



# Building the corporate business case for electric vehicles

# ACKNOWLEDGEMENTS

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## About Clean Air Partnership

Clean Air Partnership (CAP) is a charitable environmental organization launched in June, 2000. CAP's mission is to help municipalities become sustainable, resilient, vibrant communities where resources are used efficiently, the air is clean to breathe and greenhouse gas emissions are minimized. We achieve this mission through research, knowledge transfer, and by fostering collaboration among all orders of government, academia, NGOs and a range of additional stakeholders.

# ABOUT THIS REPORT

Electric vehicles (EVs) can be a key ingredient in low-carbon societies. The EV market is growing rapidly, manufacturing costs are falling and governments are committing to increasing EV adoption through policy and program development. Increasingly, private and public sector corporations are using EVs in their fleets to maintain or elevate the quality of fleet operations, reduce fleet expenses and fulfill environmental commitments. At the local-scale however, barriers to implementation exist, especially in the public sector and more specifically, municipal governments. In these resource-constrained contexts, stakeholders can struggle to build robust EV business cases which could advance adoption by effectively communicating to decision makers the environmental, economic and social advantages of EVs over conventional vehicles.

This report is designed to help fleet managers and other stakeholders build EV business cases. It does so by providing an overview of important considerations based on existing North American business cases and guidance documents. It is not intended to be prescriptive or exhaustive, but provides a framework of considerations which stakeholders can use to effectively communicate the advantage of EV fleet vehicles to municipal decision makers.

This report is divided into 4 sections. Section 1 provides an overview of EVs and EV charging infrastructure. Section 2 provides an overview of the rationale for the transition of corporate fleets to EVs. Section 3 outlines the key considerations in building EV fleet business cases. Section 4 provides suggestions on how EV business cases can advance adoption of EV fleet vehicles.

The 15 portals employ a diverse range of approaches to enable users to explore climate data over time, where most use either a 30-year or 20-year time interval to compute climate trends and tend to offer at least 3 future time periods. Nearly all portals provide a range of climate variables and derived indices to users to explore climatic change. Types of climate variable vary across the examined portals often relating to the pertinence of certain aspects of locally relevant climate change impacts. Types of derived climate indices also vary across the examined portals, with most portals providing indices relating to temperature and precipitation, with fewer provide ocean- and wind-related indices.

# 1. EVS AND EV CHARGING

There are 3 basic types of EVs: battery EVs, plug-in hybrid EVs and hybrid EVs. Battery EVs use on-board electric motors alone. Plug-in hybrid EVs make use of both an on-board motor and a small internal combustion engine, drawing on their internal combustion engine when more power is required or when the batteries are running low. Hybrid EVs use a conventional internal combustion engine and an electric drive but differ from plug-in hybrid EVs in that all energy for propulsion is generated from fuel with electrical energy generated by a built in alternator or regenerative braking. As hybrid EVs cannot be plugged into the electricity grid and fully rely on fossil fuels they are not covered in this report.

Battery EVs and plug-in hybrid EVs require charging. Currently, there are 3 charging levels available each with varying charging efficiencies. Level 1 chargers (120v) are essentially a specialised power cord that uses a standard household outlet and cost around \$400-1,250<sup>1</sup>. This is the slowest form of EV charging taking over 8 hours to recharge a depleted EV battery and is typically carried out by EV owners at home overnight. Level 2 chargers (220v or 240v) are specialized stations that cost around \$2,500-4,000<sup>1</sup>. These stations are commonly seen at public locations such as workplaces, parking lots and grocery stores. Homeowners may also choose to install a Level 2 charger for faster recharge times, typically 4 hours for a full charge. Level 3 chargers (or DC fast chargers) cost around \$30,000-50,000<sup>1</sup> and are currently the fastest form of EV charging available, providing a full charge in about 30 minutes. Nevertheless, they are a newer innovation and are mainly used for commercial applications.

