

City of Toronto Electric Mobility Strategy Assessment Phase

FINAL PROJECT REPORT

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Prepared by Pollution Probe and The Delphi Group



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Abbreviations and Acronyms

AC – alternating current

BEV – battery electric vehicle

CASE – connected, autonomous, shared and electric

CAV – connected autonomous vehicle

CCS – combined charging system

DC – direct current

DCFC – direct current fast charger (synonymous with Level 3 charger/charging station)

DER – distributed energy resource

DVP – Don Valley Parkway

EHVAP – Electric and Hydrogen Vehicle Advancement Partnership (Ontario)

EV – electric vehicle (includes both battery and plug-in hybrid electric vehicles)

EVIP – Electric Vehicle Incentive Program (Ontario)

EVSE – Electric vehicle supply equipment

EVWG – Electric Vehicle Working Group (Toronto)

FCEV – hydrogen fuel cell electric vehicle

FSA – forward sortation area (determined by first three postal code characters)

GHG – greenhouse gas

GPS – global positioning system

GTA – Greater Toronto Area

GTHA – Greater Toronto and Hamilton Area

HEV – hybrid electric vehicle

HOV – high occupancy vehicle

ICE – internal combustion engine

IEA – International Energy Agency

ITS – intelligent transportation system

kW – kilowatt

kWh – kilowatt hour

LEV – low-emission vehicle (includes electric and hydrogen fuel cell electric vehicles; synonymous with ZEV)

MURB – multi-unit residential building

OECD – Organisation for Economic Co-operation and Development

PHEV – plug-in hybrid electric vehicle

SAE – Society of Automotive Engineers

TGS – Toronto Green Standard

TRAP – traffic-related air pollution

TTC – Toronto Transit Commission

V - volt

VKT – vehicle kilometres travelled

ZEV – zero-emission vehicle (includes electric and hydrogen fuel cell electric vehicles; synonymous with LEV)

1 Executive Summary

With roughly 2.8 million inhabitants, Toronto is the largest municipality in Canada. The Greater Toronto Area, which includes several surrounding municipalities, is home to almost 7 million people. Transportation is the cause of 33% of Toronto's net greenhouse gas (GHG) emissions.

Through its climate action strategy, *TransformTO: Climate Action for a Healthy, Equitable and Prosperous Toronto*, Toronto has committed to reducing its GHG emissions by 30% of 1990 levels by 2020, 65% by 2030, and 80% by 2050. The increased uptake of electric vehicles is expected to make a significant contribution towards meeting the TransformTO targets. Indeed, the strategy establishes the goal that 100% of transportation modes used in Toronto by 2050 will be low or zero carbon. In addition to electrified passenger vehicles, it also stresses that helping citizens transition to more efficient modes of transport such as walking, cycling and public transit will lead to a wide range of benefits in addition to GHG reductions.

Given Ontario's mix of emissions-free electricity generation, each battery electric vehicle adopted in Toronto will lead to GHG emissions reductions of 3 to 5 tonnes per year, relative to gas-powered vehicles. Each plug-in hybrid electric vehicle will lead to reductions of 2 to 3.5 tonnes per year. Creating a landscape that is conducive to the increased adoption of electric vehicles is therefore a central goal of TransformTO.

To deliver on this and related goals, Toronto began engaging electric mobility stakeholders in 2018 to contribute to the development and implementation of a comprehensive Electric Mobility Strategy beginning in early 2019. This report is the primary output of the Assessment Phase of the Strategy. Its goal is to highlight key considerations for the Electric Mobility Strategy and to create a baseline on which subsequent plans and activities can be based. Other goals of the Assessment Phase include initiating engagement with key stakeholder groups to be consulted during the Strategy's development and implementation, and identifying barriers, opportunities and best practices related to the deployment of electric mobility solutions in Toronto.

The report's introduction (Section 2) includes a high-level look at Toronto's Electric Mobility Strategy and the purpose of the Assessment Phase. It then introduces readers

to different types of commercially available electric vehicles, and the types of charging infrastructure available for these vehicles.

Section 3 overviews the state of electric vehicle adoption from global, national, provincial and municipal perspectives. It then highlights key policies and programs in place to support electric mobility in Toronto.

Section 4 delves into best practices in municipality-led efforts to advance electric mobility, breaking down types of actions into different categories that are in some cases best facilitated by contributions from specific stakeholder groups. It also discusses how social equity considerations can be incorporated into electric mobility strategies.

Section 5 discusses key steps and considerations in the development of Toronto's Electric Mobility Strategy. It explores potential impacts that EVs pose to local electrical grids, and how utilities are planning for such impacts. It highlights the need to make charging infrastructure accessible to potential electric mobility users regardless of their type of housing, income level, or travel patterns. This section then explores emerging transportation technologies and trends that could significantly influence the direction and scope of the City's Electric Mobility Strategy in the near future. Gaps in Toronto's existing suite of low-carbon transportation actions are then discussed, with an eye towards potentially addressing these gaps in the Electric Mobility Strategy. Section 5 concludes with a general discussion on the environmental, social and economic benefits of electric mobility deployment, with a focus on Toronto.

Section 6 overviews the key areas for action that the Toronto Strategy should address. It outlines which stakeholder groups are candidates to make valuable contributions to different types of actions. Further, it describes the stakeholder engagement event conducted on November 15, 2018, and some of the ongoing electric mobility collaborations that were identified at that event.

Section 7 provides a high-level summary of the report and outlines next steps in the development of Toronto's Electric Mobility Strategy.

2 Introduction

The City of Toronto is the most populous municipality in Canada, with a population of roughly 2.8 million. The Greater Toronto Area (GTA), which includes several municipalities immediately surrounding Toronto, has a population of almost 7 million people, and comprises approximately 19% of Canada's total population. The city is also notable for having the longest daily commute times in the country, with an average of 68 minutes (round-trip).¹ Transportation is the leading source of greenhouse gas (GHG) emissions in Toronto, accounting for roughly 33% of total emissions, and 35% of emissions in Ontario.² Roughly half of transportation emissions are caused by the use of passenger cars and trucks.

As electric mobility options have zero tailpipe emissions and are now commercially viable across multiple modes of transport, governments at all levels and in all parts of the world are increasingly looking to electrified transportation as a means to achieve environmental targets while enhancing social well-being and fostering economic growth. In 2017, the City of Toronto adopted its new climate action strategy *TransformTO: Climate Action for a Healthy, Equitable and Prosperous Toronto*. TransformTO lays out a series of long-term climate goals to 2050, across the full range of high-emitting sectors, including buildings, energy, transportation and waste.³ TransformTO's economy-wide targets include:

- 30% net GHG reduction from 1990 levels by 2020
- 65% reduction by 2030
- 80% reduction by 2050
- Transportation-specific long term goals include transitioning 100% of transportation modes to low or zero carbon energy by 2050; and ensuring that at least 75% of trips less than 5 km are completed using active transportation.

In order to help achieve its TransformTO targets, the City of Toronto contracted Pollution Probe and The Delphi Group in the fall of 2018 to lead work on the Assessment Phase of its Electric Mobility Strategy. The objectives of the Assessment Phase are to:

¹ <https://www150.statcan.gc.ca/n1/daily-quotidien/171129/dq171129c-eng.htm>

² <https://docs.assets.eco.on.ca/reports/climate-change/2018/Climate-Action-in-Ontario.pdf>

³ <https://www.toronto.ca/wp-content/uploads/2017/10/99b9-TransformTO-Climate-Action-for-a-Healthy-Equitable-and-Prosperous-Toronto-Report-2-The-Pathway-to-a-Low-Carbon-Future-Staff-Report-April-2017.pdf>

- Conduct a comprehensive review of the state of electric mobility in Toronto
- Identify barriers, opportunities, and best practices with regard to electric mobility
- Identify and preliminarily engage key stakeholders who may be willing to contribute to the development of the subsequent Electric Mobility Strategy
- Summarize and present findings in a project report

To deliver on the objectives of the Assessment Phase, the project team undertook the following activities:

- A literature review on municipality-led electric mobility initiatives
- Data collection and analysis incorporating public and private sources
- A series of one-on-one interviews with leading experts in their fields
- The organization and hosting of a stakeholder consultation event
- The development of a report detailing findings from the Assessment Phase of the Strategy

The development of the Strategy itself is slated to begin in early 2019. As a precursor, this report shares key findings from the Assessment Phase of the Strategy in order to inform the development of specific actions that will contribute to the achievement of the City's TransformTO transportation targets.

2.1 Electric Mobility Options: A Brief Overview

There are currently four broad classes of vehicles that can be used to deliver electric mobility. The common feature of these vehicles is that they are able to provide propulsion via an electric motor for at least a portion of total distance travelled. The four types are briefly described below, along with a conventional internal combustion engine (ICE) vehicle.

Internal Combustion Engine (ICE) Vehicle: A conventional vehicle that burns gasoline or diesel to generate motive power. The average ICE vehicle is only about 21% efficient, meaning that almost 80% of the energy produced from burning gasoline or diesel is

wasted, predominantly as heat energy.⁴ ICE vehicles are currently used across all vehicle modes (passenger cars and trucks, medium- and heavy-duty vehicles), and continue to dominate the global vehicle market.

Hybrid Electric Vehicle (HEV): Combines an ICE with a battery-electric propulsion system. Uses regenerative braking and/or the ICE to charge the battery; no external source of power is used. These ‘conventional’ hybrids tend to have much smaller batteries and shorter all-electric ranges than PHEVs. Vehicle hybridization has emerged as an option for most modes of vehicles, and has helped to achieve modest GHG reductions.

Plug-in Hybrid Electric Vehicle (PHEV): A HEV with the option to charge the battery with an external source of electricity. These vehicles typically have larger batteries and longer all-electric ranges than HEVs. Modern PHEVs tend to have electric ranges anywhere from 25 to 85 km. This means that their users can conduct a significant amount of day-to-day driving exclusively using electric propulsion, while having the option to make longer trips using petroleum if charging is unavailable or too time-consuming.

Battery Electric Vehicle (BEV): BEVs only contain a battery-electric propulsion system. The battery is charged by plugging in to an external source of electricity. In contrast to low-efficiency ICE vehicles, BEVs tend to have efficiencies around 80%.⁵ Commercially available BEVs tend to have ranges between 150 and 540 km on a single charge.⁶

Although BEVs have zero tailpipe emissions (they don’t even have tailpipes), the quantity and location of greenhouse gas (GHG) emissions and air pollutants released to power BEVs depends on the regional grid’s mix of energy sources. In Ontario in 2017, electricity generation was 96% emissions-free,⁷ meaning that the net contribution of BEVs to emissions of air pollutants and GHGs in the province is minimal. And because a large majority of BEV charging occurs overnight, when Ontario’s natural gas peaker plants are typically not supplying any power to the grid, emissions associated with BEV use in the province are almost negligible.

⁴ <https://www.fueleconomy.gov/feg/atv.shtml>

⁵ <https://www.fueleconomy.gov/feg/atv-ev.shtml>

⁶ www.cheatsheet.com/automobiles/electric-vehicles-with-the-longest-driving-range.html/?a=viewall

⁷ <http://www.ieso.ca/en/Corporate-IESO/Media/Year-End-Data>

In addition to low emissions, BEVs are noted for requiring significantly less maintenance than ICE vehicles. This is due in part to the fact that ICE vehicle powertrains tend to contain about 2,000 moving parts, whereas BEV powertrains contain about 20.^{8,9}

In recent years, BEV architectures have emerged as viable options for almost every type of vehicle, from drones, to scooters and bicycles, motorcycles, passenger cars, delivery vehicles, buses, construction and mining vehicles, and even heavy-duty on-road freight trucks.

Fuel Cell Electric Vehicle (FCEV): Uses a fuel cell and hydrogen gas to power an electric motor which drives the propulsion system. Hydrogen (H₂) can be produced from methane (CH₄) via a process called steam reforming, or from water (H₂O) via electrolysis. Once the hydrogen is produced it must be pressurized, distributed and stored. Inside the vehicle, a fuel cell stack converts the hydrogen into electricity which is used to charge a small battery which in turn powers an electric motor. The FCEV refueling process is similar to that of conventional ICE vehicles, and only takes several minutes to complete. The efficiency of FCEVs depends on the technologies and processes used in producing, compressing, transporting, and converting the hydrogen, but conservative estimates indicate a net efficiency of approximately 30%.¹⁰

As FCEVs use electric motors for propulsion they are most often categorized as a form of electric mobility. However, due to their unique fueling requirements, the potential for integrating FCEVs into Toronto's electric mobility landscape is beyond the scope of this report. While access to electricity is ubiquitous, access to hydrogen gas requires extensive production and distribution infrastructure that currently does not exist.

The above-mentioned vehicles are often collectively referred to as zero emission vehicles, or ZEVs. Although the term is not strictly accurate, as all of the vehicles produce emissions at some point during their use, manufacture, or through the production of their fuels, it is nonetheless used in literature and in government policy documents. Sometimes the term low emission vehicles, or LEVs, is used to refer to the same group of vehicles.

⁸ <https://www.cnn.com/2016/06/14/electric-vehicles-will-soon-be-cheaper-than-regular-cars-because-maintenance-costs-are-lower-says-tony-seba.html>

⁹ <https://cleantechnica.com/2013/09/27/tesla-model-s-almost-maintenance-free/>

¹⁰ <https://cleantechnica.com/2018/08/11/hydrogen-fuel-cell-battery-electric-vehicles-technology-rundown/>

For the purpose of this report, the term electric vehicle (EV) is used to refer to all BEVs and PHEVs.

2.2 EV Charging: A Brief Overview

There are several options for EV recharging, each of which has unique benefits and limitations.

Level 1 Charging: This type of charging takes place when an EV user plugs their vehicle into a standard electrical outlet. These outlets typically supply power at a rate of 1.8 kW (120 V x 15 A), so charging a depleted 30 kWh EV battery would take over 16 hours using this method. These outlets are ubiquitous, however, and are sometimes installed in parking facilities or on the outer walls of buildings to power equipment such as engine block heaters, appliances and tools. Level 1 charging is an option when time is not of the essence; for example, when a vehicle is parked for a long period (e.g., overnight, at work, or at a transit hub) and isn't needed right away. All production EVs are compatible with this type of charging.

Level 2 Charging: This type of charging typically provides power at a rate of up to 7.2 kW (240 V x 30 A), though amperage can vary depending on the charging hardware and circuit. This is the same level of power used by clothes dryers and electric ovens, and any device that plugs into a 3- or 4-pronged 240 V outlet. A standard Level 2 outlet will charge a fully depleted 30 kWh EV battery in a little more than 4 hours. This faster speed makes Level 2 charging stations much more practical for EV users who only plan to stop for an hour or two, perhaps at sites such as restaurants, parks, retail outlets, gyms, theatres, or visitor parking lots for residential buildings. Most home-based charging stations are Level 2, and can be programmed to begin the charging process during off-peak electricity usage hours, regardless of when a user actually plugs in their vehicle. SAE J1772 ports and connectors are the North American standard for Level 1 and Level 2 charging, and all EVs are compatible with this type of charging.

Level 3 Charging (DC fast/quick charging): This type of charging provides direct current (DC) power – the same type of power distributed by high-voltage electricity transmission infrastructure in North America, and the same type of power stored by EV batteries. DC fast charging uses at least 480 V, and net power delivered can range from

50 kW to 350 kW or greater in modern ‘ultra-fast’ DC chargers.¹¹ Most currently available EVs can charge at a rate of up to 50 kW, so a 30 kWh battery could be fully charged in 30 to 40 minutes. Eventually, ultra-fast DC chargers could allow EVs with longer than typical ranges (and therefore larger batteries) to fully charge in under 10 minutes. Level 3 chargers are much more expensive to purchase and install than Level 2, and as a result are not typically used in residences. They are suitable at sites where EV users do not want to remain for any longer than necessary, such as highway rest stops between major destinations.

Table 1: Summary of Charging Station Types

Descriptor	Level 1	Level 2	Level 3
EVs Supported	All PHEVs and EVs	All PHEVs and EVs	BEVs (not all)
Typical Voltage	120	240	480
Current Type	AC	AC	DC
Requirements	Requires standard electrical outlet	Requires 240 volt electrical outlet (for portable chargers) or circuit (stationary charger)	Charging facility in a fixed location
Charging Time Range	8 - 30 hours	4 - 10 hours	25 - 30 min (to 80% of full charge)
Range Added per Hour (approx.)	8 km	40 km	320+ km
Hardware and Installation Cost	\$0	\$1,000 - \$5,000	\$50,000 - \$100,000
Applications	Long term parking (home, work, etc.)	Long and short-term parking (home, office, retail storefronts, etc.)	Long-distance travel (highways)

Source: Adapted from *Accelerating the Deployment of Zero Emission Vehicles: Atlantic Canada and the Prairies*¹²

¹¹ <https://evsafecharge.com/dc-fast-charging-explained/>

¹² <http://www.pollutionprobe.org/publications/accelerating-deployment-zevs-atlantic-canada-prairies/>

A useful resource on the technical specifications and installation considerations around different types of public EV charging stations is Hydro Quebec's *Electric Vehicle Charging Stations: Technical Installation Guide*.¹³

3 Toronto's Electric Mobility Landscape

3.1 Electric Vehicle Adoption

3.1.1 State of Zero Emission Vehicles – International Perspective

The global EV market is growing at a very rapid rate. In its *Global EV Outlook 2018*, the International Energy Agency (IEA) estimates that over 1 million EVs were sold worldwide in 2017, an increase of 54% over the previous year. Figure 1 shows leading countries in EV adoption by total volume and market share. China and the United States had the highest sales volume of EVs in 2017, at approximately 579,000 and 198,000 vehicles, respectively. In terms of sales share, Norway is the world's leader, with over 39% of new sales being electric in 2017, followed by Iceland at 11.7% and Sweden at 6.3%.¹⁴ In most other countries, including Canada, EV sales share represented less than 2% of total passenger vehicle sales in 2017.

Supportive policies have been a key driver of EV uptake in leading jurisdictions, which have employed a combination of measures including EV purchase price subsidies, investments in refuelling/charging infrastructure, public procurement plans, regulatory measures, etc.

The total number of EVs on the road reached 3.1 million worldwide in 2017, up 57% from the previous year. China has the world's largest EV market, with over 1 million vehicles in active service, which accounts for about 40% of the global EV fleet.¹⁵ The United States and Japan follow with 762,000 and 205,000 vehicles, or 24% and 7% of the global total, respectively.

¹³ <http://www.hydroquebec.com/data/electrification-transport/pdf/technical-guide.pdf>

¹⁴ https://webstore.iea.org/download/direct/1045?filename=global_ev_outlook_2018.pdf

¹⁵ https://webstore.iea.org/download/direct/1045?filename=global_ev_outlook_2018.pdf

However, the EV market remains relatively small in absolute size, considering that there are approximately 1.14 billion light-duty vehicles in use today.¹⁶ The IEA estimates that only three of its Electric Vehicles Initiative (EVI) member countries have a rolling stock share of 1% or higher: Norway (6.4%), Netherlands (1.6%) and Sweden (1.0%).

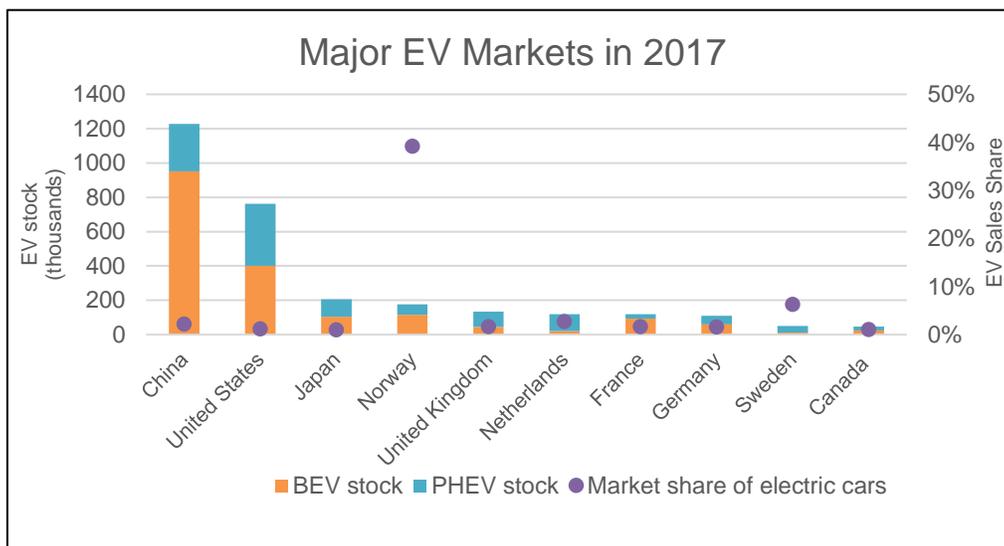


Figure 1: Major EV markets by stock volume and sales share in 2017¹⁷

Charging infrastructure trends mirror the rise in EV uptake, with private chargers at residences and workplaces estimated to number approximately 3 million worldwide in 2017, complemented by almost 320,000 publicly accessible Level 2 stations and over 110,000 DC fast chargers.¹⁸

Supportive government policies are expected to continue to drive significant growth in EV uptake.^{19,20} Several jurisdictions, including California and China, have set ZEV mandates, requiring automakers to sell a minimum percentage of ZEVs every year (those that don't meet the fleet average threshold pay a tax or buy compliance credits). A number of countries, including Norway, France, the United Kingdom and India, as well as major cities, have set EV targets or bans on conventional ICE vehicles. Falling costs of lithium-ion batteries and commitments from automakers to expand EV model availability in their fleets are other key factors driving EV market growth, enabling adoption among a wider

¹⁶ <https://www.greencarcongress.com/2015/07/20150706-navigant.html>

¹⁷ https://webstore.iea.org/download/direct/1045?filename=global_ev_outlook_2018.pdf

¹⁸ https://webstore.iea.org/download/direct/1045?filename=global_ev_outlook_2018.pdf

¹⁹ https://webstore.iea.org/download/direct/1045?filename=global_ev_outlook_2018.pdf

²⁰ <https://bnef.turtl.co/story/evo2018?teaser=true>

range of consumers. Bloomberg New Energy Finance's (BNEF) survey of more than 50 companies, found that the average cost of an EV battery pack was \$209 per kilowatt-hour in 2017, an 80% drop since 2010. BNEF expects the cost will fall below \$100 per kilowatt-hour by 2025, a rate that is seen as "a tipping point in the adoption of EVs."²¹ The number of commercially-available EV models is expected to increase from 155 in 2017 to 289 by 2022. A number of automakers are pledging to sell only electric models beginning in the next 7 to 10 years.²²

Forecasts for EV adoption vary widely, with global EV sales projected to comprise 11 to 25% of car sales by 2025,^{23,24,25} and up to 55% by 2040.²⁶ IEA estimates that electric light-duty vehicles (LDVs) will number between 125 and 228 million, or 6 to 12% of the global LDV stock by 2030, depending on the scenario.²⁷ Bloomberg New Energy Finance forecasts 559 million EVs on the road by 2040, representing 33% of the global passenger vehicle fleet.²⁸

3.1.2 EV Landscape in Canada

Canada has seen a massive expansion in the EV market over the past several years (see Figure 2). As of October, 2018, cumulative EV sales to date reached approximately 84,715 vehicles. EV sales increased by approximately 80% between 2017 and Q3 of 2018, bringing the national EV market share to 2.2%.²⁹ For comparison, the 2017 EV market share was 0.9%. On average, Canadian EV sales have increased by more than 66% a year in each of the previous five years.³⁰

²¹ <https://www.bloomberg.com/news/articles/2017-12-05/latest-bull-case-for-electric-cars-the-cheapest-batteries-ever>

²² <https://bnef.turtl.co/story/evo2018?teaser=true>

²³ <https://www.goldmansachs.com/insights/technology-driving-innovation/cars-2025/>

²⁴ https://rmi.org/wp-content/uploads/2017/04/RMI_Electric_Vehicles_as_DERs_Final_V2.pdf

²⁵ <https://bnef.turtl.co/story/evo2018?teaser=true>

²⁶ <https://bnef.turtl.co/story/evo2018?teaser=true>

²⁷ https://webstore.iea.org/download/direct/1045?filename=global_ev_outlook_2018.pdf

²⁸ <https://bnef.turtl.co/story/evo2018?teaser=true>

²⁹ <https://canadaevsales.com/>

³⁰ <https://www.fleetcarma.com/electric-vehicles-sales-update-q3-2018-canada/>

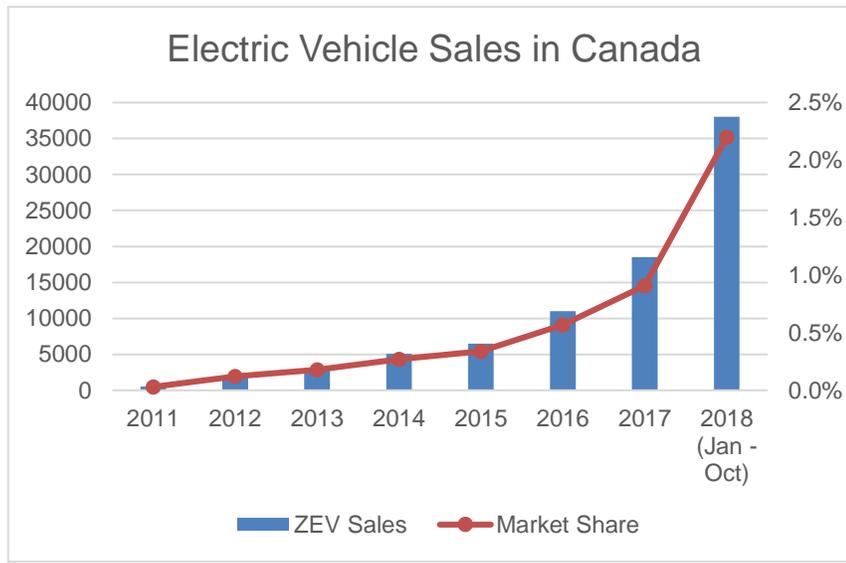


Figure 2: Electric Vehicle Sales in Canada³¹

In addition to supportive government policies, key factors that have contributed to strong growth in EV sales in Canada in recent years have included increased consumer familiarity and interest in the technology, expanded model availability, and increased demand in the Province of Ontario driven by the provincial purchase rebate program.³² FleetCarma estimates that at current rates of uptake, Canada will see more EVs sold in 2018 than in the previous three years combined.³³

The cancellation of EV purchase rebates in Ontario in Q3 of 2018 may hinder future EV sales in the province, impacting Canadian EV market trends. However, it is important to note that other factors, such as the soon-to-be released federal ZEV Strategy, increasing model availability and declining battery costs are important considerations that may continue to drive EV uptake in the province. FleetCarma expects the Canadian EV market share to stay above 2% by the end of 2018.

