TORONTO

REPORT FOR ACTION

Preparing Toronto for Electric Vehicles

Date: October 3, 2017
To: Public Works and Infrastructure Committee
From: General Manager, Transportation Services and Chief Corporate Officer
Wards: All

SUMMARY

Electric vehicles are increasing in popularity and innovation globally because this technology presents a significant opportunity to reduce greenhouse gas emissions and emissions harmful to air quality and urban noise. In July 2017, Toronto City Council unanimously adopted TransformTO: Climate Action for a Healthy, Equitable and Prosperous Toronto. Through technical modelling and community engagement, the electrification of transportation, including personal vehicles, is one of the key strategies to meet Toronto's target of an 80% reduction in greenhouse gas emissions by 2050.

Included in the TransformTO report is the - Prepare for Electric Mobility Campaign - where the City of Toronto and partners will develop a process to support the development of an electric vehicle transition strategy for Toronto. This report is the first step towards developing that strategy and its purpose is to:

- seek Council approval to implement the Residential On-street Electric Vehicle (EV) Charge Station pilot where Toronto Hydro-Electric System Limited (Toronto Hydro) will install up to fourteen (14) EV charge stations on its electrical and street light poles at up to seven (7) locations thereby providing on-street charging of EVs in residential permit parking areas;

- provide an update on the status of the previously endorsed pilot project deploying five (5) EV charge stations at three (3) locations downtown;

- provide information on the current status of Federal, Provincial and City policies, programs and incentives supporting adoption of EVs in Toronto;

- provide an overview of international EV best-practices (see Appendix B); and

- discuss the challenges and opportunities associated with increased use of EVs in Toronto.

RECOMMENDATIONS

The General Manager, Transportation Services and Chief Corporate Officer recommend that:

1. City Council approve the Residential On-street EV Charge Station pilot to enable Toronto Hydro to utilize electrical and street light poles at two (2) locations in each of Wards 19, 30 and 32, for up to twelve (12) EVs as well as at one location opposite Toronto Hydro's facilities at 500 Commissioners St. (Ward 30) to serve two (2) EVs for a one-year period with location details seeking appropriate parking amendments, through a follow-up report to the Toronto and East York Community Council.

2. City Council request the General Manager, Transportation Services to report back to the Public Works and Infrastructure Committee with an evaluation of the Residential On-street EV Charge Station pilot at the end of a one-year evaluation period.

FINANCIAL IMPACT

The cost of implementing the Residential On-street EV Charge Station pilot will be borne by Toronto Hydro through the provision of up to seven (7) dual EV charging locations. Funding for the accompanying signage and pavement markings required to delineate the associated on-street parking spaces, amounting to $6,000, is available within Transportation Services' 2017 Council Approved Operating Budget.

In support of implementing the downtown On-street EV Charge Station pilot, funding for the five (5) single EV on-street charge stations at three locations, approximately $40,000, is available within Transportation Services' 2017 Council Approved Capital Budget. These costs include a subscription to operate, and accompanying station kiosks as well as, signage and pavement markings. Toronto Hydro would be responsible for the cost of bringing power to the EV charge station spots.

In July 2017, Toronto City Council adopted TransformTO Pathway to a Low-Carbon Future Report. One of the TransformTO long-term climate action acceleration campaigns, "Prepare for Electric Mobility", focuses on developing an electric vehicle transition strategy for Toronto. TransformTO strategies will be included in the 2018-Budget submission for Facilities, Real Estate, Environment & Energy (FREEE) as part of the 2018 Budget process for Council consideration. These strategies include requests for resources for TransformTO Planning & Research, which incorporate the strategy to "Enable Electric Vehicles" and will lay the foundation for the "Prepare for Electric Mobility" campaign.

The Deputy City Manager & Chief Financial Officer has reviewed this report and agrees with the financial impact information.

DECISION HISTORY

At its meeting on November 30, 2009 to December 7, 2009, City of Toronto Council adopted the "Power to Live Green: Toronto's Sustainable Energy Strategy" (The Sustainable Energy Strategy) (item 2009.EX36.9). The Sustainable Energy Strategy identified that the development of electric vehicle technology has the potential to assist Toronto in achieving its goals of reducing local smog and greenhouse gas emissions. http://www.toronto.ca/legdocs/mmis/2009/cc/decisions/2009-11-30-cc42-dd.htm.

On July 11, 12 and 13, 2012, City Council approved a one-year pilot project (item 2012.PW16.4) to provide curb-side charging stations for electric vehicles. http://app.toronto.ca/tmmis/viewAgendaItemHistory.do?item=2012.PW16.4

On September 11, 2012, Council approved the designation of five electric vehicle charging station parking areas for the exclusive use of electric vehicle charging for a one-year pilot project, on Ed Mirvish Way, Elizabeth Street and Wellington Street West (item 2012.TE18.68).
http://app.toronto.ca/tmmis/viewAgendaItemHistory.do?item=2012.TE18.68

On September 26, 2016, the Public Works and Infrastructure Committee requested the Transportation Services and Environment & Energy Divisions report back on expanding electric vehicle charging stations in Toronto (item 2016.PW15.0):
http://app.toronto.ca/tmmis/viewAgendaItemHistory.do?item=2016.PW15.9

On July 4, 2017, City Council unanimously adopted TransformTO: Climate Action for a Healthy, Equitable and Prosperous Toronto (item 2017.PE19.4). TransformTO identifies a pathway for Toronto to reduce our city-wide emissions by 80% by 2050. Presented in the TransformTO report were three acceleration campaigns, including a Prepare for Electric Mobility campaign which focuses on developing an electric vehicle transition strategy for Toronto.
http://app.toronto.ca/tmmis/viewAgendaItemHistory.do?item=2017.PE19.4

COMMENTS

Electric vehicles (EVs) are increasing in popularity and innovation globally because this technology presents a significant opportunity to reduce greenhouse gas emissions and emissions harmful to air quality and urban noise. In July 2017, City Council unanimously adoption the TransformTO report and recognized that accelerated implementation of EVs would help the city move closer towards the target of 80% reduction in GHG emissions by 2050.

Definition of Electric Vehicles

An electric vehicle (EV) is a vehicle that uses electricity as its primary source of energy. EVs include those powered partially or wholly by electricity and can be divided into two main categories:

1. Battery Electric Vehicles (BEVs) are powered 100% by the battery energy storage system available on board the vehicle. There is no internal combustion engine in a battery electric vehicle, therefore fuel is supplied through a connection to the electric grid. The Nissan LEAF and Mitsubishi i-MiEV are examples of BEVs.

The batteries found in battery electric vehicles are rechargeable lithium ion batteries. Lithium ion batteries are commonly used in portable electronics such as cell phones and laptop computers.