EV chargers are also divided between those that are networked and non-networked. Non-networked chargers do not feature an internet connection. These are cheaper but do not have any kind of use-management system. This can introduce administrative burdens as protocols for appropriate usage, etiquette and payment (if applicable) need to be enforced by staff. Networked EV chargers feature an internet connection and, for a premium paid to the service provider, use a management system with the ability to stop, start, delay and monitor charging remotely. Advantages are that system usage can be evaluated and improved over time and that appropriate charger usage, etiquette and payment (if applicable) can be enforced. Networked chargers are costlier but make up the majority of newly installed chargers<sup>2</sup>.

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1 Partners in Project Green, 2015. *Charge Up Ontario: A Guide for Businesses to Invest in Electric Vehicle Charging Stations*. Vaughan, ON, Canada: Partners in Project Green.

2 Energetics Incorporated, 2015. *Workplace Electric Vehicle Charging Policies: Best Practices Guide*. Albany, NY, USA: New York State Energy Research and Development Authority.

## 2. WHY EVS?

### GREENHOUSE GAS REDUCTION

EVs are recognized as essential ingredients of low carbon futures. Transportation accounts for 24% of GHG emissions nationally and is the 2<sup>nd</sup> largest GHG emitting sector<sup>3</sup>. In Ontario, transportation accounts for approximately 34% of all GHGs and is the largest emitting sector<sup>4</sup>. Similarly, fleet operations account for a large portion of corporate GHG emissions. As municipalities are increasingly taking action to set and achieve emission targets, EVs are an attractive option given their ability to reduce GHGs and other pollutants in a cost effective way. Additionally, Ontario has a comparatively low carbon electricity sector, which uses fossil fuel electricity generation mainly to support peak electricity demand.

### INCREASING PENETRATION AND FALLING COSTS

The global EV market has a 2016 value of \$103bn, with a projected 2023 value of \$351bn<sup>5</sup>. Additionally, global EV stock reached 1 million for the first time in 2015 with the 2 million mark being reached just a year and a half later. Moreover, 2017 marked the first time that 1 million EVs were sold in a single year<sup>6</sup>.

This growth is in large part due to the falling price of EV batteries which have declined 73% since 2010<sup>7</sup>. The range of EVs available on the market is also rapidly increasing. For example, 2017 saw 156 EVs available on the Canadian market compared to just 97 at the beginning of 2016<sup>9</sup>. Many leading automotive manufacturers have further plans to release more models and/or entirely reposition themselves as EV-only producers in the immediate future<sup>8</sup>.

In Canada, 2017 saw a 68% increase in EV sales nationally on the previous year and a 120% increase in Ontario; the province with the highest rate of vehicle ownership<sup>9</sup>. Furthermore, the availability of Canadian EV makes and models is set to increase as

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3 Environment and Climate Change Canada, 2018. *National Inventory Report 1990-2016 - Greenhouse Gas Sources and Sinks in Canada*. Gatineau, QC, Canada: Environment and Climate Change Canada.

4 Government of Ontario, 2014. *Ontario's Climate Change Update 2014*. Toronto, ON, Canada: Government of Ontario.

5 Pundir A., 2017. *EV Market by Type and Vehicle Type - Global Opportunity Analysis and Industry Forecast, 2017-2023*. Pune, India: Allied Market Research.

6 Clean Energy Canada, 2017. *Stuck in Neutral: Tracking the Energy Revolution 2017*. Vancouver, BC, Canada: Clean Energy Canada.

7 Bloomberg New Energy Finance, 2017. *Lithium-ion Battery Costs and the Market*. London, UK: Bloomberg New Energy Finance.

8 IEA, 2018. *Electric vehicles: Tracking Clean Energy Progress*. Paris, France: IEA.

9 Schmidt E., 2018. *Electric vehicle sales in Canada, 2017*. Waterloo, ON, Canada: FleetCarma. IEA, 2018. *Electric vehicles: Tracking Clean Energy Progress*. Paris, France: IEA.

leading manufacturers aim to penetrate the market (see box 1 for a list of EV makes and models currently available in Canada). Given increasingly favourable market conditions, falling costs and the visions of leading automobile manufacturers, transitioning corporate fleets to EVs is becoming evermore cost-effective.