³¹ Adapted from Matthew Klippenstein's "Canadian Plug-In Electric Vehicle" spreadsheet for GreenCarReports.com.

https://docs.google.com/spreadsheets/d/1dLFJwZVdvNLRpmZqPznIzz6PB9eHMe5b-bai_ddRsNg/edit#gid=25

³² <https://www.fleetcarma.com/electric-vehicles-sales-update-q2-2018-canada/>

³³ <https://www.fleetcarma.com/electric-vehicles-sales-update-q3-2018-canada/>

Around 38 EV models (either fully electric or plug-in hybrids) are available for sale in Canada today.³⁴ The Chevy Volt, Nissan Leaf and Tesla Model S have been the most popular models with 16,653, 10,640 and 7,699 vehicles sold, respectively, between 2011 and 2018. However, the Tesla Model 3 has recently become the most popular EV in Canada, with 4,855 vehicles sold since the model was introduced in 2018.^{35,36} While the price differential between conventional ICE vehicles and EVs is declining, affordability remains an issue. Based on data provided by Plug'n Drive, only three EV models available on the market have a lower starting price than the average price of a new passenger vehicle in Canada, which reached \$33,464 in 2017.^{37,38}

3.1.3 State of EVs – Provincial Perspective

BC, Ontario and Quebec have been leading the charge in EV adoption in Canada. The substantial year-over-year growth in EV sales (see Figure 3 below) is supported by the implementation of comprehensive EV strategies in these three provinces.³⁹ According to FleetCarma estimates, Ontario accounted for 45% of total EV sales in Canada, followed by Quebec at 34% and BC at 18% in 2018 (Q1-Q3).

³⁴ <https://www.fleetcarma.com/electric-vehicles-sales-update-q2-2018-canada/>

³⁵ <https://www.fleetcarma.com/electric-vehicles-sales-update-q2-2018-canada/>

³⁶ <https://www.fleetcarma.com/electric-vehicles-sales-update-q3-2018-canada/>

³⁷ <https://www.plugndrive.ca/discover-electric-vehicles/electric-cars-available-in-canada/>

³⁸ <http://canada.autonews.com/article/20180208/CANADA/180209785/average-price-of-new-car-rose-again-last-year-but-at-slower-pace>

³⁹ <http://www.pollutionprobe.org/publications/accelerating-deployment-zevs-atlantic-canada-prairies/>

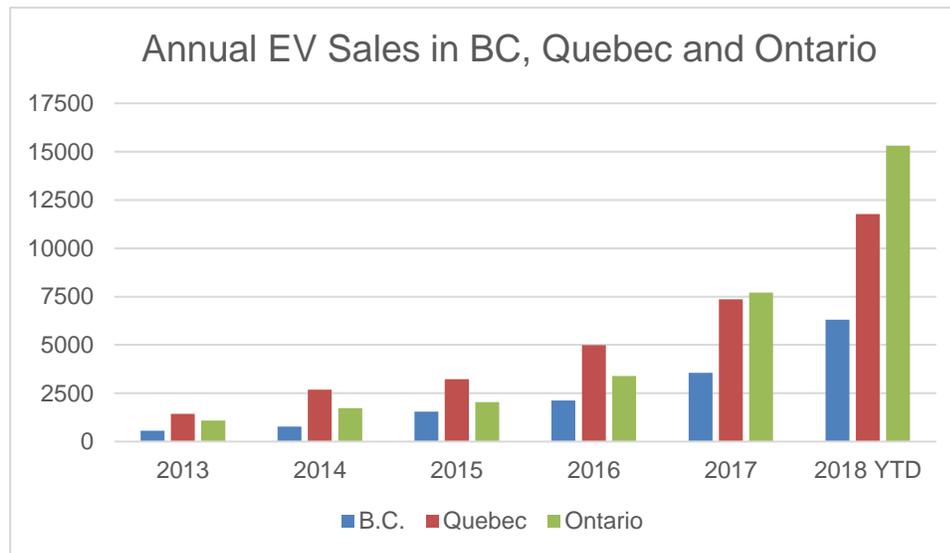


Figure 3: Electric Vehicle Sales in B.C, Quebec and Ontario⁴⁰

In Ontario, the rate of EV uptake began to increase rapidly in 2016, when the province announced a target of 5% of new passenger car sales or leases being electric and hydrogen vehicles by 2020 and expanded consumer support programs for EVs. In 2016, Ontario recorded the highest EV annual sales growth of any province in Canada (67%).⁴¹ In 2017, Ontario EV sales more than doubled, with year-over-year growth of over 120%, and the province recorded the highest EV sales volume in Canada, at 7,706 units sold. In 2018 (Q1-Q3), Ontario saw 15,307 EV sales, which represents over 5% of total passenger car sales in the province.⁴² In Q3 2018, Ontario saw 5,800 EV sales, a 209% increase over the previous year’s quarter, representing 8.2% of all new passenger car sales.⁴³

A report by Pollution Probe and The Delphi Group detailing achievements from the first year of Ontario’s Electric and Hydrogen Vehicle Advancement Partnership (EHVAP)⁴⁴

⁴⁰ Adapted from FleetCarma’s “Electric Vehicles Sales Update Q2 2018, Canada”.

⁴¹ <https://www.fleetcarma.com/electric-vehicles-sales-update-q2-2018-canada/>

⁴² <https://www.fleetcarma.com/ev-sales-canada-2016-final/>

⁴³ <https://www.fleetcarma.com/electric-vehicles-sales-update-q3-2018-canada/>

⁴⁴ <https://www.fleetcarma.com/electric-vehicles-sales-update-q3-2018-canada/>

⁴⁴ The Electric and Hydrogen Vehicle Advancement Partnership was established by the Government of Ontario to help achieve Ontario’s 2020 sales target that 5% of new passenger car sales and leases in 2020 would be plug-in electric and hydrogen fuel cell vehicles. EHVAP engaged automakers (and associations), dealerships, dealer organizations, electrical utilities, EV advocacy organizations, charging infrastructure

estimated that annual sales of EVs in the province would reach more than 20,000 units by the end of 2020, or 7% of passenger car sales. The report was based on 2017 data and published in early 2018, yet the 7% sales projection was exceeded before the end of 2018. This illustrates how rapidly the EV market is evolving, and serves as a reminder to ensure any data analyzed with regard to EV sales or forecasts is up-to-date. It should be noted that these sales forecasts were based on assumptions around the continuation of the Government of Ontario's existing and planned policies and incentives for EVs, such as rebates for the purchase or lease of eligible EVs under the Electric Vehicle Incentive Program (EVIP). EV sales in Ontario could be subject to a near-term decline, but other positive developments and trends, such as the announced federal ZEV Strategy, declining battery costs and increased model availability, may continue to drive EV adoption in the province.

3.1.4 State of EVs in Toronto

As of November 3, 2018, over 6,200 EVs were registered in Toronto. For comparison, there were 1,600 EVs in the city in 2016, which means the number of EVs increased by 288% in two years. Toronto accounts for approximately 20% of all EVs registered in Ontario. This is consistent with experiences in other major cities as initial EV adoption hot-spots tend to be concentrated in and around major urban centres, where consumers have high levels of wealth and education, charging infrastructure is more readily available and driving distances are shorter.⁴⁵

Figure 4 below shows the levels of EV adoption across the City of Toronto, by forward sortation area (FSA, the first three characters of an area's postal code).⁴⁶ The Midtown, Uptown, North York and south Etobicoke are among the areas with the highest levels of EV uptake in Toronto.

companies and government, providing a framework within which partners made commitments that contributed to the uptake of electric and hydrogen vehicles in Ontario.

⁴⁵ <https://www.navigantresearch.com/reports/market-data-ev-geographic-forecasts>

⁴⁶ EV registration data supplied by the Government of Ontario's Ministry of Transportation.

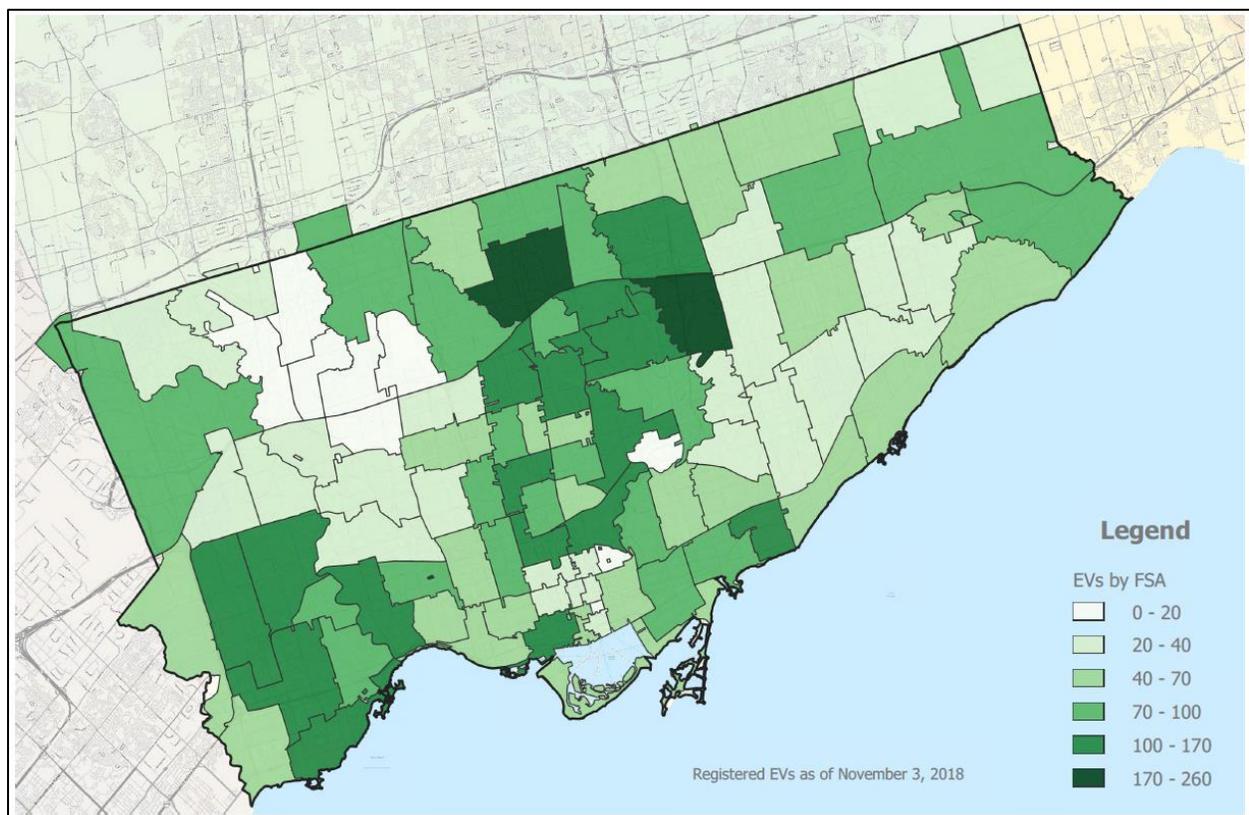


Figure 4: Levels of EV adoption across the City of Toronto

A 2017 survey commissioned by Plug’n Drive provides valuable insights on the attitudes, beliefs, and driving patterns of EV and gasoline-powered car drivers in the Greater Toronto and Hamilton Area (GTHA). The survey suggests that more than 40% of EV owners in the region were introduced to EVs by a trusted colleague, friend or relative.⁴⁷ This highlights the influence of word of mouth of EV owners on EV diffusion. In contrast, 90% of ICE vehicle owners had no exposure to EVs before buying their cars. More EV owners (80%) than gas car owners (62%) do online research on new vehicles before they buy one.

EV drivers cited environmental benefits (36%) and lower cost of charging and maintaining an EV (30%) as the top reasons for buying an EV. Gasoline car owners cited high price as the most common reason (33%) for not buying an EV. Other notable reasons included range anxiety (13%), the inconvenience of charging (12%), limited choice (8%), and lack

⁴⁷ <http://www.plugndrive.ca/wp-content/uploads/2017/10/Driving-EV-Uptake-in-the-Greater-Toronto-and-Hamilton-Area.pdf>

of knowledge about EVs (7%). The survey found that ICE vehicle owners had lower levels of awareness and knowledge about EV incentives than EV owners.

Most drivers in the GTHA are aware that conventional vehicles powered by fossil fuels emit GHG emissions that contribute to climate change. However, less than 50% of surveyed ICE vehicle owners believe that a global shift to EVs could help mitigate climate change, compared to more than 75% of EV owners.

EV owners in the GTHA tend to be well-educated, with nearly 40% having a graduate or professional degree. They are also more affluent, with an average household income of \$114,300 (versus \$83,100 for ICE vehicle owners). A larger proportion of ICE vehicle owners are retired. EV owners are more urban and tend to live in detached houses, predominantly in Toronto and North York, while ICE vehicle owners are more likely to live in suburban neighbourhoods. More than 75% of surveyed EV owners are male.

EV owners are willing to pay more upfront for their vehicle and expect to pay less in fuel and maintenance costs than ICE vehicle owners. For example, about 75% of ICE vehicle owners intend to pay less than \$30,000 for their vehicle while more than 50% of current EV owners intend to pay \$30,000 or more for their car.

With regard to driving habits, the survey found that EV owners are about 20% more likely to drive very frequently every day and are more likely to have longer commutes (an average of 46 km/day versus an average of 32 km/day for ICE vehicle owners).

Surveyed EV owners reported high levels of satisfaction with their vehicles including range and battery performance, noise levels, driving experience, and maintenance. However, they are less satisfied with the availability of charging stations on public roads, at condominiums, and in parking lots.

Importantly, over 70% of EV drivers are likely or very likely to buy or lease another EV in the future. Only about 33% of ICE vehicle owners said they are unlikely or very unlikely to buy an EV in the future.⁴⁸ The survey therefore suggests that most residents in the region are willing to consider buying an EV. It also highlights the importance of adequately addressing consumer concerns regarding EVs to ensure their widespread diffusion in the City of Toronto.

⁴⁸ <http://www.plugndrive.ca/wp-content/uploads/2017/10/Driving-EV-Uptake-in-the-Greater-Toronto-and-Hamilton-Area.pdf>

Another survey conducted by Environics Research for The City of Toronto in 2018 provides important insights into Toronto residents' perceptions about EVs as a means to address climate change and their willingness to adopt more sustainable transportation options for the benefit of the environment.⁴⁹

The 2018 survey found that a large majority of Toronto residents (87%) agree that their transportation choices have an impact on climate change. When it comes to climate action, at least 40% of Toronto residents walk, cycle, carpool, drive less, use transit or work remotely as part of their regular routines. Only 8% report that they already drive an EV or a conventional hybrid, however, 52% of respondents have aspirational intentions to switch to these types of vehicles. Among those who are unlikely to use hybrids or EVs, high purchase cost is the top reason (66%), followed by lack of availability (23%) and inconvenience of use (19%). The majority of Toronto residents (83%) reported that purchase incentives, infrastructure and support for sustainable transportation options, such as EVs, would encourage them to use these options.⁵⁰ These findings are broadly consistent with the 2017 survey by Plug'n Drive, which identified costs, the inconvenience of charging and limited choice as common reasons for not buying an EV.⁵¹

3.1.5 Barriers to EV Adoption in Toronto

As highlighted by the surveys from Plug'n Drive and Environics Research, a number of barriers exist that can prevent consumers from buying an EV. The upfront cost of EVs relative to ICE vehicles is a key factor affecting the purchasing decisions of consumers. While EVs can have lower Total Costs of Ownership (TCO) than comparable ICE vehicles, most consumers do not conduct this level of assessment when making a vehicle purchasing decision, and merely consider the sticker prices of different options.⁵² Providing informational support to prospective car buyers such as vehicle ownership cost calculators was identified by several project stakeholders as an area in which municipal governments can play a key role.

⁴⁹ Environics Research. (November, 2018). City-Wide Climate Perceptions Study. Prepared for The City of Toronto.

⁵⁰ Environics Research. (November, 2018). City-Wide Climate Perceptions Study. Prepared for The City of Toronto.

⁵¹ Environics Research. (November, 2018). City-Wide Climate Perceptions Study. Prepared for The City of Toronto.

⁵² <http://www.pollutionprobe.org/publications/accelerating-deployment-zevs-atlantic-canada-prairies/>

Lack of access to sufficient and convenient charging infrastructure is another barrier to EV adoption. Most EV charging occurs at home, so consumers living in multi-unit residences or houses without a dedicated parking spot are faced with a formidable challenge with regard to EV ownership. EV owners in this scenario, who are often referred to as ‘garage orphans,’ often rely on charging infrastructure in workplaces, retail locations and other public locations, but these options may not be conveniently located. Limited charging infrastructure along intercity and inter-provincial highways can present a barrier to long-distance travel. The lack of charging opportunities contributes to consumer ‘range anxiety,’ a concern that the vehicle will run out battery power before reaching its destination or an appropriate charging point.⁵³ Limited consumer awareness of existing charging stations and charging requirements for EVs is another contributing factor to range anxiety.

Consumers lack knowledge and understanding of EVs, such as model availability, charging requirements and availability, TCO, environmental benefits, and available incentives. While a number of resources exist, there is no centralized one-stop-shop resource that provides brand neutral, up-to-date and user-targeted information and tools that could help consumers understand how an EV could meet their specific needs.

Limited supply and long wait times at dealerships are other challenges that potential EV buyers face.⁵⁴ A recent survey by Clean Energy Canada has found that only 40% of dealerships across BC, one of Canada’s leading EV markets, had at least one EV on the lot.⁵⁵ Most BC dealerships estimated that the wait times for newly ordered EVs to arrive would typically be between three months to a year, and up to 18 months in some cases.⁵⁶ The study also found that some dealers lacked knowledge about EVs, and/or a willingness to sell them, which contributes to the customer experience barrier. Project stakeholders expressed that similar barriers are facing residents of Toronto.

The barriers discussed above represent important opportunities for action on the part of the City of Toronto, working in collaboration with stakeholders who are likewise trying to overcome these barriers.

⁵³ <http://www.pollutionprobe.org/publications/accelerating-deployment-zevs-atlantic-canada-prairies/>

⁵⁴ <https://nationalpost.com/pmnl/news-pmn/canada-news-pmn/electric-vehicle-sales-growing-but-supply-lack-of-knowledge-remain-barriers>

⁵⁵ http://cleanenergycanada.org/wp-content/uploads/2018/10/Report_EVAvailability2018_Web-1.pdf

⁵⁶ http://cleanenergycanada.org/wp-content/uploads/2018/10/Report_EVAvailability2018_Web-1.pdf

3.2 Existing Policies and Programs

TransformTO: Climate Action for a Healthy, Equitable and Prosperous Toronto is Toronto's most recent ambitious and forward-thinking plan to transform Toronto to a sustainable and healthy city for all residents. The plan has four major pillars: homes and buildings, energy, transportation, and waste diversion. Under the transportation pillar, the goal is that 100% of vehicles in Toronto utilize low-carbon energy by 2050 and 75% of trips under 5 km will be walked or cycled.⁵⁷

Toronto's Electric Vehicle Working Group (EVWG) was established in 2010 and comprises staff from City Agencies, Divisions and Corporations. The EVWG has held working sessions with non-profit, academic and business partners to explore issues related to the introduction of EVs to the consumer market.⁵⁸

The remainder of this section outlines current objectives, policies and programs in place in Toronto that support the City's transition to an electric mobility future. Activities in other areas, such as active transportation, that intersect with electric mobility are discussed in Section 5.5.

3.2.1 Toronto Official Plan

Lead Division/Agency: City Planning

Objective and Goals: The Official Plan integrates transportation and land use planning at both the local and regional scales. It provides complementary policies to make more efficient use of the city's road, rapid transit and inter-regional rail networks and to increase opportunities for walking, cycling, and transit use to support the goal of reducing car dependency throughout the city. The Official Plan contains a range of policies to support active transportation and reduce demand for automobile transportation. Policies that support or impact an electric mobility strategy include:

⁵⁷ TransformTO. <https://www.toronto.ca/services-payments/water-environment/environmentally-friendly-city-initiatives/transformto/>

⁵⁸ Preparing Toronto for Electric Vehicles. Report for Action. <https://www.toronto.ca/legdocs/mmis/2017/pw/bgrd/backgroundfile-107507.pdf>

- Integration and consideration of active transportation in the design of all streets, neighbourhoods, major destinations, transit facilities and mobility hubs throughout Toronto
- Transport demand measures to support active transportation and reduce the demand for vehicular travel
- Planning for new development undertaken in the context of reducing auto demand
- Encouraging parking providers to install charging stations for EVs
- Multiple additional policies to support active transportation

City Planning Division is currently updating the Official Plan, with updates targeting transportation and expected to inform the Electric Mobility Strategy.

3.2.2 Fleets

Lead Division/Agency: Fleet Services

Objective and Goals: One of the TransformTO goals is to have 45% of the City-owned fleet as low-carbon vehicles by 2030.

Current Status and Timelines:

- As part of the City of Toronto Green Fleet Strategy, Fleet Services is choosing vehicles, equipment, fuels, and practices that: consume less fuel and emit less GHG and air pollution, meet the City's operational requirements, are sustainable, and are economically viable. The fleet currently includes eight battery EVs and twelve plug-in hybrids.
- There are currently 20 City-owned EV charging stations in Toronto; 19 of these charging stations are Level 2 and one is a DC fast charging station (Level 3). These stations are only available to City vehicles and are located at the following locations:
 - City Hall, 100 Queen Street West
 - Metro Hall, 55 John Street

- North York Civic Centre, 5100 Yonge Street
- Scarborough Civic Centre, 150 Borough Drive
- Ellesmere Yard, 1050 Ellesmere Road
- Disco Yard, 150 Disco Avenue
- Central Yard, 843 Eastern Avenue (DC fast charging station)
- Finch Yard, 1026 Finch Avenue

Budget: Procurement of electric and other green vehicles is included as part of each divisional 10-year capital budget

Barriers and Challenges:

- Current EV range limitations and model availability
- Charging station infrastructure and capacity
- Funding and government incentives

3.2.3 Freight

Lead Division/Agency: Transportation Services

Objective and Goals: A Freight and Goods Movement Strategy (FGMS) Study consulting assignment will be undertaken in support of City Council's Public Works and Infrastructure Committee endorsed objectives of the FGMS Framework report, as amended.⁵⁹

The goal is to develop a better understanding of goods movement patterns, routes and needs in the City, both at present and in the future (i.e., out to 2041), and the potential for harnessing advantages of new and emerging technologies and business models to find balanced solutions that will satisfy needs cost-effectively, reduce local greenhouse gas and air pollutant emissions, preserve quality of life, and maintain economic competitiveness of the City and of trucking.

⁵⁹ See: <http://app.toronto.ca/tmmis/viewAgendaItemHistory.do?item=2017.PW24.8>.

In regards to emissions, recognizing that goods movement contributes a significant portion of the transportation related emissions in Toronto, minimizing the GHGs and air pollutants associated with goods movement is essential to the long-term sustainability of the GTHA region.

Current Status and Timelines:

- The consulting assignment is set to begin in 2019

3.2.4 Public Transportation

Lead Division/Agency: Toronto Transit Commission (TTC)

Objective and Goals: The Toronto Transit Commission (TTC) is targeting steady-state procurement of zero emission buses by 2025 with the overall goal of a zero emission bus fleet by 2040.⁶⁰

Current Status and Timelines:

- The TTC has purchased 30 eBuses slated for delivery by end of 2019 and has approval to purchase 30 more, which would be delivered by March 31, 2020.⁶¹ The first 30 eBuses will be housed at three locations across the city (10 buses at each):
 - Mount Dennis Garage, 121 Industry Street
 - Arrow Road Garage, 700 Arrow Road
 - Eglinton Garage, 38 Comstock Road
- Substation and backup generator procurement will occur prior to March 31, 2020 and will be commissioned by end of 2020.⁶²

⁶⁰ TTC 2018-2040 Green Bus Technology Plan. November 2017.
https://www.ttc.ca/About_the_TTC/Commission_reports_and_information/Commission_meetings/2017/November_13/Reports/2018-2040%20Bus%20Green%20Technology%20Plan%20Presentation%28November%2020.pdf

⁶¹

https://www.ttc.ca/About_the_TTC/Commission_reports_and_information/Commission_meetings/2018/June_12/Reports/Decisions/27_Green_Bus_Technology_Plan_Update_Decision.pdf

⁶²

https://www.ttc.ca/About_the_TTC/Commission_reports_and_information/Commission_meetings/2018/June_12/Reports/27_Green_Bus_Technology_Plan_Update.pdf

- Steady state procurement of eBuses is slated to start from 2025 onwards; prior to that it will be a mix of hybrid and eBus
- The TTC has also commissioned two studies: the first is a feasibility assessment of all bus depots for charging, energy storage, effort, timeline, and cost, and the second is a modelling study of all bus routes to determine how charging could work and what other types of buses may be required.

Budget:

- eBus budget: \$120 million for purchase of first 60 eBuses. \$18 million for related infrastructure (i.e., substation and backup generator at one bus garage).⁶³

Barriers and Challenges:

- eBus capital cost (\$350,000 more than diesel buses)⁶⁴
- Charging infrastructure requires significant investment
- Long term reliability of the eBuses is unknown
- Constraints of existing garages; e.g., electrical capacity (the largest constraint), ceiling height, space for chargers, etc.

Lessons Learned:

- An energy management system and energy storage system will need to be used in parallel to help manage peak loads within the electrical capacity and to manage the charging window within the operational and infrastructure limits.
- Need to future proof garages to facilitate different possible future technologies.

⁶³

https://www.ttc.ca/About_the_TTC/Commission_reports_and_information/Commission_meetings/2018/June_12/Reports/Decisions/27_Green_Bus_Technology_Plan_Update_Decision.pdf

⁶⁴

https://www.ttc.ca/About_the_TTC/Commission_reports_and_information/Commission_meetings/2017/November_13/Reports/2018-2040%20Bus%20Green%20Technology%20Plan%20Presentation%28November%2020.pdf

3.2.5 Charging Infrastructure

Lead Division/Agency: Toronto Hydro, Transportation Services, Toronto Parking Authority

Objective and Goals: Three charging infrastructure pilots/projects are underway:

- Residential On-street EV Charge Station Pilot: Toronto Hydro, in collaboration with Transportation Services, will install up to 14 EV charging stations on its electrical and street light poles at up to seven locations thereby providing on-street charging for EVs in residential permit parking areas.
- Downtown On-street EV Charge Station Pilot: Toronto Hydro in collaboration with Transportation Services will install three EV charging stations at two locations downtown to service short-term (up to three hours) EV charging in public on-street space.
 - East side of Elizabeth Street, south of Fosters Place (behind City Hall)
 - South side of Wellington Street West, east of Clarence Square (two spaces)
- Parking Garage Charge Station Project: Toronto Hydro, in collaboration with the Toronto Parking Authority (TPA), will install EV charging stations in over 200 locations in TPA operated parking garages. Many of these charging stations will be in neighbourhoods with high concentrations of MURBs and garage orphan households.

Current Status and Timelines:

- Locations for the downtown pilot have been selected and installation timelines are pending
- Locations for the residential pilot have been selected and installation timelines are pending

Budget:

- Procurement, installation and operation of each on-street charging station is expected to cost approximately \$65,000.

Barriers and Challenges:

- For garage orphan neighbourhoods the biggest challenge is the idea of allocating high-demand parking space for a specific segment of the population that is still relatively small (i.e., EV users). For example, residents who own ICE vehicles may not react well to EV-only parking in their neighbourhoods. Toronto is seeking to find a balance in this regard as the transition to EVs continues. It is therefore engaging in relatively small pilot projects at this time, and will gauge public reaction as work in this area progresses.