2. Plug in Hybrid Electric Vehicles (PHEVs) use both a re-chargeable battery and an internal combustion engine (ICE) powered by either gasoline or diesel with the battery being the main source of power and the ICE as a back-up source of power. The Chevrolet Volt is an example of a PHEV.

Provincial and Federal Funding and Direction for Infrastructure Implementation

Recent renewed interest in electric vehicles from federal and provincial governments has resulted in EVs being an integral part of their respective climate change program commitments. The use of EVs is recognized as a way to curb rising carbon emissions originating from the transportation sector, while tapping into innovation and growth opportunities in vehicle manufacturing and trades.

Federal
In April 2017, the Government of Canada released the Pan Canadian Framework on Clean Growth and Climate Change with a 2017 budget proposal to invest $21.9 billion over 11 years. This investment includes $3.25 million in funding for electric and alternative fuel vehicle information technology development; an additional $120 million to fund both a national network of electric vehicle stations including alternative refuelling stations, and technology demonstration projects with the aim of creating jobs while reducing GHG emissions.

Provincial
Ontario's Climate Change Action Plan (2016-2020) focuses on the sales of EVs by setting a target of 5% of all vehicles sold by 2020 to be EVs. To this end, the Provincial Electric Vehicle Incentive Program aims to make electric vehicles, plug-in electric vehicles and hydrogen-fuel cell vehicles more affordable by providing incentives of up to $14,000 in rebates to electric vehicle purchasers and up to $1,000 to install charging stations. In addition, purchasers of zero-emission vehicles (ZEVs) such as fully battery electric vehicles, will be exempt from HST.

The Province is developing a network of electric vehicle stations using an electric highway concept joining cities together by installing charging stations on highways, and at workplaces and public places across Ontario. Once completed, nearly 500 charging stations will be installed across Ontario at approximately 250 locations. This network will have the largest public network of Level 3 stations in Canada.

In late May 2017, the province released building code changes (332/12) related to the charging of EVs. The provisions will come into effect on January 1, 2018 and intend to create electric vehicle-ready homes and workplaces across the province. These changes do not apply to apartment buildings or parking spaces located outside a building.

The Province is also encouraging action on EVs through the provision of various financial grants available to municipalities, businesses and residents. The grants are funded from proceeds of Ontario's Cap and Trade program. Most recently the Province announced the Municipal GHG Challenge Fund which will fund up to 100% of eligible costs for greenhouse gas emissions reduction projects proposed by municipalities. Municipalities may request up to $10 million per project and the deadline to apply is November 14, 2017.

State of Electric Vehicles in Toronto

Major urban centres tend to experience higher EV market penetration compared to national averages.[1] As of 2016, over 1,600 EVs were registered in Toronto, and although this is a small percentage of total passenger vehicles, it is double what it was only one year ago. Figure 1 provides an overview by Ward of where people live in Toronto who have purchased EVs. As EV ownership increases, access to EV infrastructure and EVs themselves is increasingly being raised as an issue by residents. Both the City and Toronto Hydro have been making policy and program changes to support the use of EVs and those activities are summarized in Appendix A of this report.

Equitable access to EVs

Although financial incentives lower the upfront cost of purchasing a new EV (up to $14,000 in rebates for the purchase of an EV as well as up to $1,000 towards the purchase and installation of a charging station) low to moderate-income drivers are still unable to afford EVs. Currently early adopters of EVs had annual household incomes of $120,000 or more, significantly higher than the median income for Torontonians of $78,280.[2]

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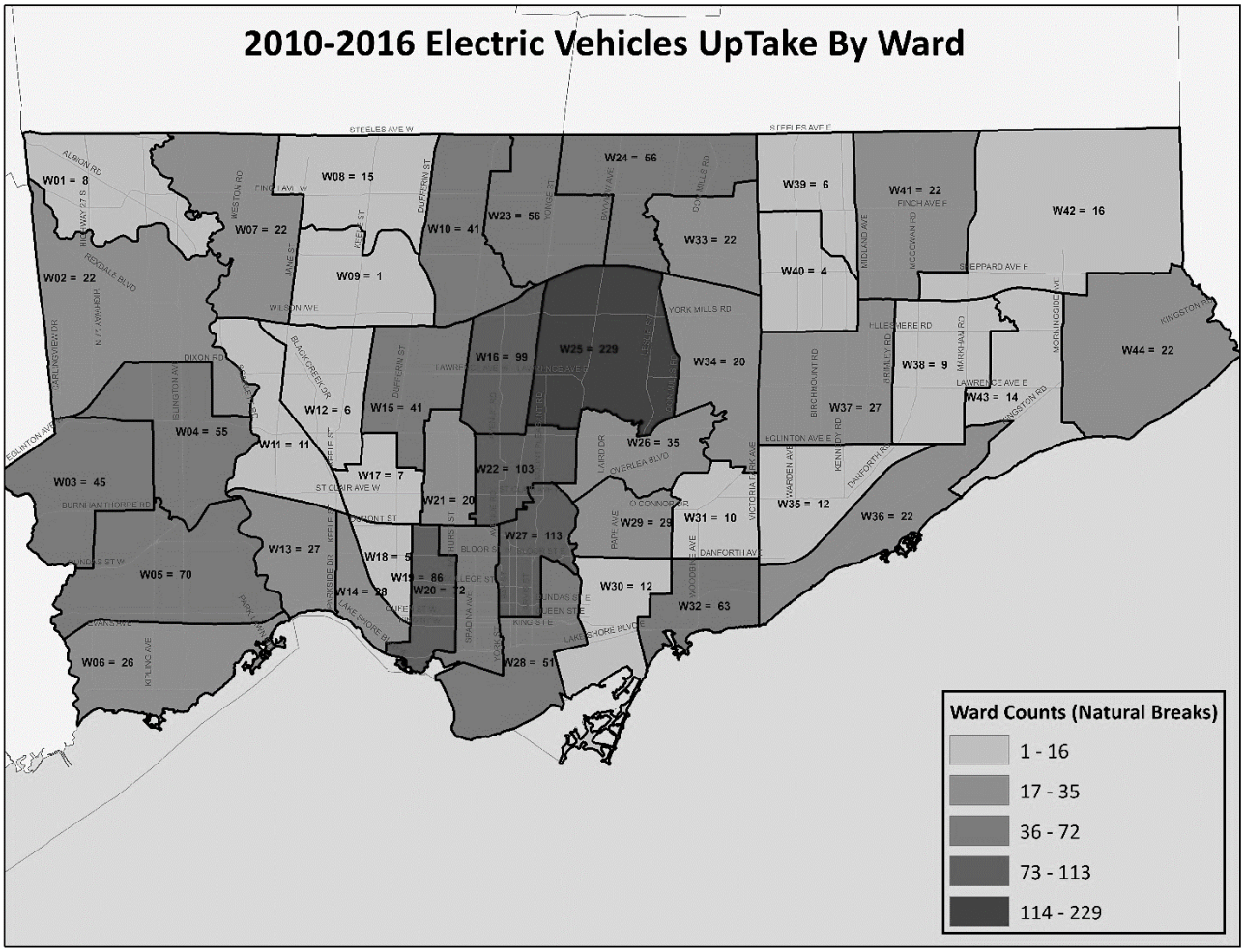
[1] The metropolitan areas with the highest electric vehicle sales in 2015 were in Shanghai (41,179 electric vehicles), Los Angeles (23,652), Beijing (18,065), and Shenzhen (17,699). The metropolitan areas with the highest share of electric vehicles sold in 2015 relative to total passenger vehicle sales were Oslo (27%), Utrecht (15%), Shanghai (11%), and Shenzhen (10%).1