## OPPORTUNITIES FOR MUNICIPAL LEADERSHIP

Despite this growth, the Canadian EV market share stands at only 0.59% which is small compared to other developed countries (e.g. Norway: 39.2%; Sweden: 6.2%; UK: 1.7%)<sup>10</sup>. This is largely due to inadequate and disaggregate provincial and national EV policies.

Effective EV policies use a portfolio of demand-side and supply-side measures (see box 1). Recent policy reviews reveal a predominance of demand-side measures to encourage consumer uptake while supply-side measures and federal-level EV policies are lacking in Canada<sup>11</sup>. Current assessments show that policies in place today will not push EV sales to a market share of 40% by 2040 as per the federal government goal. Moreover, the vision for a 5% market share by 2020 is unlikely to be attained<sup>12</sup>.

Other countries have more sophisticated supply-side and demand-side policy portfolios. For example, federal-level bans on the sale of certain fossil fueled vehicles, and fuel economy and GHG emission standards are commonplace in leading EV countries, with emerging economies following suit<sup>13</sup>. In the USA, the Corporate Average Fuel Economy (CAFE) standard requires manufacturers to increase their average fuel economy by 16% compared to the 2012 model year, with US states using complementary demand-side tax benefits and rebates to incentivise consumer purchase as well as state level supply-side GHG emission standards to encourage EV manufacture and uptake<sup>14</sup>.

As widespread federal-level EV policy support is still forthcoming in Canada, municipal level commitments to climate action and corporate social responsibility are key to achieving a sustainable transportation future. The City of Vancouver was one of the first to try to capitalize on the benefits of EVs. Work began in 2005 to create a municipal EV fleet which is now Canada's largest. Complementary policies include the development of building codes which require new multi-unit residential buildings to make 100% of their car parking EV-ready. The City also rolled out an extensive network of EV chargers which now numbers over 90 City-managed locations and has advanced EV car sharing by enabling local car sharing companies to use these charger locations. In 2016 the City approved a more encompassing Electric Vehicle Ecosystem Strategy which aims to include EVs as an integral part of an all-renewable transportation sector by 2050. Municipal fleets are also good models for the early adoption EVs because they can

### DEMAND-SIDE MEASURES

Demand-side measures aim to encourage the consumer uptake of EVs and include purchase incentive programs, EV-friendly building regulations and carbon pricing among others.

### SUPPLY-SIDE MEASURES

Supply-side measures aim to support/require EV suppliers to develop and sell EVs. Examples include zero emission vehicle mandates, research and development investment and low-carbon fuel standards among others.

10 IEA, 2018. *Electric vehicles: Tracking Clean Energy Progress*. Paris, France: IEA.

11 Axsen et al., 2016. *Canada's Electric Vehicle Policy Report Card*. Vancouver, BC, Canada: Sustainable Transportation Action Research Team.

12 Heavy duty, public transit and specialty EVs are nascent innovations, especially throughout much of Canada. As such, research programs and pilot studies are still building the picture of how they will contribute to electrified corporate fleets meaning they are often not ready for consideration in EV business cases at present.

13 Schmidt E., 2018. *Electric vehicle sales in Canada, 2017*. Waterloo, ON, Canada: FleetCarma.

14 IEA, 2018. *Hybrid and electric vehicle technology and collaboration programme: United States – policies and legislation*. Available at: <https://tinyurl.com/y8h3fyZ>. Last accessed: 27th July 2018.

get around the conundrum where neither EVs or EV charging stations are present in sufficient numbers to make the other viable. Corporate fleet vehicles have defined service lives which creates a formal window of opportunity to consider new options. EVs and charging infrastructure can therefore be considered together and so get around this “chicken and egg” issue more easily. Furthermore, fleet operations are far more defined and predictable than in wider society and can often involve light drive cycles (i.e. frequent short trips). Therefore, issues around range anxiety, lengthy recharge times and the sparsity of public charging stations are less prohibitive to EV adoption in corporate fleets than in wider society.



