for the technology. Regulations can now be considered as they have the ability to have a larger impact on supporting and accelerating the technology.

6.2 OPPORTUNITY AREAS

Based on the best practices review and the themes derived from the stakeholder engagement and market research, the following opportunity areas have been identified:

- Education & Marketing
- Electric Vehicle Charging Infrastructure
- Incentives & Financial Tools
- Regulations
- City Leadership
- Collaboration, Partnerships & Advocacy

The six opportunity areas are described on the following pages, and have been listed such that they align with the market transformation curve, though many of the strategic actions can occur concurrently as they may complement each other. Each opportunity area is described as to its context and is accompanied by a number of supporting Strategic Objectives. Specific tactical action items for each recommended Strategic Objective are listed under separate cover (**Edmonton's Electric Vehicle Strategy - Strategic Actions**) as described at the end of this section.

The strategic actions include an indication of the implementation timeframe within the five-year scope of Edmonton's EV Strategy, which is based on considerations such as readiness, level of effort, and level of impact. It assists in identifying actions that could be "lower hanging fruit" for attention in the initial years of implementation, as well as actions that tend to be longer-term and greater effort but often associated with important or impactful outcomes.

OPPORTUNITY AREA 1

Education & Marketing

The stakeholder engagement and market research confirmed that education and marketing is one the most important first steps in improving Edmontonians' knowledge and experience with electric vehicles.

As an emerging technology, electric vehicles can be complicated and difficult to understand. People lack familiarity with battery technology, the types of charging stations available, and how to operate the vehicle. EVs do not enjoy the same level of popular familiarity as gasoline vehicles, mainly due to the fact that gasoline powered cars have been part of the fabric of society for over a century.

Fifty-three percent of Edmontonians surveyed indicated that they have no experience of any kind with EVs. Other Canadian research shows that two-thirds of car buyers do not know the difference between a conventional hybrid, a plug-in hybrid, and a BEV.[3] In addition, respondents indicated that the top three factors that would shape their opinion on EVs included 1) talking with an EV owner, 2) physically seeing more EVs and charging stations in the public realm, and 3) talking with family and friends. These results were consistent with those from the Edmonton Insight Community. It is clear that creating opportunities for people to experience EVs is very important. These experiences will create familiarity, understanding, and comfort with EV technology. The consensus from the stakeholder workshops was that actions in this opportunity area would yield good returns for relatively low effort.

Edmontonians identified that information on the financial and environmental benefits of EVs would positively impact their decision to purchase an EV. Therefore, educational and marketing tools that include messaging that highlights these benefits of EVs could be highly effective. In undertaking strategic actions in this opportunity area, the City will reach out to jurisdictions that have undertaken similar initiatives to learn from their experiences and perhaps build on their knowledge.

STRATEGIC OBJECTIVES

1a.

Undertake public education and marketing activities to create awareness and build support for EVs among Edmontonians.

This objective aims at big-picture, longer-term positive shifts in the perceptions of the general population toward electric vehicles. It strives to increase general support for EVs at a societal level as well as building an increasingly supportive market of potential EV purchasers.

This objective complements market trends and efforts to increase the number of EV makes and models, by supporting the longer-term demand for EVs.

This objective can also aim to impact vehicle purchasing decisions, from the buyer's perspective, to accelerate EV uptake in the short-to medium-term.

Market research information is available to assist in identifying effective approaches for the current market cohorts ("early adopters"), as well as how marketing approaches would evolve as the market grows into the mainstream.

1b.

Undertake EV education and marketing activities targeted at professionals in the car dealership industry who have potential to influence EV purchasing decisions.

This objective aims to impact vehicle purchasing decisions, from the seller's perspective, to accelerate EV uptake in the short-to-medium-term. This includes automobile dealers, as well as related industry players such as automotive writers and publications. This objective complements automobile manufacturer trends toward increasing the number of EV makes and models.

OPPORTUNITY AREA 2

Electric Vehicle Charging Infrastructure

Improving and increasing the availability of EV charging infrastructure was identified as a key opportunity in the stakeholder engagement and market research. The availability of charging infrastructure was the most frequently cited barrier by the stakeholders at the EV workshops. As well, Edmontonians identified the ability to easily charge at home, within the city, and outside of the city enroute to major destinations, as the top three most important factors in their decision to purchase an EV. Conversations with EV owners in Edmonton also suggested that an extensive charging station network, particularly one that offers Level 3 fast chargers, can encourage more Edmontonians to purchase electric vehicles.

Research has shown that the majority of EV charging takes place at home where it is convenient and easy. Although Level 2 home EV charging units offer the advantage of reduced charging time, an EV can also charge via a typical 120 V wall outlet (albeit much slower - 8 to 16 hours to fully charge depending on battery size, though this type of charging might be more acceptable for PHEVs which only require 4-12 hours to fully charge and have a gasoline engine for backup). Charging while at a place of work is the second most popular location, if charging facilities are available. Incorporating the electrical needs of EV charging at the time of residential or commercial construction reduces installation costs to a fraction of the cost it would be to accommodate an EV charger in a retrofit situation.

In addition, it has also been established that the presence of a public charging station network can help improve range confidence for potential EV owners, show tangible support from government and businesses, and demonstrate the increasing presence of EVs as a normal and feasible alternative to the ICE automobile.

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STRATEGIC OBJECTIVES

2a.
Improve opportunities for residential EV charging.

This includes improving single-family residential charging opportunities, as well as addressing barriers in multi-family residential contexts.

2b.
Improve opportunities for workplace EV charging.

This includes parking facilities at workplaces such as employment centres, educational institutions, and other similar sectors where people are located during scheduled hours away from home on a regular basis.

2c.
Develop local and long-distance public EV charging networks.

This refers to the development of publicly-accessible EV charging networks for:

- shorter-distance, typically more-frequent or regular, trips within the city; and
- longer distance, typically less-frequent or occasional, trips outside the city (such as inter-city travel for vacation or work purposes).

The direct purpose of the public EV charging network is to provide "life line" charging support as a back-up plan for EV users in the event the charge from their typical residential or workplace runs low.

The indirect purpose of the public EV charging network is to increase the profile of EVs as a popular and viable alternative.

OPPORTUNITY AREA 3

Incentives & Financial Tools

Access to both monetary and non-monetary incentives has proven to accelerate EV adoption in a number of jurisdictions including Norway, Ontario, British Columbia, and Quebec. Norway in particular, which leads the world in EV market share, has seen enormous success due to a substantial package of incentives developed to promote zero emission vehicles (incentives including free municipal parking, access to bus lanes, low annual road tax, and exemption from the 25% value-added tax, among other incentives).[4]

Stakeholder engagement and market research confirmed that the provision of incentives would make EVs more appealing to Edmontonians. Both the high purchase price of an EV and the lack of incentives were identified as key barriers to adoption. A number of opportunities were identified to help overcome these barriers including financial incentives that make EVs more affordable to the consumer and non-monetary incentives that prioritize EVs over gasoline-powered vehicles.