3.2.6 Autonomous Vehicles

Lead Division/Agency: Automated Vehicles Team

Objective and Goals: Toronto is in the process of developing an autonomous vehicle strategy which will include considerations for integration with its Electric Mobility Strategy. The autonomous vehicle strategy will be fuel and technology agnostic, but there is an expectation of significant linkage between autonomous and electric vehicles in the future.

3.2.7 Codes, Standards and By-laws

Toronto Green Standard

Toronto has outlined sustainable design requirements for new private and City-owned developments in the Toronto Green Standard (TGS). The Standard includes tiers of performance measures with supporting guidelines. Tier 1 is required through the planning approvals process; Tiers 2 through 4 are higher level, voluntary standards associated with financial incentives (may be eligible for refund on development charges paid to the City). EVs were first addressed in 2010, in the first version of the TGS. The TGS is now in its third version. Current Tier 1 standards for mid- and high-rise residential and all non-residential developments requires that buildings be designed to provide 20% of parking spaces with electric vehicle supply equipment (EVSE) and that the remaining parking spaces to be designed to permit future EVSE installation. Current Tier 1 standards for City agency, corporation and division-owned facilities requires that buildings are to

provide 25% of parking spaces with EVSE and that the remaining spaces be designed to permit future EVSE installation.⁶⁵

Waterfront Toronto

Waterfront Toronto was created by the Government of Canada, the Province of Ontario and the City of Toronto to oversee the renewal of Toronto's waterfront. All building developments governed by Waterfront Toronto must meet the Minimum Green Building Requirements (MGBR), which set out minimum requirements related to EV infrastructure. The MGBR mandates that EV infrastructure must be provided for 2% of tenant parking spaces in residential buildings and for 2% of parking spaces in commercial buildings; a minimum of Level 2 EVSE is required. Metering with the ability to bill the user for the electricity delivered to each parking space is also a requirement. Remaining residential and commercial parking spaces must be 'EV-ready' to allow for future installation of Level 2 EV charging infrastructure.⁶⁶

Taxi By-Law

In 2014, Toronto City Council directed all taxicabs in Toronto to transition to low emission (or 'green') vehicles. City of Toronto By-law No. 503-2014 requires all taxicabs to be replaced with an alternative fuel or hybrid vehicle at the scheduled time of replacement. City Council set a goal for all sedan taxi cabs to be 'green' vehicles by 2021.⁶⁷

Provincial Codes and Standards

Provisions related to EV Supply Equipment (EVSE) are under O.reg.48/01 of the Ontario Condominium Act. Condo boards in Ontario are required to approve an application to install EVSE unless certain exemptions exist. The Ontario Condominium Act is currently under review by the Ministry of Government and Consumer Services. A group of EV stakeholders in Toronto have been working to ensure that changes made to the legislation

⁶⁵ Toronto Green Standard Version 3. <https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/toronto-green-standard/toronto-green-standard-version-3/>

⁶⁶ Waterfront Toronto Minimum Green Building Requirements V2.1 November 2014. https://waterfronttoronto.ca/nbe/wcm/connect/waterfront/60b07f39-6990-4f47-9436-cacf165f43c2/mgbr_version_2_1_november_2014_final_1.pdf?MOD=AJPERES&CONVERT_TO=url&CACHEID=60b07f39-6990-4f47-9436-cacf165f43c2

⁶⁷ Preparing Toronto for Electric Vehicles. Report for Action. <https://www.toronto.ca/legdocs/mmis/2017/pw/bgrd/backgroundfile-107507.pdf>

will make it easier for condominium owners and corporations to install EV charging infrastructure.⁶⁸

Ontario Building Code

The Ontario Building Code amendment (O. Reg. 332/12) relating to EV charging in commercial buildings came into effect on January 1, 2018. The amendment requires that at least 20% of parking spaces in new large non-residential buildings be equipped with EVSE.⁶⁹ The remaining 80% of parking spaces should be designed to permit future installation of EVSE.⁷⁰ In addition, The Ontario Ministry of Municipal Affairs held consultations in 2017 on changes to the Building Code that would require EV charging in 20% of indoor parking spaces and ‘rough-ins’ in the remaining spaces in apartment buildings.⁷¹ The feedback from those consultations is currently under review.

Leadership in Energy and Environmental Design (LEED)

Under LEED BD+C v4, credits are available related to EVs and EVSE as Location and Transportation (LT) credit Green Vehicles. A possible 1 point is available by meeting the following requirements:⁷²

- Designate 5% of all parking spaces as preferred parking for green vehicles or provide a discounted parking rate of at least 20% for green vehicles.
- Install level 2 or greater EVSE in 2% of all parking spaces (separate from and in addition to preferred parking spaces in the first requirement). The chargers must be networked or internet addressable to participate in demand response programs or time of use pricing. Alternatively, install liquid or gas alternative

⁶⁸ Preparing Toronto for Electric Vehicles. Report for Action.

<https://www.toronto.ca/legdocs/mmis/2017/pw/bgrd/backgroundfile-107507.pdf>

⁶⁹ O. Reg. 332/12: Building Code. <https://www.ontario.ca/laws/regulation/120332>

⁷⁰ Ontario Ministry of Municipal Affairs, Technical Support for Electric Vehicle Charging Requirements in the Building Code that are in effect January 1, 2018, Non-residential Buildings, Questions and Answers, December 19, 2017. <http://www.hastingshighlands.ca/deptdocs/Electric%20Vehicle%20Charging%20-%20Technical%20Support%20-%20Non-Residential%20Buildings%20%28Part%203%29%20-%20MMA%20Dec%202017.pdf>

⁷¹ Toronto, Toronto Green Standard Version 3 – Review of Potential Incentives and Results of Additional Consultation, May 2, 2018. <https://www.toronto.ca/legdocs/mmis/2018/pg/bgrd/backgroundfile-115478.pdf>

⁷² Canada Green Building Council, LEED v4 Zone, https://www.cagbc.org/CAGBC/Programs/LEED/LEEDv4/LEED_v4_Zone.aspx

fueling facilities or a battery switching station capable of refueling a number of vehicles per day (equal to at least 2% of all spaces).

3.3 Installed Charging Infrastructure

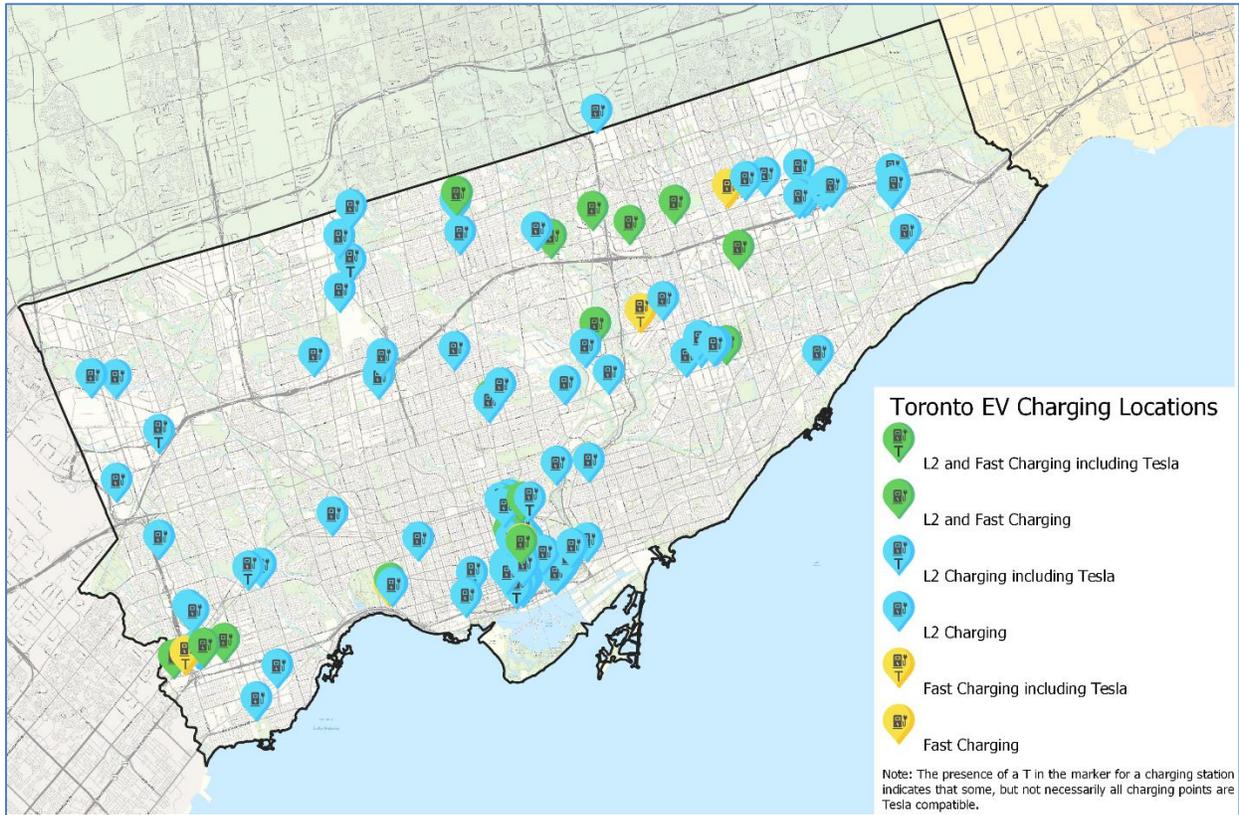


Figure 5: Publicly accessible charging infrastructure in the City of Toronto (Source: ChargeHub)

As shown in Figure 5, publicly accessible charging stations in Toronto are currently clustered downtown and along major corridors.

4 Municipal Electric Mobility Strategies

4.1 Municipal Best Practice

A growing number of municipalities around the world are preparing and actively planning for a transition to electric mobility. Electric mobility offers municipalities a means to reduce transportation-related greenhouse gas (GHG) emissions as well as other emissions that contribute to reduced air quality. A strategic and thoughtful plan can expedite a municipality in implementing a cleaner, low-carbon transportation network. This section of the report documents examples of how leading municipalities around the world are preparing for this transition.

The City of Toronto previously carried out research to identify key characteristics that contribute to successful electric mobility uptake at the municipal and regional scale.⁷³ The research drew on work of the International Council on Clean Transportation (ICCT), which assessed 14 major cities in North America, Europe and China who are leaders in promoting electric mobility. The research showed that the following key themes could be attributed to successful electric mobility uptake:

- Incentives (financial and non-financial)
- Research and community engagement through awareness campaigns
- Charging infrastructure

The current work identifies best practices at the municipal level for cities that have developed strategies to accelerate the deployment of electric mobility and/or have higher than average electric mobility uptake. While global cities were considered, the research focused on cities in Canada and the U.S., given similarities to Toronto in terms of vehicle use and the regulatory landscape. A growing number of North American cities have developed or are in the process of developing some form of local or regional electric mobility strategy.⁷⁴

⁷³ City of Toronto. Preparing Toronto for Electric Vehicles October 2017.
<https://www.toronto.ca/legdocs/mmis/2017/pw/bgrd/backgroundfile-107507.pdf>

⁷⁴ The International Council on Clean Transportation. The Continued Transition to Electric Vehicles in U.S. Cities. July 2018.
https://www.theicct.org/sites/default/files/publications/Transition_EV_US_Cities_20180724.pdf

Electric mobility strategies vary in complexity for each individual city as they are tailored to address specific barriers, political landscapes, and/or existing partnerships. The following common themes can be drawn from leading cities' electric mobility strategies:

- Charging Infrastructure
- Education and Outreach
- Collaboration and Partnerships
- Regulations and Policies
- Fleets, Transit and Car Sharing
- Incentives
- Economic Development

These correlate well with the five areas of opportunity previously identified by Toronto, which included:

- Policy and regulation
- Research, community awareness and behaviour change
- Financial and non-financial incentives
- Availability of charging infrastructure
- Understanding and developing the EV industry, workforce, and training

The remainder of this section provides examples of initiatives/actions in each of these areas from leading jurisdictions with city-level electric mobility strategies and/or exceptionally high uptake of electric mobility options such as EVs.

4.1.1 Charging Infrastructure

Ensuring that EV charging infrastructure is located in strategic areas of a city is crucial to the success of any electric mobility strategy. The City of Vancouver's EV Ecosystem Strategy recognizes EV infrastructure as an increasingly important community amenity and focuses on integrating EV infrastructure in such a way that EVs can assimilate into the urban environment and daily life.

Charging EVs is a different experience than going to a gas station – even DC fast charging (Level 3) can take 10-40 minutes depending on battery size. There is therefore a correlation between where vehicles are parked for longer periods of time, and where

charging solutions are most important. Most charging occurs at home (80-90%⁷⁵), followed by work, then public charging.⁷⁶ This section considers each of these charging locations separately.

For home and workplace charging, municipalities typically focus on codes and standards with incentives provided by other entities (e.g., other levels of government). Municipalities take a more direct role in the installation of public charging infrastructure.

4.1.1.1 Home Charging

As mentioned above, home charging is the most important type of charging to enable EV ownership. Home charging is relatively straightforward for single-family homes with driveways as the decision to install charging equipment rests solely with the homeowner and the main barrier is typically cost. It is less straightforward for residents of multi-unit residential buildings and garage orphans (homes with no driveways or garages requiring residents to park on the street). In these cases, charging equipment must be installed in communal parking areas, or curbside, and requires the involvement of property owners/managers or municipal governments. In addition to cost, other barriers facing MURB and garage orphan charging include electrical capacity, space, regulations for on-street charging and the requirement to allocate charging costs to equipment users.

Single Family Homes

The City of Vancouver has amended the building code for new construction to require one energized outlet per parking area (garage, carport) for single family dwellings. North Vancouver is incorporating into its zoning bylaws that all new residential developments (one and two unit) be Level 2 EV ready.⁷⁷

To address costs, several jurisdictions provide incentives toward the purchase and/or installation of Level 2 chargers at home. For example, the Charging Solutions and Incentives Program in BC provided \$750 for single family homes.⁷⁸

⁷⁵ Bruce Power, Plug'n Drive, Pollution Probe, University of Waterloo, Accelerating the Deployment of Plug-In Electric Vehicles in Canada and Ontario, 2016. https://www.plugndrive.ca/wp-content/uploads/2017/07/160159_ElectricVehicleReport_R001.pdf

⁷⁶ Hardman, S., et al. Considerations for the development of plugin electric vehicle charging infrastructure for consumers – A review, UC Davis, September 2017. <https://phev.ucdavis.edu/wp-content/uploads/PEV-Infrastructure-Literature-Review-.pdf>

⁷⁷ Plug In BC, Policy. <https://pluginbc.ca/policy/>

⁷⁸ Plug In BC, Charging Solutions and Incentives. <https://pluginbc.ca/incentives/charging-solutions-incentives/>

Garage Orphans

Charging for garage orphans is addressed through the installation of public curbside charging. Examples of best practice are provided in Section 4.1.1.3.

MURBs

Vancouver's EV Ecosystem Strategy requires every parking space in MURBs, excluding visitor parking, to have an energized outlet capable of supporting Level 2 EVSE installation. Many other cities in BC have similar requirements for new builds, requiring that 20% to 100% of parking spaces be EV ready.⁷⁹

Apartment buildings pose additional challenges as well that can be addressed through regulation. For example, in California, Assembly Bill 2565 provides for renters to be able to install chargers in their parking spots.⁸⁰ Senate Bill 880 makes it illegal to prohibit or restrict charger installation in a designated parking spot in a MURB and provides for certain conditions if the charger is installed in a common area.⁸¹ A common interest development may not prohibit or restrict the installation or use of EVSE in a designated parking spot.⁸²

The Charging Solutions and Incentives Program in BC provides a rebate for MURBs of 75% up to \$4,000 for Level 2 charging equipment.⁸³

4.1.1.2 Workplace Charging

Where close to home charging solutions are seen as reasonable but less convenient (e.g., on-street charging), having access to workplace charging as a secondary solution can significantly improve the value proposition for EV ownership. A nation-wide U.S. study by the International Council on Clean Transportation (ICCT) found that people are 20 times more likely to buy an EV if their employer provides workplace charging stations.⁸⁴

⁷⁹ Plug In BC, Policy. <https://pluginbc.ca/policy/>

⁸⁰ California Legislative Information, AB-2565 Rental property: electric vehicle charging stations. http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB2565

⁸¹ Senate Bill No. 880. http://www.leginfo.ca.gov/pub/11-12/bill/sen/sb_0851-0900/sb_880_bill_20120229_chaptered.pdf

⁸² US DOE, Alternative Fuels Data Center, Electric Vehicle Supply Equipment (EVSE) Policies for Multi-Unit Dwellings. <https://afdc.energy.gov/laws/9579>

⁸³ Plug In BC, Charging Solutions and Incentives. <https://pluginbc.ca/incentives/charging-solutions-incentives/>

⁸⁴ https://www.theicct.org/sites/default/files/publications/ICCT_EV-promotion-US-cities_20150729.pdf

Barriers to workplace charging are similar to challenges with MURB and garage-orphan charging – except for new lots, workplace parking was not originally designed to accommodate charging.

Workplace charging is typically addressed through non-municipal incentives. The Charging Solutions and Incentives Program in BC rebate for workplaces is 50% up to \$4,000 for Level 2 charging equipment or \$2,000 for Level 1.⁸⁵ Charge to Work NY provides \$8,000 per EV workplace charging station in New York City.⁸⁶ The Branché au travail program in Quebec offers a 75% rebate for the purchase and installation of a workplace charging station to a maximum of \$5,000.⁸⁷

In addition to incentives, policies can also enable and mandate EV readiness. For example, San Francisco has the 100 percent EV Ready ordinance, which requires all new residential and commercial buildings to have 10% of spots be ‘turnkey ready’ (ready for EV charger installation), 10% of spots be ‘EV flexible’ (ready for potential charging and upgrades), and 80% of spots be ‘EV capable’ (have conduit run to avoid future cost barriers).⁸⁸ The Ontario Building Code was amended for buildings (including commercial buildings) to include the provision that not less than 20% of parking spaces be provided with EVSE installed (excluding apartment buildings). The remaining parking spaces in the building are to be designed to permit future installation of EVSE.⁸⁹ In the District of North Vancouver, approximately 10% of parking stalls in commercial and industrial buildings must be EV ready (i.e., wired for level 2 charging).⁹⁰

4.1.1.3 Public Charging

Most municipal-level electric mobility strategies include specific actions to increase the number of public charging stations. While public charging is the least-used type of charging, it does provide key benefits:

- Increases visibility of charging solutions and hence addresses range anxiety concerns for potential EV owners

⁸⁵ Plug In BC, Charging Solutions and Incentives. <https://pluginbc.ca/incentives/charging-solutions-incentives/>

⁸⁶ <https://www.chargetoworkny.com/>

⁸⁷ <http://vehiculeselectriques.gouv.qc.ca/english/entreprises/entreprises.asp>

⁸⁸ <https://electrek.co/2017/03/01/san-francisco-electric-vehicle-charging-ready/>

⁸⁹ Building Code Online, The Ontario Building Code. <http://www.buildingcode.online/120.html>

⁹⁰ Plug In BC, Policy. <https://pluginbc.ca/policy/>

- Enables travel where EV owners no longer have access to home and/or workplace charging

Barriers to public charging include:

- Supply equipment owners/operators are not allowed to mark up electricity rates (resulting in a poor business case for public EVSE deployment). Charging solutions typically have to price usage based on the time spent at the charging space, and not based on the amount of electricity used.
- Interoperability between charging systems (apps, payment, cards, etc.)
- Lack of deployment – e.g., on-street opportunities limited/unavailable in downtown locations.

One of the strategic goals of Montreal’s Transportation Electrification Strategy is to “*roll out a network of charging stations to support the desired gradual conversion of Montreal’s automobile stock.*”⁹¹ The City is installing a charging network for privately owned EVs with a goal of 1,000 charging stations by 2020 to serve the entire municipal territory.⁹²

The Drive Clean Seattle Electrification Initiative has numerous implementation actions to promote increased adoption of electric mobility by increasing access to charging, such as developing a network of off-street charging station clusters and exploring pathways to allow EV charging in the right-of-way. Other actions include pilot projects in collaboration with City Light (a local electrical utility), including installing 20 DC fast chargers and at least 200 charging stations in customer homes.⁹³

The City of Portland’s Electric Vehicle Strategy prioritizes charging infrastructure in areas that have fewer existing public charging stations, higher proportions of multi-family housing and garage-free homes, residents with higher average vehicle kilometres travelled, and higher proportions of low-income residents, as well as at destinations where

⁹¹ City of Montreal. Electrifying Montreal Transportation Electrification Strategy 2016-2020. http://ville.montreal.qc.ca/pls/portal/docs/PAGE/PROJ_URBAINS_FR/MEDIA/DOCUMENTS/TRANSPORTATION_ELECTRIFICATION_STRATEGY_2016_2020_PDF

⁹² City of Montreal. Electrifying Montreal Transportation Electrification Strategy 2016-2020. http://ville.montreal.qc.ca/pls/portal/docs/PAGE/PROJ_URBAINS_FR/MEDIA/DOCUMENTS/TRANSPORTATION_ELECTRIFICATION_STRATEGY_2016_2020_PDF

⁹³ Seattle Office of Sustainability & Environment. 2017 Drive Clean Seattle Implementation Strategy. http://www.seattle.gov/Documents/Departments/Environment/ClimateChange/Drive_Clean_Seattle_2017_Report.pdf

people tend to travel longer distances to access. One of the goals of Portland's Strategy is to double the number of Level 2 and DC Fast Chargers available to the public.⁹⁴

One of the goals of Vancouver's EV Ecosystem Strategy is to maximize access to EV charging. The Strategy outlines a suite of actions to achieve this goal. Examples of actions include a curbside pilot project (program for commercial business and single-family home owners that do not have access to off-street parking), the development of charging hubs that support residents, commercial fleets, EV taxis and EV car sharing, and improving public Level 2 charging access and visibility.⁹⁵

The municipality of Oslo, Norway owns and operates charging infrastructure on public lands. The municipality also partners with private real estate entities to support publicly accessible charging infrastructure that is privately owned and operated.⁹⁶

In Amsterdam, Netherlands there are over 1,300 total charge points and over 30 fast charge points, with 4,000 charge points planned by the end of 2018. All public charging stations are powered by locally-generated wind power.⁹⁷

4.1.2 Education and Outreach

While education and outreach intent can vary (e.g., educating landlords on EV charging versus educating consumers on electric mobility benefits), many city-level electric mobility strategies include some actions and/or goals related to education and outreach. Cities with exceptional electric mobility uptake typically have some form of education and outreach actions or events conducted at the municipal level.

For example, the City of Portland's Electric Vehicle Strategy includes developing outreach and education materials and developing programs to engage builders and architects, as

⁹⁴ City of Portland. 2017 City of Portland Electric Vehicle Strategy. <https://www.portlandoregon.gov/bps/article/619275>

⁹⁵ City of Vancouver. Vancouver's EV Ecosystem Strategy November 2016. <https://vancouver.ca/files/cov/EV-Ecosystem-Strategy.pdf>

⁹⁶ World Economic Forum. Electric Vehicles for Smarter Cities: The Future of Energy and Mobility January 2018. <https://www.weforum.org/reports/electric-vehicles-for-smarter-cities-the-future-of-energy-and-mobility>

⁹⁷ International Council on Clean Transportation (ICCT). Electric Vehicle Capitals of the World. March 2017. https://www.theicct.org/sites/default/files/publications/Global-EV-Capitals_White-Paper_06032017_vF.pdf

well as increasing public awareness of EV chargers via improved signage, marketing and outreach.⁹⁸

The City of Seattle's Implementation Strategy outlines specific actions to increase awareness of the benefits of electrification and consumer exposure to electric mobility, such as developing a website dedicated to providing electric mobility information and participating in National Drive Electric Week as well as other electric mobility events.⁹⁹

The City of Vancouver's EV Ecosystem Strategy intends to '*improve community experience and knowledge in vehicle charging*'. Examples of specific actions to support this goal include developing public charging points to be sources of information for ICE drivers as well as providing education to landlords and property managers to further the acceptance of MURB EV charging retrofits.¹⁰⁰

As part of its electric mobility promotion, the City of Shanghai, China works with the federal government to operate an EV Demonstration Zone, which helps auto companies to engage a wide variety of consumers and collect consumer EV data. Elements of the Demonstration Zone include an EV service centre, an EV rental plan, promotion of EVs via a car sharing service, a network of charging stations, and free EV test drives.¹⁰¹

4.1.3 Collaboration and Partnerships

Most municipality-led electric mobility strategies rely on partners to achieve the desired shift to electric mobility adoption. Partnerships are important during implementation, but also during strategy development where they lay the groundwork for implementation and build the buy-in necessary to gain City approval. Utility companies are common allies, particularly with respect to charging stations and infrastructure as well as pilot projects. Other partners include various levels of government, automakers, real estate developers, technology companies, and transportation authorities, to name a few. Often, electric

⁹⁸ City of Portland. 2017 City of Portland Electric Vehicle Strategy. <https://www.portlandoregon.gov/bps/article/619275>.

⁹⁹ Seattle Office of Sustainability & Environment. 2017 Drive Clean Seattle Implementation Strategy. http://www.seattle.gov/Documents/Departments/Environment/ClimateChange/Drive_Clean_Seattle_2017_Report.pdf.

¹⁰⁰ City of Vancouver. Vancouver's EV Ecosystem Strategy November 2016. <https://vancouver.ca/files/cov/EV-Ecosystem-Strategy.pdf>

¹⁰¹ International Council on Clean Transportation (ICCT). Electric Vehicle Capitals of the World. March 2017. https://www.theicct.org/sites/default/files/publications/Global-EV-Capitals_White-Paper_06032017_vF.pdf

mobility strategies are supported by other city, province/state, and/or federal initiatives. Partnerships are a strong cornerstone for municipalities with high electric mobility uptake.