# 3. KEY CONSIDERATIONS IN DEVELOPING EFFECTIVE EV BUSINESS CASES

There are a number of key considerations that should be examined when forming a corporate EV business case:

- Ownership costs
- Vehicle administration costs
- Fuel costs
- Maintenance costs
- Total cost of ownership
- GHG reductions
- Charging infrastructure costs

These considerations can help identify opportunities which best match fleet needs and optimize benefits. This section outlines each key consideration to assist fleet managers and other stakeholders to build robust EV fleet business cases. These considerations have been identified through an examination of existing corporate EV fleet business cases in North America and other EV project guidance documents.

## BOX 1

FleetCarma | A lengthy list of EVs currently available in Canada

<https://www.fleetcarma.com/electric-vehicles-currently-available-in-canada/>

FleetCarma provides a useful comprehensive list of the car makes and models currently available in Canada (as of 2017) as well as the manufacturer's suggested retail price, EV type, range and charge time.

## 3.1 OWNERSHIP COSTS

### Vehicle scoping

An EV business case begins with the scoping of new vehicles that can successfully meet fleet needs. Light duty vehicles are commonly considered in existing EV business cases<sup>15</sup>. Trip length, passenger capacity and storage capacity are typical considerations.

An increasing number of EVs are available in Canada giving managers increasing options to meet fleet needs (see box 1 for a comprehensive list of Canadian EVs). In Ontario, fleet managers and other stakeholders can access the [Plug N' Drive Discovery Centre](#) to test drive a range of EVs to help scope potential vehicles as well as gain an understanding of EV technology in general. Business cases by [Fraser Valley Regional District \(BC\)](#) and [Project EVAN](#) identify specific models suited to specific fleet needs.

### Purchase costs

Once possible fleet vehicles have been scoped, it is important to consider their purchase costs. Existing EV business cases commonly use the manufacturer's suggested retail

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<sup>15</sup> Heavy duty, public transit and specialty EVs are nascent innovations, especially throughout much of Canada. As such, research programs and pilot studies are still building the picture of how they will contribute to electrified corporate fleets meaning they are often not ready for consideration in EV business cases at present.



pricings. EVs are commonly subject to rebates and incentive programs meaning actual ownership costs can be significantly reduced. Factoring in this cost offset can create substantial savings relative to conventional vehicles and can be critical to ensuring a successful EV business case. The availability and type of rebates and incentives differ depending on location. At the time of writing, BC is running the [Clean Energy Vehicles for British Columbia](#) – Point of Sale Incentive Program offering rebates of up to \$5,000. Quebec is also running the [Drive Electric Purchase or Lease Rebate Program](#) offering a rebate of up to \$8000 (see box 2 for a resource on EV rebates and incentives). While the Ontario government established the Electric and Hydrogen Vehicle Incentive Program in 2010, it was cancelled in July, 2018 when Ontario pulled out of the Western Climate Initiative cap-and-trade program.

Some provinces, like Ontario, also operate programs enabling EVs to travel in high occupancy vehicle and high occupancy toll lanes regardless of vehicle occupancy. While these do not impact EV fleet finances directly, it is worth highlighting in a business case as they can mean better transit times and more efficient use of staff resources for EVs.

## 3.2 VEHICLE ADMINISTRATION COSTS

### Insurance and licensing

EV business cases mainly consider insurance and licensing fees in accounting for vehicle administration costs. Some business cases apply a constant vehicle administration cost to all vehicles considered. For example, the Project EVAN business case assumes a uniform cost of \$792. Others differentiate insurance and licensing fees depending on the electric/fossil fuel vehicles under consideration. Specific licensing fees are often found on provincial government websites and many existing business cases use information from these sources. A range of insurance calculators are available. The Fraser Valley Regional District business case used the [BC Automobile Association's online insurance calculator](#). For other jurisdictions, the [Canadian Automobile Association's insurance calculator](#) can be used. More accurate rates can be obtained by contacting your existing insurer.

It is also important to consider whether any extra EV insurance premium penalties/benefits apply and to select a cost minimizing insurer accordingly. At present, some insurance providers offer penalties and some offer benefits. Companies apply penalties because of the increased purchase pricing of EVs, which makes them costlier to repair, meanwhile other companies apply insurance benefits to show environmental leadership. In light of this, researching different providers and acquiring a range of quotes is recommended.

