GREEN FLEETS

BUSINESS CASE SERIES

Canada

FCM FEDERATION OF CANADIAN MUNICIPALITIES FÉDÉRATION CANADIENNE DES MUNICIPALITÉS

Clean Air Partnership

Clean Air Partnership

ABOUT THE CLEAN AIR PARTNERSHIP:

Clean Air Partnership (CAP) is a registered charity that works in partnership to promote and coordinate actions to improve local air quality and reduce greenhouse gases for healthy communities. Our applied research on municipal policies strives to broaden and improve access to public policy debate on air pollution and climate change issues. Clean Air Partnership's mission is to transform cities into more sustainable, resilient, and vibrant communities where resources are used efficiently, the air is clean to breathe and greenhouse gas emissions are minimized.

REPORT AUTHORS:

Desislava Stefanova, Clean Air Partnership

Kevin Behan, Clean Air Partnership

This initiative is offered through the Municipalities for Climate Innovation Program, which is delivered by the Federation of Canadian Municipalities and funded by the Government of Canada.

FCM FEDERATION OF CANADIAN MUNICIPALITIES FÉDÉRATION CANADIENNE DES MUNICIPALITÉS

Canada

ACKNOWLEDGMENTS:

This report represents the culmination of efforts invested by many parties who offered their policy and technical expertise to the research compiled in this report. We are grateful for the support of:

Doran Hoge, *Municipality of Clarington*

Mary Gracie, *City of Ottawa*

Adam Walker, *City of Ottawa*

Steve Mollon, *City of London*

Angelo Klaric, *City of Toronto*

For more information, contact:
Clean Air Partnership
75 Elizabeth Street,
Toronto, Ontario,
Canada, M5G 1P4.
416.460.6320
cleanairpartnership.org
kbehan@cleanairpartnership.org

Layout Design by Carly Popenko

TABLE OF CONTENTS

GLOSSARY

AAEF — Annual Average Emissions Factor. It is a measure of the average amount of carbon pollution produced per kWh of electricity consumed.

BEV — Battery Electric Vehicle. A 100% battery-powered Electric Vehicle.

CHARGING STATION — Infrastructure that supplies electricity to recharging electric vehicles, also known as Electric Vehicle Supply Equipment (EVSE).

CONNECTOR — A device attached to the cable from an EVSE that connects to an electric vehicle.

DC FAST CHARGING — The fastest (high powered) way to charge electric vehicles quickly with an electrical output ranging from 50kW–120kW. This will charge an average electric car in 20–30 minutes.

EVSE — Electric Vehicle Supply Equipment. A safety protocol that enables two-way communication between a charging station and electric vehicle to control the safe current flow between the charger and an EV.

HYBRID ELECTRIC VEHICLE — A car that integrates a small battery and an electric motor to enhance the efficiency of the engine. The battery's charge is maintained by the internal combustion engine — it cannot be charged by plugging into an electrical supply.

ICEV — Internal Combustion Engine Vehicle. The technical name for the gas-powered engine in most cars, SUVs, and trucks. It generates power by igniting an air-fuel mixture the combustion chamber which applies a force on the pistons.

LDC — Local Distribution Company. Entity that maintains the portion of the utility supply grid that is closest to the residential and small commercial consumer.

PHEV — Plug-in Hybrid Electric Vehicle. A hybrid electric vehicle whose battery can be charged by plugging into an EVSE in addition to through its on-board gasoline engine and generator.

TCO — Total Cost of Ownership. The total cost of a product during its lifecycle. It highlights the difference between purchase price and long-term cost.

ZEV — Zero Emission Vehicle. A vehicle that emits no tailpipe pollutants from the onboard source of power.

EXECUTIVE SUMMARY

Canadian municipalities have been reducing their greenhouse gas (GHG) emissions to help mitigate climate change. Sustainable transportation options, including fleet electrification is key to their climate action commitment and corporate social responsibility. Currently, most electric vehicle models available on the Canadian market are light-duty / passenger vehicles. This report provides a business case for purchasing electric light-duty / passenger vehicles (EVs) and supports fleet managers and other stakeholders to build their own EV business cases.

The first part of the report provides an overview of EV considerations, identifying differences from internal combustion engine vehicles (ICEV). EVs can be either battery electric (BEV), with a battery-powered motor; or plug-in hybrid (PHEV), with both electric and combustion engines for propulsion, and the ability for the battery to be recharged through the onboard combustion engine or through an external power source. Both can be plugged in an EV charger. EV chargers are stations that supply electric energy. Municipal fleets normally use Level 2 chargers which take around 4–8 hours to charge a 40–50 kWh battery car (standard battery for an electric car). Today's 40–50 kWh battery powered cars can travel 200–400 km on a single charge.