[2] Statistics Canada. (2017). Median total income, by family type, by census metropolitan area (All census families) Retrieved from: http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/famil107a-eng.htm

Figure 1: Map of EV ownership in Toronto



Additional EV charging infrastructure is needed to support EV uptake in Toronto.

Availability of Charging Stations
While most EV charging is done at home (in residential driveways or garages), in urban centres like Toronto, the location of EV charging infrastructure is becoming more challenging as the city landscape changes to include more mixed-residential and mixed-used areas.

Currently, about 80% of EV charging is done at home, as most early EV adopters live in single-family houses with on-site parking and access to an electrical outlet. However, many Torontonians do not have on-site parking and rely on the City's residential permit parking system to be able to park on-street close to their place of residence. This presents a major challenge for potential EV owners living in these areas. Some EV owners in such circumstances, have been observed to extend cords over or under sidewalks, or affix unauthorized devices to public infrastructure in order to charge their vehicles. Not only is this illegal, violating City bylaws and Provincial Electrical Code Regulation, but it constitutes a serious public safety hazard. To address this issue, Transportation Services with the support of Toronto Hydro, is proposing the creation of a pilot program.

Residential On-street EV Charge Station Pilot

The Residential On-street EV Charge Station pilot will provide EV charge stations in residential permit parking areas with either no or a limited opportunity for charging personal EVs on private property. This will be accomplished by deploying EV charge stations on electrical and street light poles owned by Toronto Hydro with direct access to on-street spaces that would be designated for this purpose. The pilot would help the City and Toronto Hydro:

- understand the technical constraints associated with installing electric vehicle charging on or very near poles in these areas;
- understand usage patterns and optimal locations for use; and
- test payment systems and infrastructure.

To test the concept, Toronto Hydro has set aside enough funding to place EV charge stations at two locations in each of Wards 19, 30 and 32, for up to twelve (12) EVs. These wards were selected based on significant resident interest. While details of the locations and associated parking by-law amendments will be the subject of a future report to the Toronto and East York Community Council, the following criteria has been established to identify candidate sites:

- in a permit parking area with available permits (i.e. < 90% capacity);
- on a street block with at least two fewer permits issued than parking spaces available;
- on a street that does not have any daytime parking restrictions or alternate side of street parking;
- on a street that has the presence of electrical or street light poles placed between the back of curb and sidewalk;
- on a street that allows for the placement of two parking spaces (ideally) end-to-end on-street without encroaching on driveways, intersections, fire hydrants, or other significant encumbrance; and
- in an area that provides sufficient electrical capacity and can otherwise support the EV charge stations.

As part of the pilot, Toronto Hydro has also requested the placement of one dual EV charge station at one location (i.e., two EV parking spaces on-street) directly in front of 500 Commissioners Street, its main service centre within an industrial area with available on-street parking used by employees and visitors. A charge station at this location would allow Toronto Hydro to promote and directly monitor the functionality of the charge stations associated with the pilot. It is intended that this pilot location would be in operation before or concurrently with the other pilot locations. Transportation Services will report back on the Residential On-street pilot upon final By-law approvals at Community Council.

Downtown On-street EV Charge Station Pilot
In July, 2012 Council approved an on-street charge station pilot for three locations downtown but this project was put on hold while a partnership agreement was established between Transportation Services and Toronto Hydro. Early in 2017, Toronto Hydro informed Transportation Services of their interest in completing the originally envisioned Downtown On-street EV Charge Station pilot.

Concurrent with the Residential On-street EV Charge Station pilot, Transportation Services is working with Toronto Hydro to implement the Downtown On-street EV Charge Station pilot comprising of five EV Charge Stations deployed at three downtown locations to service short-term (up to three hours) EV charging in public on-street space.

The three EV charge station locations (with up to five EV spaces) are:
- Ed Mirvish Way, east side, from a point 24.0 metres north of King Street West to a point 11.0 metres further north (2 spaces - Under review due to development proposal)
- Elizabeth Street, east side, from a point 9.0 metres south of Foster Place to a point 5.5 metres further south (1 space); and
- Wellington Street West, south side, from a point 37.0 metres east of Clarence Square to a point 11.0 metres further east (2 spaces).

Deployment of the EV charge stations at these locations is anticipated November 2017.

Reporting on the Lessons from the Charge Station Pilots
The two on-street EV charge station pilots outlined in this report will help the City and Toronto Hydro increase its understanding and knowledge about:
- the technical aspects associated with the installation and maintenance of EV charge stations in the City's right-of-way;
- changes required in the City's operating procedures around road maintenance, snow removal and other operations needed due to the presence of the on-street charge stations; and
- the potential use and issues associated with the use of these stations.

Upon completion of the one-year pilot period, the General Manager, Transportation Services will report back to the Public Works and Infrastructure Committee on the following:

a. Location and parking space selection criteria and considerations;
b. Operational issues, including charger availability, space utilization and enforcement;
c. Outreach efforts to bring these spaces to the attention of EV owners;
d. Required signage and pavement markings; and
e. Revenue generation opportunities.

Multi-Residential Buildings and Condominiums
Residents living in multi-residential buildings and condominiums may experience a significant barrier to purchasing EVs, as there may not be available EV charging infrastructure in their building.

To help address this issue in all new buildings, The Toronto Green Standard includes mandatory provision of electric vehicle supply equipment (EVSE) in all new residential buildings. Tier 1 of TGS requires the physical provision of EVSE when excess parking is being provided above the number of parking spots required by the Zoning By-Law. Voluntary Tier 2 encourages the provision of 2% or more of residential parking designated for EVs.

Additionally, for all building developments governed by Waterfront Toronto, the Minimum Green Building Requirements (MGBR) now mandate the provision of EV infrastructure for 2% of tenant parking spaces in all new residential buildings. This includes a minimum Level 2 EVSE that provides the ability to bill the user for the electricity delivered to each parking space.