#### BOX 2

Electric Mobility Canada | An overview of Canadian EV rebates and incentive programs

<https://emc-mec.ca/ev-101/ev-incentives/>

Electric Mobility Canada provides a comprehensive list of available EV rebates and incentive programs across different provinces as well as detailing eligibility criteria.

### 3.3 FUEL COSTS

The main benefit of EVs is their reduced fuel costs. Partners in Project Green estimates EVs can enjoy fuel savings of about 60-70% relative to conventional vehicles<sup>16</sup>. Existing business cases such as Project EVAN have also examined fuel costs for specific EVs and provide ranges of savings compared to similar conventionally fuelled vehicles. The FleetWise EV300 Program, which used data loggers to analyze the performance of 52 EVs across 16 fleets in the Greater Toronto Area, found fuel costs that were 87.9% and 21.3% lower than fossil fuel vehicles for battery EVs and plug-in hybrid EVs respectively. Nevertheless, potential energy costs/savings are often sensitive to the specific operations of a fleet. Therefore, to accurately capture total energy costs in EV business cases, 2 elements should be considered: local fuel prices and actual fuel economy.

#### Fuel prices

Local fuel prices, either \$/L for conventional vehicles or \$/kWh for EVs, should be considered. For conventional vehicles, business cases tend to derive an average price using recent historical, present day and projected figures as a means to better capture price fluctuations. For example, the Fraser Valley Regional District business case identifies the difference in historical (2007-2014) fossil fuel prices in BC to derive a percentage increase. This is used to forecast future fossil fuel prices for the business case.

For EVs, business cases tend to use current verified electricity rates provided by provincial energy boards. Some business cases also factor in time-of-use rates (i.e. on-peak, mid-peak and off-peak). Most affordable currently available Canadian EVs are suitable for light drive cycles involving frequent, short trips and passenger transport. Overnight charging is highly recommended meaning EV "re-fueling" is subject to cheaper off-peak electricity rates. Factoring in time-of-use rates to the calculation of fuel costs can produce greater fuel savings for EVs versus fossil fuel vehicles. The increasing price volatility of fossil fuels relative to electricity prices is another cost justification for the transition to EVs.

#### Fuel economy

Fuel economy refers to the amount of fuel consumed per unit of distance travelled; either L/km for fossil fuel vehicles or kWh/km for EVs. Accurately including fuel economy values into an EV business case is one of the most crucial yet troublesome considerations in calculating total fuel costs. Guidance documents strongly warn against using vehicles manufacturer's fuel economy values (sticker values). These are derived from laboratory-based dynamometer testing meaning they do not accurately capture real-world driving conditions and styles nor fleet-specific drive cycles.

Many robust EV business cases have used data loggers on existing fossil fuel and pilot electric vehicles to identify fuel economies that are representative of actual fleet drive cycles. Unfortunately, running a pilot program using data loggers can be time- and

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16 Partners in Project Green, 2016. Charge Up Ontario: A guide for businesses to invest in electric vehicle charging stations.

cost-prohibitive, especially for resource-constrained municipalities. In the absence of this option, many business cases use government-published and validated (as opposed to manufacturer-published) fuel economy figures. The US Department of Energy (see box 3) and Natural Resources Canada (see box 5) usefully publish the fuel economies for an extensive list of conventional and electrically fuelled vehicles.

## Total fuel cost

Combining the information on local fuel price and actual fuel economy can produce an accurate total fuel cost for all vehicles. Existing business cases use different approaches to do this. Some consider fuel costs over a pre-set distance of travel (e.g. 100km, 100,000km) and calculate a total fuel cost per unit of distance. For example, FleetWise EV300 compared total energy costs per 100km travelled for all vehicles regardless of fuel type. Meanwhile, other business cases have compared the total lifetime fuel cost by extrapolating energy costs over a vehicle's projected annual mileage and expected service life. Projected annual mileage is often derived from the actual annual mileages of existing fleet vehicles as in the Fraser Valley Regional District business case example of 13,000km/year. Expected service lives are commonly assumed to be around 7 to 10 years (and as discussed below is also advantageous for reducing maintenance costs). Both approaches – total fuel cost per unit of distance and total lifetime fuel cost - are effective as they are a common metric and so enable the business case to clearly illustrate fuel savings between fossil fuel and electric vehicles.