The second part of this report look at the costs and benefits associated with electrifying municipal fleets. EVs in place of fossil fuel vehicles bring about drastic reductions in GHG emissions allowing municipalities to act on climate change, reach their corporate targets, and improve local air quality. The transportation sector causes air and noise pollution, both linked to adverse impacts that cost billions per year in health care costs.

In addition to the health and climate benefits, passenger EVs are also cost-effective as this report will demonstrate. Despite higher upfront costs, EVs are less expensive to operate and maintain. With continuous EV market growth and regulatory and incentive support, fleet electrification will be increasingly financially viable in the coming years.

The third section of this report provides examples of EV business cases. The first business case was developed by Clean Air Partnership and provides a step-by-step analysis to determine the total cost of ownership and total GHG emissions. It compares a 2019 Ford FUSION S ICEV and 2019 Chevrolet BOLT EV. The results show that Chevrolet Bolt EV is $1,695 less expensive than Ford Fusion and reduces over 13 tonnes of carbon dioxide from the municipal fleet. The second business case is from the Fraser Valley Regional District, BC, and compares the total cost of ownership between two hybrid vehicles, and two EVs. The results show that an all-electric 2015 Nissan Leaf is the lowest cost fleet vehicle compared with the existing fleet vehicles (Ford Escape-hybrid and Toyota Prius-hybrid).

Lastly, City of London Business Case compares the total cost of ownership and the total GHG emissions between electric and gas ice resurfacers. The results show that the electric ice resurfacer will be around $30,000 per unit more expensive than gas units, but with a positive benefit-cost ratio. The conversion of the entire ice resurfacing fleet (14 units) to battery-electric, operational units will mitigate 212 tonnes of GHG emissions annually and contribute to about 25% of the City's overall corporate GHG reduction target.

This report shows that the transition to fleet electrification provides public health and climate benefits for the community as well as financial and leadership benefits for the municipality.

1.0 | EV PROCUREMENT CONSIDERATIONS

1.0 | EV PROCUREMENT CONSIDERATIONS

EVs are essential ingredients in low carbon futures as they reduce GHG emissions and improve air quality. Transportation accounts for 24% of GHG emissions nationally and is the 2nd largest GHG emitting sector. In Ontario, transportation accounts for approximately 35% of all GHGs and is the largest emitting sector[1]. 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. Air quality improvements from EVs are directly linked with public health benefits. A recent study conducted in the Greater Toronto and Hamilton Area (GTHA) showed that shifting to 100% electric cars would provide up to $2.4 billion per year in social benefits[2]. Fleet electrification also demonstrates corporate municipal leadership and commitment to climate action.

While EVs can offer many benefits to the fleet, there are certain elements that require consideration. Charging infrastructure must be installed, range anxiety and driver behaviour changes can require training, and cost calculations are more complex, incorporating the total cost of ownership that involves extrapolating ownership costs, vehicle administration costs, fuel costs and maintenance costs across a vehicle's service life. This report will discuss these issues in depth.

1.1 | AVAILABILITY

The number of EVs available on the Canadian market increased from 10 in 2015[3] to 48 in 2019[4]. These are mostly light duty / passenger vehicles, and currently, Canadian municipalities are mostly electrifying these types of vehicle in their fleets. However, fleet managers are facing an urgent need for low carbon medium and large vehicles. Currently, there is a lack of commercial options for EV pickup trucks, vans, and class 3-5 trucks, which represent a large portion of the municipal fleet. The volume of light-duty trucks and SUVs in fleets is more than double the volume of passenger cars in rural municipalities and in Ontario's north. While new EV pickup trucks and SUVs will soon be available, it will take time to test the technology and make the business case for their acquisition.

Nevertheless, other fleet vehicles such as ice resurfacers and buses are currently available as EVs. The City of London, Ontario, is procuring six new electric ice resurfacers. The business case for that purchase can be found in the EV Business Case Examples section of this report. Ontario municipalities are also electrifying their transit. Numerous municipalities in the GTHA are already deploying electrical busses, primarily supported by the federal 'Investing in Canada Infrastructure Plan'. However, uncertainties with charging cost, load power variations, battery ageing, and the high upfront cost for buses and infrastructure are still barriers that municipalities must overcome.

1.2 | CHARGING

There are three basic types of EVs: ***battery EVs (BEV)***, ***hybrid EVs (HV)***, and ***plug-in hybrid EVs (PHEV)*** vehicles.