However, for many people who live in existing multi-residential buildings and condominiums, there may not be any charging infrastructure. There are legislative, regulatory and financial issues that must be addressed to support the retrofitting of existing multi-residential buildings for EV charging.

For example, under the Ontario Condominium Act 1998, Condominium Boards have authority to regulate common use of property and decide what elements should be considered in building modifications including provision of additional electricity outlets in areas such as tenant parking garages. Currently costs incurred by EV owners using these outlets would be shared among all tenants as opposed to the owner of the EV.

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

Charging in public spaces
Installing EV charging infrastructure in common public areas like community centres, schools, churches etc., can help address the shortage of EV charging infrastructure for EV owners without driveways or garages. However, changes to Zoning By-Laws may be required to allow for public EV infrastructure installation on such sites and may also raise safety and privacy issues. While addressing these barriers may be problematic, investigating these options presents an opportunity to increase EV adoption in Toronto.

Privately-owned charging spaces
Private businesses can help address the EV charging infrastructure shortage by hosting EV chargers on their property. For example, property managers in downtown office buildings, such as Oxford Properties Group has added 14 EV parking stalls and seven Level 2 chargers in their lots to accommodate employees with EVs and encourage low-emission vehicle adoption. In 2015, IKEA announced the installation of free charging stations in all its Canadian stores: 6 are located in North York, 2 of which are fast-chargers.

Electric Grid Capacity and Safety Issues
An increased adoption of EVs includes ensuring the electrical distribution system has the capacity to accommodate EV charging which is necessary to build a robust and reliable EV charging network in the city of Toronto.

Research has showed early EV adopters tend to cluster in specific neighborhoods and share similar charging patterns, for instance charging between 7pm and 9pm. As a peak demand issue, multiple vehicles charging on the same street simultaneously could potentially lead to localized electrical service disruption, particularly as the number of EV owner households increase.

Toronto Hydro is actively working on this issue and in 2016 completed the Charge TO project with its industry partners to manage local electrical impacts. Toronto Hydro has also created web-based educational material and various social media material towards encouraging EV charging to avoid local impacts.

Vehicle to grid
An opportunity exists for electric vehicle owners to benefit from emerging smart grid technologies, and even use their vehicles as emergency back-up power for their homes in the event of a power failure, known as vehicle-to-grid (V2G) systems. V2G is a mechanism used by utilities to control customer loads and it allows EV owners to generate revenue by feeding stored battery power from their vehicles back to the electrical grid during peak demand, and then fully recharging at night when energy prices are at their lowest. EV owners would require additional electrical infrastructure, namely a V2G-capable inverter box, installed in their vehicle to convert the DC battery power to volt alternating current (VAC). In order for wider adoption of V2G systems, local government and utilities must work together to find balance between promotion of active technologies and implementation of the City's long-term environmental, social and economic plan.

Next Steps

With growing support for EV adoption from the federal and provincial government, EV innovation in the automotive industry, as well as international and local mobilization around climate action, widespread electric vehicle adoption in Toronto is inevitable. The City of Toronto needs to be prepared for increased public interest in EV adoption, as well as a growing need for EV charging infrastructure. Toronto needs to ensure its policies, bylaws and regulations support the increased use of EVs in balance with other City priorities and issues like safety and security.

Facilitated by the Environment and Energy Division, the City's interdivisional EV Working Group has seen collaboration on research studies, pilot projects and public engagement campaigns. The EV Working Group currently includes representation from Economic Development, Fleet Services, Toronto Hydro, Transportation Services, Toronto Zoo, The Atmospheric Fund and the Environment & Energy Division. In addition, the EV Working Group has engaged with staff from relevant Provincial Ministries and organizations, such as, Plug'n Drive.

In order to reduce greenhouse gas emissions and pollutants that impair air quality, there must be a reduction in emissions from motor vehicles. Reducing emissions from motor vehicles requires a number of approaches and actions, such as, creating more opportunities to leave the car at home by increasing cycling and pedestrian infrastructure and improving and expanding transit services.

As highlighted in the TransformTO report, the electrification of transportation is part of how Toronto will see a reduction in vehicle emissions. The Prepare for Electric Mobility Campaign outlined in the TransformTO report will be the forum for engaging residents and partners in implementing an approach that supports electrification but also asks the question, how can the electrification of transportation occur so that addresses City building goals around equity, health and prosperity.

The EV Working Group will be the starting point for the development of that campaign and the potential activities of the Work Group are outlined in Appendix C of this report.

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ATTACHMENTS

Appendix A: Toronto policy and program updates
Appendix B: Innovation in the Electric Vehicle Sector
Appendix C: EV Working Group Areas of Future Work

Appendix A: Toronto policy and program updates

To prepare Toronto for broad-scale adoption of EVs, the City of Toronto, its partners and agencies, as well as external stakeholders, have been working on addressing some of the identified challenges.

EV Working Group

In mid-2010, the Electric Vehicle Working Group was established and is comprised of staff from City Agencies, Divisions and Corporations. The EV Working Group has held working sessions with non-profit, academic and business partners to explore issues related to the introduction of electric vehicles to the consumer market. It has also invited comments from the public on electric vehicles which are summarized here: http://www1.toronto.ca/city_of_toronto/environment_and_energy/key_priorities/files/pdf/electric_vehicles_cocmment_wall_summary.pdf.

Almost 90 comments have been posted on the comment wall. In general, comments have been wholly supportive of the City playing a role regarding the introduction of electric vehicles in the City.

The EV Working Group has examined policies and programs of cities across the globe regarding the introduction of electric vehicles. Some highlights of international best-practices on EV implementation are enclosed in Appendix B.

Additionally, different members of the EV Working group have been involved in policy development, research studies and projects pertaining to electric vehicle implementation in Toronto and the Greater Toronto and Hamilton Area (GTHA). Overview of key projects and findings is provided in the next sections.

City of Toronto Divisions – Electric Vehicle Projects and Programs

City Planning

A required component of the Toronto Green Standard (TGS) – Tier 1 which applies to all new mid to high-rise residential development and all industrial, commercial and institutional (ICI) development, requires the physical provision for electric vehicle charging when excess parking is being provided above the required number of parking spaces denoted in the Zoning Bylaw. These required parking spaces must be distributed on each parking level of the building.

In the case of the ICI sector, when exceeding the required minimum number of parking spaces required under the Zoning bylaw, any excess spaces must be dedicated as priority parking spaces for low emitting vehicles (LEV), carpooling or car sharing.

A voluntary component of the TGS – Tier 2 encourages electrical provision for at least 2% of residential parking spaces for future EV charging.