Innovative partnerships can be found in Vancouver's EV Ecosystem Strategy, which indicates that the city will partner with Carbon Neutral City cities with the intent of developing a carbon credit mechanism with respect to charging infrastructure. The intent is to create a stronger business case for private sector investment. The City of Vancouver also partnered with Telus to integrate EV charging with cellular monopolies at four locations.¹⁰²

Montreal's Transportation Electrification Strategy details ongoing collaboration with public and private partners, including Hydro-Québec, the Government of Québec, Caisse de dépôt et de placement du Québec (CDPQ), the future regional transportation agency (Agence régionale de transport (ART)), the Montreal taxi bureau, the Montreal electric services commission, and Téo Taxi. Specifically, Montreal joined Hydro-Quebec's Electric Circuit in 2013, which prompted the city to acquire and install 240-volt charging stations. Most of these stations are installed off-street.¹⁰³

The City of Portland has many partnerships as part of its Strategy, including utilities, Neighbourhood Prosperity Initiative (NPI) districts, TriMet (the local transit authority), Drive Oregon, Portland State University, and public and private stakeholders. The Strategy outlines several actions and denotes where the City of Portland is directly responsible for implementation versus where the city plays a supporting role. Examples of actions where the city plays a supporting role include: EV charging hubs (where the city will work with public and private partners to support installation of multi-modal EV charging pods), utility transportation electrification plans (where the city will partner with local utilities to finalize and implement transportation electrification plans), bus electrification (the city will support TriMet's efforts to transition to electric buses), and EV Showcase (the city will support Drive Oregon's Northwest EV Showcase initiative).¹⁰⁴

¹⁰² City of Vancouver. Vancouver's EV Ecosystem Strategy November 2016.
<https://vancouver.ca/files/cov/EV-Ecosystem-Strategy.pdf>

¹⁰³ City of Montreal. Electrifying Montreal Transportation Electrification Strategy 2016-2020.
http://ville.montreal.qc.ca/pls/portal/docs/PAGE/PROJ_URBAINS_FR/MEDIA/DOCUMENTS/TRANSPORTATION_ELECTRIFICATION_STRATEGY_2016_2020_PDF

¹⁰⁴ City of Portland. 2017 City of Portland Electric Vehicle Strategy.
<https://www.portlandoregon.gov/bps/article/619275>

The City of Seattle plans on partnering with the Electric Power Research Institute (EPRI) to test a range of charging technologies on the city's fleet vehicles.¹⁰⁵

To implement its Electric Vehicle Strategy, the City of Edmonton plans on collaborating with the automobile industry and non-profit organizations to create learning opportunities for Edmontonians on , local car sharing and ride sharing organizations to expand access to electric mobility options, utility companies and academic institutions to investigate impacts of EVs on electricity grid capacity or redesigning rate plans, and provincial and federal governments on the development of strategies and policies.¹⁰⁶

The City of Oslo's Vulkan project exemplifies how smart partnerships can provide templates of smart electric mobility design solutions for other cities. The Vulkan project is a public-private partnership between the city, a utility company and a real estate firm. Vulkan is a sustainable urban development project located on the city's outskirts and includes a smart charging hub equipped with multi-speed charging stations that offer smart charging, battery reserve and vehicle-to-grid technologies. Charging stations can be pre-booked by fleet operators and car sharing services.¹⁰⁷

4.1.4 Regulations and Policies

Quite often, electric mobility strategies are part of a larger suite of policies aimed at greening municipal operations. For example, Vancouver's EV Ecosystem Strategy is part of a broader suite of city policies meant to increase the transition to electric mobility. Supporting policies, for example, include the Renewable City Strategy, which commits the city to deriving 100% of its energy from renewable sources before 2050.¹⁰⁸ The EV Ecosystem also aligns with the Greenest City Action Plan, Transportation 2040 and the Healthy City Strategy.¹⁰⁹

¹⁰⁵ Seattle Office of Sustainability & Environment. 2017 Drive Clean Seattle Implementation Strategy. http://www.seattle.gov/Documents/Departments/Environment/ClimateChange/Drive_Clean_Seattle_2017_Report.pdf

¹⁰⁶ City of Edmonton. Edmonton's Electric Vehicle Strategy September 2018.

https://www.edmonton.ca/city_government/documents/PDF/EdmontonElectricVehicleStrategy.pdf

¹⁰⁷ World Economic Forum. Electric Vehicles for Smarter Cities: The Future of Energy and Mobility January 2018. <https://www.weforum.org/reports/electric-vehicles-for-smarter-cities-the-future-of-energy-and-mobility>

¹⁰⁸ City of Vancouver. Vancouver's EV Ecosystem Strategy November 2016.

<https://vancouver.ca/files/cov/EV-Ecosystem-Strategy.pdf>

¹⁰⁹ City of Vancouver. Vancouver's EV Ecosystem Strategy November 2016.

<https://vancouver.ca/files/cov/EV-Ecosystem-Strategy.pdf>

Effective electric mobility strategies include amending or implementing local regulations or policies to promote electric adoption.

For example, the City of Vancouver first amended the *Vancouver Building By-law* to require new developments to have electrical supply for EVs (20% of parking stalls in new apartment buildings, condos, townhomes and other buildings with three units or more must include a receptacle for charging cars and the electrical room must include enough space to install all equipment necessary to provide charging to all residents in the future). More recently, it was amended to allow for the use of electrical load management technologies as well as ensure minimum power outputs.¹¹⁰ Vancouver's Green Homes Program requires all new one- and two- family homes to be built to accommodate future green energy technologies, including powering the next generation of EVs¹¹¹. The EV Ecosystem Strategy includes a number of 'quick starts' that involve updating existing city policies, including updating *Vancouver's Standards of Maintenance By-law* to require reasonable access to existing EV charging equipment (including outlets for e-bikes and e-scooters) and removing the 200A panel exemption for new construction of one- and two- family homes under the *Vancouver Building By-law*¹¹².

Part of Montreal's Transportation Electrification Strategy is to implement the measures outlined in the Parking Policy (adopted in June of 2016). Proposed measures include providing on-street parking and charging for electric mobility, developing sustainable mobility options, creating pricing for EV charging, and evaluating the feasibility of an urban goods distribution centre that would focus on electric mobility for 'last kilometre' delivery.¹¹³

In its 2017 Electric Vehicle Strategy, the City of Portland indicates that it is going to explore policy options that would require new buildings, particularly apartments and condominiums to be built to support cost effective charging infrastructure.¹¹⁴

¹¹⁰ City of Vancouver. Vancouver's EV Ecosystem Strategy November 2016. <https://vancouver.ca/files/cov/EV-Ecosystem-Strategy.pdf>

¹¹¹ City of Vancouver. Electric vehicle charging requirements webpage. <https://vancouver.ca/home-property-development/electric-vehicle-charging-requirements.aspx>

¹¹² City of Vancouver. Vancouver's EV Ecosystem Strategy November 2016. <https://vancouver.ca/files/cov/EV-Ecosystem-Strategy.pdf>

¹¹³ City of Montreal. Electrifying Montreal Transportation Electrification Strategy 2016-2020. http://ville.montreal.qc.ca/pls/portal/docs/PAGE/PROJ_URBAINS_FR/MEDIA/DOCUMENTS/TRANSPORTATION_ELECTRIFICATION_STRATEGY_2016_2020_PDF

¹¹⁴ City of Portland. 2017 City of Portland Electric Vehicle Strategy. <https://www.portlandoregon.gov/bps/article/619275>

San Francisco, California requires new residential, commercial and municipal buildings to have sufficient electrical infrastructure to charge vehicles in 20% of the parking spaces simultaneously.^{115,116}

4.1.5 Fleets, Transit and Car Sharing

Converting municipal fleets and electrifying a city's bus fleet are common actions to support a city's transition to electric mobility. To support such actions in Canada, NRCan has released a guide to greening government fleets.¹¹⁷ While a city has direct influence over municipal vehicle procurement, local transportation authorities may have jurisdiction over a city's bus fleet and may be responsible for developing their fleet's electrification strategy. As a result, conversion of a city's bus fleet is not always part of an electric mobility strategy per se, but may be supported via the strategy. Car sharing programs or partnerships may also be supported by electric mobility strategies. Leading electric mobility municipalities typically also support the transition of fleets and transit vehicles to electrification.

For example, the City of Portland's Electric Vehicle Strategy aims to increase the percentage of EVs in its sedan fleet from 20% to 30% by 2020. It also includes the establishment of 'electric first' guidelines, which will direct city bureaus to purchase all-electric vehicles when usage is compatible with available electric light-duty vehicles. The strategy includes actions for supporting the electrification of freight vehicles as well.¹¹⁸ The strategy also identifies Portland's support of TriMet's efforts to transition to electric buses. TriMet is currently testing new electric buses and charging infrastructure.¹¹⁹

Seattle has outlined multiple actions to exemplify its role as a leader in increasing electric mobility uptake. For example, the Implementation Strategy includes launching a workplace charging program for City of Seattle employees as well as installing 200 new charging stations for fleet vehicles (in 2017/18), and sets a goal of achieving 40%

¹¹⁵ San Francisco Municipal Transportation Authority. 2017 San Francisco Transportation Sector Climate Action Strategy. https://www.sfmta.com/sites/default/files/reports-and-documents/2017/12/cap_draft_full_document-final1.pdf

¹¹⁶ San Francisco is in the process of developing an Electric Mobility Strategy (expected release date is Fall 2018). Example provided here is outlined in San Francisco's Transportation Sector Climate Action Strategy, which includes a chapter on EVs and EV Infrastructure.

¹¹⁷ <https://www.nrcan.gc.ca/energy/transportation/alternative-fuels/resources/21314>

¹¹⁸ City of Portland. 2017 City of Portland Electric Vehicle Strategy. <https://www.portlandoregon.gov/bps/article/619275>

¹¹⁹ TriMet website. <https://trimet.org/betterbus/serviceimprovements-fy20.htm>

electrification of its current light-duty municipal fleet. Electrification of transit is also noted in Seattle's Strategy, indicating that King County Metro has acquired three all-electric buses and has set a goal of having 120 in service by 2020.¹²⁰

The San Francisco City Fleet Zero Emission Vehicle Ordinance requires the conversion of the city's light-duty passenger vehicle fleet to EVs by 2022.^{121,122} The San Francisco Municipal Transportation Agency (SFMTA) has made a commitment to have an all-electric bus fleet by 2035. To help meet this goal, the SFMTA will only procure all-electric buses beginning in 2025.¹²³

As part of its Transportation Electrification Strategy, the City of Montreal has a goal to convert the municipal fleet of ICE vehicles to EVs. The Strategy also outlines the electrification of the public transportation network, operated by Montreal's municipal transportation agency, the Societe de transport de Montreal (STM). The STM is tasked with planning and operating the City's public transportation network and has developed an electrification strategy. The STM's 2016-2025 electrification strategy includes actions such as replacing diesel buses with hybrid vehicles, acquiring electric or hybrid service vehicles, increasing the number of electric trains and participating in the City Mobility Project. Further, the Montreal taxi bureau's Taxi Industry Policy proposes to support the electrification of the city's taxi and limousine fleet by 2020 by increasing the number of EVs and accelerating the installation of charging stations.¹²⁴

To aid in its goal of becoming the world's first carbon neutral capital, the City of Copenhagen, Denmark has indicated in its climate plan that the municipality will purchase

¹²⁰ Seattle Office of Sustainability & Environment. 2017 Drive Clean Seattle Implementation Strategy. http://www.seattle.gov/Documents/Departments/Environment/ClimateChange/Drive_Clean_Seattle_2017_Report.pdf

¹²¹ https://www.sfmta.com/sites/default/files/reports-and-documents/2017/12/cap_draft_full_document-final1.pdf

¹²² San Francisco is in the process of developing an Electric Mobility Strategy (expected release date is Fall 2018). Ordinance will be the result of recommendations of the Electric Vehicle Working Group (EVWG).

¹²³ SFMTA Press Release. <https://www.sfmta.com/press-releases/san-francisco-commits-all-electric-bus-fleet-2035>

¹²⁴ City of Montreal. Electrifying Montreal Transportation Electrification Strategy 2016-2020. http://ville.montreal.qc.ca/pls/portal/docs/PAGE/PROJ_URBAINS_FR/MEDIA/DOCUMENTS/TRANSPORTATION_ELECTRIFICATION_STRATEGY_2016_2020_.PDF

only EVs (starting in 2011) and that the entire bus fleet is to be replaced with electric buses (starting in 2019).¹²⁵

In Paris, France, RATP (the primary public transportation operator) in the Ile-de-France region intends to electrify up to 80% of its bus fleet by 2025.¹²⁶

4.1.6 Incentives

Incentives, both financial and non-financial, can be part of a municipality-led electric mobility strategy. Cities with exceptional electric mobility uptake typically offer a number of incentives to consumers and drivers, which are often supported by other levels of government.

The City of Edmonton's Electric Vehicle Strategy recommends non-permanent financial incentives for residents. The intent of the incentives would be to 'kick-start' an increase in EV market share by addressing the cost barrier. The incentive would be reduced and ultimately eliminated as EVs gain popularity. The strategy also suggests free public access to city-owned Level 2 charging stations, which also could be tapered as adoption momentum increases. Additional incentives suggested in the strategy include a rebate towards an EV upon retirement of an older vehicle.¹²⁷

The City of Shanghai, China offers EV owners both financial and non-financial incentives. The city provides regional subsidies of up to 30,000 yuan renminbi (about \$5,600 CAD) and EVs are exempt from the region's expensive and restrictive license plate auction system.¹²⁸

¹²⁵ International Council on Clean Transportation (ICCT). Electric Vehicle Capitals of the World. March 2017. https://www.theicct.org/sites/default/files/publications/Global-EV-Capitals_White-Paper_06032017_vF.pdf

¹²⁶ World Economic Forum. Electric Vehicles for Smarter Cities: The Future of Energy and Mobility January 2018. <https://www.weforum.org/reports/electric-vehicles-for-smarter-cities-the-future-of-energy-and-mobility>

¹²⁷ City of Edmonton. Edmonton's Electric Vehicle Strategy September 2018. https://www.edmonton.ca/city_government/documents/PDF/EdmontonElectricVehicleStrategy.pdf

¹²⁸ International Council on Clean Transportation (ICCT). Electric Vehicle Capitals of the World. March 2017. https://www.theicct.org/sites/default/files/publications/Global-EV-Capitals_White-Paper_06032017_vF.pdf

Oslo, Norway does not charge purchase or import tax on EVs. EVs are also exempt from ferry and road tolls, are granted free municipal parking and receive free electricity for normal charging. The city also offers non-financial incentives such as bus lane access.¹²⁹

The City of Laval, Quebec is currently the only Canadian municipality that offers its citizens a purchase rebate on BEVs and electric bicycles. The City offers a rebate of \$2,000 on the purchase of a BEV, and \$400 on the purchase of an e-bike. When the rebate program began in April, 2018, the city of about 420,000 budgeted for 100 BEV rebates and 100 e-bike rebates. As of October, 2018 however, the program has already led to the sale of over 1,100 BEVs and over 200 e-bikes. The program's budget was increased to accommodate the greater than anticipated demand. The Government of Quebec offers \$8,000 purchase rebates for BEVs, which means that citizens of Laval can receive a total rebate of \$10,000.¹³⁰

4.1.7 Economic Development

Leading cities recognize that supporting the shift to low-carbon transportation may very well result in substantial economic benefits, potentially by becoming an electric mobility technology hub. Several municipality-level electric mobility strategies have specific goals/actions with respect to the potential economic windfall electric mobility could bring.

For example, Portland's Electric Vehicle Strategy aims to support Portland as a leader in clean technology development. The strategy includes actions to support employment opportunities by connecting EV manufacturers with qualified underemployed or unemployed residents, providing business development assistance to EV-related companies, as well as providing business opportunities for existing electric mobility firms. Further, the strategy aims to increase electric mobility sector networking by working with Drive Oregon, TriMet, Metro and Greater Portland Inc., and support efforts to bring major EV conferences to Oregon.¹³¹

Montreal recognizes that its Transportation Electrification Strategy may result in substantial economic benefits. To maximize economic and technological benefits, the city

¹²⁹ International Council on Clean Transportation (ICCT). Electric Vehicle Capitals of the World. March 2017. https://www.theicct.org/sites/default/files/publications/Global-EV-Capitals_White-Paper_06032017_vF.pdf

¹³⁰ <https://www.cbc.ca/news/canada/montreal/laval-electric-vehicle-subsidy-demand-1.4864028>

¹³¹ City of Portland. 2017 City of Portland Electric Vehicle Strategy. <https://www.portlandoregon.gov/bps/article/619275>

will create and implement an economic development action plan for the electric/intelligent vehicle sector. The action plan will be used to identify high-impact sectors and actions, as well as guide decision-making with respect to electric mobility sector development. The city also plans on organizing events related to cutting-edge technologies and innovations for electric and intelligent vehicles.¹³²

4.2 Social Equity Considerations for Electric Mobility

Changes in transportation options and networks can both positively and adversely affect communities. Ensuring changes are made to benefit all people should be an important consideration when designing and implementing goals, actions, guidelines and policies to support the use of electric mobility options.

U.S. Executive Order (E.O.) 12898 focuses federal attention on the environmental and human health effects of federal actions on minority and low-income populations with the goal of achieving environmental protection for all communities.¹³³

The U.S. Department of Transportation (U.S. DOT) outlines the following principles of environmental justice:

- To avoid, minimize, or mitigate disproportionately high and adverse human health or environmental effects, including social and economic effects, on minority populations and low-income populations.
- To ensure the full and fair participation by all potentially affected communities in the transportation decision-making process.
- To prevent the denial of, reduction in, or significant delay in the receipt of benefits by minority populations and low-income populations.¹³⁴

A recent study identified four primary performance measures that could be used to formulate high-level discussions on various transportation options with respect to the

¹³² City of Montreal. Electrifying Montreal Transportation Electrification Strategy 2016-2020. http://ville.montreal.qc.ca/pls/portal/docs/PAGE/PROJ_URBAINS_FR/MEDIA/DOCUMENTS/TRANSPORTATION_ELECTRIFICATION_STRATEGY_2016_2020_PDF

¹³³ United States Environmental Protection Agency (US EPA). Summary of Executive Order 12898. <https://www.epa.gov/laws-regulations/summary-executive-order-12898-federal-actions-address-environmental-justice>

¹³⁴ U.S. Department of Transportation. Environmental Justice. https://www.fhwa.dot.gov/environment/environmental_justice/ej_at_dot/

social equity of a shared, autonomous and electric vehicle future.¹³⁵ These metrics include:

- Cost: low-income households typically spend a larger percentage of income on transportation
- Access: lack of access to vehicles, public transportation and safe active transportation options reduces employment opportunities
- Public Health: the current transportation system is often most detrimental to disadvantaged communities (e.g., poorer air quality, longer commute distances)
- Employment: while a different transportation future may result in benefits, there may also be disadvantages including a reduction in the number of jobs and changes to the types of jobs available and skills needed to fill these positions

Some city-level electric mobility strategies specifically address social equity and include goals or actions to ensure municipalities are creating equitable solutions.

For example, Portland’s Electric Vehicle Strategy states that the city is “*committed to creating mobility solutions that are equitable and empowering*”. The strategy includes actions to research financing options for individuals with no or damaged credit, as well as a community mobility assessment to ensure that electric mobility solutions meet the needs of low-income populations and communities.¹³⁶ Further, the City of Portland and Multnomah County developed a Climate Action Plan Equity Implementation Guide, which City and County staff can leverage to integrate equity into their work via tools and best practices.¹³⁷

The 2017 Drive Clean Seattle Implementation Strategy includes two actions dedicated to race and social justice, which are aimed at maximizing benefits for those most impacted by the air pollution associated with the current transportation system. These specific actions include partnering with the Environmental Justice Committee to “*implement projects in Equity and Environment Initiative (EEI)*”¹³⁸ *communities which deliver racial*

¹³⁵ Cohen, Stuart and Sahar Shirazi. February 2017. Policy Brief – Can We Advance Social Equity with Shared, Autonomous and Electric Vehicles? <http://www.transpogroup.com/assets/3revolutions---can-we-advance-social-equity-with-shared-autonomous-and-electric-vehicles.pdf>

¹³⁶ City of Portland. 2017 City of Portland Electric Vehicle Strategy. <https://www.portlandoregon.gov/bps/article/619275>

¹³⁷ City of Portland and Multnomah County. July 2016. Climate Action through Equity. <https://www.portlandoregon.gov/bps/article/583501>

¹³⁸ The Equity and Environment Initiative (EEI) is a partnership between the City of Seattle, the community, several City departments and private foundations to solidify Seattle’s commitment to race and social justice in environmental work. More on the initiative can be found at the website: <https://www.seattle.gov/environment/equity-and-environment/equity-and-environment-initiative>

equity outcomes identified in the Drive Clean Seattle Racial Equity Toolkit” and to “*complete additional racial equity toolkits for major Drive Clean Seattle projects and policies.*” The Strategy also includes the results of a racial equity analysis and outlines important racial equity implementation actions for 2017. Examples of these racial equity implementation actions include utilizing creative and culturally relevant strategies and fostering community cohesion by connecting electric mobility and transportation programs to community centers, places of worship, and service providers; engaging the community to identify potential disadvantages of increased electric mobility infrastructure and working with the community and stakeholders to mitigate any negative impacts; and partnering directly with community-based organizations and service industry anchors.¹³⁹

Vancouver’s EV Ecosystem Strategy specifically addresses the issue of equity and environmental justice and aims to ensure that all residents are given opportunities with respect to electric mobility. The strategy indicates that Vancouver “*will ensure that EV charging that is required in lower income housing presents options for reasonable and accessible technologies to the residents*”. It also indicates that the city will ensure that individuals will pay for their own charging and that cost is not passed onto other residents in multi-family situations. The strategy also acknowledges environmental justice considerations and states that “*the most vulnerable members of society will have the biggest health benefits from improved air quality and a more stable climate.*”¹⁴⁰

In its Electric Vehicle Policy Task Force Draft Policy Recommendations, the City of Philadelphia, Pennsylvania briefly discusses social equity impacts and identifies that Philadelphia’s demographics differ from those elsewhere in the U.S. Simply put, electric mobility does not currently offer a practical mobility solution for Philadelphia’s low-income residents and much more needs to be done to encourage electric mobility use across the city.¹⁴¹

¹³⁹ Seattle Office of Sustainability & Environment. 2017 Drive Clean Seattle Implementation Strategy. http://www.seattle.gov/Documents/Departments/Environment/ClimateChange/Drive_Clean_Seattle_2017_Report.pdf

¹⁴⁰ City of Vancouver. Vancouver’s EV Ecosystem Strategy November 2016. <https://vancouver.ca/files/cov/EV-Ecosystem-Strategy.pdf>

¹⁴¹ City of Philadelphia. Electric Vehicle Policy Task Force Draft Policy Recommendations. January 2018. http://www.phillyotis.com/wp-content/uploads/2018/01/ElectricVehiclePolicyTaskForce_Final_Draft.pdf

5 Planning for a Toronto Electric Mobility Strategy

5.1 Grid Impacts

Understanding potential impacts to Toronto's electrical grid due to the advancement of electric mobility is a critical preliminary step in the development of the Electric Mobility Strategy. Most near-term grid-related impacts are expected to result from the increased adoption of personal EVs by Toronto residents. While the adoption of EVs by major fleets will also pose potential challenges to the operators of Toronto's grid, in most cases these challenges will be easier to manage, as fleet duty cycles tend to be predictable, and most fleet EVs will return to a 'home base' or centralized depot for charging overnight. Further, because fuel costs are a major concern for fleet managers, it is likely that steps will be taken to ensure that fleet vehicles are only charged during off-peak electricity usage hours and that adequate infrastructure for power supply be established prior to the adoption of EVs by fleets. This section explores potential risks to the grid that high EV adoption levels might pose, as well as the state of grid readiness in Toronto to accommodate loads from the charging of EVs.

Over 80% of all privately-owned EV charging occurs at the residences of owners during night-time hours.¹⁴² While EVs represent a major household power demand, the total amount of electricity used to power an EV for a year can be less than that required to power a water heater or air conditioner.¹⁴³ However, because EVs are designed to draw a lot of power in a short amount of time (power consumed can be anywhere from 3.3 to 19.2 kW at Level 2), they can pose risks to local grid stability if many households in the same area are plug in to charge at the same time.

As EV adoption levels have increased in recent years concerns have been raised, and have sometimes been aired in the popular news media, about a potential threat that EVs pose to local power grids. The typical concern revolves around multiple people on the same street, or drawing power from the same local distribution transformer, plugging EVs in to charge at the same time. If enough people in close enough proximity to each other did this, it could cause their distribution transformer to overload and potentially fail. Such a failure could stress other nearby transformers or potentially cause a localized power outage.

¹⁴² <https://www.energy.gov/eere/electricvehicles/charging-home>

¹⁴³ <https://www.energy.gov/eere/electricvehicles/charging-home>

The analysis completed during the Assessment Phase suggests that as long as EV adoption continues to grow at a steady pace, no major grid capacity issues at the neighbourhood or municipality-wide levels are anticipated. The clustering of EVs within certain neighbourhoods will impose the first noticeable impacts on the local electricity distribution system. Typically there are spikes in electricity usage during the late afternoon/early evening peak in demand. If there is a significant amount of EV charging during those peak times, there could be some transformer overloading in certain neighbourhoods and/or significant increases in peak demand. The overloading of distribution/street-level transformers could, in theory, spread to bigger distribution arteries. Electricity system operators would see the impacts on the main supply points feeding a city only after the secondary, neighbourhood-level distribution systems are impacted. By the time this would happen, however, electrical utilities would be able to see the new electricity usage trends developing and would take measures to avoid impacts at the municipal level.

Such measures would likely include, as a first step, upgrading or increasing the number of street-level distribution transformers in a given neighbourhood. This would happen when a particular transformer is consistently being overloaded, which would increase the risk that it could eventually fail. This is the typical approach taken by electrical utilities when they see an increase in electricity usage within a given area. The piecemeal approach to grid upgrades resulting from high levels of EV adoption means that it is not necessary at this time to identify areas of cities such as Toronto that would need to be targeted for grid upgrades based on EV adoption projections. In addition to transformer upgrades or additions, if EV adoption occurs more rapidly than expected, electrical utilities would look into aggregating smart charging to defer net electricity consumption for EV charging. This would entail delaying the charging of participating customers from when they initially plug in to a time (overnight, for example) when electricity usage rates are lower and there is excess capacity in the system.

This deferment of charging is analogous to managing traffic congestion by taking measures to stagger the times at which people use highways, rather than simply adding more lanes to those highways. Peak hours of electricity usage are comparable to 'rush hour' traffic, and as a first step to managing such traffic it is ideal to utilize measures that are not capital-intensive (such as infrastructure expansion), but involve changes in peoples' behaviour to better utilize existing infrastructure. There is no reason why the majority of EV users need to charge their vehicles to full capacity as soon as they get home in the evening, especially if those vehicles still have an adequate amount of range

for evening errands. The entire night will be available for charging without the risk of stressing the local distribution system.

Most electrical utilities in Canada have begun investigating behind-the-meter platforms to manage EV charging loads for residential customers. Such platforms would work similarly to smart thermostats that provide utilities with a degree of control over monitoring and managing temperatures in residences. These solutions give utilities added flexibility to manage demand during peak usage periods, without having to bring additional electricity generation options online. If participating customers were to permit their utility company to have a degree of control over the timing and/or rate of EV charging (within user-defined parameters, of course), it would provide the utility with much-needed flexibility to help accommodate peak loads with its existing asset base. In this case, if a utility detected that multiple households drawing power from the same distribution transformer plugged in EVs to charge at the same time, it would toggle the rate and perhaps the timing of charging so that net power output from the transformer would remain within safe operating parameters.

Participants in such a program would specify two things to their utility: the minimum state of charge of their EV battery at any time they are plugged in, and the time, typically in the morning, when they need their EV to be fully charged. For example, an EV user could specify that whenever they plug their vehicle in, they need it to charge to at least 25% of its capacity right away, but the remaining 75% of capacity could be charged at any time or rate before, say, 8:00 am (i.e., before they leave for work in the morning). And this is just one of many possible emerging smart charging solutions. Another type of solution could include voluntary partnerships with EV owners to encourage or incentivize them not to charge during peak hours. As EV adoption and technologies continue to advance, so too will the number and efficacy of solutions to grid capacity issues.

