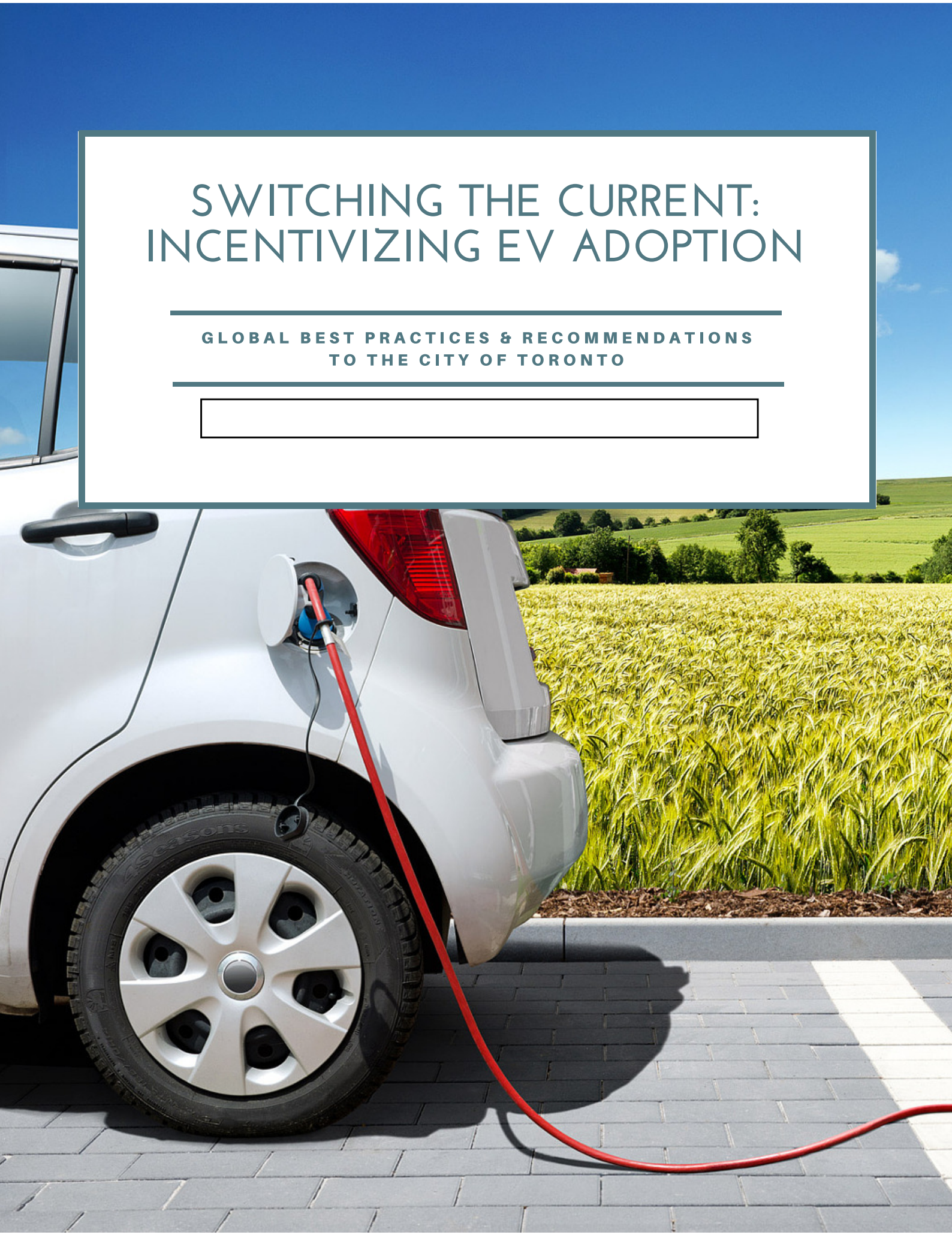
SWITCHING THE CURRENT: INCENTIVIZING EV ADOPTION

GLOBAL BEST PRACTICES & RECOMMENDATIONS TO THE CITY OF TORONTO



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INTRODUCTION

The City of Toronto has established ambitious goals for becoming a leader in sustainable energy[1] and reducing its greenhouse gas (GHG) emissions by 80% relative to 1990 levels by the year 2050.[2] To facilitate this change, the City in conjunction with the Toronto Atmospheric Fund (TAF) has created Transformation Toronto (TransformTO), a program to identify and promote feasible options for promoting sustainability.[3]

One increasingly popular option to achieve GHG reductions is to transition from the use of conventional fossil fuel-based vehicles (FFVs) to electric vehicles (EVs). As of 2013, about 41% of the City's total emissions result from transportation.[4] A broad-based switch to EVs, therefore, could lead to substantial emissions reductions, among other benefits.

EV adoption nevertheless remains low with a penetration of approximately 0.09%. In April 2013, the City of Toronto's EV Working Group identified several barriers to broader adoption of EVs. These barriers included logistical issues, such as insufficient knowledge of electricity grid capacity and potential safety concerns arising from installation. The barriers also included cultural issues contributing to low consumer demand for EVs, such as range anxiety, the fear that EVs are not able to travel as far as conventional vehicles, and have less refueling facilities available. This, along with the limited selection of EVs on the market, the prohibitive cost of home charging station installation, and current low levels of publicly available EV infrastructure, serve to dampen potential demand.[5] With all this, how can the city bring about a shift to EVs?

In light of these challenges, this report makes recommendations to the City of Toronto to promote and incentivize electric vehicle uptake among city residents. We focus primarily on passenger plug-in electric vehicles, as these are the largest segment and the technology for other vehicle classes, such as freight, is not significantly developed. We begin by outlining our motivating research questions, and then outline the challenges preventing greater EV uptake in Toronto. We present EV adoption as a strategy for mitigating climate change through GHG reductions, placing EV policy in the context of the City's TransformTO agenda.

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[1] City of Toronto. 2007. *Toronto Sustainable Energy Plan - Background Report.* http://www.toronto.ca/legdocs/mmis/2007/pe/bgrd/backgroundfile-4989.pdf (accessed 31 March 2016).
[2] City of Toronto. 2007. *Change is in the Air: Climate Change, Clean Air and Sustainable Energy Action Plan - Moving from Framework to Action.* http://www1.toronto.ca/City%20Of%20Toronto/Environment%20and%20Energy/Programs%20for%20Residents/Files/pdf/C/clean_air_action_plan.pdf (accessed 31 March 2016).
[3] City of Toronto. 2016. *TransformTO - Climate and Emissions Info.* http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=7921402b5782f410VgnVCM10000071d60f89RCRD (accessed 31 March 2016.)
[4] City of Toronto. 2013. *Toronto's 2013 Greenhouse Gas Inventory* (corrected report). http://www.toronto.ca/legdocs/mmis/2016/pe/bgrd/backgroundfile-87697.pdf (accessed 31 March 2016.)
[5] City of Toronto. 2009. (Internal memo).

We begin our analysis with a look at the current state of EV use in Toronto, as well as the existing policies and incentives already in place to support EV owners and stimulate further uptake. Having framed EVs in the Toronto context, we conduct a scan of cities around the world to identify selected global best practices in EV policy initiatives. We highlight those cities with approaches that are innovative, interesting, and relevant to Toronto.

Finally, we present four recommended areas in which the City could better support and incentivize EV uptake through policy: charging infrastructure development requirements, municipal EV fleets, fostering an EV charging sharing economy, and congestion and traffic management-based incentives. We outline the challenges facing further EV inclusion in each area, present a recommended action based on global best practices, and assess the potential impact of our recommendations on EV uptake and GHG emission reductions. In concluding, we discuss the future prospects for EVs in Toronto and around the world, touching on the upcoming Canadian federal budget as well as cost projections for the EV market, based on innovations in battery technology that may make EVs even more appealing in the future.

THE PROBLEM

The City of Toronto faces a twofold problem. First, Toronto like other cities must grapple with the global problem of reducing GHG emissions, which threatens the environment and public health in Toronto. Second, low-transportation alternatives such as EVs have low penetration in Toronto, as residents who drive continue to opt for cars powered by fossil fuels. The City has delayed significant investment in public charging infrastructure as it would benefit only a small minority of drivers and therefore cannot be justified until EV penetration increases. However, a well-known impediment to EV adoption is range anxiety, which can be mitigated by the addition of charging stations. This catch-22 requires the City to search for policy options beyond direct investment in charging infrastructure development to stimulate residents' demand for EVs.

METHODOLOGY

In terms of how Toronto could incentivize greater adoption of EVs, we sought to address two questions: what are the best practices from cities worldwide in integrating EVs into existing sustainable, low-carbon transportation networks; and what role should the City of Toronto play in supporting EVs in a manner consistent with its sustainable transportation goals?

With regard to the first question, the broad aim of our project was to investigate how other cities around the world have encouraged EV adoption, in order to learn from those cities and propose policies that would be appropriate for the Toronto context. In

order to achieve this aim, our methodology included four steps, which all involved consultation with contacts at the City of Toronto and various other stakeholders in the EV sector.