Fleet Services – Green Fleet
In "The Power to Live Green: Toronto's Sustainable Energy Strategy" Fleet Services was directed to introduce electric vehicles into the City's fleet as part of the City's Green Fleet Strategy. Since 2004, Fleet Services through the Green Fleet Strategy has replaced more than 500 conventional vehicles with more fuel efficient and alternative fuel vehicles. By the end of 2016, Fleet Services fleet included five full electric vehicles (one Mitsubishi i-MiEV, two Nissan Leaf and two Ford Transit Cargo Electric Vans), six plug-in hybrids and 335 electric-hybrid vehicles.

Furthermore, there are currently twenty (20) City-owned electric vehicle charging stations in Toronto: one DC fast charging (Level 3) and nineteen Level 2 charging stations, available to City vehicles only, located at the following eight City 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

The Atmospheric Fund
The Atmospheric Fund (TAF) has funded York University to pilot a solar-powered EV charging station on campus and to undertake research and analysis on the environmental and business case for building and operating such stations in Toronto.

Recently TAF also funded Plug ‘n Drive to research which factors drive the uptake of EVs in the Greater Toronto and Hamilton Area, and to develop and disseminate evidence-based recommendations based on these factors. This project culminated in the recent report, Driving EV Uptake in the Greater Toronto and Hamilton Area. The report, based on a survey of 1,000 gasoline-powered car owners and almost 200 EV owners across the GTHA, explored the behaviours, perceptions and beliefs that shape local consumers’ car purchasing decisions.

Environment & Energy Division
The Environment and Energy Division continues to support EV adoption in Toronto through policy and planning. The EED, in partnership with The Atmospheric Fund, recently completed the development of the City's new climate action plan - TransformTO: Climate Action for a Healthy, Equitable and Prosperous Toronto.

As transportation-related emissions account for over 35% of overall emissions in Toronto, one of the key recommendations from TransformTO is for 100% of transportation options, including personal vehicles, to use low or zero-carbon emission fuel by 2050. To reach that goal, TransformTO's implementation plan includes a Prepare for Electric Mobility campaign which focuses on the development of an electric vehicle transition strategy for Toronto.

Taxi By-Law Update
In 2014, Toronto City Council directed all taxicabs in Toronto to transition to low-emission, or 'green' vehicles, to help reduce emissions associated with transportation. City of Toronto By-law No. 503-2014, requires all taxicabs to be replaced with an alternative fuel, or hybrid vehicles, at the scheduled time of replacement. City Council set a goal for all sedan taxi cabs to be 'green' vehicles by 2021.

Summary of private and non-for profit activities

As widespread electric vehicle adoption seems fast approaching, sectors outside of the federal, provincial and municipal government have had an opportunity to show leadership in EV implementation. Stakeholders in the private and non-profit sectors in Toronto have supported the adoption of electric vehicles and necessary infrastructure, through various education, engagement and research projects.

Plug'n Drive
Founded in 2011, Plug'n Drive is a non-profit organization focusing on accelerating the adoption of EVs through awareness and education; supporting the installation of charging stations; as well as supporting EV focused research and policy. Recently, Plug'n Drive partnered with TAF on EV uptake research study for the GTHA. Plug‘n Drive is meeting with key decision-makers from industry, government and civil society to share recommendations from the study in support of Ontario’s ambitious goal of increasing the share of EVs to 5 % of new car sales by 2020.

Plug'n Drive's new EV Discovery Centre in North York provides an experiential learning environment to potential car owners by including an opportunity to test drive several popular models of electric vehicles.

Pollution Probe
Pollution Probe is a Canadian non-profit environmental organization involved in environmental and health focused research, education and advocacy. As a part of their work, Pollution Probe has been involved in supporting EV adoption and infrastructure preparedness in Canada and Ontario.

In 2013, Pollution Probe, with municipal, provincial and private sector partners, launched an Electric Mobility Adoption and Prediction (EMAP) project that focused on identifying barriers and opportunities to EV adoption in several local municipalities, including the City of Toronto. The EMAP Toronto report provides an overview of early EV adopter demographics in Toronto, as well as highlights neighbourhood-level electrical grid capacity and capital investment opportunities. Pollution Probe also recently released several EV-related research studies and reports, including the 2016 Accelerating the Deployment of Plug-In Electric Vehicles in Canada and Ontario report which provides recommendations to further accelerate local EV adoption and an EV-Grid Gap Analysis Study which includes an overview of local utility sector's preparedness for wide-spread EV adoption.

Partners in Project Green

Partners in Project Green (PPG), a collaboration between the Greater Toronto Airport Authority and Toronto Regional Conservation Authority focusing on greening business operations around the Pearson Airport Zone, recently completed an electric-vehicles infrastructure pilot project. Between 2014 and 2017, PPG and 17 of their partner business organizations installed 124 EV charging stations across the GTA. The project focused on identifying easy and cost-effective processes that would support businesses in installing EV charging infrastructure. As a part of the project, PPG offered subsidies for EV charging station installation costs and produced a 'how-to' report to guide future interested businesses in EV infrastructure installation.

Appendix B: Innovation in the Electric Vehicle Sector

1. International best practices

As electric vehicles begin to gain popularity worldwide, many municipalities and countries are showing leadership in supporting electric mobility. A scan of international best-practices has identified several key characteristics in successful EV adoption on a municipal and regional scale. A recent review of electric-vehicle policies in fourteen major metropolitan areas that are leading in electric-vehicle adoption in Europe, China and North America, attributed successful EV implementation to:

- Financial and non-financial incentives;
- Research and community engagement through awareness campaigns; and,
- Availability of charging infrastructure.[3]

Incentives

Financial subsidies, credits and rebates are a popular method to encourage EV uptake. Internationally, the types of financial incentives for EVs vary. While most incentives are offered by the federal or regional government, some additional incentives are offered by municipalities as well (Table 1).

In the United States, for example, an income tax credit of up to $7500 is offered for the purchase of an electric vehicle. Some states offer financial incentives in addition to the federal tax credit, with the state of California, for example, providing a rebate of up to $2500 to EV owners. Similarly, in China, a federal subsidy of up to 54 000 CNY ($10 000 CAD) is combined with a regional and municipal subsidies ranging from 20 000 CNY to 44 000 CNY ($ 3500 CAD to $ 8000 CAD). [4]

[3] Hall D., Moultak M., and Lutsey N. 2017. *Electric Vehicle Capitals of the World: Demonstration the Path to Electric Drive.* The International Council on Clean Transportation. Retrieved from: http://www.theicct.org/sites/default/files/publications/Global-EV-Capitals_White-Paper_06032017_vF.pdf

[4] Yang, Z., Slowik, P., Lutsey, N., & Searle, S. 2016. Principles for effective electric vehicle incentive design. Retrieved from http://www.theicct.org/principles-for-effective-EV-incentive-design