BEVs are 100% electric vehicles that are powered by an electric motor. The battery is charged by plugging into an EV charger. HVs are vehicles that have an electric motor and a small battery that allows the car to travel very short distances on battery power. HVs have an internal combustion engine that automatically charges the battery. The hybrid drivetrain assists the gas engine when accelerating from a stop. PHEVs are hybrids that use an electric motor for propulsion, and an internal combustion engine that charges the on-board battery when the battery level is low. When the gas engine is running, it slowly recharges the battery, but it must be plugged in to be fully recharged. PHEVs have a larger battery that permits longer distance driving on electric power only (around 80km). This report will focus on BEVs primarily, as they provide the greatest GHG and cost savings to municipalities.

FIGURE 1: EV CHARGING LEVELS

LEVEL 1 PUBLIC CHARGERS **LEVEL 2 PUBLIC CHARGERS** **LEVEL 3 PUBLIC CHARGERS**

(Source: ChargeHub)

TABLE 1: EV CHARGER LEVELS

	LEVEL 1	LEVEL 2	LEVEL 3
VOLTAGE	120V	220V–240V	DC Fast Chargers
HOURS TO FULL CHARGE (FROM EMPTY BATTERY)	200km–20h 400km–43h	200km–5h 400km–11h	200 km–30 min 400km–1h
PRICE	$400–$1,250	$2,500–4,000	$30,000–$50,000

(Source: ChargeHub)

BEVs require charging. Currently, there are three charging levels available. Level 1 is a specialized power cord that uses a standard household outlet. They are used primarily when charging at home. Most municipalities use Level 2 chargers which are specialized stations that charge an EV up to 7 times faster than a level 1 charger, or up to 3 times faster for a PHEV. Level 3 chargers are used primarily for commercial applications and public charging on highways.

EV chargers can be smart (networked) and non-networked (no internet connection). The former uses a management system that can remotely stop, start, delay and monitor charging, allowing easier enforcement of etiquette and payment. Additionally, smart charging considers energy costs, dispatch schedules, vehicle battery size, environmental conditions and other factors when charging EVs. This is particularly useful when municipalities have multiple EVs in their fleets.

1.3 | CHARGING INFRASTRUCTURE

Charging infrastructure is the foundation of an EV fleet. Electric vehicle supply equipment (EVSE) is the physical network that transfers electricity from the grid to the vehicles themselves. A charging station has one or more charging cables equipped with a connector like a gas-pump nozzle and is used in the same way, connecting the EV's charging socket to charge the battery. A useful technical resource on specifications and installation considerations around different types of EV charging stations is Hydro Quebec's Electric Vehicle Charging Stations: Technical Installation Guide.

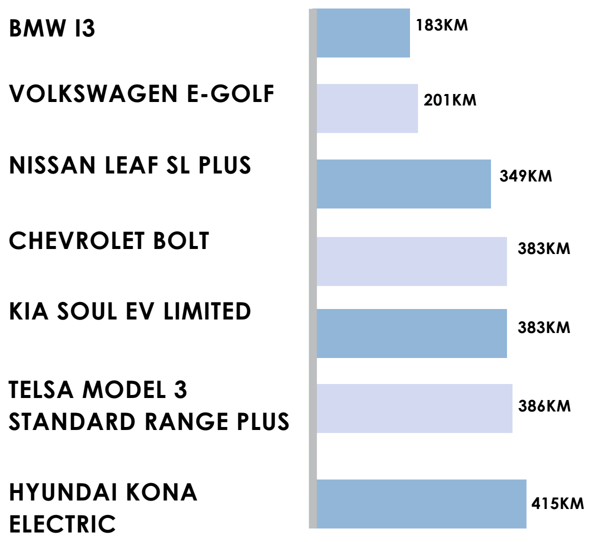
Thorough planning is key to the successful installation of fleet EVSE. During this process, continuous consultation with your electrical utility and EVSE providers is essential. Fleet managers must estimate the projected EV acquisitions over the short and medium-term. Considering future EV growth is important, adding extra circuits, electrical capacity, and conduit from the electrical panel to allow for future EVSE locations. Managers must determine how much energy each vehicle will need over an average day (load profile), and the time it will take to deliver that energy (charging window). This enables fleet managers to assess electrical upgrade needs and choose the appropriate number and type of EVSEs.

Challenges associated with charging infrastructure include building relationships with electrical utilities to determine grid capacity and support eventual upgrades. Furthermore, lack of control of charging rates, time of day or energy optimization can result in significantly higher energy costs from peak demand charging when electricity is more expensive. However, using networked / smart charging stations considers energy costs, dispatch schedules, vehicle battery size, environmental conditions and other factors when charging EVs. These are important features that enable communication between cars, fleet managers, electric utilities and charging operators to optimize charging.

1.4 | RANGE

The latest generation of EVs travel 200–400 km on a single charge[5]. The concern around the range is easing as batteries gain capacity and efficiency.