First, we assessed the feasibility of increased EV adoption in the city. This was necessary to ensure that increased adoption of EVs would actually contribute to the larger goal of reducing GHGs in Toronto, and to ensure that logistical issues, such as grid capacity, would not preclude any policy recommendations from being effective.

Second, we undertook an assessment of Toronto's current EV policy suite in order to understand the context in which any of our proposed policies might take place. This gave us an understanding of the institutional environment and policy space free for implementing any new initiatives targeting EV use.

Third, we undertook a survey of global EV policies at the municipal level. We investigated a number of cities around the world that were of interest to the City of Toronto, as well as some others that were known to be leaders in EV policy and adoption. We catalogued various policies that different cities had pursued, and in a number of cases discussed with contacts in those cities the rationale for their policies, as well as any resulting impact.

Our final step was to assess the appropriateness of the policies from our survey of global policies in the Toronto context. We discarded a number of policies based on obvious incongruence and decided to focus on four policy options that showed promise from initial assessments or discussions with City. A more focused assessment has led to the policy proposals contained in this report, and an evaluation of their possible impact.

FEASIBILITY

In order to make the case for incentivizing greater EV adoption, it was important first to demonstrate that such a shift would contribute to the goals of the TransformTO project, and could be handled by Toronto's energy infrastructure.

GHG EMISSIONS REDUCTION

By the end of 2014, Ontario had successfully completed its plan to phase out coal from its electricity generating mix. The only remaining source of electricity that emits significant amounts of GHGs is natural gas, which accounts for 28% of Ontario's generating mix.[6] This positive development means that EV uptake should now be seriously considered as a part of the strategy for meeting the GHG emission reductions target of the TransformTO project.

A May 2015 report by Plug'n Drive illustrates the potential impact of EV adoption on GHG emissions in Ontario.[7] The report measures GHG emissions in kilograms (kg) of CO_2 per 20,000 km driven, which is the conventionally used average per vehicle every year. It demonstrates that an EV "can reduce GHG emissions by 67-95% per vehicle, varying by make, model, and technology."[8]

Exhibit 1: Average GHG Emissions in Ontario by Vehicle Type

Vehicle Type	Average GHG emissions per 20,000 km driven	Source of GHG emissions
Average Battery Electric Vehicle	233 kg	Electricity Generation
Average Plug-in Hybrid Electric Vehicle	1,294 kg	Electricity Generation and Gasoline
Average Compact Gas Car	3,948 kg	Gasoline
Average Mid-Size Gas Car	4,700 kg	Gasoline
Average Full-Size Gas Car	5,029 kg	Gasoline

Source: Plug'n Drive

The transportation sector produces almost half of Canada's direct end-use GHG emissions, making it the most significant contributor to the country's end-use carbon footprint.[9] Of the vehicles that comprise the transportation sector, the vast majority are light passenger vehicles. In 2009 there were 19.7 million light vehicles in Canada, but fewer than 100,000 medium and heavy trucks.[10] If a significant share of Canada's light

[6] Independent Electrical System Operator (IESO). 2016. *Installed Energy Capacity by Fuel Type (March 2016)*. http://www.ieso.ca/Pages/Ontario%27s-Power-System/Supply-Mix/default.aspx (accessed 31 March 2016).
[7] Plug'n Drive, 2016. *Electric Vehicles; Reducing Ontario's Greenhoues Gas Emissions.*
[8] Natural Resources Canada (NRC). 2009. *Canadian Vehicle Summary Report 2009*, pg. 3
[9] *Ibid.*, 3
[10] *Ibid.*, 4

vehicle fleet could be converted to electric, the impact on GHG emissions would be substantial.

GRID CAPACITY

EV proliferation may require an increase in the capacity of Toronto's electrical grid. As more Toronto drivers switch to EVs, more EVs will be simultaneously charging, requiring the grid to sustain a higher maximum possible load. Grid capacity is therefore a potential bottleneck to EV penetration that the City must consider before promoting widespread EV adoption.

To evaluate the capacity for EV penetration of Toronto's electric system we made a calculation involving two steps: first, estimation of the power demand from EVs as uptake increases over time; and second, estimation of the load capacity of Toronto's electrical grid at the transformer, feeder, and station levels of local distribution. In the latter estimate we treat Toronto Hydro-Electric System Limited (THESL) distribution to the city as an aggregate rather than on a neighbourhood-by-neighbourhood basis. This heuristic allows for a broad assessment of Toronto's grid capacity for EVs but has the drawback of assuming that EV demand will be met by any station with available capacity, regardless of location.

Excess capacity available to serve EVs is estimated by subtracting peak load reported by Toronto Hydro-Electric System Ltd. (THESL) from THESL's total installed capacity at the transformer, feeder, and station levels, and then from the Independent Electricity Systems Operator's (IESO) reported excess generated capacity. For simplicity, we assume that any non-EV-related incremental increase in peak load will be accompanied by an equal increase in supply, and as such that excess capacity available for EVs remains constant over time.

We attempt to counteract any optimism in our supply-side assumptions by making several aggressive assumptions about EV power demand in order to avoid overstatement of Toronto's grid capacity. Specifically, we assume that the number of EVs driven in Toronto will grow at an annual rate of 75%, 25% higher than the four-year historical CAGR of 50% from approximately 200 EVs in 2012 to over 1,000 in 2016. We also assume that the power demanded per charger will increase by 20%, implying that 65% of all chargers will be Level 2 and 35% Level 3. Another aggressive assumption made is that the ratio of EVs to charging stations will remain constant at one-to-one, even as public charging becomes more available, fast-charging proliferates and car batteries become more efficient.

The current level of charging demand is estimated as follows. First, we estimate the distribution of charging station by their levels (1-3), which demand differing levels of

power, using PlugShare data.[11] We then find the weighted average level of power demanded per charging station in Toronto to be about 6.5 kW. By multiplying this average per charger demand by the number of EVs in Toronto, we find the estimated total demand from EVs.

Given these base case assumptions, we find that capacity for EV uptake will be inadequate at both the station and feeder levels by 2025 (see Exhibit 2). This finding indicates that THESL should anticipate the need to install new capacity in the next 10 years, particularly at the station level, to support increasing EV proliferation.

Exhibit 2: Grid Capacity Available for EV Charging Demand

	2016	2017E	2018E	2019E	2020E	2021E	2022E	2023E	2024E	2025E
Market										
Millions of Vehicles in Toronto	1.16	1.18	1.19	1.20	1.22	1.23	1.25	1.26	1.27	1.29
EVs in Toronto	1,008	1,764	3,087	5,402	9,454	16,544	28,953	50,667	88,668	155,168
EV Penetration	0.09%	0.15%	0.26%	0.45%	0.78%	1.34%	2.33%	4.02%	6.96%	12.05%
EV Demand										
Average Per Charger (kW)	6.5	7.1	7.9	8.6	9.5	10.5	11.5	12.7	13.9	15.3
Total demand (MW)	6.5	12.6	24.3	46.7	89.9	173.1	333.2	641.3	1,234.6	2,376.6
Excess Supply Less EV Demand										
THESL - Station Level (MW)	1,333	1,327	1,316	1,293	1,250	1,167	1,007	699	105	-1,037
THESL - Feeder Level (MW)	1,729	1,723	1,711	1,689	1,645	1,562	1,402	1,094	501	-641
THESL - Transformer Level (MW)	3,283	3,277	3,265	3,243	3,200	3,116	2,956	2,648	2,055	913
IESO - Generation Level (MW)	10,868	10,862	10,851	10,828	10,785	10,702	10,542	10,234	9,640	8,498
Assumptions										
Per Annum Growth Rates										
Vehicles in Toronto	1.1%									
EVs in Toronto	75.0%									
Avg. Demand/Charger (kW)	10.0%									
Excess Power Supply (All Levels)	0%									
Charger Level	1	2	3							
Estimated Share of Installed Chargers	1%	95%	4%							
Volts	110	220	480							
Amps	15	30	60							
AC/DC	AC	AC	DC							
Power (kW)	1.4	5.6	28.8							
Power Factor	85%									
THESL Peak Load (MW)	4,907									
Supply in Excess of Peak Load (MW)										
THESL - Station Level	1,340									
THESL - Feeder Level	1,735									
THESL - Transformer Level	3,289									
IESO - Generation Level	10,875									

A table showing the sensitivity of THESL station-level capacity to annual growth rates in the average power demanded per charger and EV penetration illustrates the high potential for capacity constraint (Exhibit 3). We see that if the EV penetration rate continues to increase at 50% per annum, capacity constraint will occur in 2025 if the power demanded per charger grows more than 20% per year.

[11] PlugShare. 2016. *EV Charging Map*. http://www.plugshare.com/ (accessed 20 March 2016).