Perhaps a bigger challenge than adapting to individual EV adoption will be for electrical utilities to work with major fleets on developing measures to transition vehicles such as transit buses to exclusively use electric power. Even with relatively short all-electric ranges, electric buses will be equipped with large batteries that will draw a lot of power and will likely require specialized charging platforms and equipment.

Supporting the roll out of public on-street charging stations will also be a major undertaking for electrical utilities as EV adoption continues to grow. Working on solutions for 'garage orphans' (residents limited to on-street parking) that will involve installing charging stations on sidewalks or utility poles will also pose challenges. Most utilities across Canada are also preparing to work with development and property management

companies to provide any service upgrades that may be required to facilitate EV charging at workplaces or in multi-unit residential buildings.

The approach of most utility companies to handle local capacity issues stemming from EV use is, in short, to deal with them as they arise, on a case-by-case basis. No major disruptions to the local distribution systems are anticipated as a result of EV adoption. The replacement of ICE vehicles with EVs will take place gradually over the coming years and decades, and utilities will almost certainly have adequate time to respond to resulting increases in electricity demand. And if EV adoption does accelerate faster than anticipated, utilities accept that they will simply have to devote more resources to preparing the grid. Generally speaking, utilities are ready, able and willing to adapt to an electric mobility future. Distribution transformers can be upgraded or added if and when such actions are required, the number of customers drawing power from each transformer can be reduced, and electricity system planners can monitor EV adoption levels and develop solutions that minimize the impact of EVs on the grid while optimizing grid asset utilization.

Utilities are particularly interested in understanding where they can deploy charging infrastructure investments that wouldn't be of interest to private businesses (e.g., residential on-street charging, MURB charging). Where there are opportunities for utilities to participate in EV charging solutions, their participation would be facilitated if there was a more straightforward business model for them to engage in. Further facilitating the work of utilities in the electric mobility space would be ensuring that they are provided with up-to-date data on factors such as: the number and location of garage orphans in their service areas, the addresses of registered EV owners, EV-related building code requirements and updates, transportation patterns in different regions, and transportation modes available to residents in different neighbourhoods.

A prominent barrier to the ability of electrical utilities to efficiently and cost-effectively accommodate increased EV charging is the fact that provincial regulations do not allow utilities to capture the costs of EV products and services within their rate bases (i.e., the value of a utility's assets, which is used by regulators to help determine electricity prices).¹⁴⁴ Electric utilities from across Canada have been encouraging provincial regulators to amend the laws around what can be included in their rate bases since EVs became widely available. If a transformer fails due to many of the households drawing power from it plugging in an EV to charge, that transformer can be replaced and any costs

¹⁴⁴ <http://www.pollutionprobe.org/publications/pollution-probe-ev-grid-gap-analysis-study/>

can be passed on to a utility's rate base. However if that utility wants to offer smart charging services to those same EV-using customers to avoid stressing local transformers, it is currently not allowed to do so under provincial law. An amendment in this area would greatly facilitate the provision of EV-related products and services by utilities. If the City of Toronto added its voice to the many groups advocating for change from the Ontario Energy Board, it would no doubt help to move this issue forward.

Electrical utility companies should have no major issues dealing with current levels of EV adoption. As adoption levels increase markedly, however, having access to data on current and forecasted adoption levels will become more important. This will allow them to efficiently and affordably roll out an appropriate level of infrastructure to support EV use at the appropriate times. Emerging technologies such as smart charging will help utilities manage consumption behaviour and limit the costs of having to upgrade electrical infrastructure to accommodate electric mobility.

5.2 Charging Infrastructure

Ensuring that EV charging infrastructure is located in strategic areas of a city is crucial to the success of any electric mobility strategy. The City of Vancouver's EV Ecosystem Strategy recognizes EV infrastructure as an increasingly important community amenity and focuses on integrating EV infrastructure in such a way that EVs can assimilate into the urban environment and daily life.

Charging EVs is a different experience than going to a gas station – even DC fast charging (Level 3) can take 10-40 minutes depending on battery size. There is therefore a correlation between where vehicles are parked for longer periods of time, and where charging solutions are most important. For EV owners, the most convenient place to charge is at home. The second most convenient place is at work, with other locations typically becoming less and less convenient.

As described in Section 3.1.4, the majority of current EV owners in Toronto live in single family homes in areas of the city where homes have driveways and/or garages, which allow for the installation of private charging stations for at-home charging. However, the majority of Toronto's housing stock does not have private driveways and/or garages for parking. As shown in Figure 6, multi-unit residential buildings (MURBs) comprise almost half of the housing stock. In addition, a portion of the single detached houses and semi-detached/row houses are garage orphans – houses dependent on on-street parking.

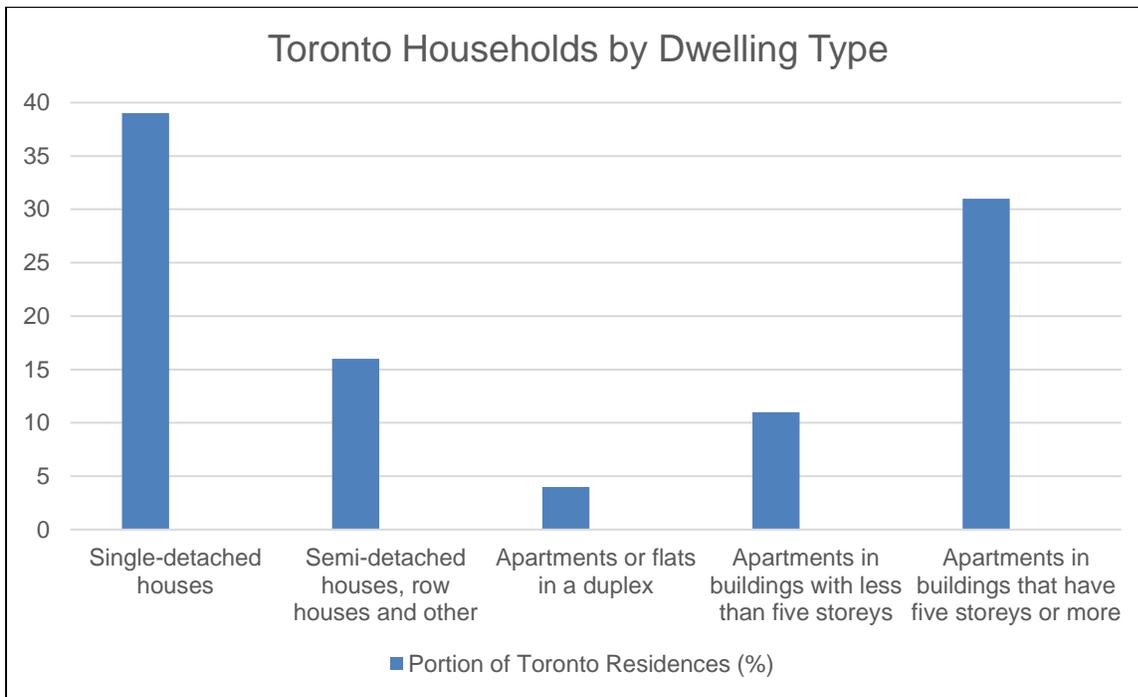


Figure 6: Toronto housing by dwelling type, adapted from 2016 census data

This section explores existing electric vehicle supply equipment (EVSE) in the city and discusses EVSE considerations during strategy development. An inventory of private charging equipment is not available, and the discussion focuses on how existing publicly accessible charging infrastructure meets current and forecasted demand. Note that an additional social equity lens should be brought to charging equipment considerations, and this is explored in Section 4.2.

5.2.1 Garage Orphans

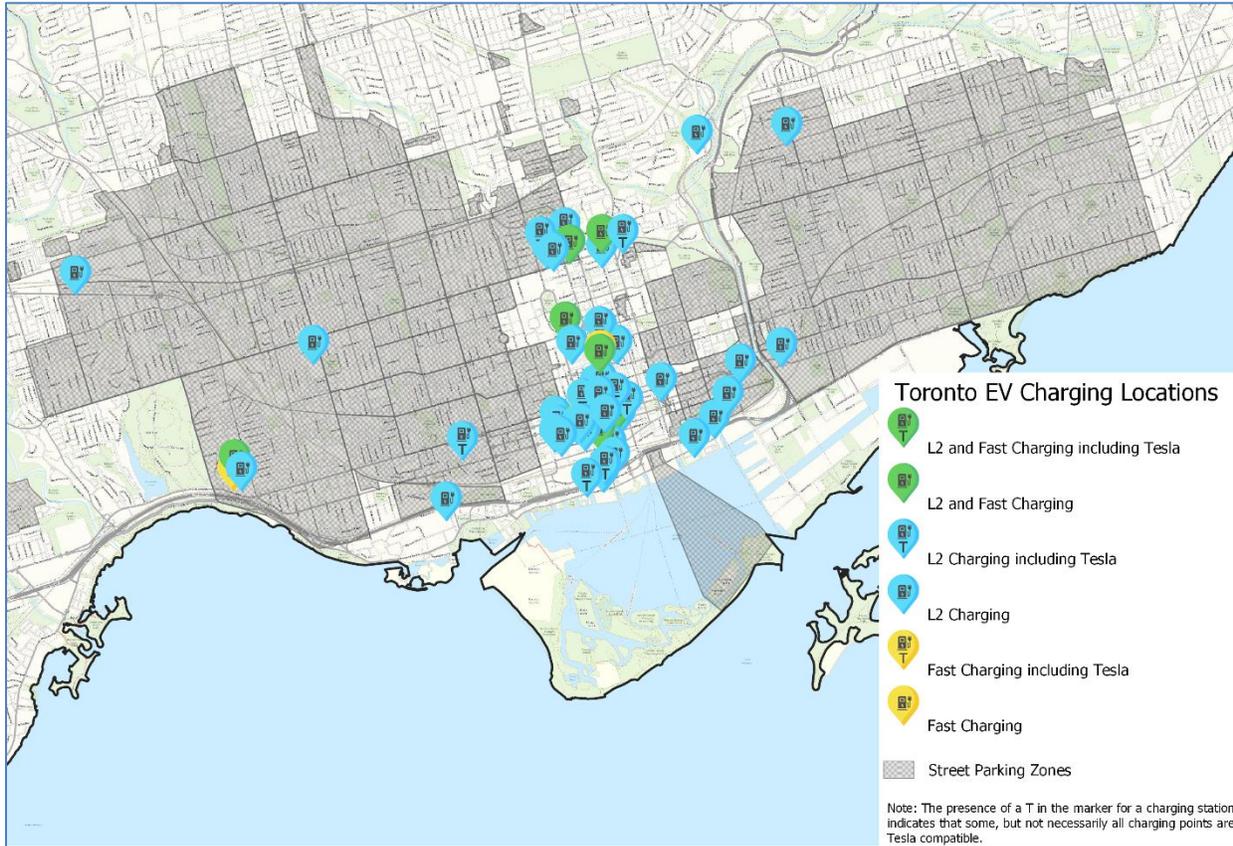


Figure 7: On-street parking areas and nearby publicly accessible charging infrastructure

Toronto has two prominent on-street parking areas: one located in the Leslieville/Upper Beaches and surrounding area (including the area directly west of the DVP/Regent Park area) and one located in the Brockton Village/Bloor West Village/Swansea/Parkdale/Sunnyside area. EV owners in these areas are likely 'garage orphans', in that they likely have no access to at home charging in garages or driveways. A review of the EV chargers available in these areas indicates that there are only a handful of public charging stations. Most of these stations are Level 2 and are located in areas such as car dealerships, commercial stores and malls where regular overnight charging is not feasible.

While clusters of DC fast chargers represent a potential charging solution, on-street charging is likely to be the preferred solution for EV owners in these areas. Toronto is

currently launching on-street charging demos (Section 3.2.5), and its Electric Mobility Strategy could consider how to roll-out deployment.

5.2.2 Multi-unit Residential Buildings

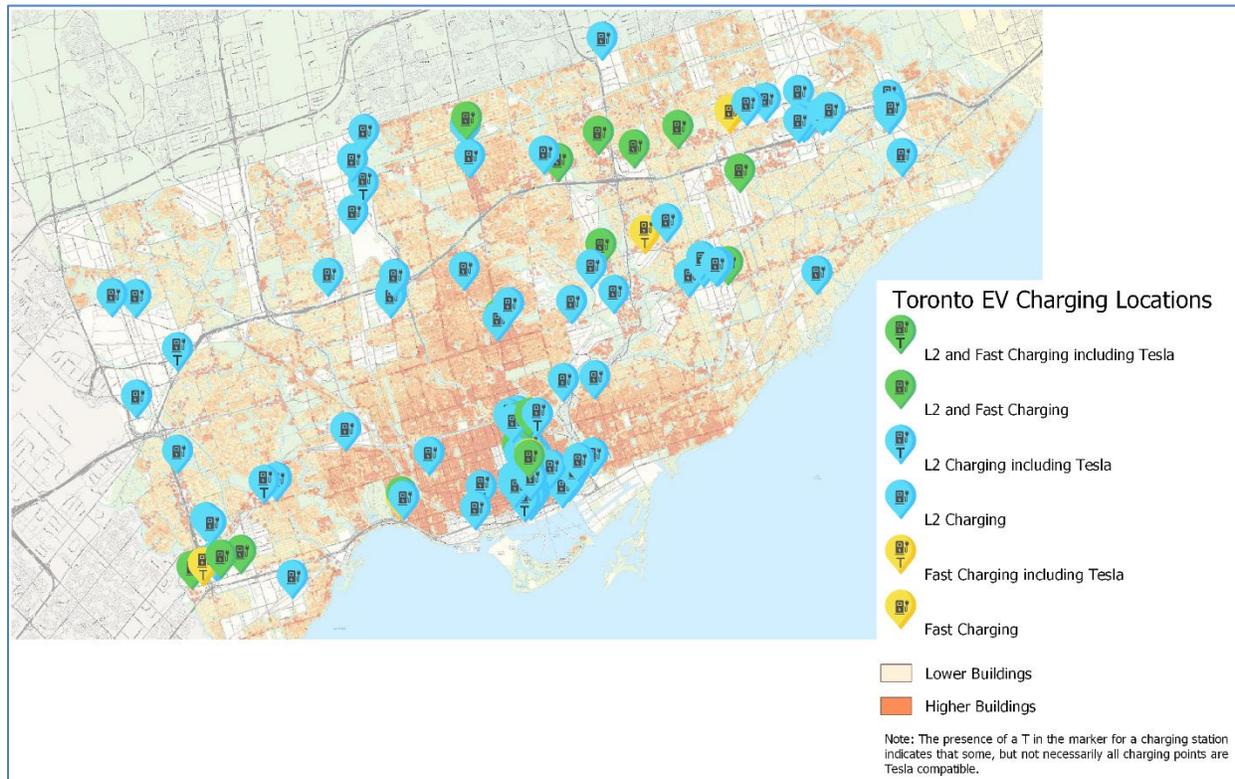


Figure 8: Building height (in shades of orange) overlaid with existing publicly accessible charging infrastructure

Figure 8 indicates areas of higher buildings in Toronto. The dataset used to generate the figure does not differentiate between residential and commercial buildings; and the assessment below considers the exclusion of areas such as the downtown central business district, which consists primarily of office space.

Toronto encompasses many neighbourhoods with a high density of MURBs. For example, the Yonge Street corridor, particularly north of the 401, has a high concentration of MURBs, as does sections of the DVP corridor, the Yonge and Eglinton area, the Eglinton corridor, and much of the downtown area running parallel to the waterfront. With the exception of the downtown core, there are only a handful of publicly available chargers in these areas and often they are located at car dealerships, banks, malls, or commercial

buildings. Most chargers in these areas are Level 2; there are two Level 3 (or DC Fast Chargers) located along the Yonge Street corridor and four along the DVP. The locations of the current publicly available chargers are not conducive to owners having the ability to routinely and regularly charge their EVs, and it is unlikely that EV owners would drive to these locations to charge their vehicles daily. Further, the current number of EV charging stations would not be sufficient to serve growing EV adoption rates in the MURB communities.

Addressing charging for EV ownership in existing MURBs remains a challenge across municipalities. Two general areas of solution under consideration are the deployment of EVSE within existing MURB parking and the creation of Level 3 charging hubs to service MURB clusters. Within the Electric Mobility Strategy, the City could participate in the location of these hubs and work with stakeholders (residents, property owners, property managers) for both types of EVSE deployment.

5.2.3 Options for Publicly Accessible Charging Infrastructure Deployment

Publicly available charging infrastructure should be deployed in areas of the city where space permits and does not contribute to increased congestion or parking pressure. Potential areas in the city include municipally owned parking lots, privately owned parking lots, large retailers/shopping centres and roadsides. There are many public parking lots located across Toronto (see Figure 9) which could be leveraged in combination with roadsides to expand EVSE accessibility. Similarly, there are many large retail locations (i.e., supermarkets) and shopping centres located throughout the city where private land owners could become involved in expanding charging infrastructure. Two considerations for these types of charging will include grid readiness (especially for Level 3 hubs) and enforcement. An enforcement strategy is a key component of shared charging infrastructure to ensure that charger usage and accessibility are optimized.

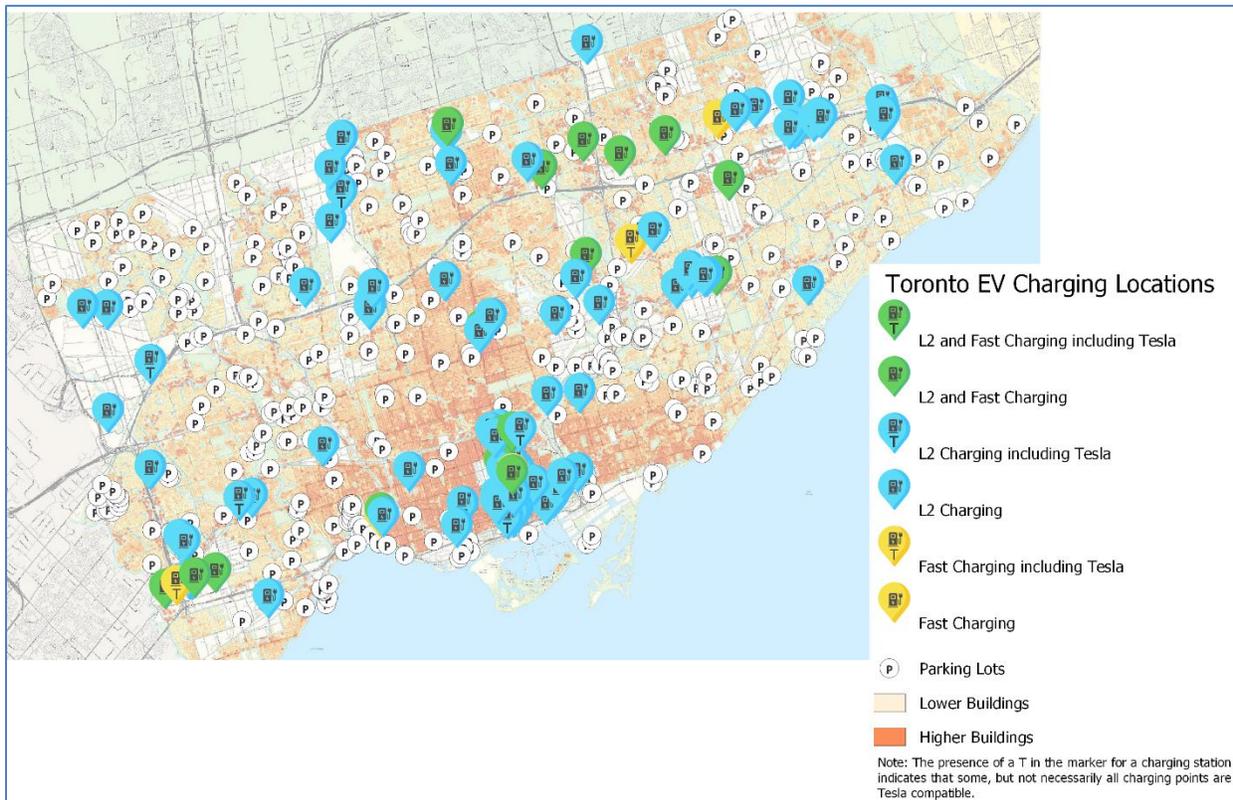


Figure 9: Building height, charging infrastructure and Green P parking lots

5.2.4 Workplace Charging

As discussed in Section 4.1.1.2, the availability of workplace charging makes EV purchasing more attractive. The Toronto Green Standard requires that all non-residential developments provide 20% of parking spaces with electric vehicle supply equipment (EVSE) and that the remaining parking spaces to be designed to permit future EVSE installation. The Electric Mobility Strategy can consider how to work with existing workplaces to expand EVSE installation.

5.2.5 Charging Infrastructure for Public Transportation and City Fleets

As noted in Section 3.2.2, Toronto has a number of existing charging stations for its fleet. The TTC has commissioned studies to assess how charging infrastructure would need to be expanded to support the electrification of city buses. The results of this work can be integrated into the Electric Mobility Strategy.

5.3 Social Vulnerability Analysis

Goals, actions, guidelines and policies that support the transition to electric mobility should be designed to ensure that benefits are realized by all people. Low-income and underserved communities are often exposed to higher levels of vehicle-related air pollution, often drive less fuel efficient vehicles, have longer commutes and spend a higher percentage of their income on transportation.¹⁴⁵ A healthy, equitable transportation policy recognizes that good transportation has an impact on income and should connect all people (especially underserved and low-income communities) to employment and other opportunities. It may also help to create well-paying jobs for disadvantaged residents in the transportation construction, maintenance and service sector.¹⁴⁶ Further, community members should be represented and involved in decision making on issues that impact their communities, infrastructure and options for travel.¹⁴⁷ Social equity considerations implemented in leading electric mobility municipalities are discussed in Section 4.2 of this report.

In the context of Toronto, a socially equitable electric mobility strategy should ensure all residents, including those in socio-economically vulnerable communities, have access to electric mobility options, charging infrastructure and clean air benefits. Further, all community members should be part of the decision making process for any actions and/or policies that impact their communities.

¹⁴⁵ Policy Link/Prevention Institute/Convergence Partnership. Healthy, Equitable Transportation Policy Recommendations and Research.

<http://www.preventioninstitute.org/sites/default/files/publications/Healthy%20Equitable%20Transportation%20Policy%20Recommendations%20and%20Research.pdf>

¹⁴⁶ Policy Link/Prevention Institute/Convergence Partnership. Healthy, Equitable Transportation Policy Recommendations and Research.

<http://www.preventioninstitute.org/sites/default/files/publications/Healthy%20Equitable%20Transportation%20Policy%20Recommendations%20and%20Research.pdf>

¹⁴⁷ Policy Link/Prevention Institute/Convergence Partnership. Healthy, Equitable Transportation Policy Recommendations and Research.

<http://www.preventioninstitute.org/sites/default/files/publications/Healthy%20Equitable%20Transportation%20Policy%20Recommendations%20and%20Research.pdf>

5.3.1 Mapping Socio-Economic Vulnerability

In order to map socio-economic vulnerability, 2016 Census data provided at the neighbourhood level through Wellbeing Toronto was assessed using the following indicators:

- Social assistance recipients
- Social housing units
- Low income population
- Unemployed
- Recent immigrants
- Visible minorities

The results are shown in Figure 10. For the purposes of this analysis, each indicator was given equal weighting and the darkness of shading is cumulative – e.g., a neighbourhood with darker shading indicates higher populations of individuals within a higher number of indicator categories.

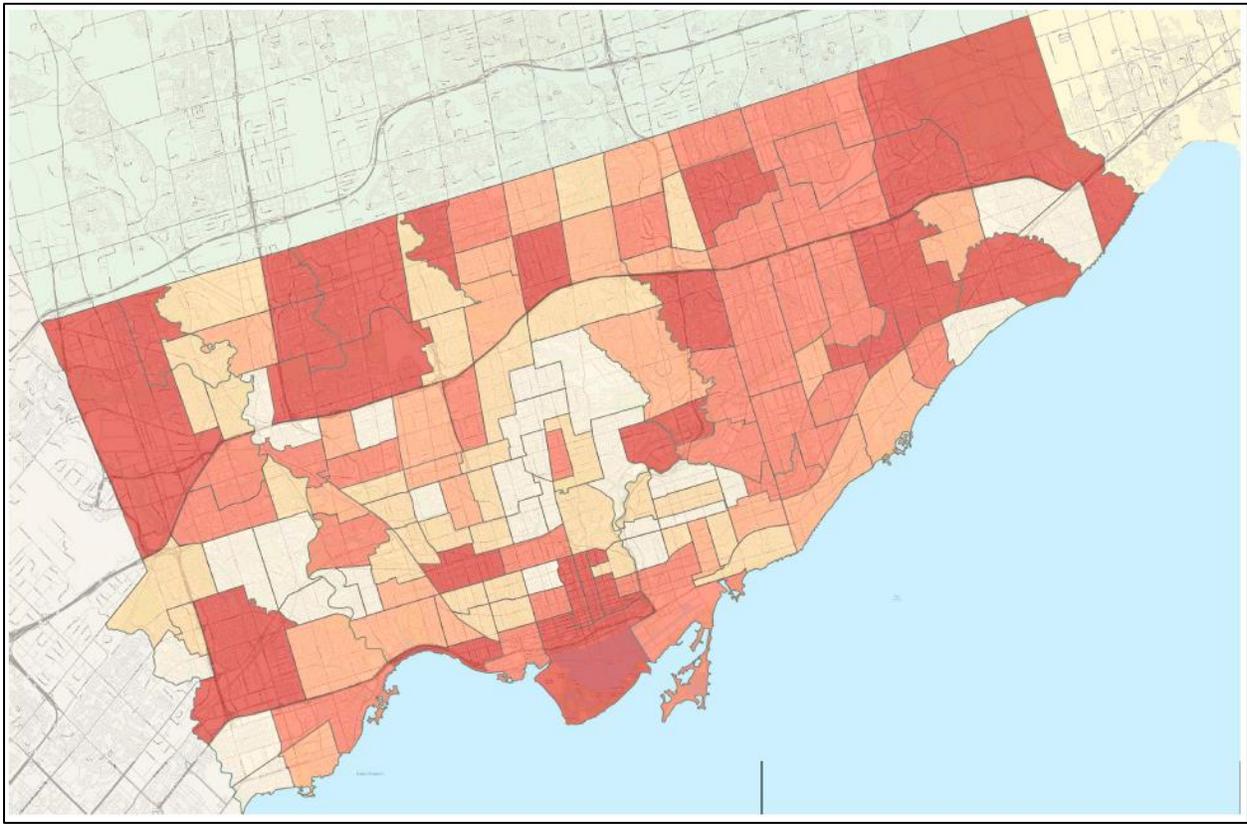


Figure 10: Socio-economically vulnerable neighbourhoods (in darker shading)

There are a number of neighbourhoods in Toronto with communities that have high socio-economic vulnerability. These areas include Malvern, some areas to the south of the 401 in Scarborough, the Clairville area, York University Heights/Jane and Finch area, Islington – City Centre West area, and the Willowdale and L’Amoreaux areas, among others.