FIGURE 2: RANGE COMPARISON FOR SOME COMMON EVS



(Source: BC Hydro Power Smart)

Range is also impacted by driving style, load, terrain and interior and ambient temperature. The day-to-day range is affected by temperature primarily due to auxiliary heating and cooling. At optimal temperatures, EVs perform better than their rated range, peaking at 115% at 21.5 degrees Celsius[6]. However, a decrease in temperature to -6°C can result in a 12% decrease in driving range and using a cabin heating system can further decrease the range to up to 40%[7].

To maximize EV range, fleet managers should provide driver training. To maximize battery life and increase range, drivers should limit harsh acceleration and maximize the use of the regenerative braking system. Furthermore, during the winter, fleet managers might want to encourage departure-time charging. This allows a car to fully complete its charge shortly before departure to keep the battery primed. Like internal combustion cars, fuel efficiency comes with rightsizing the vehicle to its task. Maintaining the correct tire pressures also helps to get the best mileage out of each charge. Also, EVs require planning for daily mileage and proximity to appropriate charging infrastructure[6].

1.5 EMISSIONS

Concerns about the environmental burden of manufacturing EVs can be a barrier to purchase. These concerns are mainly due to the manufacturing of EV batteries. However, two Canadian studies[8,9] that explore the comparison of the lifetime impact of EVs and conventional ICEVs show that EVs charged from clean sources in Canada can pay off this environmental burden within three years. In contrast, ICEVs continue to add GHGs to the atmosphere for as long as they are driven.

A lot of energy (generated mainly with fossil fuels) is needed to mine and transport the metals that go into an EV's battery: lithium, cobalt, manganese, nickel and graphite. EVs have a higher burden during manufacturing, but their emissions over their lifetime are lower than those of an ICEV.

Plug In BC estimate that EVs charged in BC pay off their environmental burden after three years, after which every kilometer driven is carbon negative.

Similarly, a study from 2 Degrees Institute shows that over 15 years of driving 10,000km/year, EVs such as the Nissan Leaf generate lower emissions: 99% lower in BC, and 81% lower in Ontario, and 50% lower in Alberta, where a significant amount of coal is used to power the electrical grid[8,9].

Regarding battery end-of-life, which occurs after 6 to 8 years, the battery can either be repurposed or recycled to obtain the raw materials. Retired EV batteries can maintain 70–80% of their initial capacity[10]. While this cannot satisfy the energy needed to power an EV, they can be used in other applications, such as stationary energy storage. For example, one of the biggest telecommunication companies in China uses retired EV batteries as back-up power for their telecom towers. EV manufacturers such as Nissan, Renault, BMW, Volkswagen, and BYD have also been exploring various usage scenarios for second life EV batteries from residential – to commercial – and grid-scale energy storage applications[11].

TABLE 2: COMPARING LIFE CYCLE EMISSIONS OF A *BEV* AND *ICEV*

KG CO_2					
ONTARIO	MANUFACTURING	MAINTENANCE	DRIVING	TOTAL	EMISSIONS DIFFERENCE
EV	10,509	2,378	2,980	15,867	81.2%
ICEV	7,257	6,086	71,185	84,528	

(Source: 2 Degree Institute, 2017)

2.0 |

COSTS AND BENEFITS

2.0 | COSTS AND BENEFITS

This section identifies a list of costs and benefits of EVs. These will be used later in cost-benefit analyses. A triple bottom line approach is needed to drive decision making with focus on social, environmental and financial aspects of EV procurement.

2.1 | COSTS

Vehicle cost

Depending on the EV make and model, the price on the Canadian market ranges from $36,000 to $90,000, excluding premium makers which exceed $100,000. To learn more about the EVs available on the Canadian market fleet managers based in Ontario can visit the Plug N' Drive Discovery Centre. A fleet assessment helps fleet managers understand what EV best suits their needs. This determines daily mileage, payload, routing, etc. Some fleet managers use tools like the FleetCarma EV Suitability Assessment. This tool recommends EVs based on vehicle-requirements, range-capability, and the total cost of ownership (purchase, maintenance costs).

Charging infrastructure

Significant resources are needed for building EV charging infrastructure for fleets. Planning, time, expertise, and collaboration are required to correctly size EV parking and charging for fleet applications. Currently, the cost of charging stations for Level 1 and Level 2 can range from $400–$4,000. Installation cost varies depending on electrical service upgrades (if necessary), distance to the electrical panel, the number of stations installed, indoor versus outdoor installations, permits and inspection costs.

The estimated cost of installation for Level 2 is around $1,000–2,000 per charging port.