Exhibit 3: Sensitivity of Station-Level Capacity in 2025 (MW) to Annual Growth Rates in Average Power Demand Per Charger in kW (Col.) and EV Adoption Rate (Row)

-1,037	80%	75%	70%	65%	60%	55%	50%
30%	-12,433	-9,348	-6,894	-4,954	-3,431	-2,246	-1,329
25%	-8,336	-6,169	-4,445	-3,082	-2,012	-1,179	-535
20%	-5,361	-3,861	-2,666	-1,722	-982	-405	41
15%	-3,229	-2,206	-1,391	-748	-243	151	455
10%	-1,722	-1,037	-491	-59	279	543	746
5%	-675	-224	135	419	642	815	950
0%	41	332	564	746	890	1,002	1,088

The City should therefore anticipate the need to install new electricity distribution capacity to support the EV policies it adopts to boost uptake. These calculations are in line with other reports that found that under current rates, Toronto will soon reach electrical capacity.[12]

[12] IESO. 2015. *Central Toronto Area Integrated Regional Resource Plan 2015.* http://www.ieso.ca/Documents/Regional-Planning/Metro_Toronto/2015-Central-Toronto-IRRP-Report.pdf (accessed 31 March 2016), p. 81-84.

THE TORONTO CONTEXT

The City of Toronto has stated its intention to promote EV adoption repeatedly over the last several years, however it has been hesitant to commit municipal funds to that end. In April 2013, the City of Toronto's EV Working Group identified several barriers contributing to the hesitation to install public EV infrastructure, including logistical issues and cultural resistance creating low consumer demand. Partially due to these barriers, the EV file has been relatively dormant at the City since 2013-2014. Fortunately, new provincial policies and changing market conditions have re-ignited interest in EVs at the City. As it stands, there are 1,008 electric vehicles in Toronto, and that number has grown from around 200 in 2012—a significant increase.

As part of Ontario's Climate Change Strategy,[13] the province has created the Electric Vehicle Chargers Ontario (EVCO) grant program, which will provide $20 million in funds for municipalities to support the purchase and installation costs of fast-charging stations in across Ontario.[14] The City of Toronto has applied for a portion of this grant money and if successful, the City will install a number of new charging stations across its jurisdiction. The current number of publicly available charging stations in the city is 142, with an additional 8 Tesla Superchargers available to the drivers of Tesla vehicles.

Aside from the EVCO program, the province also operates one tax incentive program that is available to Toronto residents: the Ontario Electric Vehicle Incentive Program (EVIP). EVIP was introduced in 2010 to support EV adoption, reward early adopters, and to create market demand for new technology.[15] Since then it has provided incentives for the purchase of 4,800 EVs and roughly 1,100 home chargers.

Effective February 2016, the EVIP has been modernized with a goal of making EVs more affordable, providing additional incentives for vehicles with large batteries and greater capacity to carpool, and to cap incentive amounts for luxury vehicles. Under the modernized program, Ontarians are eligible for $6,000-$10,000 for the purchase of an EV, with an additional $1,000 available for vehicles with five or more seats and up to $3,000 for vehicles with larger batteries. A total of $1,000 is available for the purchase and installation of chargers for home and business use.[16]

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[13] Government of Ontario. 2015. *Ontario's Climate Change Strategy*. https://dr6j45jk9xcmk.cloudfront.net/documents/4928/climate-change-strategy-en.pdf (accessed 31 March 2016).
[14] Ontario Ministry of Transportation. 2016. *Electric Vehicle Chargers Ontario Program Guide.* http://www.mto.gov.on.ca/english/vehicles/electric/electric-vehicle-chargers-ontario-program.shtml (accessed 15 March 2016).
[15] Ontario Ministry of Transportation. 2016. *Electric Vehicle Incentive Program Guide.* http://www.forms.ssb.gov.on.ca/mbs/ssb/forms/ssbforms.nsf/GetFileAttach/023-2096E~3/$File/2096E_Guide.pdf (accessed 31 March 2016).
[16] Government of Ontario. *Ontario Making Electric Vehicles More Affordable* (news release). https://news.ontario.ca/opo/en/2016/02/ontario-making-electric-vehicles-more-affordable.html (accessed 31 March 2016).

In addition to provincial funds, the 2016 Federal Government budget has indicated that $62.5 million will be provided over the next two years in order to support infrastructure for alternative transportation fuels, including EVs.[17] This represents an additional source of funding for EV charging infrastructure in Toronto.

THE TORONTO GREEN STANDARD

The Toronto Green Standard is a set of performance measures for sustainable building and design. The TGS is comprised of two-tiers, and applies to different types of new construction throughout the city. Tier 1 is mandatory for new construction, while Tier 2 is optional, but incentivized through development charge rebates.[18]

Current Toronto policy, under the Toronto Green Standard Tier 1, requires new mid and high-rise residential buildings to rough-in infrastructure for EV charging, but only if such buildings have more than the minimum required number of parking spaces.[19] Tier 2 requires that all mid- and high-rise residential buildings provide 2% of parking spaces will full EV charging infrastructure.[20] The City does not collect data on what the results of this policy have been. However, given the 'above minimum' parking threshold required to engage the Tier 1 standard, it does not appear to provide a significant incentive to provide EV-ready parking spaces. In fact, discussions with the City indicated that the Tier 1 standard was adopted as a disincentive for the provision of more parking than was necessary under zoning by-laws. Our research led us to the conclusion that during the last TGS update, market conditions were such that it did not make sense to require anything more of developers than the current residential Tier 1 standard. However, the City has expressed interest in incorporating further EV charging requirements into the 2018 TGS update.

CONSOLIDATION GREEN FLEET PLAN 2014-2018

The Consolidated Green Fleet Plan provides an overview of the City of Toronto's objectives in addressing environmental impact with strategies that aim to reduce hazardous emissions from the City's vehicle and equipment fleet operations. The Plan is the product of cooperation between five fleets: Fleet Services Division, Emergency Medical Services, Toronto Fire Services, Toronto Police Service, and Toronto Transit Commission.

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[17] Government of Canada. 2016. *Federal Budget 2016*, p. 151.
[18] City of Toronto. *Toronto Green Standard*. http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=f85552cc66061410VgnVCM10000071d60f89RCRD (accessed 29 February 2016).
[19] City of Toronto. 2016. *Toronto Green Standard for New Mid to High-Rise Residential and All Non-Residential Development, Version 2.0*, p. 1.
[20] *Ibid*.

The goal of the Consolidated Plan is to choose vehicles, equipment, fuels, and practices that consume less fuel and omit less GHG and air pollution, meet the City's and Fleets' operational requirements, are sustainable, and are economically viable.[21] Although the goal does express a desire to reduce GHG emissions of the City's fleets, there are no specific reduction targets included.

City Fleets has had success in adopting hybrid vehicles and equipment in areas with high operational utilization. However, they have encountered a number of challenges with EVs. Most of the PHEVs and BEVs that have been added to the Fleet Services Division would require higher utilization in order to reach their potential for reducing fuel consumption and lowering the total cost of vehicle ownership.[22] Range issues, exacerbated by Toronto's climate, have been a significant contributing factor to the low rate of utilization. As a result of the lack of GHG emissions reduction targets and challenges associated with prior EV adoption, the Consolidated Green Fleet Plan does not contain any goals or initiatives for greater EV adoption in the City's fleets.

2014-2018/2016-2020 CONGESTION MANAGEMENT PLAN

The city is grappling with record volumes of traffic, driven by increasing numbers of drivers on the roads every year. As part of its efforts to reduce emissions and logistically handle these volumes of traffic, Toronto has created traffic management policies. This includes road classification, where city roads are designated/classified and treated according to their intended service use to help guide urban development and road management; signal optimization systems, to use traffic signals to smooth traffic flows; and the introduction of a Toronto-wide congestion management plan for 2014-2018.[23]

The Congestion Management Plan is of particular importance here. Toronto's Congestion Management Plan for 2014-2018, and its update to a 2016-2020 version,[24] includes provisions on adopting advanced traffic systems, readiness for autonomous/data-connected vehicles, and support for all modes of transportation, in particular through expanding bike paths.[25] However, there is no mention anywhere of EVs — something that is a current blind spot, but also a possible opportunity.

[21] City of Toronto. 2014. *The Consolidated Green Fleet Plan 2014-2018*, p. 2
[22] *Ibid.*, 2.
[23] City of Toronto. 2013. Congestion Management Plan 2014-2018. https://www1.toronto.ca/City%20Of%20Toronto/Transportation%20Services/TMC/Files/PDF/Congestion%20Management/Congestion%20Management.pdf (accessed 31 March 2016).
[24] City of Toronto. 2015. *Congestion Management Plan - 2016-2020 Update.* http://www.toronto.ca/legdocs/mmis/2015/pw/bgrd/backgroundfile-83480.pdf (accesed 31 March 2016).
[25] *Ibid.*

GLOBAL BEST PRACTICES

As part of our approach, we conducted a scan of cities worldwide and their EV-related policies, in order to determine which best practices and innovative ideas could be imported, and possibly improved on, in the Toronto context. We briefly outline some of our findings from this scan, and the notable cities leading the way on EV adoption.