In terms of the scale of vehicle purchase incentives, not surprisingly, Edmontonians indicated that a larger incentive would more greatly impact their decision to purchase an EV. The results of the survey indicate that the incentive amount was directly related to the degree of impact on the decision to purchase an EV. A tripling of vehicle incentives (from $4,000 to $12,000) led to a tripling in the positive impact it would have on the decision to purchase an EV. Only between 1 to 5% of respondents felt that no rebate should be offered at all. A similar trend in the survey results was noted with rebates for the purchase and installation of home EV charging units.

STRATEGIC OBJECTIVES

3a.

Provide non-permanent financial incentives, aimed at residents, to reduce the cost of EV purchase and charging as compared to ICE vehicle costs.

This objective is intended to kick-start an increase in EV market share by addressing one of the key initial barriers to greater uptake in EV sales: the incremental cost of purchasing an EV and the additional cost of home EV charging infrastructure. The intention would be to reduce and ultimately eliminate this type of incentive as EV vehicle and charging infrastructure costs come down with increased volumes, and markets gain popularity, "momentum," and maturity.

This objective would also support initially allowing free public access to City-owned Level 2 EV charging stations. The provision of free Level 2 charging would signal City support for EVs and the cost to the City, in these early days of EV adoption, would be relatively low. The City could consider introducing fees for Level 2 charging once EVs begin to constitute a larger portion of the on-road fleet. By comparison, Level 3 fast charging services could have a fee for use right from inception given that this type of EV charging infrastructure offers superior convenience and service to users.

3b.

Provide ongoing tangible benefits and advantages to EV ownership and operation.

This objective relates to long term benefits and advantages that the City of Edmonton can provide or support to increase the perception of EVs as a preferred alternative to gasoline and diesel vehicles. For example, a rebate could be offered towards an EV upon retirement of an older vehicle. The City will need to work collaboratively with the Province and industry partners on these initiatives.

OPPORTUNITY AREA 4

Regulations

The City has the ability to drive an accelerated uptake of electric vehicles in Edmonton by using its regulatory tools. For example, the City's off-street parking requirements could potentially be used to support EV deployment goals by allowing parking reductions and variances where shared-use EVs are proposed.

The City has some regulations which are ultimately enabled or required by provincial or federal regulations. The proposed City Charter for Edmonton (and Calgary) may open up opportunities to apply regulatory approaches to either enabling or requiring EV-friendly actions. The draft revisions of the MGA are also proposing a new municipal purpose related to the environment.

STRATEGIC OBJECTIVES

4a.

Leverage municipal regulations and processes to better support the advancement of EVs.

This objective reflects the need to amend bylaws and approval processes to enable and/or require practices to increase the availability of EVs and EV charging infrastructure at residential and workplace locations.

4b.

Support the provincial and/or federal governments in establishing a zero-emissions vehicle (ZEV) mandate.

This objective is beyond the control of a municipality, but represents a pivotal change in managing the supply and growth of zero-emissions vehicles such as EVs. There is evidence from global best practices which indicates this may be the single most influential mechanism to increase EV uptake toward levels necessary to achieve environmental and mobility goals. It is important to note that supply-side measures should be in place prior to support the success of a ZEV mandate.

The Government of Quebec represents a Canadian example, where a 2016 zero-emission vehicle mandate was adopted which requires automakers to sell zero-emission vehicles (either electric or hydrogen-powered) as 15 percent of their sales in the province by 2025.

OPPORTUNITY AREA 5

City Leadership

Achieving higher uptake of electric vehicles in Edmonton will ultimately require strong consumer interest among Edmontonians. The City is well positioned to accelerate EV adoption by demonstrating leadership in this critical – and emerging – area of technology. Stakeholders identified the City leading by example as a key element in encouraging greater EV adoption by Edmontonians. In particular, visual and meaningful demonstrations by the City were cited as important. This included increasing the number of EVs in the City fleet as well as installing EV charging stations at City-owned facilities.

A number of City actions are already being pursued including a commitment to introduce up to 40 electric buses by 2019 into the transit fleet, plans to incorporate low / zero emission vehicles in its municipal fleet, operating (and planning for additional) public Level 2 charging stations at municipal facilities.

A number of other cities in Canada including Montreal and Vancouver have demonstrated leadership on EVs; both municipalities have adopted EV strategies outlining how their respective local governments will be involved to help accelerate EV adoption. The City could pursue a number of initiatives to accelerate adoption and, more importantly, signal to Edmontonians the importance of developing an EV market that is consistent with the City's social, economic, and environmental goals.

STRATEGIC OBJECTIVES

5a.

Maximize opportunities to transition the City's municipal fleet to EVs wherever feasible.

This objective would continue the move toward electrifying buses and electrifying the municipal fleet where possible. One way to facilitate that would be to examine rigorously when smaller vehicles (typically more aligned with current EV model availability) can functionally be an alternative to larger vehicles such as pickup trucks.

5b.

Implement and showcase demonstration EV(s) and infrastructure at municipal facilities and projects.

This objective seeks to use the influence of the City to demonstrate key facets of supporting EV uptake as an employer and as a facilities owner, such as the provision of EV charging infrastructure for customers and staff at municipal facilities. Also, this objective would capitalize on the unique prominence of certain City facilities by showcasing an EV and charging station at a location such as City Hall.

This objective would work in conjunction with Strategic Objective 1 via outreach and publicity to ensure broad dissemination of the City's leadership-by-example.

5c.

Explore innovative programs to reduce EV-related purchase costs

With this objective, the City would provide leadership by exploring innovative ways to harness pricing benefits through bulk purchases. This could involve organizing a joint purchase of EVs or charging infrastructure with the City of Calgary, the Government of Alberta or other institutions of municipalities. This could also involve exploring the development of a group-buy program to obtain pre-negotiated savings resulting from pooled purchases by residents, businesses and building owners.

OPPORTUNITY AREA 6

Collaboration, Partnerships & Advocacy

Achieving a significantly higher EV market share in Edmonton cannot be accomplished by the City alone – other levels of government, private companies, and utilities need to be engaged to collectively advance EV adoption. An example of this from the Quebec context: the local utility in Montreal (Hydro-Quebec) and the Government of Quebec have been actively involved in promoting electric vehicles. The Electric Circuit – a province-wide initiative that provides an extensive public charging station network – has involved over 100 partners from private businesses to municipalities. There are many other opportunities for collaboration with partners to make EVs a more viable option for Edmontonians.

STRATEGIC OBJECTIVES

6a.

Collaborate with automobile industry and non-profit organizations.

This objective would involve working with organizations such as vehicle associations and driving schools to create opportunities for Edmontonians to learn about electric vehicles.

6b.

Collaborate with local car-sharing and ride-sharing organizations.

Car-sharing and ride-sharing organizations are potential allies to champion and expand access to electric vehicles, potentially promoting an "EV experience" and helping build public support for the technology.

6c.

Collaborate with utility companies and academic institutions.