Table 1: Examples of financial and non-financial incentives for EV ownership

Jurisdiction	Financial Incentives	Non-financial incentives
California, United States	Federal tax credit of up to $7500 Regional rebate of up to $2500	Regional: Access to HOV lanes Preferential utility EV charging rate City parking benefit
China	Federal subsidies of up to 54 000 CNY ($10 000 CAD) Regional and municipal subsidies of up to 60 000 CNY	Federal: Subsidies for a reserved parking space in centre district Exceptions from restrictive license place auction Regional: One hour of free parking Exemption from vehicle registration lottery Exemptions from traffic restrictions
Amsterdam, Netherlands	Exemptions from vehicle registration and road taxes €5000 subsidy for fully electric taxis	Priority for EVs in low emission zones Residential parking permit priority
Oslo, Norway	No purchase or import tax on EVs Low annual road taxes Exempt from ferry or road tolls	Free parking zones Free electricity for normal charging Bus lane access
London, UK	Federal grant of up to £4500 EVs except from annual circulation tax	Exception from congestion charges Free or reduced parking costs in some areas

Source: Adapted from Hall, Moultak and Lutsey. 2017. Electric Vehicle Capitals of the World: Demonstration the Path to Electric Drive. The International Council on Clean Transportation.

In addition to tax credits and rebates for electric vehicle purchase, many regions offer other tax exemptions, subsidies and credits, including: exemptions from vehicle taxes; credit towards a purchase of other low-emission vehicles (i.e. e-bikes and mopeds); exemptions from road tolls; exemption from vehicle registration tax; and tax refunds on electricity used to charge electric vehicles. The California Air Resources Board has a program to promote low income individuals to switch out their older high emission vehicles for more fuel-efficient cars (including EVs).Although subsidies are available to individuals of various income levels, individuals whose earnings fulfill the low income criteria receive additional rebate amounts to reduce barriers to widespread EV ownership.[5]

Apart from financial incentives, behaviour-focused or non-financial incentives and disincentives are offered to encourage a shift to electric mobility. For example, Oslo, Norway, where electric vehicles sales share is over 25%, offers free municipal parking, as well as free electricity for normal charging and bus lane access to electric vehicle drivers. Other similar incentives worldwide include: exemption for vehicles/ license registration lottery; subsidies for reserved parking; exemption for traffic restrictions and congestion charges; priority for electric vehicles in restricted zones; and preferential utility EV charging rate.

Research and Community Engagement

As electric vehicle technologies continue to evolve, the public sector can support innovation and broad-scale adoption of EVs through research and community engagement initiatives. Different levels of government, research institutions, utility companies and other non-government organizations worldwide are becoming more engaged in supporting EV research as well as community engagement campaigns. Various consumer awareness schemes and education campaigns have been utilized by municipalities in conjunction with EV incentives and infrastructure roll-out.

The City of London, UK, combined EV infrastructure installation with a community engagement and behaviour change campaign to address poor neighbourhood-level air quality in various areas in London. As a part of the Go Ultra Low "Neighborhoods of the Future" campaign, six neighborhoods in London were selected to host various EV infrastructure pilots inducing a zero-emission zone, 'electric streets' with a high concentration of EV chargers, and rapid charging stations for EV taxis. In addition to infrastructure pilots, the projects included training for mechanics to increase their familiarity with EVs as well as broad-scale community and business engagement campaign to encourage behaviour change.[6]

[5] California Air Resources Board. (2017). Income Eligibility. Retrieved from: https://cleanvehiclerebate.org/eng/income-eligibility

[6] UK government announces new investment to boost 'green' car adoption. 2016. Traffic Technology Today. Retrieved from http://www.traffictechnologytoday.com/news.php?NewsID=76903

Electric-vehicle demonstration centres or zones have been piloted in several municipalities and provide an opportunity for the public to become more familiar with EVs and related technologies. The Beijing New Energy Vehicle Experience Centre and Shanghai's Jiading District EV demonstration zone, for example, offer the public an opportunity to test different EV models, connect with various automotive companies, as well as learn more about electric vehicle technology[7]. A similar facility is run by Plug n' Drive in Toronto.

In North America, cities in the U.S. and Canada hold a number of outreach and informational events during the National Drive Electric Week. The week long, EV focused awareness campaign is supported by the automotive industry, non-profit sector, local utility companies and municipalities. The campaign takes place in early fall and includes events around EV education, opportunities to test-drive EVs and talk to other EV owners.

In Canada, EV research and innovation is being supported through the launch of several research centres like the Red River College's Electric Vehicle Technology & Education Centre (EVTEC), and University of Waterloo's Green and Intelligent Automotive (GAIA) Research Facility. Many of the research projects supported in these types of institutions focus on testing, modifying and improving the performance of new EV technologies and charging infrastructure.

Charging infrastructure

Availability of charging infrastructure can enable or impede the rate of adoption of electric vehicles locally. Federal, regional and municipal levels of government, in counties that have shown leadership in EV adoption, have invested in charging infrastructure by:

- Installing public charging stations;
- Providing subsidies to residents and businesses to install charging stations, and;
- Providing EV charging at a subsidised or free rate at public locations.

[7] Hall, Moultak and Lutsey. 2017. Electric Vehicle Capitals of the World: Demonstration the Path to Electric Drive. The International Council on Clean Transportation. http://www.theicct.org/sites/default/files/publications/Global-EV-Capitals_White-Paper_06032017_vF.pdf

Most municipal-level involvement in the provision of public charging infrastructure is supported by federal and regional levels of government. In China, where EVs accounted for nearly 1% of all vehicle sales in 2015[8], the federal and regional governments, in collaboration with state-owned utility company, are building networks of fast-charging stations across the country. The country has set a target of having one charging station per every 2000 EVs by 2020. The state government also provides support to municipalities by subsidising construction of local charging stations.[9]

Norway, the world's leader in electric mobility, where market share for EVs was at 29% in 2016, set a target to install charging stations every 50 kilometers on all main roads by 2017. To further accelerate EV adoption locally, Norway's capital city Oslo has further invested in local EV charging infrastructure. The City of Oslo owns over 1000 public charging points, hosts the world's first indoor EV charging garage and works with the private sector partners to promote the installation of fast chargers at workplaces, bringing the total number of EV charging ports available in the city of 650 000 people to 2000 by 2016.[10]

In addition to direct government investment into state-owned charging infrastructure, many governments encourage wide-spread installation of charging stations by providing subsidies to residents and businesses, as well as supporting public-private partnerships.