## 3.4 MAINTENANCE COSTS

Battery EVs and plug-in hybrid EVs contain fewer moving parts and have less fluids to change compared to conventional vehicles which can translate into significant maintenance cost savings. It is important that EV business cases capture this by accurately considering maintenance costs; covering costs associated with regular and preventative maintenance as well as the replacement of “wear-out” items (e.g. lights, brake pads).

Partners in Project Green suggest EVs can save about 30-35% in vehicle maintenance costs compared to conventional vehicles<sup>17</sup>. However, general estimates for the maintenance cost savings between fossil fuel and electric vehicles are not recommended because they vary significantly depending on vehicle make, model, drive cycle and other factors. Recognizing this, it is important to derive estimates that are based on specific fleet operations. There are a number of approaches that can help stakeholders do this. For fossil fuel vehicles, maintenance cost information on existing fleet vehicles can often be carried forward into the business case as an accurate estimate. When such information is not available, municipalities can look to other fleets that are both nearby and have similar operational needs to estimate costs for fossil fuel vehicles as well as possible EVs. For example, the Fraser Valley Regional District business case averages vehicle maintenance costs from 3 nearby municipalities that had experience using fossil fuel and electric vehicles.

### BOX 3

US Department of Energy | Fuel Economy Guide: Model Year 2018

<https://www.fueleconomy.gov/feg/pdfs/guides/FEG2018.pdf>

The US Department of Energy's Fuel Economy Guide provides a comprehensive list of car makes and models and their fuel efficiencies.

17 City of Markham, 2017. *Electric vehicle workplace charging pilot*. Available at: <https://tinyurl.com/y9f4dpju>. Last accessed: 27th July 2018.

Additionally, the Canadian Automobile Association [Driving Cost Calculator](#) is another useful tool which can provide maintenance cost estimates across a range of fossil fuel and electric vehicles in line with location, make, model, year, annual mileage, city-highway driving split and trim.

As with energy costs, effective EV business cases extrapolate maintenance costs over a vehicle's service life to derive total lifetime maintenance cost. Again, using this common metric allows for a direct comparison between fossil fuel and electric vehicle maintenance costs/savings.

### 3.5 TOTAL COST OF OWNERSHIP

Effective business cases consider the total cost of ownership for EVs versus fossil fuel vehicles. Previous studies suggest total cost of ownership for EVs is typically 25% lower than for fossil fuel counterparts over an 8-year service life<sup>16</sup>. This approach involves extrapolating ownership costs, vehicle administration costs, fuel costs and maintenance costs across a vehicle's service life and so provides lifetime costs under each category. The sum of these minus any resale/salvage value provides a total cost of ownership.

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$$\text{Total cost of ownership} = \text{ownership costs} + \text{lifetime vehicle admin. costs} + \text{life time fuel costs} + \text{life time maintenance costs} - \text{resale/salvage value}$$

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Deriving a total cost of ownership clearly identifies the costs/savings that accrue across the full service life of a fossil fuel versus electric vehicle. This is an effective approach because it highlights how EVs are a cost-effective option in the long-term for corporations; reduced fuel and maintenance costs over an EVs lifetime more than offset their increased purchase prices (see box 4 for an example business case using this approach).

### 4.6 GHG EMISSIONS

EVs in place of fossil fuel vehicles bring about drastic reductions in GHG emissions and an effective business case should highlight this major benefit. For example, the FleetWise EV300 project compared the GHG emissions of 31 EVs relative to existing fossil fuel counterparts in the GTA and reported 92% and 60% GHG emission reductions in battery EVs and plug-in hybrid EVs respectively.

Effective business cases consider both tailpipe and upstream GHG emissions to estimate the difference between fossil fuel and electric vehicles. Tailpipe GHG emissions values – typically given as gCO<sub>2</sub>/km – are available from trusted and verified sources such as Natural Resources Canada and Environment and Climate Change Canada for numerous vehicles (see box 5).