5.3.2 Access to Electric Mobility

Generally speaking, neighbourhoods with higher socio-economic vulnerability correspond to lower rates of EV uptake. This trend is likely to continue given higher costs associated with EV purchases and low numbers of EVs on the used vehicle market. Personal electric mobility in the near term may be more accessible through sharing services such as ride sharing, car sharing, e-bike sharing and electric scooter sharing.

In terms of access to public electric mobility, while the routes travelled by the first fleet of the TTC’s e-buses have not been finalized, the depots piloting e-buses do service routes within socio-economically vulnerable neighbourhoods. Based on the outcome of the

routes and charging analyses underway at the TTC, further deployment can integrate a consideration of equitable deployment to these neighbourhoods.

5.3.3 Access to Charging Infrastructure

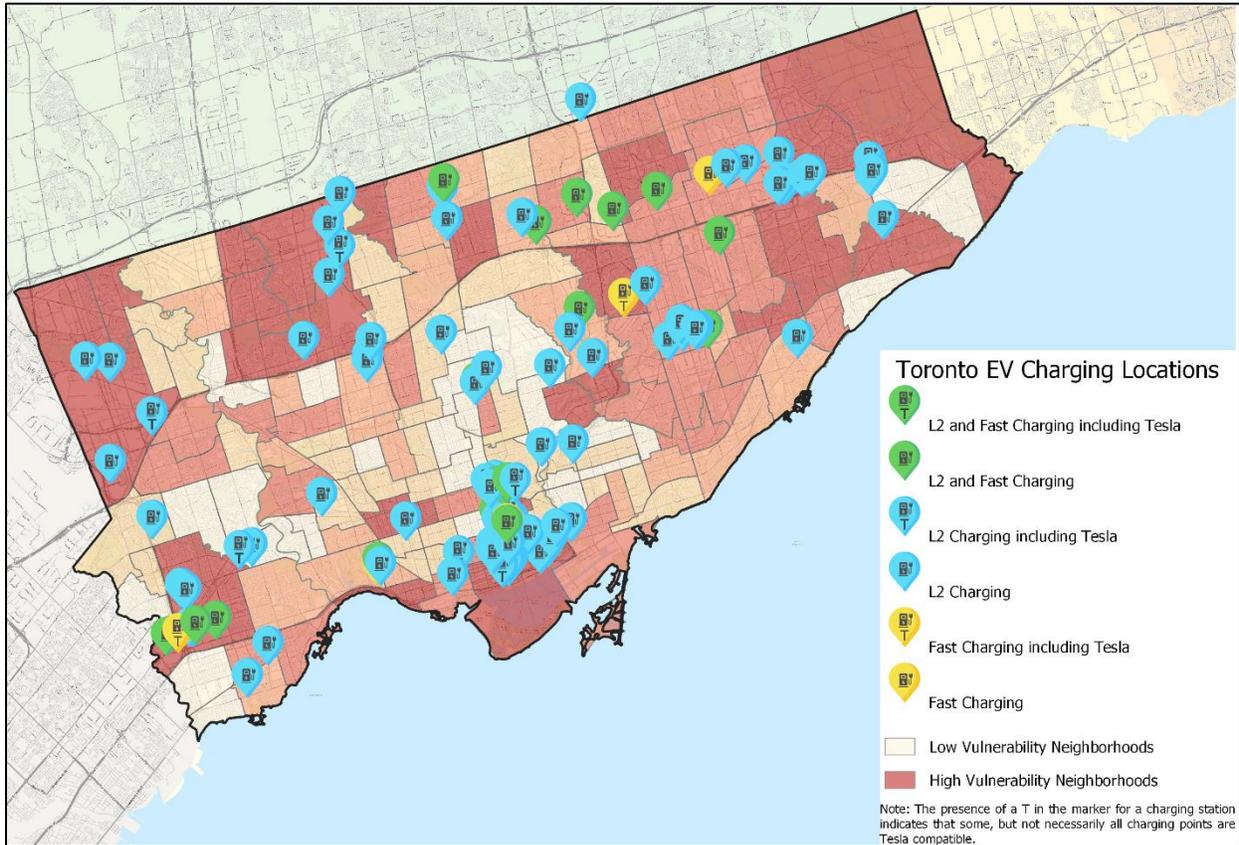


Figure 11: Charging infrastructure and socio-economic vulnerability

In most areas with high socio-economic vulnerability there are few publicly accessible chargers. Very small numbers of publicly accessible chargers are available in the Clairville area, York University Heights/Jane and Finch areas and Malvern area. There are slightly more publicly accessible chargers in the Islington – City Centre West area: four Level 2 chargers and three DC Fast Chargers.

Key considerations for Strategy development will include:

- While not included in the indicators mapped, socio-economically vulnerable neighbourhoods contain higher numbers of rental units and rental units in MURBs

where private charging solutions face significant barriers. Working with building owners and operators and exploring public charging solutions will be of increased importance.

- Matching charging solutions to electric mobility usage. The focus may be less on issues such as working with MURBs on personal vehicle charging solutions and more on charging solutions for first and last kilometre transit solutions, or shared vehicle charging solutions.
- Ensuring a user-pays approach to charging infrastructure and avoiding the integration of charging costs into expenses shared with non-electric mobility users.

5.3.4 Access to Clean Air Benefits

Human health impacts associated with traffic-related air pollution (TRAP) are most pronounced for those living near busy roads and highways. TRAP has the greatest impacts on vulnerable populations such as young children, the elderly and people with pre-existing medical conditions. Impacts can include breathing problems, heart disease, cancer, and premature death.¹⁴⁸

Efforts to mitigate negative health impacts from TRAP tend to revolve around reducing congestion, making active transportation (cycling and walking) more accessible, promoting greater public transit usage, and electrifying all modes of transport. City of Toronto initiatives aimed at reducing exposure to TRAP include the Walking Strategy, the Toronto Complete Streets Guidelines, the 10-year Cycling Network Plan, TransformTO, and updates to the City's Official Plan.¹⁴⁹

Additional approaches to mitigating TRAP focus on more stringent standards for ICE vehicles. Because this is an area outside of municipal government control, Toronto's Medical Officer of Health and Deputy City Manager have recommended that City Council lobby the federal government with the following requests:

- Harmonize Canadian environmental emissions standards for fuels, vehicles, and engines with those applicable in the State of California

¹⁴⁸ <https://www.toronto.ca/legdocs/mmis/2017/pe/bgrd/backgroundfile-108665.pdf>

¹⁴⁹ <https://www.toronto.ca/legdocs/mmis/2017/pe/bgrd/backgroundfile-108665.pdf>

- Identify a strategy to reduce emissions of air pollutants and greenhouse gases from older model heavy-duty diesel trucks
- Include in Canada's Clean Fuel Standard limits to emissions of air pollutants, in addition to the proposed limits on greenhouse gases¹⁵⁰

While replacing the ICE vehicles on Toronto's roads with EVs would lead to significant air quality improvements, it would do little to address issues such as congestion and a lack of parking availability. This fact reinforces the point that actions taken by Toronto to advance electric mobility must take a holistic perspective and should only be adopted after careful consideration of available alternatives. It also reinforces the point that privately-owned passenger vehicles, whether electric or not, should be a last-resort option for passenger transport in cities like Toronto. Active transportation and public transit are far more efficient and are the best options in terms of human and environmental health. Ensuring that all Torontonians have access to well-connected active transportation networks and electrified public transit will allow everyone to utilize modes of low-carbon transport and thereby contribute to improved air quality.

5.4 Emerging Technology and Energy Trends

It is critical that the City of Toronto continues to monitor key developments and considerations that could significantly influence the adoption rates, utility, and infrastructure requirements of electric mobility options. Several such developments and considerations are overviewed in this section, with the aim of ensuring the City's Electric Mobility Strategy is as future-proofed as possible. It isn't necessary that the Strategy explicitly address each of these considerations, but the City should be prepared to adapt the Strategy if there are significant advancements within any of these emerging developments and trends.

5.4.1 Wireless charging

Wireless EV charging requires two pieces of hardware – a ground-based wireless charging pad that is connected to a charging station and a wireless receiver mounted on the underside of an EV. The wireless charging feature works similarly to wireless charging

¹⁵⁰ <https://www.toronto.ca/legdocs/mmis/2017/pe/bgrd/backgroundfile-108665.pdf>

pads that are now available for a wide variety of smartphones. EVs park directly on top of the charging pad and the wireless receiver connects with the pad. Users can then initiate charging via remote or in-vehicle apps.

Wireless charging via current magnetic resonance technologies is slightly less-efficient than plugging in, as about 7-10% of the power provided is lost as it moves through the air. Even so, the convenience of wireless charging is expected to appeal to EV users, and as more research and development is dedicated to this area the technologies and efficiencies involved are expected to improve. For example, researchers at the U.S. Department of Energy's Oak Ridge National Laboratory recently announced that they are able to wirelessly provide 120 kW of power (the equivalent of some existing DC fast chargers) to an EV battery at an efficiency of 97%.¹⁵¹

In 2017, the Society of Automotive Engineers (SAE), the leading global body for the standardization of automobile components, released a wireless charging standard for EVs that allows for the transfer of up to 11kW of power.¹⁵² The SAE is currently working on a bi-directional wireless charging standard that would allow for the transfer of energy from EVs to the local grid. The implementation of such standards across the automotive sector will lead to a better user experience for EV drivers and will simplify the decision-making process for charging infrastructure providers such as municipal governments.

At least seven major automakers currently produce vehicles and components that are compatible with wireless charging. Most other major automakers are developing such capabilities for their vehicles, so planners should expect to see wireless charging become commonplace in the medium term.

Research consortiums around the world have recently been exploring the idea of installing wireless EV charging hardware directly into roadways, so that EV users can charge while they drive. If implemented, this approach could allow for greater range and/or smaller batteries for EVs. However, due to a number of factors including costs, technological compatibility, and EV ownership levels, this technology is not expected to play a major role in EV deployment in the short or medium term.¹⁵³ Companies that now provide wireless EV charging solutions include ELIX Wireless,¹⁵⁴ Plugless Power,¹⁵⁵

¹⁵¹ <https://www.ornl.gov/news/ornl-demonstrates-120-kilowatt-wireless-charging-vehicles>

¹⁵² https://www.sae.org/standards/content/j2954_201711/

¹⁵³ <https://cleantechnica.com/2018/03/28/batteries-schmattered-wireless-ev-charging-hits-the-road/>

¹⁵⁴ <https://www.elixwireless.com/>

¹⁵⁵ <https://www.pluglesspower.com/>

WiTricity,¹⁵⁶ and Qualcomm.¹⁵⁷ Jurisdictions currently exploring the possibilities of this technology include Israel,¹⁵⁸ UK,¹⁵⁹ the State of Illinois,¹⁶⁰ and Paris, France.¹⁶¹

Charging cables are heavy, expensive, and in some cases pose possible safety hazards (e.g., tripping, obstacles for strollers or wheelchairs, damage from vehicles or snow removal equipment). Wireless charging pads without exposed wires may not only be more convenient for EV users, but could be the least intrusive option for all citizens of Toronto. Wireless charging is also expected to be complementary to autonomous vehicles, which would be able to navigate to a charging station on their own, but would require a human to actually plug them in to charge if plugging in was the only option available.

While implementing its Electric Mobility Strategy, Toronto should aim to ensure that the public charging stations it installs are able to be upgraded to wireless charging as this technology continues to mature and is rolled out in more production EVs.

5.4.2 Distributed energy generation and storage

Distributed energy resources (DERs) are small, modular electricity generation units (such as solar panels at residences or businesses) and/or energy storage systems (such as batteries) that are interconnected with the grid at the distribution/street level. Examples of DERs include small-scale hydro, wind, solar, geothermal and biomass-based generation technologies. In some cases DERs are managed within self-contained micro-grid (or smart grid) settings like those used by large facilities such as universities or hospitals.

In recent years, the prevalence of DERs in the GTA has grown significantly, as costs have come down and efficiencies have gone up for many emerging technologies. As electricity continues to become more of a distributed commodity (i.e., as technologies allow individuals and businesses to generate, store and share electricity at increasingly lower capital costs), it is expected that the value proposition of EV ownership will continue to grow. Instead of lining up at a gas station, EV owners could produce all the clean and

¹⁵⁶ <http://witricity.com/>

¹⁵⁷ <https://www.qualcomm.com/products/halo>

¹⁵⁸ <https://www.scientificamerican.com/article/israel-tests-wireless-charging-roads-for-electric-vehicles/>

¹⁵⁹ <https://www.highwaysindustry.com/wireless-charging-roads-and-motorways-for-electric-cars-could-be-coming-to-the-uk/>

¹⁶⁰ <https://www.cspdailynews.com/fuels/illinois-tollway-considers-wireless-ev-charging>

¹⁶¹ <https://www.connexionfrance.com/French-news/Electric-car-charging-road-tested-in-France>

renewable fuel their vehicle needs by investing in a modestly-sized solar array for their home. As EV ownership can save a typical Canadian driver \$1,500-2,000 per year on fuel costs alone,¹⁶² the payback period on DERs like solar power generation and storage systems can now be as short as several years. A 3 kW solar array should be sufficient to provide all the power required by an EV each year, assuming average daily driving distances of about 44 km,¹⁶³ and such an array would take up less than 28 square meters of surface area on a rooftop or ground-mounted pedestal.¹⁶⁴

A moderately-sized EV battery of 30 kWh stores roughly as much energy as an average household uses in one day.^{165,166} EVs themselves are therefore a type of DER whose benefits will become increasingly pronounced as adoption levels increase and smart energy technologies (such as bi-directional meters and home energy management systems) mature. A recent report from the U.S. Energy Storage Monitor concluded that by 2020 there will be more available energy connected to the grid via EV batteries than all of the generation capacity in the U.S. combined at any given time. And this projection was based on conservative estimates for EV adoption and average EV battery sizes of several years ago.¹⁶⁷

The same types of batteries that EVs use can also be used externally, as stationary energy storage units. Automakers such as Tesla, Nissan and BMW already offer home battery storage units to consumers, which are sometimes packaged with solar panels. Battery storage units would be particularly useful in jurisdictions, like Ontario, that offer time-of-use electricity pricing. Batteries can be recharged overnight, when electricity use is minimal and the grid is supplied by low-carbon renewable energy, and then during peak hours the batteries can be discharged. Such a pattern undertaken by a significant number of consumers would help to lower energy costs for producers, distributors and end-users alike, as well as optimizing the use of low-carbon energy. Tesla has even employed stacks of its batteries to provide grid-scale back-up power and load balancing to utilities in Australia, Puerto Rico and Belgium.¹⁶⁸

While developing and implementing its Strategy, the City could identify several optimal sites for DER EV charging pilots. If DC fast charging is provided at these sites, it should

¹⁶² <https://www.plugndrive.ca/discover-electric-vehicles/electric-vehicles-faq/>

¹⁶³ <http://oee.nrcan.gc.ca/publications/statistics/cvs08/chapter2.cfm?attr=0>

¹⁶⁴ <https://www.gogreensolar.com/products/3kw-diy-solar-panel-kit-microinverter>

¹⁶⁵ https://rmi.org/wp-content/uploads/2017/04/RMI_Electric_Vehicles_as_DERs_Final_V2.pdf

¹⁶⁶ <https://www.wired.com/story/nissan-solar-panels-home-batteries/>

¹⁶⁷ <http://www.pollutionprobe.org/publications/pollution-probe-ev-grid-gap-analysis-study/>

¹⁶⁸ <https://www.wired.com/story/nissan-solar-panels-home-batteries/>

consider installing some high-capacity stationary energy storage (perhaps incorporating used EV batteries) to provide a buffer against large electrical loads.



Figure 12: Rendering of Sheridan College's Brampton Campus planned solar carport – a great example of the synergistic relationship between EVs and distributed energy generation¹⁶⁹

5.4.3 Ultra-fast charging

Current DC fast chargers typically provide power at rates between 50 and 120 kW. However, major advancements in charging technologies in recent years have led to several companies developing stations that can charge at rates up to and beyond 350 kW. Such rates would allow EVs to add over 200 km of range in as little as 8 minutes. Unfortunately there aren't currently any production vehicles with hardware capable of charging at such rates, but many automakers are developing vehicles that will be able to, with the first of these vehicles expected to begin rolling out in the next couple of years.

¹⁶⁹ Melissa Giles, Sheridan College. <https://www.sheridancollege.ca/news-and-events/news/solar-carport-at-brampton-campus>

CHAdeMO, the DC fast charging platform developed by Japanese automakers, recently released a protocol for 400 kW charging.¹⁷⁰ CCS (or Combined Charging System) is the DC fast charging platform most common in North America, and stations with the ability to charge batteries at a rate of 350 kW are already beginning to be installed.¹⁷¹ Tesla has a proprietary brand of DC fast chargers known as Superchargers, which currently provide charging at up to 120 kW. While Tesla's Superchargers are not compatible with non-Tesla vehicles, most, but not all, public DC fast charging stations are now compatible with both CHAdeMO and CCS charging.

Ultra-fast charging stations are designed to fully charge an EV's battery in less than 10 minutes. Because they draw such a large amount of power in such a short period of time, they are often used in conjunction with stationary energy storage.¹⁷² The implementation of ultra-fast chargers will not only improve the appeal of passenger EVs, as it will help to facilitate long distance trips via EVs, but it will also help pave the way for larger vehicles with much larger batteries to transition to electrification.

When selecting an appropriate vendor and equipment for Level 3 charging stations, Toronto could assess whether the chargers it installs are upgradable to ultra-fast charging (as these stations will likely be in operation for 10 to 15 years).

5.4.4 Battery energy density and costs

Batteries are both the heaviest and costliest components of EVs of all types. Costs of lithium-ion batteries have come down significantly since production EVs entered the market in 2010, from about \$1,000 per kWh to about \$200 today.¹⁷³ Analysts expect these costs to continue decreasing as technologies continue to mature and economies of scale exert a bigger influence on EV production. Some suggest that battery costs could reach \$100 per kWh in the next several years, and that this will mark the point at which production costs of EVs will be equal to those of conventional ICE vehicles.^{174,175} Lower

¹⁷⁰ <https://electrek.co/2018/06/15/chademo-faster-electric-vehicle-charging-400-kw-protocol/>

¹⁷¹ <https://insideevs.com/insideevs-visits-first-ultra-fast-ccs-station-in-u-s/>

¹⁷²

https://www.researchgate.net/publication/266888272_Toward_Ultrafast_Charging_Solutions_of_Electric_Vehicles

¹⁷³ <https://www.ucsusa.org/clean-vehicles/electric-vehicles/electric-cars-battery-life-materials-cost#.W9CziIVKi70>

¹⁷⁴ https://www.greencarreports.com/news/1114245_lithium-ion-battery-packs-now-209-per-kwh-will-fall-to-100-by-2025-bloomberg-analysis

¹⁷⁵ <https://www.mdpi.com/2313-0105/4/3/30/htm>

battery costs will also mean that prices for stationary energy storage units will further decrease in the near future.

- **Lithium-ion battery advantages**

- Lithium-ion batteries are **low maintenance** and hold their charge well compared to other battery types.¹⁷⁶ They tend to have self-discharge rates of about 5% per month if unused.¹⁷⁷
- Lithium-ion batteries are **stable and safe** to use, which is why they've been the battery type of choice for laptop computers and cellphones since the 1990s.¹⁷⁸ Most EV batteries are now protected under manufacturer warranties for 8 years or 160,000 km.¹⁷⁹
- Lithium-ion cells provide very **high power output** for energy-intensive applications such as driving.¹⁸⁰
- **Modular designs** for lithium-ion batteries mean that they can be easily scaled up or down for different applications, and that costs and weight can be minimized.¹⁸¹

- **Lithium-ion battery disadvantages:**

- Although lithium-ion batteries have greater **energy density** than most other types of commercially-available batteries, their energy density is far lower than fossil fuels or pressurized hydrogen.
- As with the lithium-ion batteries found in consumer electronics, EV **battery capacity deterioration** is a major point of concern for potential EV owners. An ongoing study on the Tesla Model S, however, shows that battery capacity only declines by an average of about 8% after 200,000 kms

¹⁷⁶ https://batteryuniversity.com/index.php/learn/archive/is_lithium_ion_the_ideal_battery

¹⁷⁷ <http://large.stanford.edu/courses/2016/ph240/mok2/>

¹⁷⁸ https://batteryuniversity.com/index.php/learn/archive/is_lithium_ion_the_ideal_battery

¹⁷⁹ https://batteryuniversity.com/learn/article/electric_vehicle_ev

¹⁸⁰ https://batteryuniversity.com/index.php/learn/archive/is_lithium_ion_the_ideal_battery

¹⁸¹ <https://www.mdpi.com/2313-0105/4/3/30/htm>

driven.¹⁸² Some automakers have cautioned consumers to expect battery degradation in the range of 10-40% after 160,000 km driven.¹⁸³

- Battery charging and discharging rates are impacted by **ambient temperature**. Most EV batteries are now equipped with liquid heating or cooling to maximize efficiency in hot or cold temperatures.^{184,185}

A wide variety of alternatives to the prevailing lithium-ion battery are being actively explored by research institutes and businesses around the world. These alternatives are purported to have cost, capacity and/or performance advantages over lithium-ion. While the specific technical merits of emerging battery chemistry options are beyond the scope of this assessment report, some notable alternative battery chemistries worth monitoring developments on include: solid-state, lithium-sulphur, lithium-air, lithium polymer, sodium-sulphur, flow/vanadium redox, and magnesium-ion.

While none of the aforementioned battery chemistries may ultimately replace lithium-ion, features or individual components of them could be integrated into improved lithium-ion battery designs. For example, changes to materials used to construct or coat a battery's anode or cathode could significantly reduce degradation. Materials better-suited to ultra-fast charging or resistance to extreme temperatures could also be incorporated into existing battery designs.

The first production EV models only became available to consumers in Canada in 2010. As the average lifespan of passenger vehicles is in the range of 12 to 15 years, the first generation of EVs haven't yet reached their retirement age. When they begin to, however, it is expected that an end-of-life market for EV batteries will emerge, and stakeholders such as electrical utilities may create a role for these batteries in stationary energy storage (to buffer EV charging loads) or even to provide grid-level backup power or load management functions. It is expected that retired EV batteries will retain approximately 50-70% of their original capacities, so they will still be useful in certain roles. Several automakers are actively exploring opportunities to utilize and re-market retired EV batteries for a variety of stationary energy storage applications. As existing EV fleets

¹⁸² <https://www.fleetcarma.com/exploring-electric-vehicle-battery-life-degradation-developments/>

¹⁸³ https://www.greencarreports.com/news/1107751_2017-chevy-bolt-ev-10-to-40-percent-battery-capacity-loss-possible-but-unlikely

¹⁸⁴ https://batteryuniversity.com/learn/article/electric_vehicle_ev

¹⁸⁵ http://www.greenemotion-project.eu/upload/pdf/deliverables/D6_2-Performance-validation-Results-from-EV-measurements_submitted.pdf

continue to age, it is important that stakeholders monitor and explore opportunities for the re-use of retired batteries.

Some production EV models can already surpass 500 km on a single charge, and on average ranges are increasing by about 10% every year.^{186,187} As ranges increase, the need for public EV charging may decrease, with the possible exceptions of inter-city corridors and neighbourhoods with high concentrations of garage orphans. Over 80% of charging already occurs at home,¹⁸⁸ and this percentage may increase further as EV batteries and charging solutions continue to evolve.

When building out a network of public charging stations, the City should examine how increased EV range due to battery enhancements might impact the location and type of public charging stations required in a given area. It may also want to explore stationary energy storage opportunities for retired EV batteries, perhaps tied to DERs.

5.4.5 Autonomous vehicles

Vehicle autonomy will play an increasingly large role in the transportation systems of the future, and is expected to significantly impact all modes and types of vehicles. It is intended to address a wide variety of transportation challenges, such as safety (more than 90% of accidents are caused by human error), congestion, parking limitations and air pollution.¹⁸⁹ The role that vehicle autonomy will play in determining driving patterns of the future is anything but certain at this point. Autonomy working in combination with vehicle connectivity, electrification and ride sharing is seen by many as critical to addressing persistent passenger transportation issues, especially in and around major cities.¹⁹⁰ These elements are sometimes referred to with the acronym CASE – connected, autonomous, shared, and electric.

Some experts refer to autonomous vehicles as CAVs, or Connected and Autonomous Vehicles, due to the need for them to communicate with each other and with transportation infrastructure itself (e.g., roads, traffic signals) via wireless information

¹⁸⁶ <https://about.bnef.com/blog/long-range-ev-market-set-get-crowded-2020/>

¹⁸⁷ <https://electrek.co/2017/12/26/average-electric-car-range/>

¹⁸⁸ <https://www.energy.gov/eere/electricvehicles/charging-home>

¹⁸⁹ https://www.ictc-ctic.ca/wp-content/uploads/2018/01/ICTC_-_Autonomous-Vehicles-and-The-Future-of-Work-in-Canada-1-1.pdf

¹⁹⁰ https://www.ictc-ctic.ca/wp-content/uploads/2018/01/ICTC_-_Autonomous-Vehicles-and-The-Future-of-Work-in-Canada-1-1.pdf

networks. Ensuring that autonomous vehicles are able to ‘speak’ to each other and the surrounding environment will help to maximize the benefits they can offer to issues like congestion, accidents, travel times, and on-road freight movement.¹⁹¹ Cloud connected EVs would also be able to speak to local utilities, who could determine the best time for them to initiate charging, and the best rate to charge at given current load demands.

It may come as a surprise to some that they have been driving ‘autonomous’ vehicles for years without even realizing it. There are six different levels of vehicle autonomy that have been generally agreed upon by automotive experts.¹⁹² The defining characteristics of these levels are described below.

- **Level 0 – No automation.** Human drivers perform all steering, braking and acceleration functions.
- **Level 1 – Driver assistance.** The vehicle can control either steering or speed in certain circumstances (e.g., adaptive cruise control, active park assist).
- **Level 2 – Partial automation.** The vehicle can control both steering and speed in certain circumstances, but drivers must remain attentive (e.g., Tesla Autopilot, Volvo Pilot Assist, Audi Traffic Jam Assist).
- **Level 3 – Conditional automation.** In some circumstances, the vehicle controls most driving functions (speed, steering, monitoring the road), but drivers must be able to take control at any time.
- **Level 4 – High automation.** In certain circumstances (e.g., on highways), the vehicle can operate without a human driver, but drivers are required to take control in certain situations, areas, or conditions.
- **Level 5 – Full automation.** The vehicle can operate without a human driver in all circumstances.¹⁹³

¹⁹¹ <http://www.pollutionprobe.org/wp-content/uploads/Pollution-Probe-Pathways-Initiative-Workshop-Report.pdf>

¹⁹² <https://www.caranddriver.com/features/path-to-autonomy-self-driving-car-levels-0-to-5-explained-feature>

¹⁹³ <https://www.caranddriver.com/features/path-to-autonomy-self-driving-car-levels-0-to-5-explained-feature>

On average, passenger vehicles sit unused for 95% of their working lives, and when they are being used it is most often to transport a single occupant.¹⁹⁴ During this down time they occupy valuable and increasingly scarce real estate, and offer little in the way of value-added services. An electrified, grid-connected autonomous vehicle, however, could park wherever space is available, could transport multiple people simultaneously or over the course of a day, and could serve as a distributed energy resource to help utilities manage peak loads.