Since charging infrastructure is expensive, funding is crucial. The 2019 federal government budget provided $130 million over five years to support the deployment of EV charging infrastructure at workplaces, commercial and multi-unit residential buildings, public places, on-street and projects for fleets and transit. Many municipalities already benefit from this funding.

Training

While switching to EVs requires small changes in the way drivers fuel / charge and drive, those changes are crucial to achieving greatest return on investment. Driver training focusing on conserving momentum, avoiding harsh braking, and refueling, have both safety and efficiency benefits.

Currently, there are no PHEV / EV Driver Training programs available for fleets in Canada. However, FleetCarma has created A Simple Training Guide for New Electric Car Drivers that highlights key differences between gas and electric car driving. We recommend that municipalities create training materials to ensure drivers operate vehicles efficiently. EV centers across Canada, such as Plug N' Drive (Toronto, ON), Electric Vehicle Technology & Education Centre (EVTEC) (Winnipeg, MB), and Plug-in BC (Vancouver, BC) often provide opportunities for drivers to test various electric cars. Additionally, some EV vendors loan EVs to fleet departments for test drives.

Maintenance

While maintenance costs between ICEVs and EVs vary significantly depending on vehicle make, model, drive cycle and other factors, research shows that EVs have substantially lower maintenance costs[12,13,14,]. BEVs contain fewer moving parts and have fewer fluids to change than conventional vehicles.

A study of 2,400 cars in Canada showed 47% average cost savings in maintenance of operating a BEV over an ICEV[12]. This is consistent with other scientific papers on this topic[13,14]. When looking at the Provincial level, a study by the 2 Degree Institute, comparing four models (2 ICEVs and 2 EVs), found that the annual savings on fuel and maintenance of driving BEVs per household in Quebec are 77% and in Saskatchewan 65% compared to ICEVs (see Table 3).

It should be noted that since EVs have fewer moving parts, with potentially fewer visits to repair shops, which can result in more productive time for staff (less time spent repairing cars).

TABLE 3: ANNUAL SAVINGS ON FUEL AND MAINTENANCE OF DRIVING BEVS PER HOUSEHOLD

	AVERAGE ICEV COSTS			AVERAGE BEV COSTS			SAVINGS	
PROVINCE	MAINT.	FUEL	TOTAL	MAINT.	FUEL	TOTAL	$	%
BC	$797	$2,339	$3,136	$419	$400	$819	$2,318	74%
AB	$1,330	$3,251	$4,581	$698	$567	$1,265	$3,316	72%
SK	$1,225	$3,025	$4,250	$643	$841	$1,484	$2,766	65%
MB	$831	$2,207	$3,038	$438	$342	$779	$2,259	74%
ON	$952	$2,583	$3,535	$500	$694	$1,194	$2,341	66%
QC	$776	$2,157	$2,933	$408	$254	$663	$2,270	77%
NL	$1,048	$2,970	$4,018	$551	$519	$1,070	$2,948	73%
PEI	$798	$2,363	$3,161	$421	$657	$1,077	$2,084	66%
NB	$899	$2,574	$3,473	$474	$565	$1,039	$2,434	70%
NS	$891	$2,527	$3,418	$469	$694	$1,163	$2,255	66%

(Source: 2 Degrees Institute, 2018)

Fuel

Current local electricity prices for EVs ($/kWh) can be derived using electricity rates provided by provincial energy boards. Similarly, the fuel price ($/L) for gas cars can be defined using historical, present, and projected figures to capture price fluctuations.

The total fuel cost captures local fuel price and the vehicle fuel economy. The NRCan fuel consumption rating search tool estimates the fuel economy for every make and model car available on the Canadian market, allowing for comparison of EV and ICEVs. To determine total lifetime fuel cost, fleet managers extrapolate energy costs over a vehicle's projected annual mileage and expected service life. For a detailed analysis, please see the *Business Case Series* in Section 3.

Resale / salvage value

ICEVs depreciate quicker than EVs. However, there is insufficient data to determine the exact rate of depreciation for EVs. Also, like ICEVs, the depreciation rate varies between EV makes and models. For example, the Nissan Leaf has been on the market for ten years; but the range and battery characteristics are very different from 10 years ago. As a rule of thumb, it is often assumed that vehicle value depreciates at a rate of 30% in the first year, and 20% each subsequent year. It is recommended that fleet managers determine the depreciation rate based on their own fleet characteristics.

Total cost of ownership

The total cost of ownership (TCO) captures the vehicle purchase price plus lifetime costs for administration, fuel, and maintenance costs, minus resale / salvage value. While the purchase price is higher for EVs, the fuel and maintenance costs can offset it over a lifetime. In 2016, Partners for Project Green estimated that TCO for EVs is typically 25% lower than for fossil fuel counterparts over an 8-year service life.