BERLIN

Looking at Europe, we find even more EV-friendly policies, largely due to strong public consciousness around environmental impact and reducing emissions. One example of an innovative city in Europe is Berlin, which has several EV-friendly policies, outlined below.

EV Strategy

Berlin's political structure is unique: as a "city state", it operates at the same jurisdictional level as the other area states. As a result it has more latitude, to the extent that it has even created its own "state-level" agency devoted to electric vehicles.[26] The climate for EV in the city is already very good; roughly half of their households do not own cars, so they are particularly amenable to car-sharing models. Berlin plans to be 100% renewable by 2030, and will apply the European Union's Initiative 120 to reduce emissions per vehicle to 95g CO_2/km for passenger cars and 147g CO_2/km for vans by 2020,[27] including a project to convert its own municipal fleets starting in 2013.[28] As of 2013, Berlin reported having 350 electric cars and transporters, and 400 public charging points. The city has set ambitious goals to increase those numbers to 15,000 and 1,400, respectively.[29]

E-City Logistics

A project that introduced and demonstrated the potential for electrically powered commercial vehicles for delivery use in the city. This was applied to local distribution in courier, express, and parcel delivery, and the supply of retail stores in inner city areas. Low-noise level of these vehicles allows for goods to be delivered at off-peak

[26] Berlin Agency for Electromobility. 2016. *eMO - About Us.* http://www.emo-berlin.de/en/about-us/emo/ (accessed 31 March 2016).
[27] International Council on Clean Transportation. 2014. *EU CO2 Emissions Standards for Passenger Cars and Light Commercial Vehicles*. http://www.theicct.org/sites/default/files/publications/ICCTupdate_EU-95gram_jan2014.pdf (accessed 31 March 2016), p. 2-3.
[28] Berlin Agency for Electromobility. 2015. *Electrifying Berlin's Vehicle Fleet*. http://www.emo-berlin.de/en/showcase/projects/public-transportation/electrifying-berlin-vehicle-fleet/ (accessed 31 March 2016).
[29] Berlin Agency for Electromobility. 2014. *Berlin-Brandenburg is Going Electric Action Plan for Electromobility 2020.* http://www.emo-berlin.de/fileadmin/user_upload/140318_Action_Plan_for_Electromobility_2020_final_WEB.pdf (accessed 31 March 2016).

hours, reducing congestion. The project was conducted in partnership with Deutsche Post DHL for parcel delivery and Meyer & Meyer Transport Services for retail supply.[30]

BE Mobility

BE Mobility was an intermodal transport project for integrating EV car-sharing into public transport, with a short-term target to introduce a mobility card (and smartphone app) that connected all the city's mobility options to one card, and connect them to charging infrastructure powered by renewables. The project ended in 2013,[31] however, its knowledge and experience may be transferred other innovative car sharing initiatives like DriveNow, currently operating with some electric vehicles in Berlin.[32]

CHICAGO

The City of Chicago has only had limited engagement with policies to push EVs. That said, the City has received funding from a number of federal programs for the development of charging infrastructure on public property, including the American Recovery and Reinvestment Act and a Clean Cities Coalition Grant. The federal government also provides a tax rebate of up to $7,500 for all Americans, in addition to state-level incentive programs.[33])

Drive Clean Station

The $14 million Drive Clean Station rebate program is part of the Drive Clean Chicago program, which is funded through the Chicago Department of Transportation with support from the federal Congestion Mitigation Air Quality program. The rebate program, for which $1,425,000 has been earmarked, targets EV fleet owners and charging station developers to cover 30% of the capital costs of station construction. Preference is given to large projects (with "highest fuel displacement") and those located in areas that lack EV infrastructure.[34]

[30] National Organization for Hydrogen and Fuel-Cell Technology. 2012. *E-City Logistics.* https://www.now-gmbh.de/en/electromobility-model-regions/projektfinder/modellregionen/berlin-potsdam/e-city-logistik (accessed 31 March 2016).
[31] BeMobility. 2013. *Project Phases.* https://www.bemobility.de/bemobility-de/start/bemobilty_12_13/umsetzung_20/2509932/umsetzung_2.0.html?start=0 (accessed 31 March 2016). [In German.]
[32] DriveNow Berlin. 2016. *DriveNow* - Your Cars. https://de.drive-now.com/en/#!/yourcars/bmw-i3 (accessed 31 March 2016).
[33] US Department of Energy. 2016. *Fuel Tax Credits for All-Electric and Plug-in Hybrid Vehicles.* https://www.fueleconomy.gov/feg/taxevb.shtml (accessed 31 March 2016).
[34] Drive Clean Chicago. 2016. *About Our Programs.* http://www.drivecleanchicago.com/About/OurPrograms.aspx (accessed 31 March 2016).

LOS ANGELES

Los Angeles benefits from its location in California, one of the world's most EV-friendly jurisdictions and a major locus of innovation in electric vehicle development (being the base of operations for Tesla and the home of Silicon Valley). The City has implemented a number of ambitious policies to incentivize the adoption of EVs.

Building Codes

As of 2011, Los Angeles has incorporated EV-readiness requirements for all new residential construction. For single-family units, double family units, and townhouses, construction must include installation of an EV outlet or wiring infrastructure for such an outlet to be installed in the future.[35] For residential buildings with a common parking area, construction must include installation of EV outlets or wiring for such outlets in at least 5% of the common parking spaces.[36]

Charge-Up LA! EV Infrastructure Program

The Charge-Up LA! Program sought to encourage the adoption of Level 2 chargers by LA residents and businesses through the provision of rebates for the purchase and installation of chargers.[37] The program ran from 2013-2015, and was administered by LADWP, LA's public utility company.[38]

With respect to home charging, residential customers could receive a rebate of $500 towards out-of-pocket expenses for an EV charger.[39] Customers who also installed a dedicated time-of-use meter would also qualify for LADWP's EV discount of 2.5 cents/kWh and receive an additional $250 rebate.[40] Commercial and multi-residential property customers were eligible for a rebate of $750 for wall-mounted EV chargers and $1000 for stand-alone pedestal chargers.[41]

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[35] City of Los Angeles. *Los Angeles Municipal Code*, Section 99.04.106.4.1.
[36] City of Los Angeles. *Los Angeles Municipal Code*, Section 99.04.106.4.2.
[37] Los Angeles Department of Water and Power. 2013. *LADWP Officials Announce Expanded Electric Vehicle Program: "Charge Up LA! – Home, Work and On the Go"*. http://www.ladwpnews.com/go/doc/1475/1853978/LADWP-Officials-Announce-Expanded-Electric-Vehicle-Program-Charge-Up-LA-Home-Work-and-On-the-Go- (accessed January 21, 2016).
[38] *Ibid.*
[39] Los Angeles Department of Water and Power. 2013. *Electric Vehicle Charger Rebate Program*. https://www.ladwp.com/ladwp/faces/wcnav_externalId/r-sm-rp-ev?_adf.ctrl-state=x1u459lch_4&_afrLoop=145500344574444 (accessed January 20, 2016).
[40] *Ibid*.
[41] Los Angeles Department of Water and Power. 2013. *LADWP Officials Announce Expanded Electric Vehicle Program: "Charge Up LA! – Home, Work and On the Go"*. http://www.ladwpnews.com/go/doc/1475/1853978/LADWP-Officials-Announce-Expanded-Electric-Vehicle-Program-Charge-Up-LA-Home-Work-and-On-the-Go- (accessed January 21, 2016).

Public Charging Sites

LADWP has worked with commercial customers to install 350 publicly available charging sites.[42] Further charging locations will be added based on public interest, however there does not appear to be a clear scaling plan in place.

NEW YORK CITY

New York has had two "waves" of interest in, and policy creation targeting, EVs. First, the Bloomberg administration through its PlaNYC program began targeting EV use,[43] however this was only achieved to a limited extent. This has been followed up with Mayor De Blasio entering office, and EV programs since then may be expanding further under the One NYC plan.[44] In addition, New York –like Chicago –has received funding from a number of federal programs for the development of charging infrastructure on public property, including the American Recovery and Reinvestment Act and a Clean Cities Coalition Grant, and the current federal rebate of up to $7,500 for all Americans topping up state-level incentive programs.

Adding public charging stations (Bloomberg administration)

All parking garages and open parking lots (public and private) that are either new or undergoing electrical service must have EV charging station infrastructure for 20% of its capacity as per an amendment in building codes.[45] The City has not pledged to fund these investments, presumably because charging station companies benefit from subsidy at the state level.

Charging stations were installed at 60 city-owned garages and other facilities. These City-funded stations are being rolled out slowly as the City collects data about usage to inform subsequent installation.