A note of caution with regard to autonomous vehicles (aside from safety concerns and trust issues with this emerging technology) is that their adoption could lead to increases in average distances driven, as people may be more open to long commutes if they do not have to focus on driving. Related to this cautionary note is the consideration that if autonomous vehicles are powered by fossil fuels, they could result in net increases in transportation-related air pollution.¹⁹⁵

Although full vehicle autonomy (i.e., Level 5) is not projected to replace human-driven passenger vehicles in the short term, niche applications for autonomous vehicles have already materialized, and continue to expand. For example, Pearson Airport's Link Train has been fully autonomous since it opened for service in 2006; and Metro Vancouver's SkyTrain is one of the longest fully automated mass transit lines in the world. The City of Toronto is seeking to take vehicle autonomy a step further with a proposed pilot shuttle bus service that would cover the 'last kilometre' between public transit hubs and commuters' homes in select neighbourhoods.¹⁹⁶ As autonomous technologies continue to improve the applications for autonomous vehicles will continue to expand.

The City should continue to engage in autonomous vehicle pilot projects, in niche applications where vehicles operate at low speeds (much like the ongoing pilot), in order to help acclimatize Torontonians to these vehicles and acquire data on vehicle performance.

¹⁹⁴ https://www.ictc-ctic.ca/wp-content/uploads/2018/01/ICTC_-_Autonomous-Vehicles-and-The-Future-of-Work-in-Canada-1-1.pdf

¹⁹⁵ <http://www.pollutionprobe.org/wp-content/uploads/Pollution-Probe-Pathways-Initiative-Workshop-Report.pdf>

¹⁹⁶ <https://www.toronto.ca/legdocs/mmis/2018/pw/bgrd/backgroundfile-117633.pdf>

5.4.6 Car and ride sharing services

While EVs are favourable to ICE vehicles from an environmental standpoint, most transportation experts agree that an issue of comparable importance to grapple with is individual vehicle ownership. Simply replacing all the ICE vehicles on the road today with EVs would do little to address issues like congestion and parking availability. An ideal scenario would see more commuters making more trips via public transit, and better still would be commuters choosing an active transportation option such as walking or cycling whenever possible. Increased usage rates in car and ride sharing services would help to address issues such as congestion and parking while also offering environmental benefits. Different types of membership-based shared mobility services are described below.

- **Car sharing:** In recent years, car sharing services have emerged as a viable mobility option, especially in cities. Owning a car has traditionally been a means to provide owners with added convenience and added accessibility to amenities. In a modern city like Toronto, however, the burdens of car ownership are increasingly outweighing the benefits for many citizens. Car insurance is more expensive for urbanites because accidents are more common. Parking – in public or at home – can be expensive and scarce. Vehicle maintenance can be costly and confusing. Congestion can often make public transit or active transportation the faster, cheaper and less-stressful mobility option. But of course urbanites still need the use of cars for certain, if not daily, activities. This is the niche that car sharing services attempt to fill. These services offer members the opportunity to use vehicles for short periods, sometimes as short as an hour or two, without having to worry about factors like insurance, maintenance, parking or even fuel. These services tend to be viewed favourably by stakeholders seeking reduced environmental and/or social impacts from the transportation sector, as they reduce the need for individual car ownership and make better use of existing vehicle fleets. Car sharing services are also viewed by many as providing an excellent opportunity to introduce drivers and their passengers to EVs.
- **Subscription car services:** An increasing number of automakers, especially luxury brands, are beginning to offer subscription services to consumers. These services typically provide subscribers with access to a primary vehicle, limited access to additional types of vehicles, and no responsibilities for taking care of

maintenance, insurance, vehicle registration, etc.¹⁹⁷ Such services resemble car sharing, but provide users with additional access to a particular vehicle whenever it is needed.

- **Ride sharing:** While taxis offered commuters the original ride sharing (sometimes referred to as ride-hailing) option, new companies have emerged in recent years that offer a similar service with a few twists. Companies such as Uber and Lyft take a more decentralized approach to delivering benefits comparable to those offered by traditional taxi companies, by utilizing the rapidly evolving sharing economy. They allow individuals with a road-worthy vehicle and some time to spare the opportunity to put their vehicle to work to provide door-to-door mobility to those who lack the time, resources or willingness to use a personal vehicle. In theory they are meant to provide commuters with all the mobility and accessibility they would have with a personally-owned vehicle, but with less hassle and lower net transportation costs.

One benefit emerging ride sharing companies offer is mobility to those who live in or travel to smaller communities, most of which lack service offerings from traditional taxi companies. They can also provide services such as the delivery of food and other goods. Drivers for ride sharing companies can also avoid the sometimes costly permitting and licensing processes required by taxi companies in some jurisdictions. While some users feel better about using taxi companies with stringent licensing and training standards in place, for others transportation primarily comes down to cost and convenience, and emerging ride sharing companies aim to best the competition in these areas.

- **Bicycle and scooter ride sharing:** Related to ride sharing using passenger vehicles is the emerging trend of membership-based bicycle and electric scooter ride sharing. Like conventional ride sharing, these services aim to provide commuters with all the benefits of vehicular mobility without the hassles of vehicle ownership. While bike sharing services in Toronto have been growing in popularity since the advent of Bixi Bike (now Toronto Bike Share) in 2011, the use of shared electric scooters has been slower to gain traction. Many jurisdictions in North America have welcomed companies like Lime, Bird, and Spin, which offer members the opportunity to use a fleet of GPS-connected electric scooters in as

¹⁹⁷ <https://cleantechnica.com/2018/10/28/continuous-ev-range-increases-will-drive-us-shifts-to-leasing-subscriptions-growth-in-the-used-car-market-part-2/>

user-friendly of a manner as possible. These scooters can typically travel up to 24 km/h, have no designated pick-up or drop-off points, are locked and unlocked via a mobile app, and have low usage fees based on distance travelled.¹⁹⁸

Scooter and bike sharing services are intended to efficiently provide transit over short distances, and address the ‘last kilometre’ needs of commuters (covering the final or initial leg of a given trip). They serve to funnel commuters into public transit arteries, helping to make better use of existing mass transit infrastructure. They also provide users – including youths and those without a driver’s license – with exposure to electric mobility. Some North American cities see the deployment of electric scooters in neighbourhoods underserved by public transit as a way to address issues like social equity and exclusion.¹⁹⁹

There are several major safety issues that municipal governments need to address before permitting the use of dockless e-bike or e-scooter services on their roads. Bikes or scooters left on sidewalks or obstructing building entrances or other pedestrian infrastructure could pose tripping hazards or hinder the mobility of those with special needs. Areas in which riding e-bikes or e-scooters is permitted (or not permitted) need to be clearly defined and marked. The maximum speed of these vehicles should be determined to optimize public safety. Requirements on the use of helmets and other safety devices such as lights or horns/bells should be clearly laid out and shared with all users. Safe operating conditions for these vehicles should be tested, and warnings should be shared with users indicating which conditions (e.g., rain, snow, ice) pose increased safety risks. The shared vehicles should be regularly maintained and monitored for malfunctioning components. Finally, cities should ensure that the use of e-bikes and e-scooters will not cause an undue amount of congestion on existing active transportation corridors. If increased congestion does, or is likely to, occur, an expansion of active transportation infrastructure may be necessary.

The City should consider identifying a series of areas that would be appropriate for hosting pilot projects on the deployment of e-scooters and e-bikes. Characteristics of these areas could include: lack of or over-crowded public transit, close proximity to transit terminals (i.e., subway, train or bus stations), close proximity to densified housing or businesses,

¹⁹⁸ <https://www.cnet.com/news/electric-scooters-bikes-dockless-ride-share-bird-lime-jump-spin-scoot/>

¹⁹⁹ <https://www.wired.com/story/san-francisco-santa-monica-e-scooter-permits/>

strong network of existing active transportation infrastructure, and high daily traffic volumes.

5.4.7 Intelligent Transportation Systems

Intelligent Transportation System (ITS) is a catch-all term that generally refers to a system that collects and analyzes traffic-related data in real-time, and then initiates actions intended to optimize and manage the movement of vehicles. Moving traffic more efficiently means less pollution, less time wasted, and a reduced need for transportation network upgrades or expansions. ITSs are meant to address issues such as congestion, pollution, accidents/dangerous driving, parking availability, and emergency response. They incorporate features such as satellite tracking and navigation, variable message signs and traffic signals, electronic tolling, rapid emergency response and a central traffic information system. Components of ITSs are already beginning to appear in Toronto, manifesting in areas such as:

- Electronic highway signs that show drivers the length of time it will take to reach a given exit, weather conditions, delays, safety information, etc.
- TTC buses being equipped with GPS so riders can use apps to determine when the next bus will reach their stop
- Automated toll payments on Highway 407 (Express Toll Route)
- The Presto Card, which provides users with access to services from multiple regional transit authorities
- The Red Light Camera Program, which takes pictures of vehicles entering certain intersections after the light has turned red and automatically issues tickets as a deterrent to unsafe driving
- The introduction of High Occupancy Vehicle (HOV) lanes on highways such as the Don Valley Parkway and Queen Elizabeth Way
- The reversible centre lane on Jarvis Street

ITS components will become even more apparent once connected and autonomous vehicles become mainstream. Intelligent communications systems will be needed to enable communication between vehicles, as well as between transportation infrastructure, individual vehicles, and transportation managers. As transportation

infrastructure across Toronto undergoes maintenance, replacement or expansion, ITS components should be phased into the City's transportation network. When a traffic light needs replacing, for example, City policy could dictate that it must be replaced with an intelligent traffic light. City policy should make ITS components the default option for new transportation infrastructure procurement and installations.

5.5 Policy and Initiatives Gap Analysis

Considerations for the development of Toronto's Electric Mobility Strategy have been integrated into many sections of this report. The following section identifies gaps in existing electric mobility initiatives, and identifies areas where potential conflict between existing policies/objectives in Toronto should be examined in more detail during the development of the Strategy.

5.5.1 Active Transportation and Electric Mobility

Often, municipal-level electric mobility strategies acknowledge the fact that simply electrifying the transportation sector does not address other pressing urban issues, such as congestion. In fact, Portland's EV strategy notes that its transportation hierarchy for moving people prioritizes options that both reduce congestion and carbon emissions and ranks zero emission vehicles below walking, cycling, transit and shared vehicles, taxicabs and commercial transit. The City of Vancouver also acknowledges in its strategy that EV infrastructure should be located in areas such that it ensures "a continued shift to increased walking, cycling and public transit." The City of Seattle's strategy notes that reducing vehicle miles travelled and lone riders is an important consideration, as is replacing fossil fuel in vehicles with clean electricity.

Achieving deep GHG reductions involves increases in active transportation coupled with electrifying the remaining vehicles on the road and public transit. In developing TransformTO, modelling exercises carried out to investigate how the City could achieve its goal of an 80% GHG reduction below 1990 levels by 2050 applied the avoid, shift, improve (ASI) approach. Assumptions related to the shift to active transportation and public transit in modelling the Low Carbon Scenario (LCS) included:

- The City helps people plan their transportation options (reach 80,000 residents with personal transportation planning efforts)

- Some areas of the City are car free (car free zones include Yorkville, Kensington Market, Chinatown, Downtown, Entertainment District and Waterfront Toronto)
- Most short trips would be made via walking or cycling (75% of trips 5 km or less are walked or cycled by 2050)
- Frequent transit services in all areas of the city (transit system is built out including 24 additional rapid transit lines, Regional Express Rail, and development of an express bus network across city)

Modelling results of the 2050 LCS indicate a 34% reduction in internal trips by car compared to the 2011 baseline, and vehicle kilometres travelled (VKT) is reduced by over 1,000 km in the 2050 LCS when compared to the 2011 baseline scenario. According to TransformTO, transit and active infrastructure expansion has the potential to reduce GHG emissions by 150 kt CO₂e annually in 2050.

The City of Toronto has many existing policies that in some way encourage the shift to public transit and/or active transportation such as the Toronto Walking Strategy, Active City: Designing for Health, and Feeling Congested: Official Plan Amendment (2014). A well thought out and complementary electric mobility strategy can assist the City in strategically electrifying the public transportation system, as well as the shared and private vehicles that remain in use.

5.5.2 End-of-life Impacts

End-of-life impacts and the associated environmental and social concerns created by EVs have been called into question in recent years, particularly with respect to the issue of battery recycling. As production EVs first became available in Canada in 2010, the earliest of these vehicles are now eight years old. As most automakers offer eight-year warranties on the batteries of their EVs, this means that some first generation batteries may soon be due for replacement. As the number of EVs increases, so does the number of vehicle batteries that will eventually reach the end of their useful lives. In fact, according to the Commission for Environmental Cooperation (CEC), by 2030 almost 60,000 EV batteries will reach the end of their life in Canada alone. It is estimated that by the same time, up to 11 million tonnes of used lithium-ion batteries could accumulate world-wide.

EV batteries are expected to power their vehicles for at least eight to 10 years (about 3 to 4 years for larger vehicles), however, at retirement the batteries will likely still retain

about 50-70% of their original capacity. EV owners in China and the EU are required by law to recycle or reuse vehicle batteries, and some experts expect the U.S. to follow suit with this requirement.

Lithium-ion car and bus batteries are still useful for an additional seven to 10 years after retirement. Spent EV batteries still have reasonable energy storage and standby power capabilities that could be used in many applications. For example, EV batteries are being reused in California to power EV charging stations. In Europe, they are being used commercially to store energy for homes and grids. In Japan, Nissan has repurposed retired EV batteries to power streetlights.

There are also cutting-edge recycling operations to recover valuable materials such as cobalt, lithium carbonate and ferrous scrap metal. For example, Li-Cycle is a Canadian company that uses advanced recycling technologies that allows them to recover up to 100% of the lithium from lithium-ion batteries. Other Canadian companies that recycle and/or process lithium-ion batteries include Glencore Xstrata, located in Sudbury, ON; Raw Materials Company, Inc. (RMC) located in Port Colborne, ON; and Retriev (Toxco), located in Trail, BC. Most EV batteries at end of life will come through the auto dismantling or auto recycling supply chain via auto mechanics or official vehicle dealerships.

TransformTO sets a goal that 95% of waste is diverted in all sectors (residential, industrial, commercial and institutional) by 2050. Ensuring EV owners are aware of the reuse and recycling options available to them for their EV batteries can assist the City in ensuring retired EV batteries are dealt with responsibly. Additionally, stewardship programs could be implemented to assist in the safe decommissioning and/or reuse of EV batteries.

5.5.3 Scooters, cargo bikes and other forms of electric mobility

These types of electric mobility options have been defined and discussed in general in Section 5.4.6 of this report.

Cycling is becoming a more prevalent commuting option in Toronto and increased cycling infrastructure across the city is expected in the coming years with the approval of Toronto's Cycling Network Plan.²⁰⁰ A promising option to fully capture the benefits of Toronto's progress is to use cycling infrastructure to move goods as well as people. A

²⁰⁰ City of Toronto. Cycling Network 10 Year Plan. <https://www.toronto.ca/services-payments/streets-parking-transportation/cycling-in-toronto/cycle-track-projects/cycling-network-10-year-plan/>.

recent Pembina study investigating the opportunities for moving goods by bicycle in Toronto reports that the downtown core is well-suited for deliveries by bicycle and that “*expanding the use of traditional pedal bicycles and electric bikes to complete cargo and delivery trips can help the City of Toronto reach its goal of reducing GHG emissions by 80% by 2050.*”²⁰¹

Cyclelogistics is the integration of bicycles into the goods movement network to improve the efficiency of deliveries in congested urban areas and has been gaining traction in Europe for years, where major carriers like UPS, DHL and TNT use cargo bikes for ‘last kilometre’ deliveries.²⁰² Further, some municipalities in Europe have started to incorporate cargo bikes into their vehicle fleets. For example, the City of Vienna invested in a cargo bike fleet for city services. The City of Seville invested in over 200 cargo bikes for street cleaning and park maintenance. There are also pilot projects in cities in Spain and Belgium experimenting with micro consolidation centres, where multiple delivery companies can drop off packages for shoppers to pick up, or for cargo cyclists to pick up and deliver the ‘last kilometre.’²⁰³

Cyclelogistics is in its infancy in Toronto. While there are at least five delivery companies that offer on-demand service, there are no large carriers in the city that make use of cyclelogistics for last mile delivery.²⁰⁴ UPS however is piloting a project that uses a custom-made cargo bike to deliver packages in and around the York University campus. The pilot project is aimed at supporting UPS Canada’s strategy for larger-scale bicycle delivery in Toronto (and potentially other cities across Canada).²⁰⁵

One of the key challenges identified by the UPS pilot are regulatory barriers on the use of their electric cargo bikes on roads and paths. Regulatory barriers such as the definition of vehicles that can use roads are not within the City’s jurisdiction, but solutions including provincial and federal engagement could be integrated into the Electric Mobility Strategy.

²⁰¹ Pembina Foundation. Cyclelogistics Opportunities for moving goods by bicycle in Toronto. <http://www.pembina.org/reports/cyclogistics-final.pdf>

²⁰² Pembina Foundation. Cyclelogistics Opportunities for moving goods by bicycle in Toronto. <http://www.pembina.org/reports/cyclogistics-final.pdf>

²⁰³ Pembina Foundation. Cyclelogistics Opportunities for moving goods by bicycle in Toronto. <http://www.pembina.org/reports/cyclogistics-final.pdf>

²⁰⁴ Pembina Foundation. Cyclelogistics Opportunities for moving goods by bicycle in Toronto. <http://www.pembina.org/reports/cyclogistics-final.pdf>

²⁰⁵ UPS. UPS Launches Cargo Bike in Canada. <https://www.ups.com/ca/en/about/news/cargo-bikes.page>

5.5.4 Car Sharing and Ride Sharing

Car sharing is introduced and discussed in general in Section 5.4.6 of this report.

There are a number of car sharing and ride sharing services in Toronto, such as Zipcar, Maven, Enterprise CarShare, Communauto, Turo, Lyft and Uber. Toronto recently adopted new regulations for ride sharing services (such as Uber) however none of these regulations are related to the electrification of the service's fleet.^{206,207}

What is interesting to note is that earlier this year, Uber introduced the EV Champions Initiative, a one-year pilot project that is providing cash incentives to some of its drivers who use EVs. The pilot project is taking place in seven cities across the U.S. and Canada: Austin, Los Angeles, Montreal, Sacramento, San Diego, San Francisco and Seattle. Cash incentives for drivers who switch to EVs vary depending on the city.²⁰⁸ In some instances, the incentives are also provided by local utilities. For example, in Sacramento, the locally-owned public utility, SMUD, is providing drivers with cash incentives for trips completed in a zero-emissions vehicle (\$1.25 per trip, which Uber rounds up to \$1.50) as well as access to free charging through SMUD's DC fast charging network.²⁰⁹

There is at least one Canadian city with an electric car sharing program. Earlier this year, a 100% electric and solar powered car sharing program was launched in Saskatoon, as part of the CarShare Co-operative. Currently the fleet has four all electric vehicles available for members.²¹⁰ Recently, the City of Paris and automaker Renault announced that they will be deploying a fleet of 2,000 EVs for ride-hailing and car sharing services in Paris.²¹¹

Innovative and collaborative partnerships may offer a more attractive mechanism than regulations to increase the adoption of EVs in ride sharing and car sharing fleets.

²⁰⁶ <https://www.toronto.ca/legdocs/municode/toronto-code-546.pdf>

²⁰⁷ <http://app.toronto.ca/tmmis/viewPublishedReport.do?function=getAgendaReport&meetingId=10981>

²⁰⁸ Uber Newsroom. https://www.uber.com/newsroom/electrifying-our-network/?utm_term=wEdxaizduVAgVbORCQ0U21gRUkgybvRp3zgF1E0&adg_id=218769&cid=10078&utm_campaign=affiliate-ir-Skimbit%20Ltd.1-99_national_D_all_ACQ_cpa_en&utm_content=&utm_source=affiliate-ir

²⁰⁹ <https://www.theverge.com/2018/6/19/17480044/uber-electric-vehicle-ev-driver-cash-incentive>

²¹⁰ Saskatoon CarShare Co-operative. <https://saskatooncarshare.com/>

²¹¹ <https://electrek.co/2018/07/04/renault-fleet-electric-vehicles-ride-hailing-car-sharing-paris/>

5.5.5 Incentives

Toronto does not currently have any incentives for EV ownership. Electric mobility strategies often offer EV owners some types of financial or non-financial incentives. Municipalities leading the shift to electric mobility offer non-financial incentives such as bus or HOV lane access and priority parking spaces, as well as financial incentives such as exemption from road tolls, free municipal parking, and free electricity for charging. Financial incentives such as purchase rebates are not always feasible for municipalities due to budgetary constraints.

Offering financial incentives may be feasible, however, by working with other levels of governments to leverage available funding. For example, Canada's pending Federal ZEV Strategy may offer a financial incentive mechanism that Toronto could leverage to encourage the shift to electric mobility.

5.5.6 MURBs

Toronto is launching a residential on-street charging pilot, which is expected to help provide charging options for garage orphans. As discussed in Section 5.2.2, MURBs will require targeted charging solutions. The City should consider how to work with property owners and managers to pilot potential solutions during the development of the Electric Mobility Strategy.

5.5.7 Education and Awareness

Education and awareness is often identified as one of the key barriers to EV ownership – the benefits of EV ownership (environmental, total cost of ownership, etc.) need to be expressed and communicated in a way that addresses lack of familiarity with the technology and specific concerns such as range anxiety. While the City does provide a website, strategy development should consider the further role of the City in activities such as:

- Helping develop information to be disseminated through other avenues that identifies the advantages of EV ownership in Toronto (understanding that car purchasers would not necessarily think to visit a City website when making vehicle purchase decisions).

- Helping existing owners (e.g., from EV clubs and societies) connect with prospective owners. This type of connection is one of the most important sources of information transfer to promote EV sales.
- Use charging pilots, City fleets, and charging station signage to build awareness and promote electric mobility.

5.6 Environmental, Social and Economic Opportunities

5.6.1 Environmental Benefits

The adoption of EVs offers significant potential to reduce GHG emissions in Toronto via the use of electricity as fuel for vehicles, as opposed to gasoline or diesel. The emission reduction benefits of EVs depend on the source of electricity that is produced to charge them, but are greatest in jurisdictions with lower electricity generation carbon intensities.²¹² Toronto stands to benefit from widespread EV adoption considering that approximately 96% of electricity in Ontario is supplied from emissions-free sources, such as nuclear, hydro and wind energy.²¹³

The chart below shows potential emissions from a selection of 2018-model vehicles in Ontario, including BEVs, PHEVs, HEVs, and ICE vehicles. The emissions comparisons only include emissions from the combustion of fuel, such as emissions from a power plant generating electricity or from a vehicle consuming gasoline, as applicable. It should be noted that emissions related to mining raw materials, manufacturing, shipping, and vehicle scrappage are not included in these calculations. It is clear that BEVs have the lowest GHG emissions, while emissions from ICE vehicles are the highest. This highlights the significant GHG reduction levels that can be achieved in Toronto through the adoption of EVs.

²¹² <http://www.pollutionprobe.org/publications/accelerating-deployment-zevs-atlantic-canada-prairies/>

²¹³ <https://www.oeb.ca/sites/default/files/2017-supply-mix-data.pdf>

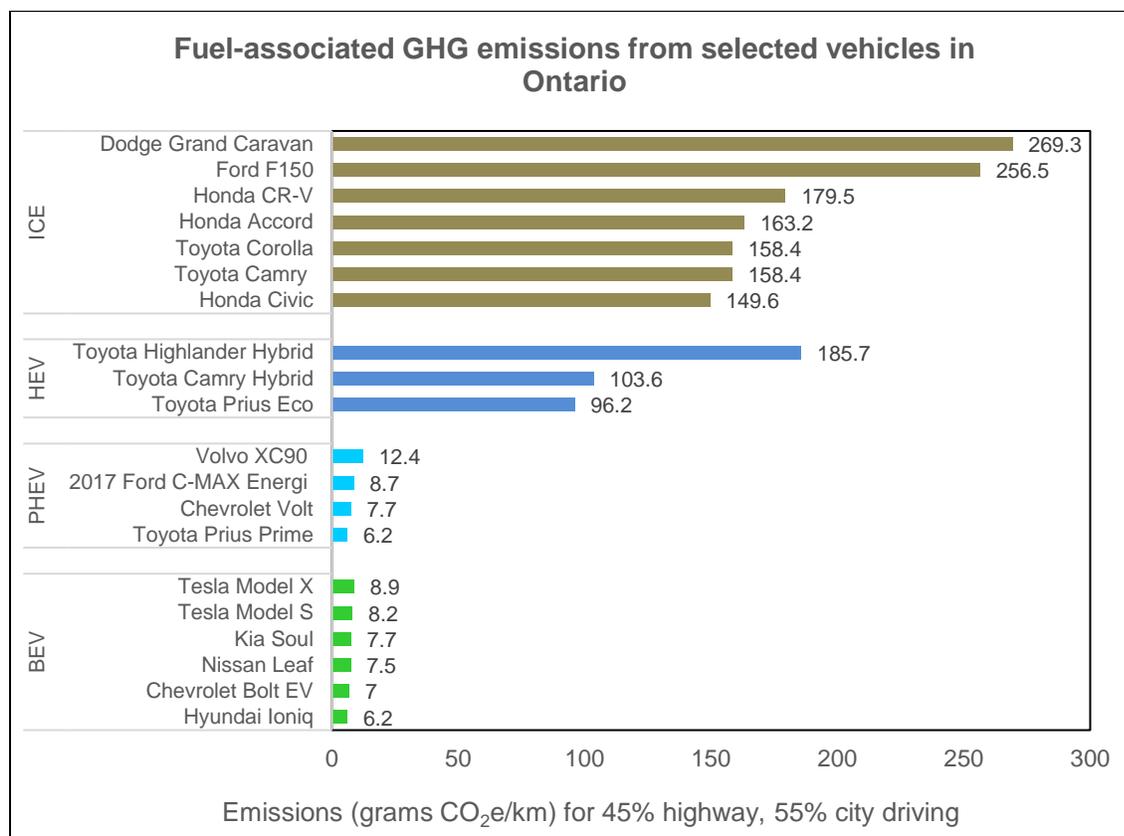


Figure 13: Fuel-associated GHG emissions from selected vehicles in Ontario²¹⁴

Maroufmashat and Fowler (2018) conducted an analysis of lifecycle GHG emissions of fuels for different vehicle types, BEVs, PHEVs, FCEVs and ICE vehicles in different electricity mix scenarios in Ontario.²¹⁵ Based on Ontario’s average grid electricity emissions, the net GHG emissions of BEVs were found to be the lowest, at 11 grams CO₂e/km, followed by HFCVs at 26 grams CO₂e/km. The study found that GHG emissions from PHEVs can range from 12 to 96 grams CO₂e/km, depending on the utility factor (i.e., the proportion of total distance travelled using electric power). For comparison, the GHG emissions of ICE vehicles were estimated to be 260 grams CO₂e/km (roughly 24 times greater than BEVs). The study found that the time of charging has a strong correlation with the net emissions of EVs in Ontario, with the greatest emissions savings achieved by charging during off-peak hours, when electricity in the province generally comes from nuclear, hydro and wind. More specifically, the study found that:

²¹⁴ Adapted from: <https://www.mdpi.com/2032-6653/9/3/38/pdf>

²¹⁵ <https://www.mdpi.com/2032-6653/9/3/38/pdf>

- A BEV would save between 3 (power from natural gas generation) and 5 (grid power mostly based on nuclear) tonnes of CO₂e per year, relative to ICE vehicles
- A FCEV would save between 0.3 and 4.7 tonnes CO₂e per year
- A PHEV would save between 2 and 3.5 tonnes CO₂e per year, assuming an average 66% utility factor for electric propulsion²¹⁶

Finally, the study estimates that having 1.7 million EVs on Ontario's roads could help avoid 5 to 7 million tonnes of GHG emissions. This is equivalent to removing of 1 to 1.5 million gasoline-powered vehicles.²¹⁷ This study highlights the important opportunity for Ontario and Toronto to leverage the clean electricity supply mix and time of use pricing to achieve substantial GHG reductions by enabling the widespread adoption of EVs.