Two recent TCO analyses in Ontario showed that comparing the total cost of ownership between EVs and ICEV, EVs have favourable cost comparisons[15,16]. It should be noted that the TCO depends on local fuel and power prices so TCO will vary by province. Nevertheless, as battery costs fall, the price gap will continue to diminish, giving EVs an increasing advantage.

2.2 | BENEFITS

GHG Reduction

As part of municipal climate mitigation strategies, fleet managers are charged with reducing fleet GHGs. Every liter of gasoline burned generates about 2.3 kilograms of CO_2. Due to the relatively clean grid in Quebec, British Columbia, Ontario and Manitoba (more than 80% from hydro), life cycle emission reductions of over 83% are estimated when replacing an ICEV with electric[9]. The average annual reduction in GHG emissions from replacing an ICEV with a comparable EV in Ontario is 4.6T CO_2. A recent study looking at GHG emissions in the GTHA modelled that if 100% of cars / SUVs were electric, it would reduce the total GHG emissions from transportation in the region by 68.5%[2].

Air Quality

The World Health Organization estimated that for 2016 there were 4.2 million premature deaths globally linked to ambient air pollution, mainly from heart disease, stroke, chronic obstructive pulmonary disease, lung cancers, and acute respiratory infections in children[17]. Canadian research shows that in the GTHA, air pollution causes more than 3,000 premature deaths every year[2]. The same study modelled different scenarios and showed that shifting to 100% electric cars and SUVs would result in 313 fewer premature deaths per year and provide up to $2.4 billion per year in social benefits.

EVs produce less noise than ICEVs, which means less noise pollution. The primary source of noise in urban areas is traffic-related noise. Research shows that noise pollution can have a significant impact on human and ecosystem health. A study from Paris, France, estimated that an average resident living in downtown Paris loses more than three healthy life-years over a lifetime due to a combination of ailments caused or exacerbated by the noise of cars, trucks, airplanes, and trains[21].

Community leadership

Many municipalities are electrifying their fleets to reduce GHGs and implement their Climate Action Plans. While larger cities have been early incubators for transportation advancements, smaller municipalities have also shown leadership. For example, Plessisville, Quebec, a city of less than 7,000 people, allows community members to rent the two City-owned EVs. The City's three double EV chargers (two Level 2 and one Level 3) are available for public use.

With GHG reduction and the potential for operational savings, another driver for fleet electrification is community engagement on GHG reduction. By advancing fleet electrification, municipalities also facilitate the community transition towards EVs.

3.0 | BUSINESS CASE SERIES

3.0 | BUSINESS CASE SERIES

This part of the report contains three different business cases. The first one, ***Clean Air Partnership's EV Business Case***, provides the methodology for EV Business Case development and a step-by-step analysis of total cost of ownership and total GHG emissions. Fleet managers can follow this step-by-step analysis or they can plug their parameters into the Plug-in BC Cost Tool (MS excel). The tool calculates and summarizes the annual savings / losses, and the annual GHG emissions. However, additional calculations are needed to determine lifetime savings. The second business case is from ***Fraser Valley Regional District, BC*** and compares total cost of ownership for six vehicles, two EV, two hybrid vehicles, and two ICEV. Lastly, the ***City of London Business Case*** compares a natural gas ice resurfacer with an electric ice resurfacer.

3.1 | CLEAN AIR PARTNERSHIP TOTAL COST OF OWNERSHIP MODEL

Clean Air Partnership created a sample EV business case that compares the total cost of ownership and total GHG emissions of a light-duty / passenger ICEV with an EV. The cars chosen for this study are a ***2019 Ford FUSION S (ICEV)*** and a ***2019 Chevrolet BOLT EV***. They are of similar size, features and quality. The case study results show that replacement with an all-electric Chevrolet Bolt is less expensive than the ICEV Ford Fusion by $1,695 over the life of the vehicle and will save 13,022kg CO_2 emissions.

Parameters

Tables 4 and 5 present operational and vehicle parameters. Operational parameters (Table 4) are typical parameters relating to service use and fuel cost. Fuel costs will need to be updated for use outside Ontario. Vehicle parameters (Table 5) are specific for the vehicles compared. Vehicles in this Business Case are typical for municipal fleets in Southern Ontario.