Streamlined home charging station installation (De Blasio administration)

The City provides quick pre-approval to homes with adequate electrical infrastructure for installation. For homes that need additional electrical wiring from the street, there is no quick solution; however, the City claims to be working with both Con

[42] Los Angeles Department of Water and Power, *supra*.
[43] City of New York. 2016. *Drive Electric NYC: City Initiatives.* http://www.nyc.gov/html/ev/html/city/city-initiatives.shtml (accessed 31 March 2016).
[44] City of New York. 2015. *Mayor de Blasio Releases One New York: The Plan for a Strong and Just City.* http://www1.nyc.gov/office-of-the-mayor/news/257-15/mayor-de-blasio-releases-one-new-york-plan-strong-just-city#/0 (accessed 31 March 2016).
[45] City of New York. 2014. *PlaNYC Progress Report 2014.* http://www.nyc.gov/html/planyc2030/downloads/pdf/140422_PlaNYCP-Report_FINAL_Web.pdf (accessed 31 March 2016), p. 18.

Edison and car manufacturers toward reducing the costs of home charging station installation.[46]

Adding public charging stations (De Blasio administration)

To facilitate EV adoption among New Yorkers who do not have home parking, the City has used federal stimulus funding to install public EV chargers throughout the city, particularly in commercial parking lots. The City is also working with consumers and private sector stakeholders (parking garage owners, co-op boards, and utility Con Edison) on awareness, and is promoting and expanding its charging station network through the GreeNYC program.[47] At present, the City operates over 800 Electric Vehicle (EV) plug-in units of some type and plans to reach at least 1,000 EV units in operation by 2017. The City also currently operates 203 EV chargers, and plans to have at least 250 chargers in operation by 2017. By 2016, the City also plans to introduce fast-charging chargers and at least one solar carport (an EV charger that draws all its power from solar panels).[48]

Fleet Conversion (De Blasio administration)

Finally, New York has announced major plans to convert its existing municipal fleet, aiming to replace up to 2,000 passenger sedans currently in use with EVs by 2025, aiming to both cut vehicle emissions and create the largest municipal EV fleet in the United States.[49]

OSLO

Oslo is perhaps the most EV-friendly city in the world. In addition to strong individual environmentalism, which manifests as public support for environmentally-friendly policies, Oslo benefits from a federal government that has financially supported its EV initiatives to a great extent, and its position as the most populous (and hence most supported) city in Norway. As such, many of the policies Oslo has implemented may currently be infeasible in a Toronto context. Nevertheless, we think that by looking at Oslo as a "frontier" of EV innovation and policy, we can find useful practices that may be applicable for Toronto.

[46] Drive Electric NYC. 2016. *City Initiatives*. http://www.nyc.gov/html/ev/html/city/city-initiatives.shtml (accessed 31 March 2016).
[47] *PlaNYC Progress Report 2014*, *supra*, p. 18.
[48] City of New York. 2015. *One New York: The Plan for a Strong and Just City*. http://www.nyc.gov/html/onenyc/downloads/pdf/publications/OneNYC.pdf (accessed 31 March 2016), p. 192.
[49] Michael M. Grynbaum. 2015. "New York City Aims for Vast Electric Car Fleet by 2025." *New York Times*, December 1 2015. http://nyti.ms/1OuGCFU (accessed 31 March 2016).

MoveAbout

MoveAbout is a car sharing company launched in 2007, using an all-electric fleet. Members, who pay a small monthly fee, can make rental reservations and use charging stations. It has partnered with Statkraft (for both renewable energy utility generating power and employee use of MoveAbout EVs) and Norwegian State Railways (both for vehicle use and placing charging stations located at rail stations), and has seen success in its car-sharing model.[50]

Municipal Charging Stations

Early charging stations in Oslo were provided by collaboration b/w Hafslund (local energy utility) and the EV users association. After the introduction of the 2008 emissions plan, City Council approved creation of 400 new public charging stations at 4 million kroner (~ $1 million CAD) per year for 4 years (2008-2011) to a total of 1000 stations planned, as well as switching municipality vehicles to an all-electric fleet. These investments are being done as the national government is also installing and expanding national-level charging infrastructure and a network of stations.[51]

Municipal Incentive Programs for EV Adoption

Oslo City Council adopted a 10-point emissions reduction plan in 2008: one key point of this plan included fostering the adoption of EVs and becoming the world's "EV capital."[52] Oslo's progress is characterized by strong municipal-national level collaboration: the national government has set a target of 50 000 EVs on the road by 2018. Together, the city and the national government have provided some of the world's most generous financial incentives to encourage EV purchases (though certain incentives, like exemption from tolls and parking fees, and use of bus/taxi lanes, have caused municipal-level concern).[53]

SEATTLE

The City of Seattle has employed a number of different initiatives to foster greater EV adoption, and its goal is to enable and support the adoption of 15,000 electric vehicles by 2025.[54] The City has received funding from a number of federal programs for the development of charging infrastructure on public property, including

[50] McKinsey & Company and Amsterdam Roundtable Foundation. 2014. *EVolution - Electric Vehicles in Europe: Gearing up for a new phase?*, p. 17.
[51] Oslo Agency for Urban Environment. 2012. *Oslo - the EV Capital of the World* (presentation). https://www.toi.no/getfile.php/mmarkiv/Forside%202015/compett-foredrag/Portvik%20-EV%20presentation%20T%C3%98I%2012.%20June.pdf (accessed 31 March 2016).
[52] *Ibid.*
[53] McKinsey & Company and Amsterdam Roundtable Foundation, *supra*.
[54] City of Seattle. 2016. *Drive Clean Seattle: FAQ*. http://www.seattle.gov/Documents/Departments/OSE/DCS_FAQ_Final.pdf (accessed 31 March 2016), p. 3.

the American Recovery and Reinvestment Act and a Clean Cities Coalition Grant.[55] The federal government also provides a tax rebate of up to $7,500 for all Americans.

Seattle City Light

Seattle City Light is the municipal electric utility which boasts carbon neutrality. This means that initiatives to support EV adoption can achieve the maximum possible reduction in GHG emissions with each conventional vehicle that is replaced with an EV.

Drive Clean Seattle

A comprehensive strategy to transition the city's transportation sector from fossil fuels to carbon-neutral electricity. The strategy includes actions to spur this shift for passenger cars, trucks, transit and maritime transportation.

About 65% of Seattle's core GHG emissions come from the transportation sector, so it has been flagged as an essential transition in order to meet the city's climate goal of carbon neutrality by 2050.[56] The Green Fleet Action Plan is one part of Drive Clean Seattle's strategy.

Green Fleet Action Plan

The City has committed to reducing GHG emissions from its fleet by 50% by 2025. The Plan calls for replacing approximately 120,000 gallons of gasoline with electricity -- about 10% of the emissions reduction goal and the equivalent of almost all of the City's passenger sedans.[57]

Since 2011, Seattle has replaced its conventional fleet with 79 BEVs (Nissan Leafs), 10 PHEVs (Prius, Volt, and Fusion), and 300 regular hybrid vehicles. To support these EVs, the City has pledged to install 4000 charging stations over the next 5-7 years for Seattle fleet vehicles. In some cases, such as the Seattle Municipal Tower, the City has installed charging stations that available for both the City fleet and public use.[58]

VANCOUVER

Turning to Canada, Vancouver has an enviable track record as a "green city." In addition to having more latitude over municipal policy by having its own charter, the city benefits from strong public buy-in for environmental programs. As such, Vancouver has adopted a number of EV-friendly policies, outlined below.

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[55] City of Atlanta. 2010. *Electric Vehicle Deployment: Municipal Best Practices Study*, http://www.rmi.org/Content/Files/Atlanta%20EV%20Readiness%20Study%20.pdf (accessed 31 March 2016), p. 29.
[56] City of Seattle. 2014. *A Clean and Green Fleet: An Updated Action Plan for the City of Seattle.* http://www.seattle.gov/Documents/Departments/FAS/FleetManagement/2014-Green-Fleet-Action-Plan.pdf (accessed 31 March 2016), p. 2.
[57] City of Seattle. *Drive Clean Seattle FAQ, supra*, p. 2.
[58] *Ibid.*, 2.

Building Codes

In 2008, the City changed its building by-law so that 20% of parking stalls in new apartments and condos, as well as all parking stalls in new houses, are required to be EV ready.[59] In 2013, the City further updated its building by-law so that 10% of parking stalls in new mixed-use and commercial buildings must be ready for electric vehicles.[60]

Charge and Go Vancouver

This program installed 69 new public EV charging stations as part of a pilot project between 2012 and 2013.[61] The project cost was $800,000 and was jointly funded by the City, the FCM, BC Hydro, and both the provincial and federal governments.[62] Stations were installed at community centres, shopping malls, curbs, and other locations throughout the city.