Studies in other jurisdictions confirm the significant GHG emission benefits of EVs, particularly BEVs, when compared to ICE vehicles over their lifetime (from cradle to grave), particularly in jurisdictions with low-emitting sources of electricity.²¹⁸

Generally speaking, major cities are ideal for electrified transportation as commuting distances tend to be short yet congestion tends to be a major problem. Unlike traditional ICE vehicles, EVs achieve better mileage in stop-and-go traffic than when travelling at highway speeds due to the benefits of regenerative braking. This uniquely EV feature captures some of the energy from a car's momentum every time the brake is applied and uses that energy to charge the battery (this technology is even used by Toronto's subway trains to enhance their efficiency). Further, electric motors don't use any energy while a car is stopped or stuck in traffic, which helps to conserve battery power. The fact that battery EVs have zero tailpipe emissions helps to address poor air quality in busy cities (and mitigates negative health impacts from vehicle emissions such as asthma, bronchitis, cardiovascular diseases, and various forms of cancer).

Ontario's electricity generation mix was 96% emissions-free in 2017, meaning EVs used in the province have minimal GHG footprints. When coupled with distributed renewable energy generation (such as household solar panels) the use of an EV can be entirely emissions free. Of course the production of EVs, like other types of vehicles, results in GHG emissions. These emissions are unavoidable from a consumer perspective, but should be taken into consideration from a life-cycle perspective, as there are

²¹⁶ <https://www.mdpi.com/2032-6653/9/3/38/pdf>

²¹⁷ <https://www.mdpi.com/2032-6653/9/3/38/pdf>

²¹⁸ https://europeanclimate.org/wp-content/uploads/2018/09/From-cradle-to-grave-e-mobility-and-the-energy-transition_IT_SP_UK_EU.pdf

environmental benefits to be realized at each stage of a vehicle's life-cycle (from production, to its useful life, to its decommissioning).

GHGs emitted from ICE vehicles include carbon dioxide, methane, ozone, and nitrous oxide. Emissions of criteria air contaminants (CACs) include sulphur dioxide, oxides of nitrogen, carbon monoxide and particulate matter. All of these pollutants are virtually eliminated through the use of EVs in Ontario, leading to significant environmental and human health benefits.

5.6.2 Social Benefits

EVs are far quieter than ICE vehicles, contributing to a more peaceful and serene quality of life for those that live near highly-trafficked areas. While benefits like this are difficult to quantify they are nonetheless significant. Beyond GHGs, the deposition of particulate matter emitted from gas-powered vehicles is a major problem in cities like Toronto, as anyone living near a major highway or arterial road can attest to. The increased adoption of EVs will not only help to clean the air in Toronto, but will help to keep the city's built environment cleaner as well.

Some benefits that EVs offer do not fit neatly into any of the three categories in this section. One such benefit is the mitigation of the urban heat island effect. On a per kilometre basis, EVs emit only 19.8% of the heat emitted by conventional vehicles.²¹⁹ A 2015 study based in Beijing, China, found that if all conventional vehicles in the city were replaced with EVs, they would reduce average daily summer temperatures by 0.94 °C, and would reduce the daily electricity consumption of air conditioners by 14.44 million kWh, in addition to reducing daily GHG emissions by 10,686 tonnes.²²⁰ While the impact of urban heat island effect mitigation would likely not be as dramatic in Toronto as in Beijing, EVs would still have a measurable impact on the city's temperatures. As one of the Beijing study's Michigan State University researchers said, "Heat waves kill, and in terms of climate change, even one degree can make a difference."²²¹ In Toronto, 120 deaths each year are attributable to extreme heat, so any measure with the potential to diminish this number warrants consideration.²²²

²¹⁹ <https://www.nature.com/articles/srep09213>

²²⁰ <https://www.nature.com/articles/srep09213>

²²¹ <https://msutoday.msu.edu/news/2015/hidden-benefits-of-electric-vehicles-revealed/>

²²² <https://docs.assets.eco.on.ca/reports/climate-change/2018/Climate-Action-in-Ontario.pdf>

Despite reductions in net GHG emissions over the last decade, 1,300 premature deaths and 3,550 hospitalizations are attributable to air pollution in Toronto each year, and transportation is the leading cause.²²³ Traffic-related air pollution (TRAP) can also lead to breathing problems, heart disease, and cancer, and has the most negative impacts on vulnerable populations such as youths, the elderly, and those with pre-existing health conditions.²²⁴ People who live and work close to major roads have been shown to be far more likely to suffer from adverse health effects related to TRAP.²²⁵ An OECD study on the health impacts of road transportation found that health costs from TRAP in Canada in 2005 were over \$27 billion, and by 2010 they had increased to over \$32 billion.²²⁶

5.6.3 Economic Benefits

EVs cost far less to operate and maintain than gas-powered cars. They have a small fraction of the number of moving parts that ICE vehicles have, and their fuel is far cheaper and more predictably priced than gasoline or diesel. Fleet managers, when budgeting for future fuel costs, are often forced to set aside large portions of their total budget to accommodate unpredictable gas prices, which can go up or down by significant margins in relatively short periods of time. Electricity rates, on the other hand, are far more predictable and are locked in for long periods. These EV benefits allow for more accurate mid- and long-term budgeting for fleet fuel and maintenance costs when fleets are electrified. This means that funds can be spent where they are most needed and do not have to be placed in reserve to buffer against future gas price fluctuations.

Further, the fact that Ontario offers time-of-use electricity pricing complements EV use well. EVs are typically charged overnight when their users are asleep or away from work – at the same time when electricity rates are lowest. Overnight EV charging also allows provincial electricity system operators to optimize the use of baseload and renewable electricity generation. Utilizing as much Ontario-generated electricity within the province as possible can also help to reduce net electricity system costs. Currently about 13% of Ontario’s low-carbon electricity is sold to neighbouring jurisdictions or curtailed, often at a net financial loss. By promoting growth in electrified transportation and practices like overnight EV charging, however, a significant amount of this clean electricity can be

²²³ <https://docs.assets.eco.on.ca/reports/climate-change/2018/Climate-Action-in-Ontario.pdf>

²²⁴ <https://www.toronto.ca/legdocs/mmis/2017/pe/bgrd/backgroundfile-108665.pdf>

²²⁵ <https://docs.assets.eco.on.ca/reports/climate-change/2018/Climate-Action-in-Ontario.pdf>

²²⁶ <http://www.oecd.org/env/the-cost-of-air-pollution-9789264210448-en.htm>

utilized within the province.²²⁷ Ontarians spend over \$11 billion each year on polluting and finite fossil fuels when cheaper, cleaner electricity could perform the same function. Electricity system benefits are compounded when EVs are coupled with energy storage technologies, which can help to ensure that energy used by EVs has the smallest possible carbon footprint (as batteries can be charged whenever emission-free electricity is available).

Ontario's cleantech sector already creates almost \$20 billion in revenue each year, and provides roughly 130,000 jobs.²²⁸ The sector, which is growing faster in Ontario than in any other province, has attracted innovative professionals and businesses from around the world, with the number of cleantech businesses in the province now numbering over 5,000.²²⁹ Electrified transportation walks hand-in-hand with the cleantech sector, and a strong commitment to it will help to signal to the world that Toronto is a prime destination for the next generation of innovative businesses and professionals. Supporting and demonstrating emerging technologies is a hallmark of municipal tech hubs around the world, and creating an environment conducive to a variety of electric mobility options will enhance Toronto's reputation as a leading destination for cleantech research and development.

6 Building a Toronto Electric Mobility Partnership

One of the key pillars of the Strategy's development is collective impact. The City understands that accelerating the deployment of electric mobility will involve the concerted actions of multiple stakeholders. One of the tasks of the Assessment Phase was to convene a stakeholder workshop to discuss the role of the City and its stakeholders during Strategy development and implementation. The workshop also served as a testing ground for the areas of action under consideration by the City, and an opportunity to hear how stakeholders are already advancing electric mobility.

²²⁷ <https://docs.assets.eco.on.ca/reports/climate-change/2018/Climate-Action-in-Ontario.pdf>

²²⁸ <https://docs.assets.eco.on.ca/reports/climate-change/2018/Climate-Action-in-Ontario.pdf>

²²⁹ <https://docs.assets.eco.on.ca/reports/climate-change/2018/Climate-Action-in-Ontario.pdf>

6.1 Areas of Action

The Electric Mobility Strategy will be organized around broad areas of action. Toronto has identified five areas of action for Strategy development:

- Availability of charging infrastructure
- Policies and regulation
- Financial and non-financial incentives
- Research, community awareness and behaviour change
- Understanding and developing the EV industry, workforce and training

As explored in the best practice discussion in Section 4.1, these categories correlate well to the typical scope of municipal electric mobility strategies with the potential addition of the following areas:

- Transit
- Fleets and shared mobility
- Goods and freight movement

To a certain degree, this is a question of organization, as relevant actions within these areas could be addressed within the original five categories (e.g., policies that address transit, or incentives applicable to shared mobility). An advantage of creating additional areas would be to help delineate actions that would be targeted to private LDVs relative to other types of electric mobility. Further delineation provided by additional areas could also be helpful between LDVs and medium- and heavy-duty vehicles, as the technology solutions and end-users are different – i.e., collaborations and partnerships on different types of vehicles would involve different stakeholders.

One consideration raised at the stakeholder event was the inclusion of hydrogen along with electricity – i.e., the reframing of the Electric Mobility Strategy as a Zero Emission Vehicle (ZEV) Strategy. This consideration was targeted at medium- and heavy-duty vehicles, and hence creating areas of activity focused on these types of vehicles could make it easier to frame specific activities that include hydrogen within the Strategy.

6.2 Regional Stakeholders Engaged

During the literature review, data analysis, and expert interview phases of this project, the project team compiled a list of key stakeholder groups that had a strong likelihood of being meaningful contributors to Toronto's Electric Mobility Strategy. In the delivery of comprehensive initiatives such as the Strategy, it is critical that experts be consulted from a wide range of groups that are likely to be impacted by and/or involved in implementation efforts. Such experts can help to identify gaps, share best practices, streamline efforts, provide data, or otherwise raise potential issues before implementation gets underway. They can also serve as partners to amplify the scope and impact of activities, and possibly help to make certain activities more affordable.

The groups identified as key regional stakeholders for the Strategy were:

- Social equity organizations
- NGOs and advocacy groups
- Property developers
- Automakers
- Electric mobility technology companies
- Ride sharing companies
- Electricity system stakeholders
- Academia
- Non-municipal government
- Transit, fleet, parking, housing, environment, energy and transportation experts from the City of Toronto

Representatives from each of the stakeholder groups were convened for a workshop on November 15, 2018. The workshop had two broad objectives: 1) to inform key stakeholders on progress to date with regard to the Assessment Phase of the Strategy, and 2) to explore opportunities for stakeholders to contribute to the design and implementation of the Strategy. The majority of the time during the workshop was dedicated to moderated breakout group discussions that sought to articulate and explore critical areas for action and important considerations for the City as it moves forward with

the development of the Strategy. Key findings from the workshop were incorporated into relevant sections of this report.

A total of 51 expert participants attended the workshop and contributed their ideas and views. While representatives from the City of Toronto came from a variety of departments and backgrounds, all have been engaged in the City's internal Electric Vehicle Working Group since its establishment following the finalization of TransformTO. Some key stakeholders were unable to attend the workshop (e.g., Toronto Transit Commission), but will be critical to the success of the Strategy and will be invited to collaborate on future initiatives. The workshop participant list by organization is included below for reference.

Each of the stakeholders who attended the workshop are involved in actions that accelerate the deployment of electric mobility. In many cases, these actions are being undertaken with minimal collaboration; however, some examples of collaboration identified at the stakeholder event include:

- Plug'n Drive's Electric Vehicle Discovery Centre (EVDC), an EV showcase centre providing test drives and information for the general public. The EVDC is a collaboration between an NGO, automakers, technology companies, and (formerly) the Government of Ontario.
- Uber and the University of Toronto. Uber is investing \$200 million in Toronto to expand an autonomous vehicle research lab which will be co-led by UofT researchers. The investment will lead to the creation of 300 jobs in the next several years and will position the City well to engage in autonomous vehicle pilots and research.²³⁰
- Partners in Project Green EVSE installations. Partners in Project Green, a partnership between the Toronto and Region Conservation Authority and the Greater Toronto Airports Authority, worked with local businesses to install 124 EV charging stations in the GTA between 2014 and 2017.
- The Flo-ChargePoint roaming agreement. In October 2018, two of the biggest public charging station providers in Canada, Flo and ChargePoint, entered into a roaming charging agreement. Much like roaming between different cell phone networks, the agreement allows users that are members of either charging network to activate charging sessions using either of the Flo or ChargePoint mobile apps

²³⁰ <https://www.utoronto.ca/news/uber-seeks-top-toronto-talent-200-million-investment>

at any station that is part of the Flo or ChargePoint networks. This allows Flo users to charge at a ChargePoint station and activate the session through their Flo app, and vice-versa. This step provides users with access to a broader group of public charging stations and makes the billing process simpler. The agreement was made possible through the use of the Open Charge Point Interface (OCPI) protocol, which allows various network operators to exchange information such as charging station location, availability and fees. It illustrates one of the many steps that are being taken to make public charging more accessible and user-friendly.

Table 2: Participating organizations at the City of Toronto’s stakeholder workshop

Stakeholder Group	Organization
Academia	Ryerson University
Academia	University of Toronto
Auto Manufacturer	Audi - Volkswagen Canada
Auto Manufacturer	General Motors Canada
Auto Manufacturer	Mercedes-Benz
Auto Manufacturer	Mitsubishi Motors
Auto Manufacturer	Porsche Canada
Auto Manufacturer	Toyota Canada
Auto Manufacturer	Volvo
Auto Manufacturer	Global Automakers of Canada
City of Toronto	City of Toronto - Automated Vehicles
City of Toronto	Toronto Environment and Energy
City of Toronto	Toronto Hydro
City of Toronto	Toronto Parking Authority
City of Toronto	Waterfront Toronto
Electricity Sector	Electricity Distributors Association
Electricity Sector	Ontario Power Generation
EV Technology Company	AddEnergie/Flo
EV Technology Company	ChargePoint
EV Technology Company	CSA Group
EV Technology Company	FleetCarma
EV Technology Company	Hydrogenics
EV Technology Company	Signature Electric
EV Technology Company	SWTCH EV
Government - Federal	Environment and Climate Change Canada

Stakeholder Group	Organization
Government - Provincial	Environmental Commissioner of Ontario
NGO / Advocacy Group	The Atmospheric Fund
NGO / Advocacy Group	Clean Air Partnership
NGO / Advocacy Group	EV Society
NGO / Advocacy Group	Ontario Climate Consortium
NGO / Advocacy Group	Pembina Institute
NGO / Advocacy Group	Plug'n Drive
NGO / Advocacy Group	Toronto and Region Conservation Authority
Property Development	Oxford Properties
Property Development	Tridel
Ride sharing	Lime
Ride sharing	Enterprise CarShare
Ride sharing	Beck Taxi

It is critical that the City not only continue to engage the stakeholders present at the workshop, but work to expand the list of organizations contributing to the Strategy as development progresses. As individual actions are planned and prioritized, the City may need to reach out to other organizations for input and collaboration on specific issues. The stakeholder groups convened during the Assessment Phase, however, represent a diverse and robust range of organizations that should continue to serve as the foundation of external stakeholders moving forward.

6.3 Partnering for Strategy Development

A key item discussed at the stakeholder workshop was the role that municipal government should play in fostering growth in Toronto’s electric mobility landscape. The two points that were frequently mentioned with regard to this topic were:

- The City should serve as a convener of the wide variety of stakeholders involved in the delivery of electric mobility solutions
- The City should work to fill the gaps left in Toronto’s electric mobility network by private sector stakeholders

With regard to the first point, the City has committed to taking a collective impact approach to delivering on its TransformTO targets. Collective impact entails consulting and

coordinating with a broad cross-section of stakeholders to develop solutions that are mutually agreeable and are actively supported by multiple parties. Collective impact approaches are in part designed to ensure that no major stakeholder groups are left out of decision making processes, and that potentially negative impacts of actions taken are mitigated. The benefits of collective impact were made evident at the stakeholder workshop, as there were cases in which a participant would articulate a challenge they'd been struggling with, only to have another participant offer advice or direct assistance on overcoming such a challenge. In other cases, participants would put forward potential solutions to a problem, but others would explain how those solutions might have unanticipated or negative outcomes for certain stakeholder groups or sectors. The take away message from such interactions was that broad stakeholder participation will lead to a more robust and effective Electric Mobility Strategy.

On the subject of filling gaps left by private sector stakeholders, this role was seen as critical to ensuring that the City's social equity mandate is fulfilled through the implementation of the Strategy. Private sector businesses will naturally be drawn to implementing electric mobility measures that will provide them with a return on their investments. Such measures might exclude actions such as providing public EV charging infrastructure in low-income neighbourhoods, where EV adoption levels tend to be lower and infrastructure usage rates would be projected to be low in the near term. Charging infrastructure at workplaces or in the vicinity of rental apartments is another area in which the City may need to take direct action, perhaps in partnership with relevant stakeholder groups to leverage funding and outreach potential. There are other areas where the private sector plays a minor role, if any role at all, such as delivering public education on electric mobility through schools or driver training programs, or procurement policies for municipal vehicles. In developing the Strategy, the City should therefore assess which actions are amenable to private sector leadership and which actions it should take a leadership role on. Through stakeholder consultations, key stakeholder groups should be assigned to lead on certain actions while the City should take the lead on critical actions that are 'left over' or are most appropriate for it to lead successfully.

Additional potential roles for the City that were identified by stakeholders over the course of the Strategy's Assessment Phase include:

- The City should take a systems-level view and approach to the implementation of actions, carefully assessing the indirect impacts of actions on related stakeholders and sectors

- The City is in a favourable position to educate the general public on the human health and environmental benefits of electric mobility
- The City should work closely with the Toronto Transit Commission to establish guiding principles on electric mobility, and help to address barriers related to electrified public transit
- The City should lead by example, by having strong electric mobility procurement policies for municipality-owned vehicles across multiple modes
- The City could lead on piloting solutions for freight movement in Toronto, which could incorporate vehicle modes across all scales, and could include benefits for companies who are committed to greening their fleets

7 Summary

Through the development of its TransformTO climate action strategy, Toronto established aggressive GHG reduction targets for the near term and for decades to come. Meeting those targets will require a significant increase in the use of electric mobility options across all modes of transport. The achievement of those targets will also be greatly facilitated by collaborating closely with a range of key stakeholders from the public and private sectors.

The global EV market is growing at a very rapid rate, driven primarily by supportive government policies and declining battery costs. The total number of EVs on the road reached 3.1 million worldwide in 2017, yet the EV market remains relatively small in absolute size and relative share. In Ontario, EV sales recently surpassed 8% of new passenger vehicle sales, signalling that the province has become a leading EV market globally. Despite this achievement, a number of barriers still exist that prevent local consumers from buying EVs. Key barriers include higher upfront costs, limited availability of public charging stations, lack of awareness and knowledge about EVs, a limited offering of EV models and a lack of EVs available to test drive at dealerships.

The City of Toronto has launched a number of electric mobility-focused programs aimed at addressing key barriers to EV adoption and use. These programs include the deployment of public charging infrastructure in strategic locations, the electrification of the City's transit bus fleet, EV charging requirements for developers of multi-unit residential and commercial buildings, and the introduction of green fleet procurement policies for the

City's fleet. Such programs represent a great start towards the realization of TransformTO targets, and the expansion of them along with the establishment of additional actions through the Electric Mobility Strategy will help to position Toronto well as it works to advance electric mobility.

During the Assessment Phase, gaps in Toronto's existing suite of actions to provide clean transportation options were identified with the intention that these gaps will be addressed by the subsequent Strategy. A key gap identified was the integration of electric mobility initiatives with other transportation initiatives such as programming to alleviate traffic congestion. Related to this gap is the lack of a formal hierarchy to prioritize certain modes of transport over others based on environmental and social impacts (i.e., active transportation → public transit → electrified car/ride sharing → privately owned EVs). It is critical that complex issues like congestion are addressed through a multi-pronged approach that aims to leverage the benefits of factors such as active transportation, public transit, car and ride sharing, vehicle autonomy, and intelligent transportation systems. Actions undertaken in any of these areas should aim to work in tandem with complementary actions. With such an approach, ancillary benefits can be realized that will have significant impacts on areas such as human health, quality of life, infrastructure maintenance and capital costs, and local economic development. Additional gaps in existing policies identified by this study include: addressing EV charging needs in existing MURBs, end-of-life programs for EVs and their batteries, emissions-free micro-mobility accessibility (such as e-bikes and scooters), car and ride sharing policies and standards, financial and non-financial incentives for EV ownership and use, and electric mobility education and awareness initiatives.

A review of municipal best practice indicates that there are a number of critical categories of action that Toronto should use to guide and prioritize specific actions within its Electric Mobility Strategy. These categories include: charging infrastructure, public education and outreach, collaboration and partnerships, regulations and policies, incentives, economic development opportunities, as well as fleets, transit and car sharing. They are very closely aligned with the areas for action that key stakeholders, City staff and the project team have identified during the Assessment Phase: availability of charging infrastructure; policies and regulation; financial and non-financial incentives; research, community awareness and behaviour change; understanding and developing the EV industry, workforce and training; public transit; fleets and shared mobility; and goods and freight movement. Within each category, stakeholder groups already exist who are working to advance specific actions, and the City has initiated engagement with members of these groups over the course of the Assessment Phase. Key electric mobility stakeholder

groups include: social equity organizations, NGOs and advocacy groups, property developers, vehicle manufacturers, electric mobility technology companies, ride sharing companies, electricity system stakeholders, academia, non-municipal government, as well as transit, fleet, parking, housing, environment, energy and transportation experts from the City of Toronto. Each group will offer different strengths and resources with regard to the development and implementation of the Electric Mobility Strategy, and the City is encouraged to expand the scope of collaboration with these groups.

Through data analytics and mapping exercises, the Assessment Phase included a social vulnerability analysis to identify neighbourhoods and populations in Toronto that currently have relatively limited access to electric mobility options. As socially vulnerable communities have been shown to be disproportionately impacted by pollution and climate change, it is critical that the Electric Mobility Strategy provides these communities with the opportunity to realize the full range of benefits stemming from climate-related actions undertaken by Toronto. People within these communities must also be provided with opportunities to utilize a variety of electric mobility options. Private sector engagement in such communities may be limited in some cases, and Assessment Phase stakeholders agreed that a key role for the City will be filling gaps in its electric mobility landscape left by private sector providers.

The ability of municipal electrical grids to accommodate significant increases in EV uptake is a common concern among transportation stakeholders around the world. Given current trends in EV adoption, it is not anticipated that the added loads related to EV charging in Toronto will pose a problem to grid operators. However, as adoption levels increase it is critical that electrical utilities are afforded the opportunity to engage in EV load management activities, especially those related to the deferment and management of EV charging at residential and commercial locations. The provision of data related to EV adoption levels and owner locations would further facilitate the ability of utilities to manage and prepare for EV charging demands.

To ensure that the Electric Mobility Strategy is as future-proofed as possible while still allowing for meaningful technology-related actions in the near-term, it is recommended that the City closely monitor emerging technologies and trends in a number of key areas. The Strategy will need to be readily adaptable in many respects to account for the rapid pace of technological development and ensure that investments made in the near term do not quickly become stranded. For example, wireless charging could become a staple of the EV industry in the near to medium term, and long-lived infrastructure should be upgradable to accommodate it. Ultra-fast charging technologies could likewise become

the norm, so the City would be advised to begin looking at potential solutions for integrating it into the local charging network. Distributed energy generation is increasing in feasibility and popularity every year, and is likely to play a key role in EV charging and electrical grid load management approaches in the future. Breakthroughs in battery chemistry and/or density are possible in the next decade, and could serve as a disruptive force in the world of EVs and charging infrastructure. Car and ride sharing services are transforming decades-old norms around vehicle ownership and personal mobility, especially for those living in major urban centres. Their role and influence is likely to continue to expand, and cities like Toronto can serve as leaders in ensuring that their environmental and social benefits are optimized. Vehicle autonomy will be a major disruptor across all modes of transport, one with the potential to either exacerbate or mitigate transportation-related issues.

A key objective of the stakeholder workshop conducted on November 15, 2018, was to attain input on what role the City should play in the implementation of its Electric Mobility Strategy and related initiatives. Stakeholders agreed that two critical roles that should be played by the City are serving as a convenor and organizer of different stakeholder groups and filling any gaps left by private sector partners with regard to the deployment of electric mobility options in Toronto. Additional roles suggested for the City include: providing an assessment of indirect impacts of actions taken under the Strategy; serving as a source of educational resources to the public on electric mobility; working closely with the TTC to deliver electrified public transit; adopting electric mobility procurement policies for its internal fleet; and leading pilots related to low-carbon freight movement in Toronto.

The electric mobility landscape is evolving rapidly, and many key stakeholder groups, including municipal governments, are scrambling to keep up with the pace of change. In such a scenario it is easy to fall victim to ‘paralysis by analysis’ and continually await the introduction of a new technology or practice that will ostensibly solve all or some of the major issues related to electric mobility. Stakeholders consulted over the course of this project, however, are uniformly eager to see actions undertaken that will have a palpable impact on Torontonians’ access to electric mobility options. And these stakeholders do not simply want to sit back and watch these actions take place, they want to take part in them. The City of Toronto has a long list of potential partners and collaborators waiting to help make the Electric Mobility Strategy a reality. It also has a long list of existing programs and policies that can be leveraged through the Strategy to ensure that impacts are felt by all of the city’s residents. By working closely with partners, monitoring new developments, implementing innovative programs, and embedding enough flexibility

within the Strategy to adapt to emerging trends and technologies, the City of Toronto can achieve its targets and also help to lead other cities towards an electric mobility future.

Using the information provided in this report and attained through stakeholder consultations to date, the City of Toronto will kick-off the development of the Electric Mobility Strategy in the first quarter of 2019. The stakeholders engaged over the course of the Assessment Phase will continue to be engaged during the Strategy's development and implementation. The City and the project team greatly appreciate the involvement and input of the wide variety of stakeholders consulted, and look forward to fostering further collaboration to advance the state of electric mobility in Toronto.