FIGURE 3: *FORD FUSION S (2019)* AND *CHEVROLET BOLT EV (2019)*

(Source: Autotrader.ca)

TABLE 4: OPERATIONAL PARAMETERS

		NOTES
EXPECTED SERVICE LIFE	7 YEARS	The service life of a vehicle depends on location, vehicle type, and usage. Generally, the expected service life of fleet passenger vehicle is 6–8 years.
AVERAGE TRIP LENGTH	35KM	This number is based on combined and averaged data from municipalities in Southern Ontario.
AVERAGE ANNUAL MILEAGE	10,000KM	This number is based on combined and averaged data from municipalities in Southern Ontario.
GASOLINE PRICE	$1.30/L	Gasoline prices vary between provinces and can rise and fall dramatically. This calculation uses NRCan's Fuel consumption rating search tool that defines estimated annual fuel cost.
ELECTRICITY PRICE	0.9 CENTS/kWh	This is the average off-peak price for the period of May 2017–March 2020 in Ontario. We recommend municipalities to use off-peak charging which managed with smart chargers.

TABLE 5: VEHICLE PARAMETERS

PARAMETERS	2019 FORD FUSION S	2019 CHEVROLET BOLT EV	NOTES
MANUFACTURER SELLING PRICE	$28,090	$44,800	The prices were found on the retailer website on Oct 6, 2020. Most manufacturers / vendors offer discounts for bulk purchases and long-term contracts to municipalities.
INSURANCE			Insurance costs were assumed to be equal and thus excluded.

PARAMETERS	2019 FORD FUSION S	2019 CHEVROLET BOLT EV	NOTES
INCENTIVES		$5000	Under the Federal Zero-Emission Vehicles Program, municipalities are eligible for federal funds (up to $5K for EVs and $2.5K for PHEV) for a max of 10 vehicles/year.
RANGE		383km	This range is achieved with the stock 60kWh battery.
FUEL ECONOMY	8.3L/100km	15.7kWh/100km	Fuel consumption is found on the Fuel consumption rating search tool by NRCan for both ICEV and EV for combined city-highway driving.
MAINTENANCE COST	$931/year	$489/year	Maintenance costs are found on Comparing Fuel and Maintenance cost of EV and ICEV in Canada. The battery is expected to last throughout the vehicle's life (7 years).
CARBON INTENSITY OF FUEL / ELECTRICITY (CO_2/L OR CO_2/kWh)	2.3 kg CO_2	31gCO_2/kWh	Carbon intensity from NRCan's Fuel consumption and $C0_2$ fact sheet. Electricity: The Annual Average Emissions Factor of 31gCO_2 /kWh is calculated with 2018 IESO data and The Atmospheric Fund's methodology[23].
DEPRECIATE / RESALE COST (LIFETIME)	$5,155	$8,221	Both vehicles depreciate at 30% in the first year and 20% in subsequent years.
CARBON TAX	$700	$0	Carbon price of $20 per tonne CO_2e in 2019, rising by $10 per tonne annually to $50 per tonne in 2022.

Results

For both vehicles, the total cost of ownership is estimated as well as the total lifetime GHG emissions

TABLE 6: STEP-BY-STEP ANALYSIS OF TOTAL COST OF OWNERSHIP FOR *2019 FORD FUSION S*

EXPLANATION	FORMULA	RESULTS
ANNUAL FUEL COST	8.3L/100km × 10,000km/year **= *830L/year*** 830L/year × 1.30$/L **= *$1,079/year***	**$1,079/year**
LIFETIME FUEL COST	1,079/year × 7 years **= *$7,553***	**$7,553**
TOTAL MAINTENANCE COST	$931/year × 7 years **= *$6,517***	**$6,517**
DEPRECIATE / RESALE COST (LIFETIME)	$28,090 - 30% **= *$19,663*** $19,663 - 20% **= *$15,730.4*** $15,730.4 - 20% **= *$12,584.32*** $12,584.32 - 20% **= *$10,067.46*** $10,067.46 - 20% **= *$8,054*** $8,054 - 20% **= *$6,443.2*** $6,443.2 - 20% **= *$5,155***	**$5,155**
CARBON TAX (LIFETIME) 2TCO_2E/YEAR STARTING AT $20/T INCREASING BY $10/T/YEAR THERAFTER	(2×$20) + (2×$30) + (2×$40) + (2×$50) + (2×$60) + (2×$70) + (2×$80) **= *$700***	**$700**
TOTAL COST OF OWNERSHIP	$28,090 + $7,553 + $6,517 - $5,155 + 700 **= *$37,705***	**$37,705**