There are a number of specific aspects of EVs which relate to the business of utility organizations, particularly the electric utilities. Some aspects of EVs are being actively researched by academic institutions. This objective recognizes the need to work collaboratively on resolution of issues such as the impacts of EVs on electricity grid capacity, or redesigning rate plans in relation to EV charging to support EV objectives within the utility financial framework. For example, this could mean designing an EV charger-friendly rate structure to mitigate the issue of demand charges for Level 3 DC fast charging.

6d.

Collaborate with provincial and federal governments.

This objective recognizes the need for the City to work collaboratively with other levels of government , particularly in the development of strategies and policies. The City may also seek to remove provincial or federal barriers or restrictions, if any, such as regulations that may not have anticipated EVs as part of the transportation system. In other cases, this will involve gaining support for enabling actions, including funding.

6.3 IMPLEMENTATION PLAN

In order to fully take advantage of the six opportunity areas and fulfill the course of action set out by the strategic directions, a substantial set of strategic actions has been developed. Implementation of these actions will put Edmonton on course to achieving the goals of Edmonton's Electric Vehicle Strategy, ultimately leading to lower energy and GHG emissions from passenger vehicle travel.

This implementation plan, including the set of action items supporting the Strategic Objectives, is presented under separate cover titled **Edmonton's Electric Vehicle Strategy - Strategic Actions.**

6.4 ENDNOTES

1 City of Edmonton. (2015). Edmonton's Community Energy Transition Strategy. Available online at: https://www.edmonton.ca/city_government/documents/EnergyTransitionStrategy.pdf

2 City of Edmonton. (2015). Edmonton's Community Energy Transition Strategy, pg. 27. Available online at: https://www.edmonton.ca/city_government/documents/EnergyTransitionStrategy.pdf

3 Axsen, J., S. Goldberg, et al. (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.

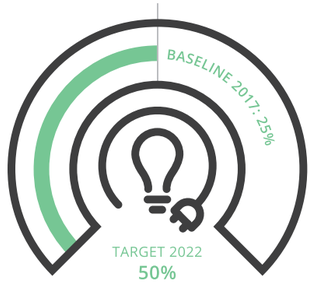
4 Norsk elbilforening. (2017). Norwegian EV policy. Available online at: http://elbil.no/english/norwegian-ev-policy/

7.0

KEY INDICATORS & TARGETS

Four Key Indicators have been identified to measure the degree of success achieved by implementing Edmonton's Electric Vehicle Strategy. The Key Indicators measure the progress made to impact all four elements of the market transformation curve, leading to accelerated EV adoption.

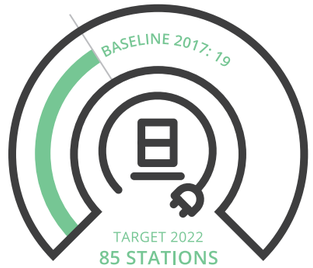
Key Indicator 1 measures the impacts of the education and outreach efforts; Key Indicator 2 measures one aspect of capacity built in the community that could support greater confidence in EV purchasing; Key Indicator 3 measures the effect of increased capacity and incentives and signals a shift in attitudes and future behaviours; and Key Indicator 4 reflects the culmination of efforts in all four market transformation elements, including the instatement of regulations to fully support the transformation.



KEY INDICATOR 1

Percent of people indicating they are knowledgeable about electric vehicles

This indicator measures the self-reported level of awareness and knowledge of Edmontonians on EVs. A base level of awareness among the population is an essential precursor to support the purchasing decisions of individuals and households.

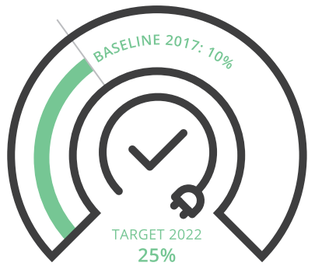


KEY INDICATOR 2

Number of pulicly accessible charging stations

Increasing the number of EV charging stations in the public realm is linked to increased consumer confidence in purchasing EVs and adoption. At the time of writing, there were 19 publicly available electric vehicle chargers[1] sited at City libraries, university campuses, business tower parkades and some malls.

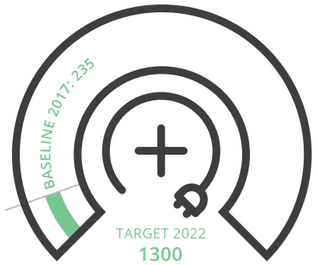
In the absence guidance on the ideal ratio of electric vehicles to charging stations, Edmonton could strive to achieve the current Canadian average of 10 to 15 electric vehicles per charging station[2]. Using a target ratio of 15 electric vehicles per charging station would mean having 25 public charging stations today. At the end of 2017, with 380 electric vehicles registered in Edmonton the ratio is 21 electric vehicles per charging station. With a target of 1,300 electric vehicles in Edmonton by 2023, the target number of electric vehicle chargers would be 85.



KEY INDICATOR 3

Percent of people indicating they would purchase an EV

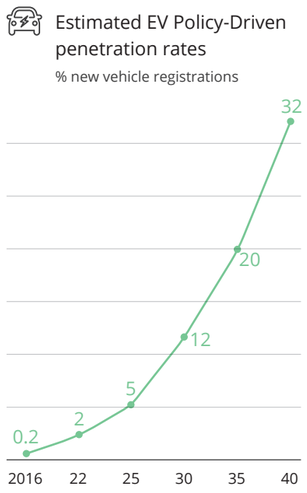
This indicator reflects the increased confidence of Edmontonians in purchasing an EV. The increased confidence can be linked to the cumulative effect of greater knowledge, exposure and comfort with EVs.



KEY INDICATOR 4

Number of EVs registered in Edmonton

This indicator provides a tangible indication of EV adoption, measuring the cumulative effects of market transformation efforts in education, capacity building, incentives and regulation. It should be noted that this Indicator is one that the City has far less influence over as compared to the first three Indicators. To move the needle on vehicle purchases there needs to be strong movement on the supply-side of EVs which is largely influenced by the private sector via auto manufacturers and dealerships, and on the government side via strong regulations.



Having 1,300 electric vehicles registered in Edmonton by 2022 would be equivalent to approximately 3% of new passenger vehicle and SUV sales being captured by EVs or about 1,000 new EVs added to Edmonton roads between now and 2022. Estimated future EV registrations for Edmonton were developed based on the existing number of EVs today, historical growth in Edmonton EV registrations over the past four years and the assumption that both supply and demand-side policies are implemented over the next five years. Canada's *Electric Vehicle Policy Report Card*[3] was used to set the 2040 penetration rate of 32% of new vehicles sales captured by EVs. This target was used to build the adoption curve for EVs in Edmonton between 2025 and 2040.

The values were developed reflecting a medium scenario technology adoption curve (see Laysell et al[4]). Achieving this target requires that provincial and federal levels of government will progressively implement policies supportive of EVs over the next decade. Auto manufacturers and their respective dealerships would also need to add new EVs to their vehicle line ups.