#### BOX 4

Project EVAN (EV ANalysis) | Business Case for EV Use in Service Vehicle Fleets

<http://www.pollutionprobe.org/publications/project-evan-electric-vehicle-analysis-business-case-for-electric-vehicle-use-in-service-vehicle-fleets/>

This report is a useful example resource on how to effectively identify a total cost of ownership between fossil fuel and electric vehicles to better communicate cost-effective options.

#### BOX 5

Natural Resources Canada | 2018 Fuel Consumption Guide

<http://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/oeef/pdf/transportation/tools/fuelratings/2018%20Fuel%20Consumption%20Guide.pdf>

This guide provides a comprehensive list of Canadian fossil fuel vehicles, PHEVs and BEVs and their estimated energy consumption and CO<sub>2</sub> emissions.

It is also important to consider the GHG emissions that result from the generation of a vehicle's fuel: its upstream emissions. In Ontario, upstream emissions for vehicle gasoline mean an additional 0.998kgCO<sub>2</sub>e/L<sup>18</sup>. Meanwhile, upstream emissions for electricity are much lower - 0.036kgCO<sub>2</sub>/kWh<sup>3</sup> – owing to the province's lower carbon electricity grid. Total upstream emissions can be added to the total tailpipe emissions to provide an accurate picture of conventional versus electric vehicles' total GHG emissions.

Likewise, for other considerations, GHG emissions can be extrapolated over a vehicle's service life to estimate total lifetime GHG emissions. This can align with previous financial lifetime costs/savings as discussed above and so make for a stronger business case.

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Total GHG emissions = tailpipe emissions + upstream emissions

Upstream emissions = (fuel economy x total mileage) x GHG emission factor

Tailpipe emissions = total mileage x tailpipe GHG emissions

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There have been concerns that the GHG emissions associated with the manufacturing of EV batteries can heavily offset their reduced tailpipe and upstream GHG emissions. The International Council of Clean Transportation (ICCT) has conducted an extensive review of existing work and finds that the GHG emissions associated with EV battery manufacturing are about the same as those of conventional internal combustion engines. Moreover, the EV battery manufacturing emissions debt is typically paid back in about 2 years of use (or 1.5 years if charged using electricity from renewable energy sources; as can be the case in Ontario's electricity grid and many other locations in Canada).

## 4.7 CHARGING INFRASTRUCTURE COSTS

Previous studies, such as FleetWise EV300 and Project EVAN, highlight the business case for EVs is strongest when charging occurs off-peak (i.e. overnight and at weekends) as cheaper rates apply. Baseload sources of electricity generation used at off-peak times are less GHG-emitting which means EVs can also accrue deeper GHG emission reductions.

In turn, considering fleet vehicles' patterns of use can help determine whether such a charging regime is suitable. Existing business cases have identified level 1 and/or 2 chargers, which can replenish a fully depleted EV battery in around 4-8 hours, as suitable for many light duty vehicle applications given their frequent short trips. This leaves enough idle time for overnight off-peak charging. Purchase pricings are around \$400-1,250 to \$2,500-4,000 for level 1 and 2 chargers respectively (see box 6 for list of suppliers). Level 3 chargers remain mostly cost-prohibitive (\$30-55,000) for public sector fleet applications (but nevertheless are increasingly common in public locations).

Installation costs are estimated to be around \$2-4,000 per charging port. Available electrical capacity and station location influence costs. Effective business cases, in turn,

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18 Sperl D. and Cannon J., 2007. *Driving climate change: cutting carbon from transportation*. San Diego, CA, USA: Academic Press.

### BOX 6

Partners for Project Green | Charge Up Ontario: a guide for business to invest in EV charging stations

[https://www.partnersinprojectgreen.com/wp-content/uploads/2017/01/PPG\\_Charge-Up-Ontario\\_EVSE-Report-UPDATED-MARCH\\_1\\_2017.pdf](https://www.partnersinprojectgreen.com/wp-content/uploads/2017/01/PPG_Charge-Up-Ontario_EVSE-Report-UPDATED-MARCH_1_2017.pdf)

This report provides a comprehensive list of EV charging station suppliers in Canada (p. 22) that can be useful for comparing specific hardware and installation costs.

suggest how costs can be minimized such as the installation of cheaper indoor wall-mounted options against more expensive outdoor pedestal-mounted locations as well as reducing charger distance to electrical panels and the need for trenching<sup>19</sup>.