Cell Tower Project

The City partnered with TELUS to provide three new charging stations in the English Bay Parks in Vancouver's West End.[63] Charger infrastructure was installed in City of Vancouver parking lots. Installation and electricity costs were paid for by TELUS.[64] Charger infrastructure was integrated with new cellular poles on the sites, which allowed TELUS to improve its service and capacity in the West End of Vancouver. Additionally, TELUS paid a rental fee for the sites to the Vancouver Parks Board.[65]

[59] City of Vancouver. *Vancouver By-Law No. 10908*, Section 10.2.3.
[60] *Ibid*.
[61] Federation of Canadian Municipalities. 2014. *Electric Vehicle Charging Infrastructure Pilot Program*. http://www.fcm.ca/home/awards/fcm-sustainable-communities-awards/past-winners/2014-winners/2014-transportation.htm (accessed January 25, 2016).
[62] *Ibid*.
[63] City of Vancouver. 2014. *Electric vehicle charging station and cellular poles in English Bay parks*. http://vancouver.ca/streets-transportation/electric-vehicle-charging-stations-and-cellular-poles.aspx (Accessed January 25, 2016).
[64] City of Vancouver. 2012. *Electric Vehicle Charging Stations and Cellular Infrastructure in English Bay Parks* (May 30, 2012). http://vancouver.ca/files/cov/electric-vehicle-brochure.pdf (accessed 31 March 2016), p. 4.
[65] *Ibid.*, 1.

POLICY RECOMMENDATIONS

Having conducted the scan of global best practices, we developed a set of policy recommendations based on tried and tested approaches that we believed were most feasible for Toronto, as well as a venture that borrows from projects on the frontier of innovation in the sector.

RECOMMENDATION 1: EV INFRASTRUCTURE DEVELOPMENT REQUIREMENTS

As noted above, one action that a number of cities have undertaken to address the lack of EV charging infrastructure is building code revisions. Both Vancouver and Los Angeles have amended their building codes so that new construction must include a given percentage of parking spaces that are EV-ready - sometimes also known as 'roughed-in' for EVs. Generally, EV-ready means that individual breakers are installed for potential future charging stations, and that empty conduit is installed in parking areas so that wiring for future EV charging stations can be installed easily without large cost.[66]

The Toronto context is slightly more complicated than that of Vancouver and Los Angeles, because those two cities each have control over their own building codes. Conversely, Ontario has jurisdiction over the building code that is applied in Toronto. Nonetheless, Toronto believes that the Planning Act gives it authority to mandate EV parking infrastructure in new buildings under certain circumstances. As such, it has pursued EV charging requirements through the TGS, as mentioned above.

Given the City of Toronto's expressed interest in a potential update to the EV standards for the 2018 TGS, our team communicated with contacts at the City of Toronto, Toronto Hydro, and the City of Vancouver in order to assess whether enhanced EV charging requirements would be appropriate in the Toronto context.

Through discussions with the City of Vancouver we sought to understand how that city arrived at the 20% and 10% standards for residential and commercial parking, respectively. Through phone conversations and email correspondence, it became clear that these standards were arrived at as a compromise between the City of Vancouver and EV enthusiasts on one side, and the developer community on the other side. It did not appear that there was a specific rationale behind the standards chosen. One factor that did appear to influence Vancouver's adoption of the policy was the significant amount of multi-unit residential construction currently taking place in the city. Like Vancouver, Toronto is currently experiencing a 'condo boom' with 9,117 new

[66] City of Toronto. 2015. *Toronto Green Standard for New Mid to High-Rise Residential and All Non-Residential Development, Version 2.0*. (p 1).

condo units completed in the City of Toronto in 2015.[67] Given the construction boom in the Toronto condominium market, new EV charging requirements for multi-unit residential construction could have a significant impact on the availability of home charging, which studies have indicated is a major constraint on EV adoption.[68]

An additional benefit of EV charging requirements for new residential construction is that the cost to the City is low, with developers bearing the greatest share. Because of this, however, any policy must take into account the fact that TGS requirements which put onerous costs on developers could face resistance from the development community. Discussions with the City of Vancouver indicated that its building code changes did face such resistance. However, anecdotally, such changes have been less controversial as the cost of EV-ready parking spaces has decreased over time. In order to understand the cost associated with a possible TGS update of EV-ready parking, our team consulted a source at the Minto Group, a major Canadian development company.

OUR PROPOSAL

Amend the 2018 TGS Tier 1 to require EV-readiness for 20% of parking in new mid and high-rise residential construction. Amend the 2018 TGS Tier 2 to require EV-readiness for 10% of parking in new commercial construction.

Our team believes that updating the TGS requirements for EV charging infrastructure would be a positive step that the City of Toronto could take in order to encourage and accommodate the adoption of EVs in the city. This policy is low-cost, and has the potential to unlock significant demand for EVs.

A significant challenge we had when determining what standard would be appropriate for the 2018 TGS update was a lack of data. This includes a lack of updated data from Vancouver and Los Angeles with respect to the impact that their policies have had, as well as a lack of data regarding the state of the EV market and consumer behaviour in Toronto. Nonetheless, given the changing market conditions, we believe it would be appropriate for Toronto to move towards the standards adopted by Vancouver. Specifically, we recommend that the 2018 TGS Tier 1 update require new mid- and high-rise residential buildings to 'rough-in' 20% of parking spaces with EV charging infrastructure. While our forecasts predict only 12% EV penetration by 2025, we believe that it makes sense to over-deliver with respect to EV rough-ins, given potential

[67] Canada Mortgage and Housing Corporation (CMHC). 2016. "Housing Now Tables: Greater Toronto Area." http://www.cmhc-schl.gc.ca/odpub/esub/64163/64163_2014_M03.pdf?fr=1456758529299&sid=VUONgLGjuaTxdjm2HfQoV16ZZMao3i1p9fJYAH1vCCG9qAQVe70GVACrDRcOT7w9 (accessed 31 March 2016), p. 40.

[68] John Axsen et al. 2015. *Electrifying Vehicles: Insights From the Canadian Plug-In Electric Vehicle Study*. Simon Fraser University (SFU), p. 161.

for exponential growth in the EV market and the relatively low cost of initial rough-ins compared to the high cost of retrofits. In order to assess the potential impact of a EV rough-in requirement on developers we discussed rough-in requirements with sources at a large Canadian developer. Based on those discussions, we estimate that the cost of a 20% rough-in during initial construction of a building would add 6-8% to the total electrical installation costs. We believe these costs are reasonable and justified, especially in the context of a larger construction project.

With respect to commercial construction, it is unclear that availability of EV charging on commercial parking lots is a major impediment to EV adoption. As such, we are not recommending that Toronto implement commercial EV charging requirements for TGS tier 1, as Vancouver has done with its building code. However, we do believe that commercial requirements would be appropriate for the optional TGS Tier 2, and recommend that Tier 2 of the TGS be updated to require that 10% of new commercial parking be EV ready.

Barriers to Implementation

As mentioned above, one complication of this recommendation is that Toronto does not have jurisdiction to amend the building code that applies in the city – that is a provincial responsibility. Nonetheless, the City has adopted an interpretation of the Planning Act that gives it the authority to implement parking requirements such as the current TGS. Given that our proposed TGS amendment would include a EV charging requirement that did not rely on a given developer providing more than the necessary number of parking spaces, this policy may interact with the Planning Act in a different manner than the previous TGS standard. Contacts at the City of Toronto indicated to us that this was likely not an issue, but that a new legal opinion would be required in order to ensure that the City was acting within its jurisdiction.

RECOMMENDATION 2: MUNICIPAL FLEET CONVERSION

The global best practice section highlights a number of cities which have initiated strategies for adopting EVs into their municipal fleets. Berlin presents an interesting example with a GHG reduction target based on average CO_2 output per vehicle in its fleet, and Seattle has a robust set of policies which are very relevant to the Toronto context. There benefits of municipal fleet EV adoption include example setting, contributing to the City of Toronto's GHG reduction targets, and removing barriers to further EV uptake by installing charging infrastructure.

We recommend that the City of Toronto develop specific goals for EV adoption in its municipal fleet in time for the creation of the new Green Fleet Plan in 2018. Despite the robust set of initiatives included in the Consolidated Green Fleet Plan of 2014-2018, the barriers to implementation that the City had previously faced when integrating EVs into its fleets precluded any further EV adoption initiatives. We believe that with upcoming federal and provincial initiatives, combined with the continuous innovation of EV technology, these barriers will reduce significantly by 2018.

OUR PROPOSAL

In its municipal fleet, the City of Toronto currently has a total of 12 EVs out of a corporate fleet of roughly 5,000. Adopt a target to grow the City's EV fleet by 50% per year in its next Green Fleet Plan, resulting in a total of 138 EVs by 2024.

This growth model is consistent with that of the City of Seattle from 2011-2015. The projected financial support from both the federal and provincial governments is similar to the stimulus packages provided by the US government which were instrumental in helping Seattle reach its goals. With the current market conditions, as well as the increased attention being paid to EVs in various levels of government, the City of Toronto can feasibly reach this goal.

Barriers to Implementation

The City of Toronto faces two types of challenges while integrating EV into its fleet: operational difficulties and cost. Operational difficulties include the limited range of EVs and their charging time. The cost challenges consist of the vehicle purchase cost, maintenance cost, and new technology risk factors.

However, as previously mentioned, innovations in EV technology will work to ease operational challenges in the coming years. An EV with a range of 320 km could reach any corner of Toronto's jurisdiction and return without having to be charged, and when it does need to charge there are faster and faster options for doing so. In terms of costs, a report by Bloomberg New Energy Finance -- which will be discussed in further detail in a later section -- has projected that EV purchase costs will drop dramatically over the next few decades, making a municipal fleet of EVs much more economically viable.