7.1 ENDNOTES

1 For the purposes of this Indicator, only chargers that are accessible to the public and available 24 hours a day, 7 days a week are considered publicly available. Not included in this are chargers that are privately controlled and require permission to access such as those at car dealerships or hotel parkades. In some cases even those that are publicly accessible may have restrictions to access such as at some malls.

2 Hall, Dale; Lutsey, Nic. Emerging Best Practices for Electric Vehicle Charging Infrastructure, ICCT October 2017. Available online: https://www.theicct.org/sites/default/files/publications/EV-charging-best-practices_ICCT-white-paper_04102017_vF.pdf

3 Axsen, J., Goldberg, S., Melton, N. (2016). Canada's Electric Vehicle Policy Report Card. Sustainable Transportation Action Research Team, Simon Fraser University. Available online at: https://sfustart.files.wordpress.com/2016/11/canadas-electricvehicle-policy-report-card.pdf

4 Layzell, D., Straatman, B. (2016). The Potential Impact of Electric Vehicles on Alberta's Energy System. Available online at: http://www.cesarnet.ca/sites/default/files/pdf/CESAR-Scenarios-Potential-Impact-EVs.pdf

8.0

APPENDICES

A: ELECTRIC VEHICLES 101

TYPES OF ELECTRIC VEHICLES

Electric Vehicles can best be organized into two distinct vehicles types: battery electric vehicle and plug-in hybrid electric vehicle. Each vehicle type is explained below. Although not within the scope of Edmonton's Electric Vehicle Strategy, hybrid cars are worth defining here to clarify how they are different from EVs.

Battery Electric Vehicle

A battery electric vehicle (BEV) is powered exclusively by electricity and must be plugged in to charge. BEVs can be charged via an EV charger or by a typical wall outlet. BEVs can, on average, travel anywhere from 100 to 400 kilometres with a fully charged battery before requiring a charge. A number of BEVs are available in the Canadian market including the Nissan Leaf, Tesla Model S, Chevy Bolt and the Mitsubishi i-MiEV.[1]

Plug-in Hybrid Electric Vehicle

Plug-in hybrid electric vehicles (PHEVs) can be fueled with both gasoline and electricity from a wall outlet or an EV charger. PHEVs can travel between 20 and 60 kilometres on electricity with a fully charged battery and subsequently transition to a full tank of gasoline for 500 to 900 kilometres. There are a number of PHEVs available in Canada including the Ford C-Max, Volvo XC90, Ford Fusion, and Chevrolet Volt.[2]

Hybrids

Hybrids are fueled with gasoline only. They recapture some energy through a regenerative braking system which charges a small on-board battery pack storing the braking energy as electricity which can help power the car. These hybrids cannot be plugged in and charged, but they can be very fuel efficient.[3]

CHARGING INFRASTRUCTURE[4,5]

Charging infrastructure is commonly referred to as electric vehicle supply equipment (EVSE). It is the intermediary between a power source and the vehicle's charging port, and is typically mounted on a wall or up on a pedestal. The electricity is provided through both alternating current (AC) and direct current (DC) power. The most common way to power a vehicle is through AC charging where AC power from the grid is provided to the vehicle through the vehicle's on-board charger. The charger converts the AC power to DC in order to charge the battery.[6]

Level 1: Alternating Current (AC)

Power Level: 120 volts (1.4kW) 8 to 16 amps, 12 amps typical
Charging Types: PHEV 8–12 hours, BEV 16+ hours

The slowest form of charging uses a plug to connect to the EVs on-board charger via a standard household outlet using 120v outlet and 15 amps. This setup provides between 3 and 8 kilometres of charge per hour. While this may sound like a trivial amount, it can work for those who travel less than 64 kilometres a day and have the ability to charge their vehicle overnight.

Level 2: Alternating Current (AC)

Power Level: 240 volts (3.3–19.2kW), 6 to 80 amps, 30 amps typical
Charging Types: PHEV 2–4 hours, BEV: 4–10 hours

This type of charging unit uses power at 220v or 240v and up to 80 amps. Drivers can add 16-25 kilometres of range in an hour of charging at home or public charging station.[7] These are the most commonly available public charging stations and offer a degree of versatility in terms of the parking settings in which they can be installed, including parkades, surface lots or curbside.

Level 3: Direct Current (DC) Fast Charger

Power Level: 200 to 450 volts (25–300kW), up to 200 amps
Charging Types: 25–30 minutes to charge BEV to 80% capacity

Level 3: This type of charger is also referred to as a "fast charger". The physical charger is larger than a Level 2, about the size of a gas pump and can deliver 80% of a full charge to an EV in 30 minutes. On a technical level, a Level 3 charging station converts AC power to DC power, effectively bypassing the vehicle's onboard charger and feeding the vehicle's battery directly. A DC charger is larger, more powerful, and more expensive than an AC charging station; however, the higher cost of the equipment can typically be recovered across many users.[8]

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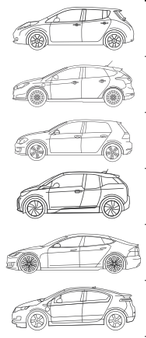
Tesla Supercharger

These EV chargers are essentially a special Level 3 charger that can only be used to charge a Tesla vehicle; other makes of EVs do not currently have access. These stations are owned and operated as part of the Tesla network of superchargers world-wide and are typically sited to support the long distance travel needs of Tesla owners, but increasingly are being installed within cities to facilitate charging for those living condos and others without access to home charging. Tesla also partners with some hotels, restaurants and shopping centres to install "Destination Charging" sites. Partners receive the first two Wall Connector chargers (Level 2) free of charge. The location of the property will then appear on the Tesla website and in-vehicle navigation systems. Currently four hotels in Edmonton host a Destination Charger including the Fantasyland Hotel at West Edmonton Mall and the Fairmont Hotel MacDonald.

Table A.1 illustrates the additional range (in kilometres) that can be obtained from a one-hour or half-hour charge at Level 2 and Level 3 charging stations respectively, for a selection of EV models.



VEHICLE TYPE	CHARGING RANGE PER HOUR (LVL 2)	CHARGING RANGE PER 1/2 HOUR (LVL 3 FAST CHARGER)
Nissan Leaf	17 - 35 km	96 - 152 km
Ford Focus Electric	35 km	no fast charging
Volkswagen e-Golf	39 km	96 - 133 km
BMW i3	39 km	96 - 132 km
Tesla Model S	47 - 96 km	273 km
Chevy Volt	18 km	no fast charging

Table A.1 *Electric Vehicle Charging Range By Level 2 and Level 3 Charger*[9]

B: A SHORT HISTORY OF ELECTRIC VEHICLES

Electric vehicles are not a new phenomenon. In fact, they have been around since the late 1800s. However, the story of the electric vehicle is best characterized as a technology that has ebbed and flowed over the last 140 years due to a variety of economic, environmental, and social factors.