As with EV vehicle purchasing, rebates and incentives can partially offset charger purchasing and installation costs. Programs vary depending on location and at the time of writing BC and Quebec offer EV charging incentive programs (see box 7). BC's [Charging Solutions and Incentives Program](#) offers an incentive of 50% of project costs for up to \$4,000 per level 2 charging station and up to \$2,000 per level 1 charging station. Quebec's [Drive Electric: Workplace Charging Program](#) offers a 75% rebate for the purchase and installation of charging infrastructure up to \$5,000. It is important to consider the extent to which any applicable incentive programs can offset costs and strengthen an EV business case.

#### BOX 7

Electric Mobility Canada | List of EV Supply Equipment Incentives

<http://emc-mec.ca/evse-101/list-evse-incentives/>

This resource provides a comprehensive list of EV charging infrastructure incentive programs in different Canadian provinces as well as detailing eligibility criteria.



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19 City of Markham, 2017. *Electric vehicle workplace charging pilot*. Available at: <https://tinyurl.com/y9f4dpju>. Last accessed: 27th July 2018.

## 4. OVERCOMING BARRIERS

Like any large change, making a switch to EVs can be disruptive to business-as-usual fleet operations in the short-term. This section highlights some strategies that can be employed to help overcome these barriers to change.

### RISK IDENTIFICATION AND MITIGATION STRATEGIES

EV business cases can be robust but like all modelled business cases contain a degree of uncertainty. However, this need not be a reason for decision makers to rule out EVs. Clear risk identification is essential. For example, the City of Markham identified risks in their [EV charging pilot report](#), including the discontinuation of incentive programs and significant changes in electricity rates<sup>20</sup>. Mitigation strategies are then suggested. A risk and mitigation strategy identification process can help bolster an EV business case and ensure that uncertainty does not become a vehicle for indecision among municipal decision makers.

### EV EDUCATION FOR FLEET MANAGERS AND DRIVERS

Transitioning to EV fleets is a social investment as much as it is a technological investment. Existing research has shown knowledge on EVs to be low and that people often have inflated concerns over range anxiety as well as a lack of knowledge around EV incentives and the link between EV use and reduced GHG emissions<sup>21</sup>. These can be a barrier to the incorporation of EVs into a fleet. Laying out plans in the business case for corporate employee training on, for example, EV use, charging practices and locations, and maintenance, can help increase EV knowledge. This helps reduce decision making resistance, ensuring appropriate EV use and catalyzing further EV adoption in the wider public. The business case can also be used as an educational piece itself for decision makers by providing an overview of what EVs are and the economic and societal benefits of transitioning to them.

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20 City of Markham, 2017. *Electric vehicle workplace charging pilot*. Available at: <https://tinyurl.com/y9f4dpju>. Last accessed: 27th July 2018.

21 Plug'n Drive, 2017. *Driving EV Uptake in the Greater Toronto and Hamilton Area*. North York, ON, Canada: Plug'n Drive.

## 5. CONCLUSION

The Canadian EV industry, market and policy portfolio is less advanced than that of many developed countries. Accordingly, corporate fleets are an excellent example for the early adoption of EVs that can build towards a more sustainable transportation sector. To advance municipal fleet EV adoption, this guidance document reviews the key considerations that fleet managers and other involved stakeholders can include in EV business cases targeting corporate decision makers. In doing so, we illustrate that the economic, environmental and social reasons for municipalities to transition to EVs are well understood and well evidenced with real-world examples in the North American context. Transitioning corporate fleets to EVs is financially viable for many jurisdictions today and will become increasingly so as the Canadian EV market innovates and grows.

It is well understood from international experience that private sector innovation and market growth will not provide sufficient market penetration in transportation systems where conventionally fuelled vehicles dominate. Transitioning municipal fleets to EVs is essential in leading broader societal change towards EV adoption. This process would be easier facilitated with stronger federal policy support, using incentive programs and other policies to bolster the supply of and demand for EVs nationally.