Charging infrastructure is an important factor for supporting EV uptake, and by investing in infrastructure on public property, the City of Toronto can provide infrastructure for citizens and for its municipal fleet. Upcoming initiatives at both the provincial and federal level will reduce the financial burden of providing this infrastructure. The Electric Vehicle Chargers Ontario grant program will likely lead to the installation of charging infrastructure near the highways that surround Toronto, as part of

its goal of making it possible for an electric vehicle to cross the province. Furthermore, as we discuss later, the 2016 Federal Budget will see more and more opportunities for the City of Toronto to secure funding for EV charging infrastructure. Together, we believe that these new developments support the argument that the City of Toronto should adopt more ambitious goals for EV adoption in its municipal fleet.

Possible Impact

Given the recommended target of EVs in the Toronto fleet by 2025, we can calculate the estimated GHG emissions reduction that would result. This calculation accounts for compounding reductions, and uses the difference in emissions between an average EV and a compact gas car, travelling the conventional average of 20,000 km/year. We find that the proposed policy may yield a net reduction of over 400,000 tonnes of GHGs by 2025.

RECOMMENDATION 3: EV SHARING ECONOMY VENTURE

While there are over 1,000 EVs currently registered with Toronto residents, there are only 150 public charging stations in the city. If EV drivers opted to share their private charging stations with the public, the number of "public" charging stations would increase by a multiple of 6.7. Such a significant increase in the availability of public chargers would reduce range anxiety, influencing more drivers with latent demand for EVs to make the switch from fossil-fuel vehicles.

PlugShare, a private company that maps over 50,000 EV charging stations in North America, has attempted to create an economy of station-sharing by allowing its users to open their private stations for public use. The company relies heavily on trust among its users, as it does not allow users to charge a fee for the public use of their charging stations. PlugShare does not disclose its number of users, therefore we cannot assess its market share as a percentage of all EV drivers in Toronto.

We recommend that the City launch a competing proprietary platform to allow EV drivers to sell the use of their private charging stations to the public on a per charge basis. The City should collect a fee on each transaction to cover the development, operating and marketing costs associated with the venture.

OUR PROPOSAL

Launch a program allowing EV owners to rent out their charging stations at an hourly rate, with a transaction fee paid to the City. With a $1 hourly charging rate and a 5% fee, the project would earn a positive return by 2025 even if it only reached half the market.

In addition to incentivizing EV adoption by addressing barriers such as range anxiety and lack of charging infrastructure, the profit projections also make a strong business case for the project

Barriers to Implementation

Barriers to implementation include various sources of project risk, augmented by the City's relative inexperience in developing an app for consumers. PlugShare's first-mover advantage also presents the risk that the City will not be able to achieve a critical mass of users. Insufficient marketing of the platform is therefore a potential barrier to successful implementation. The City is nevertheless well-positioned to succeed in this market for several reasons. First, the City could integrate its charger locating and sharing service with other payment services that Torontonians use, e.g. payment for parking (via the Green P app), parking tickets, and property tax. This bundling would make the City's digital EV charger mapping and payment services more attractive to residents, reducing switching costs for existing PlugShare users. In addition, the City as a local authority is more likely than a private company to foster the high level of trust required of users in order to share their private garages with strangers.

Possible Impact

The explosive growth of the sharing economy presents governments with a significant potential source of tax revenues, yet regulation of this economy can be elusive. By entering the sharing economy with a tool connecting private charging station owners with EV drivers, the City could address a pain point in the EV market (range anxiety) while accessing a new source of revenues. The success of this venture could increase the number of public charging stations available to EV users by over six times, while simplifying charging station location and charging payment for drivers and contributing to City revenues.

As mentioned, while the City could justify this project on the basis of its potential impact on EV uptake, it could also make a business case for the venture. For example, assuming initial development costs of $200,000 and combined operating and marketing costs of $50,000 per year;[69] 50% market share and 50% market growth per year (the historical four-year average); and two weekly charges per customer at two hours per charge and a $1 hourly charging fee, the City would need to take only a 5%

[69] These estimates are based on various estimated median costs of digital application development. See: Formotus. 2016. "Figuring the costs of custom mobile business app development."http://www.formotus.com/14018/blog-mobility/figuring-the-costs-of-custom-mobile-business-app-development (accessed 25 March 2016).

skim fee to see this investment realize a positive IRR by 2025. Our base case assumption is slightly more optimistic, with a 75% annual market growth rate and a 10% skim fee, and results in an IRR of 25% by 2025 (Exhibit 4).

Exhibit 4: Sharing Economy Venture Business Case

	2016	2017E	2018E	2019E	2020E	2021E	2022E	2023E	2024E	2025E
Revenues		$9,173	$16,052	$28,092	$49,160	$86,031	$150,554	$263,469	$461,071	$806,875
Development Costs	$200,000									
Operating Costs		$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	-$50,000
Total Costs	$200,000	$50,000	$50,000	$50,000	$50,000	$50,000	2016	$50,000	$50,000	-$50,000
Net Income	-$200,000	-$40,827	-$33,948	-$21,908	-$840	$36,031	$100,554	$213,469	$411,071	$856,875
IRR	25%									

RECOMMENDATION 4: CONGESTION MANAGEMENT INCENTIVES

One way that the City of Toronto can affect demand for EVs is by making them more convenient in various respects than conventional vehicles, giving consumers an incentive to make the switch. Two key areas in which the City of Toronto can achieve this are in traffic management and parking. By giving EVs an advantage in terms of navigating traffic during peak hours, by letting them access designated carpool/High-Occupancy Vehicle (HOV) and bus lanes,[70] EV drivers would have an advantage in traffic relative to drivers of conventional vehicles. In addition, EVs parking on designated curbside areas or in city-managed (e.g., Green P) lots could be given exemptions, discounts, or increased parking times. This could entice drivers to consider EVs, with both demand and costs for parking increasing in recent years. Such approaches to incentivizing EVs through traffic management and parking incentives are vindicated by the experience of cities such as London and Oslo, which have implemented similar measures for EVs.

OUR PROPOSAL

Amend existing road bylaws to allow EVs to have universal access to HOV lanes. Consider parking convenience incentives for EVs, including possible fee reductions or exemptions. Begin studying possible integration of EVs with existing plans for autonomous/connected vehicles and commute time-shifting.

These policies could be complementary to existing City of Toronto projects: for instance, Toronto's Congestion Management Plan for 2014-2018 (and update to 2016-2020) includes provisions on adopting advanced traffic systems, readiness for autonomous/data-connected vehicles, and support for all modes of transportation, in

[70] City of Toronto. 2011. *High Occupancy Vehicle Lanes*. http://www.toronto.ca/311/knowledgebase/64/101000040264.html (accessed 31 March 2016).

particular through expanding bike paths. While care should be taken to avoid pushing out low-carbon/no-carbon transport options (such as transit and cycling), there is good reason to believe that incorporating EV incentives would be quite complementary to such plans (especially as the next generation of EVs are likely to also be autonomous and data-connected, making traffic management itself substantially more powerful).

Barriers to Implementation

One upside to this proposed measure is that it is low-cost and relatively easy to implement. Allowing EVs to use HOV lanes and have greater exemptions from parking charges would only require changing by-laws in use by the city. The most difficult aspects of this proposal are simply the logistics of rolling out such a change, as well as potential push-back. Changing regulations, from approval in council to implementation, does take a fair bit of time, and could potentially stall. Additionally, foregoing revenues that could otherwise be earned on parked EVs could meet resistance from lot operators or internal stakeholders. Finally, we believe that care should also be exercised in implementing such policies: it is important to remember that these should (a) complement existing plans to accommodate other low-carbon transportation (such as transit and cycling); (b) should supplement existing traffic management procedures (and should not contribute to congestion or delays, which would negate emissions reductions); and (c) that these policies alone will not be enough to make consumers switch to EVs, and must be part of a broader solution.

Possible Impact

With these caveats in mind, we believe that these policies stand to make EVs an attractive option for city residents. Unfortunately, quantifying the expected impact of shifting parking and traffic convenience incentives is more difficult because of their more diffuse and passive nature; these 'indirect' incentives are typically part of an entire policy package aimed at incentivizing EVs broadly. That said, there is good evidence to suggest that these policies, used in conjunction with other incentives, help push EV uptake. For instance, London and Oslo have both experienced success in using fee exemptions, parking fee exemptions, and EV HOV lane use, had have seen their number of EVs increase[71] — though notably London levies vehicle congestion charges and Oslo benefits from generous federal-level subsidies. Additionally, studies have suggested that allowing EVs to use carpool lanes has an outsized impact on their uptake.[72] There is also the potential for combining an EV traffic incentive scheme together with the city's existing SmartCommute program, which seeks to shift

[71] McKinsey & Company and Amsterdam Roundtable Foundation. 2014. *EVolution - Electric Vehicles in Europe: Gearing up for a new phase?*, p. 17.
[72] Lingzhi Jin, Stephanie Searle, and Nic Lutsey. 2014. *Evaluation of State-Level US Electric Vehicle Incentives*. http://www.theicct.org/sites/default/files/publications/ICCT_state-EV-incentives_20141030.pdf (accessed 31 March 2016). See also: Austria Tech. 2015 (April). *Pushing the Deployment of Electric Vehicles: Options for Policymakers.* http://www.austriatech.at/files/get/00275226e438d35aa98c18bb339ca369/2015-05_atechpolicyoptions_v1.4.pdf (accessed 30 March 2016).

commuting patterns to reduce congestion and delays.[73] Moreover, by integrating this incentive with SmartCommute, it may be possible for the city to reduce the peak usage issue that would otherwise strain the city's electricity capacity when most individuals return home from work and would begin charging their vehicles around the same time. While an assessment should be performed to ensure there are not negative unintended consequences, there is good reason to believe that changing these traffic policies (and combined with SmartCommute to reduce peak usage) altogether is a low-cost, but high-impact, option.