The beginning of electric vehicles dates back to the 1830s when the first prototype electric powered carriage was invented by a Scot named Robert Anderson.[10] Other electric powered carriage prototypes were also invented during this time; however, due to the lack of efficient electric motors and rechargeable batteries, none was suitable for practical development. In the years that followed, between 1856 and 1881, direct current (DC) electric motors and rechargeable batteries saw major technological improvements, which provided a major boost for the EV market.[11]

In North America, the first electric vehicle emerged in the United States around 1890, invented by a chemist named William Morrison. He created a six-passenger vehicle that was capable of travelling 14 miles per hour, faster than an electrified wagon, which helped to spark interest in this new and exciting technology.[12] However, the first commercial EV introduced to the market was an electric taxi in 1897.

By 1900, EVs accounted for about a third of all vehicles on the road and continued to soar in popularity until 1908. Their popularity was attributed to being reliable and quiet, compared to early gasoline vehicles.

However, their popularity came to a halt when Henry Ford's mass-produced Model T became widely available and affordable to many Americans, and as gas stations started sprouting up along roadways. The ubiquity of the Model T, an expanding network of roads that allowed drivers to access new destinations, and the availability of inexpensive gasoline resulted in a steep decline in electric vehicles by the 1930s.

In addition, the short travel distances of an EV compared to a gasoline-powered vehicle, along with the lack of charging station infrastructure, only worsened the electric vehicle's competitive disadvantage over gasoline powered cars. By 1935, there was not a single EV on the road in the US.[13]

Over the next 30 years, EVs saw little advancement in technology and consequently little uptake in purchases. Between the 1970s and 1990s, EVs began to make a comeback due in large part to soaring oil prices and gasoline shortages. Climate change was starting to become part of the public consciousness and governments within the United States responded with regulatory actions to reduce air and carbon pollution while promoting electric vehicle development.[14] One of the most cited examples of strong regulatory action was California's Zero Emission Vehicle regulation implemented in 1990. The mandate required automakers to sell a certain percentage of their vehicles as electric-powered.

Rising gasoline prices continued to encourage automakers like General Motors and Toyota to commit to vehicle electrification. By 1996, General Motors produced and leased the EV1 model and one year later, Toyota introduced the world's first commercial hybrid electric vehicle in Japan where over 18,000 vehicles were sold in the first year.[15]

Around 2000, the Honda Insight and Toyota Prius came to the US market and tapped into consumers' desire to broadcast their concern for the environment or their technological progressiveness. To encourage EV adoption, some US states rewarded owners of hybrid electric vehicles with access to high-occupancy-vehicle (HOV) lanes and the federal government introduced a tax credit of up to $3,400.[16]

It was not until 2009-2010 when other automakers such as Nissan, Tesla, and Mitsubishi began to manufacture EVs in response to growing consumer demand. General Motors also released its Chevrolet Volt around this time period and recorded over 7,600 sales in the US in 2011, followed by 23,461 in 2012, an increase over 209%.[17]

C: RESEARCHED IMPACTS OF COLD WEATHER ON ELECTRIC VEHICLES

Edmonton experiences cold temperatures for six months of the year with average temperatures ranging from -15°C to 0°C from October to April. Cold weather can pose challenges for electric vehicles as colder temperatures primarily impact the time it takes to use all of the battery energy or to recharge a battery.[18] Battery performance has been found to be strongly dependent on temperature: at colder temperatures the battery's efficiency, discharge capability, and available energy decrease.[19] However, cold weather conditions have not been found to have an impact on EV propulsion or drivability in general.[20]

Impacts on Vehicle Range

On a technical level, colder weather can impact an EV system in two ways: [21]

1. There is an increase in auxiliary power consumption as drivers increase energy demand to heat the passenger cabin and to operate the defogger.

2. The vehicle's components become less efficient due to increases in internal friction as an engine or battery gets colder. Moreover, as the battery's internal resistance increases, the power that can be drawn from the battery decreases.

It has also been found that a cold battery can reduce regenerative braking, which is a technical feature that EVs use to increase driving range. A more detailed technical discussion of the cold weather impacts is summarized in ICF International's report "Electric Vehicle Investigation".[22]

Hydro-Québec has observed the effects of cold weather on vehicle range. It collected data on 30 Mitsubishi i-MiEV vehicles in Europe and Montreal from 2010-2013 as part of a study. Each vehicle was equipped with on-board instruments to register energy consumption and the effect of temperature on charging and users' charging habits.[23] They observed a loss of vehicle range of 13 km when temperatures were between 0 and 10 degrees Celsius, largely due to the need to heat the interior of the vehicle. The loss of range increased to 40% in below freezing conditions.

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Another project, led by the Government of Manitoba, involved winter testing of two Mitsubishi i-MiEV vehicles over a two-year period beginning in 2011. The testing involved driving vehicles to battery depletion in temperatures ranging from -15 to -30 degrees Celsius. The researcher found that under these temperature conditions, all interior heating had to be redirected to the defogger to maintain an unfrozen windshield. Driving in this colder weather resulted in the average range of an iMiEV to drop to 40-50 km, or about half of the average range of 110-120 km.[24]

While the projects described above conclude that colder weather can impact vehicle range, both were completed over 4 years ago. EV battery technology has improved significantly since. A number of EV manufacturers are currently exploring how thermal management systems – specifically air-cooled or liquid cooled batteries – can produce the best performance in weather extremes. Specifically, active liquid heating and cooling thermal management systems, found in new EV models, helps keep batteries within optimal temperature ranges.[25]

Tesla Motors has created a cold weather package, which provides additional seat warmers, windshield fluid heaters, and modified intake grills. The Model S is engineered in such a way that when the vehicle is driving, heat generated by the motor is used to heat up the battery which uses waste heat rather than electricity.[26]

Impacts on Vehicle Charging Time

Similar to vehicle range, cold weather can impact an EV's charging time. When batteries are cold, they have lower electrical capacity which reduces the duration in which they can provide power.[27] In addition, some types of EV chargers have greater difficulty transferring electricity to the vehicle.

In the same pilot project where Hydro-Québec evaluated the impacts of cold weather on a Mitsubishi i-MiEV's vehicle range, it also explored how ambient temperature impacted charging. The team looked at all charger times including Level 1 workplace chargers, Level 2 chargers in residential and workplace settings, and Level 3 DC fast chargers. They found that Level 2 chargers were unaffected by ambient temperatures during the winter season but observed that DC fast chargers took a much longer than its 30-minute standard charging time to reach 80% capacity in colder conditions.[28]

Another project in Gothenburg, Sweden, undertaken by the North Sea Region Electric Mobility Network, specifically evaluated fast chargers around the city. They found that when the battery temperature was less than 10 degrees Celsius, it was challenging for the vehicles to charge beyond 20% capacity.[29] The researchers also reported that the charging cables were often harder to plug into the base after charging due to the colder temperatures.

The study, however, has at least two limitations: [a] no information is provided about the type of EV used for the testing project and [b] the study was conducted in 2012, which may not accurately reflect the impacts of colder conditions on current EV battery performance.

Mitigating the impacts of cold weather on both vehicle range and charging time requires improving battery performance and utilizing waste heat. These technological issues rest with automakers who are continuing to find ways to optimize overall EV performance.