As the installation of public charging stations does not provide a viable business case in most scenarios, public-private partnerships have been utilized to help alleviate financial inefficiencies. Nation-wide installation of over 7000 public charging stations in the Netherlands has been made possible by leveraging private capital in combination with up-front government investment. On a local level, urban centres like Rotterdam and Amsterdam manage the tender process for the private installation and operation of public charging stations.[11]

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[8] Hall, Moultak and Lutsey. 2017. Electric Vehicle Capitals of the World: Demonstration the Path to Electric Drive. The International Council on Clean Transportation. http://www.theicct.org/sites/default/files/publications/Global-EV-Capitals_White-Paper_06032017_vF.pdf

[9] Shanghai Municipal People's Government. (2013, April 19). Municipal Development and Reform Commission and seven other departments to develop the "Shanghai Electric to encourage the development of electric vehicle charging facilities interim measures." Retrieved from http://www.shanghai.gov.cn/nw2/nw2314/nw2319/nw2404/nw31171/nw31173/u26aw35461.html

[10] Portvik, S. 2016. Oslo – The EV Capital of the World. City of Oslo. http://www.polisnetwork.eu/uploads/ModuleXtender/PublicEvents/375/3_-_Oslo_EV_Capital_of_the_world_-_Sture_Portvik.pdf

[11] E-Mobility in the Netherlands. 2015. Netherlands Enterprise Agency. Ministry of Economic Affairs. https://www.rvo.nl/sites/default/files/2016/05/Brochure_E-mobility_in_The_Netherlands_WT_accessible_web.pdf

Free charging at publicly-owned charging stations is another popular method to provide accessible EV infrastructure. In Los Angeles, and other cities in California, most public charging locations at libraries, museums, post offices and utility companies offer EV charging free of charge. Throughout North America, many automakers invested in promoting their EV technology, offer free EV charging for specific car models via partnerships with private EV charging infrastructure organizations like EVgo.

A Toronto-based company called SWTCH, in partnership with MaRs Clean Tech, the Centre for Social Innovation, and Ryerson University's Clean Energy Zone, is seeking to expand the current charging infrastructure to include peer-to-peer rental charging opportunities. SWTCH is a web-based app that allows private EV owners to co-ordinate and schedule charging time from private charging station owners for a fee. Based on the price of electricity at the time of charge, make and model of the EV and duration of charge, fees will vary and are set by each charger owner. Although SWTCH is still in its initial phase of creating a market for its service, peer-to-peer charging would contribute to the removal of barriers to EV ownership.

2. Car-share

With the overall landscape of urban mobility changing worldwide, car-shares are enabling a new generation of urban residents to re-consider car ownership. Growing in popularity, a variety of car-sharing services are now offered in most urban centres. To set themselves apart from the competition, and positively contribute to urban air quality, some car-share companies choose to go fully electric.

One of the biggest, and most successful international examples of an EV car-share program is Autolib in Paris, France. Autolib started as a traffic and air pollution-reduction project championed by the former mayor of Paris. From its launch in 2011, the car-share evolved into a successful partnership between the City of Paris and private car-share operator – Bollore enterprise.[12] In 2015, the EV car-sharing service had over 3500 cars, 1000 charging stations and 100 000 subscribers. The service continues to be actively promoted by the City of Paris, offering subsidies for service subscription in exchange for resident's willingness to give up car ownership. Although uncertainty about financial profitability of the scheme still exists, with the municipality currently subsidising the cost of each station, the car-share program has been linked to an overall reduction of car ownership in Paris. Moreover, EV car ownership in Paris has been further encouraged by the broad-scale presence and familiarity of Autolib, as service subscribers can charge their private vehicles at Autolib stations.[13]

[12] *Electric car-sharing service – Autolib*. 2015. The LIFE Centre for Climate, Energy and Society. Retrieved from: http://pocacito.eu/sites/default/files/Autolib_Paris.pdf

[13] Fremiot, A. 2016. *Autolib and the experience of Paris car sharing*. City of Paris. Retrieved from: https://www.carplusbikeplus.org.uk/wp-content/uploads/2016/03/2.-A-Fremiot-City-of-Paris.pdf

Following in the footsteps of other EV car-share programs, more EV car-shares are rolling out in other cities. In 2011 Car2go in Rotterdam, Netherlands launched a fully electric car-share program with 350 EVs.[14] Locally, Zipcar provides rental EVs in the GTA with rates starting as low as $9.25/hour or $70/month (including fuel and liability insurance), and allows users to reserve cars online or using the Zipcar app. However, immediate success of EV car-share is not a guarantee, with San Diego's EV Car2go fleet recently switching back to gas-fueled cars due to a lack of charging infrastructure.[15]

Equity and electric car-shares

Recognizing access to vehicle-ownership, and EV ownership specifically as a social equity issue, some municipalities chose to address this inequity through public EV car-shares.

City of Sacramento, California partnered with the local utility and air quality agencies to finance an electric car-share program for low-income communities. The Our Community, Car Share program offers an eight-vehicle electric car-share program free of charge to residents in several public housing complexes. The program was funded through a $1.3 million grant from the California Climate Investments (CCI) fund.[16]

Similarly, Los Angeles, California is launching a new electric car-sharing service that is specifically designed to provide low-income residents with an affordable and accessible transportation option. BlueLA pilot will start with 40 EVs and 100 charging stations, locations for which will be picked based on the feedback from LA residents. The pilot was funded with a $1.7 million grant from California Climate Investments (CCI) fund and will focus on providing EV car-share infrastructure in seven low-income areas in LA. Depending on the income of users, a rebate on car rental fees will be applied.[17]

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[14] E-Mobility in the Netherlands. 2015. Netherlands Enterprise Agency. Ministry of Economic Affairs. https://www.rvo.nl/sites/default/files/2016/05/Brochure_E-mobility_in_The_Netherlands_WT_accessible_web.pdf

[15] Garrick, D. March 16, 2016. *Car2go switching electric cars to gas.* The San Diego Union Tribune. Retrieved from: http://www.sandiegouniontribune.com/news/politics/sdut-car-share-car2go-fleet-gas-electric-2016mar16-story.html

[16] *Our Community CarShare Sacramento Launch*. May 5, 2017. California Air Resources Board Press Release. Retrieved from: http://www.publicnow.com/view/0B95E6B85FCA7E2CE43F38F36C9108290C7D0433?2017-05-05-23:01:16+01:00-xxx7914

[17] Spacek, Rachel. (2017). New L.A. car-sharing service aims to serve low-income neighborhoods. http://www.latimes.com/business/la-fi-bluela-20170609-story.html

3. Alternative electric vehicle technologies

While most of the municipal work on electric-vehicle adoption has focused on cars, other electric vehicles, like buses and e-bikes, present viable alternatives to further reduce congestion and transportation-related emissions. Municipalities worldwide have been involved in various alternative electric vehicle projects including municipal fleet pilots, and community & infrastructure pilots.