[73] SmartCommute. 2016. *What is SmartCommute?* http://smartcommute.ca/about-us/what-is-smart-commute/ (accessed 31 March 2016).

POTENTIAL IMPACT & FORECAST

To evaluate the potential impact of our recommendations on EV penetration, we first estimate latent demand for EVs among Torontonians, i.e. demand that is unrealized due to various constraints in the EV market. We then estimate the extent to which our recommended actions would alleviate those constraints, thereby realizing a portion of the latent demand for EVs.

We extrapolate the present share of latent demand as a percentage of demand for all new vehicles from a recent study of the Vancouver market published by the Sustainable Transportation Research Team at Simon Fraser University.[74] The study combines the results of two Canadian surveys (heavily representative of British Columbia), the 2015 Plug-in Electric Vehicle Owners Survey and the 2013 New Vehicle Owners Survey, to categorize respondents across three types of EV buyer: pioneers (current EV owners), early mainstream (next EV buyers) and later mainstream (not EV buyers). Analysis of latent demand for EVs comes from the latter two categories of respondents. The study therefore segments latent demand by type of constraint on demand, e.g. inaccessibility of charging stations or limited variety of makes and models. The results indicate that latent demand for EVs in B.C. constitutes 32% of all cars sold, with 14% latent demand constrained by lack of home charging and a combined 14% constrained by the availability of dealers or the number of makes/models, and 3% constrained by lack of familiarity.

We assume in this analysis that latent demand for EVs in the Toronto market mirrors that in B.C., although we acknowledge that the share of latent demand constrained by lack of home charging may be higher in Toronto than in B.C. on average because of Toronto's high population density. Estimating the number of cars sold to Torontonians in 2015 at 148,000 (based on a Canada-wide estimate of 1.898 million) and the number EVs sold at roughly 340 (assuming as above a 50% CAGR in EVs since 2012), we find total latent demand for EVs to amount to 47,500 vehicles in 2015, with 26,700 potential purchases constrained by charging access and 20,800 constrained by availability of dealerships, makes and models.

Because our first three recommendations (charging infrastructure development requirements, fleet adoption and charger station sharing venture) directly address the constraint of charging station access, whether at home or in public, we estimate that these recommendations will erode the percentage of latent demand constrained by charging access. Since our fourth recommendation (congestion management incentives) targets price-sensitive potential EV buyers, we predict its impact those constrained by EV make/model availability, assuming that a small but significant share of those buyers are constrained not only by brand and aesthetic but also by price.

[74] Axsen et al., 2015, *Electrifying Vehicles: Insights from the Canadian Plug-In Electric Vehicle Study.*

Our estimates, summarized in Exhibit 5, predict that our recommendations will add a total of 11,000 new EVs to Toronto by 2025. We also include estimated impacts of three driving forces in the market—the gradual addition of new charging infrastructure by both the public and private sectors, for example, as a result of the City's successful EVCO grant application; improvement in the charging efficiency (including battery capacity) of EVs, which reduces the charging access constraint by alleviating range anxiety; and the continual introduction of new EV makes and models, which alleviates those constrained by poor variety of EV options. We estimate the combined impact of these three drivers at an additional 46,200 EVs on the road by 2025. The CAGR in the total number of EVs implied by this 10-year forecast is 75%, 25% higher than the four-year historical average.

Exhibit 5: Estimated Impact of Recommended Policies on EV Uptake

Estimated Impact on Latent Demand	2017E	2018E	2019E	2020E	2021E	2022E	2023E	2024E	2025E
Constrained by Charging Access									
Realized by Recommendations 1-3	28	63	99	705	1244	1560	1781	2132	2685
As % of All Constrained by Charging Access	0.1%	0.2%	0.4%	2.3%	3.7%	4.3%	4.5%	4.9%	5.8%
Constrained by Availability of Makes/Models									
Realized by Recommendation 4	11	14	44	46	100	183	256	1356	1818
As % of All Constrained by Availability of Makes/Models	0.1%	0.1%	0.2%	0.2%	0.3%	0.5%	0.6%	3.1%	3.9%
Total Estimated Additional EVs	14,124								

Given our estimated total number of vehicles the recommended policies would add to the Toronto fleet by 2025, we can calculate the estimated GHG emissions reduction resulting from the policies. This calculation accounts for compounding reductions, as the reductions from one year carry over into the next year. We find that the proposed policies may result in net reduction of over 400,000 tonnes of GHGs by 2025 (Exhibit 6).

Exhibit 6: Estimated GHG Emissions Reductions from Recommended Policies

CO_2 Emission Reduction (Tonnes)	2017E	2018E	2019E	2020E	2021E	2022E	2023E	2024E	2025E
Annual	146	431	1,108	4,475	11,155	23,789	48,675	102,735	209,244
Total Cumulative	401,760								

LOOKING FORWARD

While we have considered the potential options and impacts for Toronto based on its current situation and policy environment, there are some very important developments on the horizon which will help fuel EV adoption in Toronto, Canada, and around the world. In forming policy, care should be taken to take these upcoming shifts into consideration.

FEDERAL BUDGET 2016

The 2016 Canadian Federal Budget was presented on March 22nd, and it contains a variety of new relevant initiatives. Firstly, the tax incentive which provides accelerated capital cost allowance rates for business investments in clean energy generation will be expanded to include EV charging infrastructure.[75] Together with Ontario's modernized EVIP, the new incentives will help to make EVs more affordable, and to stimulate the development of a more comprehensive network of charging infrastructure, the lack of which is major barrier to EV adoption.

Secondly, the Federal Budget will provide $62.5 million to Resources Canada to work with the provinces, territories, and municipalities to support the deployment of charging infrastructure for EVs.[76] The cooperation with municipalities will mean important new funding opportunities for the City of Toronto, which could be put towards policies such as those proposed in this report. Lastly, the Federal Budget also contains a commitment $2.1 million over two years to improve data collection on the clean technology sector in order to create a "statistical framework that provides regularly published information."[77] The availability of such data will contribute greatly to the ability of researchers in the government, academia, civil society, and the private sector to create evidence-based policy for stimulating EV uptake.

EV INNOVATION & MARKET PROJECTIONS

A new report by Bloomberg New Energy Finance (BNEF) has announced that by 2022, the total cost of ownership -- purchase and running costs -- for BEVs will dip below that of internal combustion engine vehicles (ICE).[78] The drop in cost is due almost entirely to the recent and rapid innovation of lithium-ion batteries, the price for which has reduced by 65% since 2010. The projection accounts for both the continuation of

[75] Government of Canada. 2016. *Federal Budget 2016*, p. 152
[76] *Ibid.*, p. 151
[77] *Ibid.*, p. 155
[78] Bloomberg New Energy Finance. 2016. *Electric Vehicles to be 35% of Global Sales by 2040.* http://about.bnef.com/press-releases/electric-vehicles-to-be-35-of-global-new-car-sales-by-2040/

low oil prices, and the current growth rate of 3.5% per year in the fuel efficiency of ICE vehicles.[79]

Due to the dramatic drop in price, the BNEF report predicts that roughly 35% of global car sales will be EVs in 2040, a number which could fluctuate by about 10% in either direction depending on future oil prices.[80] As for the environment, the shift could reduce global oil consumption by 14%, a testament to the importance of the transportation sector to the global effort to combat climate change.[81]

TESLA MODEL 3

On March 31st 2016, Tesla announced the release of its new Model 3, the most innovative and efficient EV ever to hit the market. The Model 3 will have a range of more than 320 km on one charge, and a price tag of only $30,000-$40,000 USD.[82] With these kinds of developments, it would not be an overstatement to suggest that we are on the brink of the age of the electric vehicle.

[79] *Ibid.*
[80] *Ibid.*
[81] *Ibid.*
[82] Neil Winton. 2016. *Here's the Competition for Tesla's Model 3*. Forbes, March 31 2016. http://www.forbes.com/sites/neilwinton/2016/03/31/teslas-model-3-will-join-small-group-of-pioneering-battery-powered-cars/#aceea279e889