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D: HIGHLIGHTED BEST PRACTICES FROM LEADERS IN ELECTRIC VEHICLE DEPLOYMENT

The following case studies provide examples of municipal actions that have been implemented to help support EV adoption. Cities were selected based on their overall leadership and success with EVs.

CASE STUDY 1

An Extensive Public Charging Network

PORTLAND, OREGON, US

According to the ICCT report, Portland has the most extensive EV charging network in the US. The study reported that as of 2015, Portland was among the country's leaders in the number of chargers per capita with 5.8 times the number of DC fast chargers and 2.5 times the number of Level 2 chargers than the 25-city average.[30] Figure C.1 provides a snapshot view of the charging network as depicted in PlugShare.

The report also showed how Portland had the highest number of chargers per new registered vehicle data. The report, however, does not provide any details on how Portland achieved its success with expanding its public charging network.

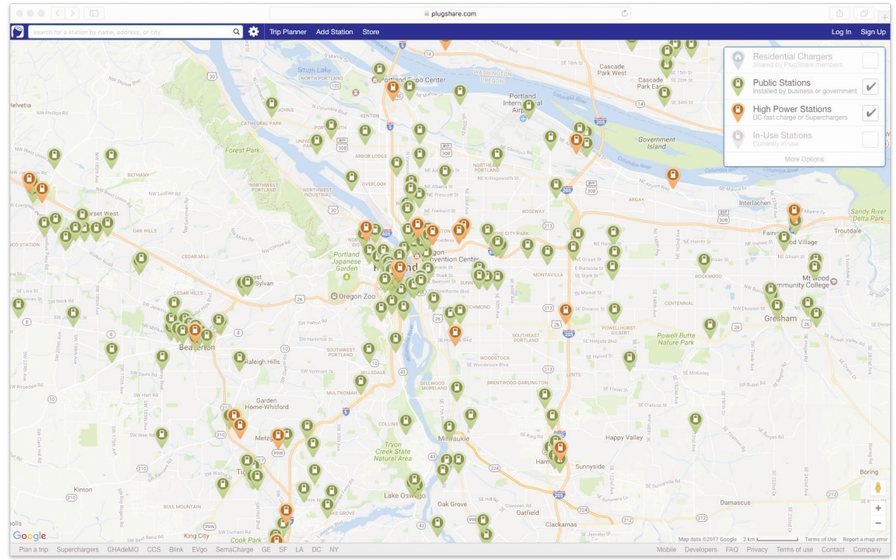
Based on available sources, there are a few lessons learned from Portland's charging station network, as follows:

- **Fast chargers** (Level 3) are popular in part because they allow EV owners to plug in and quick charge for 5 to 10 minutes which extends their vehicle range.
- **Clustering of fast chargers stations** in urban locations increases the visibility of chargers and provides a safe environment for users.
- **Marketing** information to EV owners and prospective owners helps to increase awareness about the type and location of charging stations that are available to them.[31]
- Adopting consistent **signage** and parking enforcement standards can help smooth the transition to EVs and educate the public about how EVs work. Portland adopted signage standards for identifying EV charging stations, both in the right-of-way and on private property. Also, enforcing posted parking hours for spaces in the right-of-way will ensure EV charging stations experience turnover and are available to other users while supporting nearby businesses.[32]

The City of Portland also credited its *Climate Action Plan* as a municipal document that has helped to accelerate the installation of a network of EV charging stations.[33]

Portland has also implemented a number of other EV promotion actions including a 2015 Council policy to replace City vehicles with EVs when feasible, with a goal of having 20% of the City's sedan class fleet be electrically powered by the end of the 2015-2016 fiscal year. As of April 2016, the City had 50 EVs in their sedan fleet.[35]

Figure C1. *Electric vehicle charging stations in Portland, Oregon as of February 2017, via Plugshare.*[34]



Portland's extensive public charging station infrastructure, among other initiatives, has contributed to its relatively high EV market share. According to the ICCT report, in 2014 Portland was among the leading cities with the highest share of new vehicles as EVs both on a per capita and sales share basis.[36]

KEY TAKE-WAY FOR EDMONTON

Portland's extensive public charging network has contributed to its high electric vehicle share.

The availability of charging stations offers consumers greater range and increases range confidence.

Portland has also shown that the availability of Level 3 (Fast Chargers) can help accelerate EV uptake.

CASE STUDY 2

A new Building Bylaw

VANCOUVER, BRITISH COLUMBIA, CANADA

The City of Vancouver is one of Canada's leading municipalities on EV deployment. The City is currently managing 78 Level 2 public charging stations through the City and one DC Fast Charger. There are another 175 charging points available to EV drivers that are managed by parking garages, hotels, shopping malls, and other services.[37]

The City's *Electric Vehicle Ecosystem Strategy* was approved in November 2016 with the aim to create flexible options for charging vehicles to help meet the City's goal of 100% renewably powered transportation before 2050. A number of best practices can be gleaned from Vancouver's experience, but the changes made to its Building Bylaw are cited as being the most prominent.

In 2008 the City amended its *Building Bylaw* to require 20% of parking stalls in apartments and condos and all stalls in houses to be electric vehicle ready. An amendment was made in 2013 to require 10% of stalls in mixed-use and commercial buildings to be ready for electric vehicles. The "EV-ready" locations are required to support Level 2 (240V) charging.[38] A regulatory change such as this one might not immediately increase uptake in EVs, but as more electric vehicles emerge in the Vancouver area, the charging infrastructure will be there to support it.

A public survey conducted in Vancouver in August 2016 found that 85% of the 2,143 respondents said their next vehicle would be or might be an electric vehicle. These trends suggest that the City has created a positive and supportive environment for electric vehicles.

KEY TAKE-WAY FOR EDMONTON

Requiring new developments to be "EV Ready" is one effective approach to increase charging station availability, which, as some studies show, is correlated with higher EV share. While Edmonton does not have its own Building Bylaw like Vancouver, Vancouver's experience demonstrates that EV Ready building code can support charging infrastructure in the long term.

In addition to the amendments to the *Building Bylaw*, Vancouver is also encouraging local car sharing organizations to add EVs to their fleet by allowing them to access City-operated charging stations. The City has also increased the number of EVs in its fleet with over 30 vehicles as of January 2017. Since 2011, the City of Vancouver has seen its EV sales grow by 70% year-over-year. Initiatives at the provincial level such as the Clean Energy Vehicle Program have also helped to accelerate EV uptake by providing consumers with a financial incentive of up to $5,000.[39]

CASE STUDY 3

An all-electric Municipal Fleet

MONTRÉAL, QUÉBEC, CANADA

The City of Montreal is well regarded as a leader in electric vehicle sales acceleration. The City recently released its EV Strategy *Electrifying Montréal: Transportation Electrification Strategy 2016-2020*.[40] The strategy includes ten strategic goals to make electric vehicles a larger part of the transportation network and to help the City achieve its GHG reduction target of a 30% decrease in 1990-level emissions by 2020.