Several municipalities are involved in testing alternative EV technologies as a part of their public transit system. For example, Berlin introduced four fully electric buses that charge wirelessly through inductive technology into their fleet in 2015.[18] The project was funded by German Federal Ministry of Transportation and will test the performance of the vehicles while they are in service. In Vancouver, a first electric bus has been recently included in the city's TransitLink fleet to pilot the technology as a part of the city's regular transit operation.

E-bikes and scooters are also a popular type of electric vehicles supported by municipalities to encourage the adoption of various e-vehicles locally. E-bikes have steering handlebars, working pedals, an electric motor under 500 watts and typically travel at a maximum speed of 32 km/h.[19] Unlike the traditional mechanical bicycle, there is an age requirement for e-bikes of least sixteen years in order to operate an e-bike and the user must wear a helmet (on a traditional bicycle only those under the age of eighteen must wear a helmet in Ontario). Unlike a moped or motor scooter, no registration, insurance or license plate is required to operate an e-bike in Ontario.[20] E-bikes and e-scooters are not classified as motor vehicles under the Highway Traffic Act.

[18] Bombardier. 2015. Berlin – The First Capital City with a wirelessly charger e-bus line. Retrieved from: http://www.bombardier.com/en/media/newsList/details.bt_20150901_-berlin-erste-hauptstadt-mit-kabellos-geladener-e-bu.bombardiercom.html

[19] City of Toronto. (2017). Power Assisted Bicycles. Retrieved from: https://www1.toronto.ca/wps/portal/contentonly?vgnextoid=aaf885d32acd1410VgnVCM10000071d60f89RCRD&vgnextchannel=f4d4970aa08c1410VgnVCM10000071d60f89RCRD

[20] City of Toronto. (2017). New and Emerging Vehicles E - bikes, Mopeds and Motor Scooters. Retrieved from: https://www1.toronto.ca/city_of_toronto/transportation_services/cycling/files/pdf/fact-sheet-123-new-and-emerging-vehicles.pdf

Consequently, they are neither permitted on provincial controlled access highways, nor municipal roads (including sidewalks) where bicycles are banned.[21] According to the City of Toronto's Municipal Code, e-bikes and e-scooters are prohibited from bicycle lanes/paths, and trail/park paths.

In Stuttgart, Germany the local utility company EnBW, with the support from German Federal Ministry of Transportation, provided 500 electric scooters to residents that applied to test the vehicles for one year.[22] Smaller electric vehicles, like bikes, are seen as an opportunity to provide a last-mile connection for city trips.

4. Conclusion

International best-practices that focus on promoting broad-scale EV adoption include a variety of practises made up of financial and non-financial incentives for residents and business, EV awareness and community engagement, installation of local EV charging stations, and research.

Municipal leaders in EV adoption worldwide continue to push boundaries and support EV innovation by piloting new EV technologies in their fleets, supporting EV car-shares for low-income communities, and engaging in public-private partnerships to cost-effectively install EV charging infrastructure.

With EV popularity and innovation growing globally, Toronto has a unique opportunity to demonstrate its commitment to a low-carbon future by supporting broad-scale EV adoption locally. Local implementation of a combination of some international best-practices could position our city as a leader in electric mobility in the near future.

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[21] The City of Toronto has designated two types of e-bikes: pedelecs and e-scooters. Pedelecs are considered to be bicycles, and are treated as such legally. This means that a pedelec is allowed on the same cycle tracks, paths and trails as any other bicycle. They must weigh less than 40 kg and require the user to pedal for propulsion. However, an e-scooter is not allowed on multi-use trails nor cycle tracks. These vehicles meet the provincial specifications of an e-bike but not City of Toronto specifications of a pedelec.
On a technical level, e-bikes are typically either mid-drive (with the motor attached to the crank in the middle of vehicle) or hub drive (with the motor attached to either the front or rear hub of the wheel). Friction driven e-bikes, with a roller spinning on the bicycle's tire to fuel a generator (similar to early 'dynamo lighting' systems on bicycles where a small generators would turn on the side of the tire to power the bike's lights), are less common on commercially sold models.
E-bikes can be designed as pedal assist vehicles, where the electric motor assists a user who is pedalling to propel the vehicle forward. Alternatively, e-bikes can also be designed to provide full-power with limited pedalling by the user. Modern e-bikes typically use a lithium ion battery, and the charger normally comes with the vehicle. The industrial batteries used in e-bikes must be properly disposed of in order to reduce contamination risks

[22] Stuttgart Region Economic Development Corporation. 2010. The Stuttgart Electric Mobility Pilot Region. Retrieved from: http://www.prosesc.org/fileadmin/Download/Policy-recommendations_and_tools/E-Mob_Pilot_Region_Stuttgart.pdf

APPENDIX C: AREAS OF FUTURE WORK

Leading by example
The City in its own fleet has transitioned over 300 internal combustion engine (ICE) vehicles to EVs and electric-hybrid vehicles and installed 20 charging stations at 8 City locations. The City can continue to show leadership and some areas of action are:

- Fleet Services will continue to expand its decision making matrix in an effort to replace City fleet vehicles with electric vehicles where available and cost and operationally effective.
- Encourage city employees to use EVs through the creation of preferential parking spaces.
- Install public EV charging stations on City-owned property (civic centres; community centres, libraries and arenas).
- Fleet Services to lead the investigation into additional opportunities for electric vehicles, where operationally and financially viable.

Investigate various funding opportunities
To support the deployment of EV infrastructure, there are a number of funding sources available such as:

- Working with private sector organizations (as potential opportunities for investment);
- The Municipal GHG Challenge Fund and other provincial funds;
- Federation of Canadian Municipalities' (FCM) Green Municipal Fund; and
- Natural Resources Canada's "Electric vehicle and alternative fuel infrastructure deployment initiative"

Regulatory direction and research
As EVs increase in use, municipal bylaws and regulations will potentially need to change to both support acceleration of the adoption of EVs and ensure EV owners are supported in their decision. The City could potential undertake the following types of actions:

- Encourage private property managers to install EV charging stations;
- Leverage the City's Smart Commute Initiative to work with employers to promote EVs;
- Prioritize EVs in HOV lanes;
- Support EV workforce development and training;
- Research other forms of electric vehicles (e-bikes and alternative cars); and
- Consider the use of portable EV charging stations

Awareness and education

There is still a relatively low understanding about EVs, the improvements being made in the technology and the financial incentives available to people considering an EV purchase. To help increase awareness he EV Work Group may:

- Conduct outreach on EV incentive programs to increase awareness about financial support;
- Host a consultation (or online engagement) to generate feedback from the public on their EV needs;
- Promote EV financing incentives to encourage private property managers to install EV charging stations through the Smart Commute program;
- Work with BIAs to incentivize community-level EV charging; and
- Engage BIAs in the current pilot areas.