One of the ten strategic goals is to "convert the municipal fleet of combustion engine vehicles to electric vehicles". This goal, and the City's progress so far, offer important lessons for the City of Edmonton. The City of Montreal adopted its *Rolling Stock Green Policy 2016-2020* in November 2016. One component of the policy calls for the implementation of a five-year program aimed at gradually replacing nearly 230 of its city fleet of conventional vehicles with all-electric vehicles.[41] The City estimates that the replacement of up to 250 of its municipal vehicles will reduce GHG emissions by 1,750 tonnes over five years.[42]

Montreal is already making progress with 20 electric vehicles in its fleet at the end of 2016. In March 2016, the City finalized a two-year agreement with Nissan to acquire 42 Nissan Leaf vehicles, which will be available to various municipal departments and the boroughs. Montreal has also implemented other EV promotion initiatives including the development of an extensive public charging network. With over 100 public charging stations in the City as of December 2016, the City has plans to offer a network of approximately 1,000 charging stations by 2020. The City will work closely with Hydro-Québec to accomplish this goal.

KEY TAKE-WAY FOR EDMONTON

Montreal is demonstrating how success with EV deployment can be achieved within the corporation. Committing to electrifying its fleet demonstrates municipal leadership, boosts sales of electric vehicles, and increases the exposure and awareness of this emerging technology.

SUPPORTING PRACTICES AT THE STATE AND FEDERAL LEVELS

While cities can demonstrate leadership on accelerating EV adoption, there are a number of supporting policies at the state / provincial and federal levels that can be equally if not more important at helping to advance EVs at the local level. Examples of successful policies and programs are discussed below.

Quebec's Zero-Emission Vehicle Mandate

Quebec is currently Canada's electric vehicle leader with the country's highest EV market share. From 2011-2016, 10,503 EVs were sold in the province. In 2015, 1.4% of new vehicles sales were EVs and there were 146 public chargers per 1 million registered vehicles.[43]

Quebec continues to be a Canadian leader in EV deployment. It recently adopted a zero-emission vehicle mandate which requires automakers to sell zero-emission vehicles, either as electric or hydrogen-powered, as 15 percent of their sales in the province by 2025.

In a recent report by Axsen et al. (2016) titled *Canada's Electric Vehicle Policy Report Card*, Quebec received the best grade across the nation for its electric vehicle supportive policies.[44] Since 2012, the province has introduced a number supportive EV programs and policies, summarized as follows:

- An $8,000 rebate for consumers toward the purchase or lease of an EV
- Working with municipalities and Hydro-Quebec to improve the availability and access to home, workplace, and public charging
- Providing unrestricted access to EV drivers and supporting electrification of public fleets
- The Transportation Electrification Plan lays out a number of policies to stimulate EV sales, technology innovation, market development and education.

While all of these programs and initiatives have helped to accelerate EV sales, the province's most effective EV policy is its recently adopted zero-emissions vehicle (ZEV) mandate. The mandate requires automakers to sell ZEVs, either as electric or hydrogen-powered, as 15 percent of their sales in the province by 2025.[45]

Experts predict that the ZEV mandate is likely to have the greatest impact on 2040 EV sales and is anticipated to be the most effective policy in Canada. Axsen et al. show that the ZEV mandate, combined with other high impact policies, can result in an EV market of 24% by 2040.

Norway's Charging Infrastructure Network & Zero Emissions Incentives

As of 2016, Norway had 29% EV market share making it the largest EV market in the world on a per capita basis.[46]

Norway's EV success is due to a substantial package of incentives developed to promote zero emission cars.[47] The development of its nation-wide public charging infrastructure network has also been a critical success factor in helping to advance the EV market.

Norway's extensive public charging network has been cited as being a significant measure in the elimination of range anxiety. Surveys of Norwegian auto consumers were commissioned around 2009 and found that range anxiety was the single greatest barrier to the purchase of an EV.[48] These survey results, along with the country's ambition to accelerate its EV market, resulted in a government funded, nation-wide built out of EV charging infrastructure at the cost of USD $7.4 million.[49] In the first year, the number of public charging points increased from 500 to 2,500 and by 2014, the country was home to over 5,600 Level 2 pubic plug-in locations and 92 fast charging stations.[50]

Research by Sierzchula et al. (2014) found that financial incentives, the availability of charging infrastructure per capita, and the presence of a local EV manufacturing facility were the strongest predictors of a country's EV market share.[51] Their research clearly demonstrates that Norway's generous financial incentives and extensive charging infrastructure network have contributed to the country's EV success.

Norway has the world's highest EV market share and is considered one of the most successful case studies of EV adoption. Norway has realized its success through a suite of zero emissions incentives that were introduced as early as 1990. The incentives are as follows:

- *No purchase/import taxes (1990)*
- *Exemption from 25% value-added tax (VAT) on purchase of EV (2001)*
- *Low annual road tax (1996)*
- *No charges on toll roads or ferries (1997 and 2009)*
- *Free municipal parking (1999)*
- *Access to bus lanes (2005)*
- *50% reduced company car tax (2000)*

Exemption from 25% VAT on leasing (2015)

Source: Norsk elbilforening, 2017

Ontario's Electric Vehicle Program

Ontario was the first Canadian province to support the deployment of electric vehicles. In 2010, the province introduced incentives for EV purchases and allowed EV drivers to enjoy unrestricted access to high-occupancy vehicle (HOV) lanes. In 2015, 0.7% of new vehicle sales were electric vehicles and there were 49 public chargers per 1 million registered vehicles. From 2011-2016, 7,248 EVs were sold in the province.

While a number of provincial policy measures have been implemented to support EVs, the Electric Vehicle Incentive Program (EVIP) is one of the most significant. The program began in 2010 and provides financial incentive—ranging from $3,000 to $14,000— toward the purchase or lease of an electric vehicle.[52,53]

Axsen et.al. (2016) predict that Ontario's purchase incentive program will likely have the greatest impact on increasing EV adoption through to 2040, but argue that EV market share will not exceed 9% unless Ontario considers other policies such as a ZEV mandate like Quebec or strong pricing on gasoline and carbon like in Norway.[54]

Ontario's Climate Action Plan (2016-2020) has a number of supporting EV goals, as follows:

- *Maintain incentives for electric vehicles*
- *Eliminate HST on zero emission vehicles*
- *Provide free overnight electric vehicle charging*
- *Ensure charging infrastructure is widely available*
- *Provide electric vehicle ready workplaces*
- *Increase public awareness of electric vehicles*

Source: Ontario's Five Year Climate Change Action Plan (2016-2020)

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Colorado's EV Group Purchase Program

In 2015, the Colorado counties of Boulder, Adams, and Denver, along with the City of Denver, partner together to offer local residents a discount on solar panels and electric vehicles. The initiative was part of a group purchase program featuring solar provided and one vehicle dealership: Boulder Nissan.

The program, the first of its kind in the US, has been successful resulting in the sales of 248 Nissan Leafs.[55] Boulder Nissan sold four times more Leafs per month than its average and accounted for 5% of all Leaf sales in the country, which is considerable given it is located in a county that has less than one-tenth of one percent of the US population.[56]

A recent evaluation of the program found that 28% of EV purchasers were already intending to buy an EV prior to the program. This suggests that the program may have brought in many new customers who otherwise would not have considered purchasing an EV. The program group discount, combined with state and federal credits, has brought the purchase price of a Leaf S to $12,130 (in 2015 dollars), from the manufacturer's suggested retail price (MSRP) of $31,810. This is equivalent to the same prices as the cheapest gasoline burning vehicle on the market at the time.

More information about the program, including lessons learned, is found online.[57]

E: RESEARCHED BARRIERS TO ELECTRIC VEHICLE ADOPTION

The barriers to electric vehicle adoption have been well studied. In fact, understanding the barriers to adoption is a critical first step for any jurisdiction undertaking an electric vehicle strategy and implementation plan. Identifying the barriers early on can help municipal and provincial governments with determining the most appropriate suite of policies, strategies, and incentives to alleviate barriers and increase EV adoption rates.

Based on a scan of the literature and experience from other jurisdictions, a summary of the most common barriers to EV adoption can be summarized as follows:

Lack of knowledge & experience with EV technology:
Research has widely reported that most potential EV buyers have little knowledge of electric vehicles and almost no experience with them. Surveys have also revealed that many consumers do not even know someone with practical experience with driving or charging EVs. As a result, it can be difficult for consumers to develop an interest in EVs and/or have the willingness to purchase one. This lack of familiarity can act as a major barrier to widespread EV adoption.[58]

Range anxiety: The "range" of an EV refers to the total distance that the vehicle can travel on a single charge. Potential EV buyers often cite range anxiety as one of the main reasons why they decide not to purchase a vehicle.[59,60] Range anxiety refers to the fear of running out of battery power before the next opportunity is available to charge a vehicle. While EVs have seen significant improvements in range over the last 10 years, with newer models capable of travelling up to 500+ km on a single charge[61] (under ideal conditions), their range is still inferior to gasoline-powered vehicles.

The National Renewable Energy Laboratory conducted a 2015 study on consumer views on plug-in electric vehicles. Respondents to the survey provided information about the range of miles that an EV would need to be able to charge for them to consider purchasing a vehicle. Not surprisingly, the survey found that as the range of an EV increases, so does the willingness to purchase of vehicle.[62] Only 11% of the sample would consider purchasing an EV if its range was 50 miles (80 km), whereas 56% of the respondents would only consider one if the range was over 300 miles (480 km) on a single charge.

The City of Edmonton Insight Community Survey reported that, when asked what their personal barriers were to owning an electric vehicle, over half of respondents indicated a high purchase price (52%) followed by 39% who said a lack of places to charge away from home and 32% who said there was a limited range on a charge.

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Price: EV purchase prices, which are strongly influenced by battery costs, have been identified as being one of the most significant obstacles to widespread EV adoption.[63] Research and consumer surveys have consistently found that price is a major barrier to EV sales. A 2014 study found that price was cited as the number one barrier to EV adoption for Canadians.[64]

While price has been shown to be a barrier to EV adoption, research by Axsen et al. found that some Canadian consumer market segments have high willingness-to-pay for these vehicles. The authors looked specifically at six lifestyle-based segments of potential early mainstream EV buyers. The research found that a consumer segment called "PHEV-oriented class" would pay an extra $15,000 for a PHEV. Their research also found that most consumer market segments sampled are more attracted to an EV if they have a Level 2 charger at home; willingness-to-pay for a PHEV increases by about $1000 to $3000 with a Level 2 charger, whereas the willingness-to-pay for a BEV increases by about $3000 to $6000.[65]

Lack of availability in model types: Various studies and consumer experiences have identified the lack of availability of EVs at the dealership as a barrier to EV adoption. One such study indicated that EVs will need to become available in a broader set of vehicle types, or consumers will need to shift their interests in EV vehicle types if EVs are to achieve high percentages of vehicles purchases.[66]

Lack of public charging stations: The location of public EV charging stations can play an important role in the personal mobility patterns of EV owners, including the specific travel routes they take and where they shop.[67] Even though most EV owners charge their vehicles at home, research has shown that the lack of public charging stations can act as a major impediment to EV adoption. Moreover, for households that do not have access to a carport or garage, the ability to access charging overnight can be a major problem.[68]

Charging time: Another identified barrier to EV adoption is vehicle charging time. On average, a gasoline-powered vehicle can refuel in approximately 4 minutes, whereas an EV require approximately 30 minutes at a fast charging station and up to several hours from a 110 or 220 V outlet, depending on the battery size.[69]

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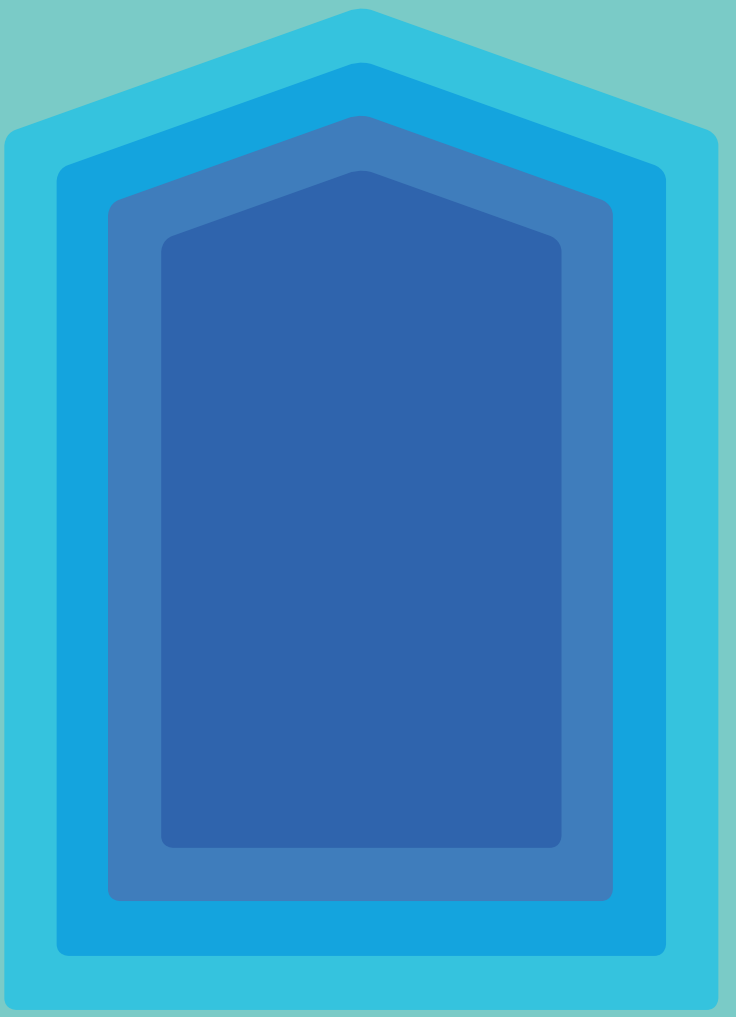

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