TABLE 7: STEP-BY-STEP ANALYSIS OF TOTAL COST OF OWNERSHIP FOR *2019 CHEVROLET BOLT EV*

EXPLANATION	FORMULA	RESULTS
FUEL ECONOMY	(Battery capacity) / Distance = 60kWh/383km = 0.157kWh/km **= *0.16kWh/km***	**0.16kWh/km**
ANNUAL FUEL COST	0.16kWh/km × 10,000km/year × $0.09/kWh **= *$144/year***	**$144/year**
LIFETIME FUEL COST	$144/year × 7 years **= *$ 1,008***	**$1,008**
TOTAL MAINTENANCE COST	$489/year × 7 years **= *$ 3,423***	**$3,423**
DEPRECIATE / RESALE COST (LIFETIME)	$44,800 - 30% **= *$31,360*** $31,360 - 20% **= *$25,088*** $25,088 - 20% **= *$20,070.4*** $20,070.4 - 20% **= *$16,056.3*** $16,056.3 - 20% **= *$12,845.06*** $12,845.06 - 20% **= *$10,276*** $10,276 - 20% **= *$8,221***	**$8,221**
TOTAL COST OF OWNERSHIP	$44,800 + $1,008 + $3,423 - $8,221 **= *$ 41,010***	**$ 41,010**

TABLE 8: SUMMARY AND COMPARISON OF TOTAL COST OF OWNERSHIP

	2019 FORD FUSION S	2019 CHEVROLET BOLT EV
SELLING PRICE	$28,090	$44,800
TOTAL FUEL COST	$7,553	$1,008
TOTAL MAINTENANCE COST	$6,517	$3,423
RESALE / SALVAGE VALUE (AFTER 7 YEARS)	$5,155	$8,221
TOTAL COST OF OWNERSHIP	$37,005	$41,010
INCENTIVES	0	$5,000
CARBON TAX (7 YEARS)	$700	0
TOTAL COST	$37,705	$36,010
DIFFERENCE		**- $1,695**

TABLE 9: ANALYSIS OF TOTAL CO_2 EMISSIONS FOR *2019 FORD FUSION S*

EXPLANATION	FORMULA	RESULTS
CO_2 EMISSIONS PER 100KM	8.3L/100km × 2.3kgCO_2/L ***= 19.09kgCO_2/100km***	**19.09kgCO_2/100km**
ANNUAL CO_2 EMISSIONS	19.09kg CO_2/100km × 10,000km ***= 1,909kgCO_2*** 1,909 kg CO_2 × 1T/1000kg ***= 1.91TCO_2***	**1.9TCO_2**
TOTAL CO_2 EMISSIONS	1,909kg CO_2/year × 7 years ***= 13,363kgCO_2***	**13,363kgCO_2**

TABLE 10: ANALYSIS OF TOTAL CO_2 EMISSIONS FOR *2019 CHEVROLET BOLT EV*

EXPLANATION	FORMULA	RESULTS
CO_2 EMISSIONS PER 100KM	0.157kWh/km × 31g CO_2/kWh × 100km ***= 486.7gCO_2/100km***	**486.7gCO_2/100km**
ANNUAL CO_2 EMISSIONS	0.4867kgCO_2/100km × 10,000km ***= 48,670g CO_2*** 0.4867kgCO_2/100km × 1kg/1000g ***= 48,67kg CO_2***	**48.67kgCO_2/year**
TOTAL CO_2 EMISSIONS	48.67kgCO_2 × 7 years ***= 340.69kg CO_2***	**340.7kgCO_2**

TABLE 11: SUMMARY AND COMPARISON OF TOTAL GHG EMISSIONS

	2019 FORD FUSION S	2019 CHEVROLET BOLT EV
ANNUAL CO_2 EMISSIONS	1,909kg CO_2	48.67kg CO_2
TOTAL CO_2 EMISSION (7 YEARS)	13,363kg CO_2	340.7kg CO_2
DIFFERENCE		**- 13,022kg CO_2**

Our analysis shows that the total cost of ownership based on driving patterns, travelling 10,000km/year and fleet management practices of resale / salvage vehicles after 7 years, a Chevrolet Bolt EV will be $1,695 less than a similar internal combustion engine vehicle such as Ford Fusion. Replacing with a Chevrolet Bolt will also save 13,022kg CO_2 emissions from the municipal fleet per vehicle replaced.

3.2 | FRASER VALLEY REGIONAL DISTRICT TOTAL COST OF OWNERSHIP MODEL

The Fraser Valley Regional District, BC[24] (FVRD) business case, was developed in 2014 to support EV purchases to meet the goals of their 2009 Corporate GHG Emissions Reduction Plan. The business case compared the total cost of ownership between two EVs (Nissan Leaf and Ford Focus EV) and two hybrid vehicles (Ford Escape and Toyota Prius). Additionally, the analysis included two types of conventional vehicles (Ford Focus SE 5-door and Toyota Corolla).

Four cars were 2015 model, and two cars were 2014 model. They accounted for the purchase price, service life, annual mileage driven, fuel economy, gasoline and electricity price, maintenance cost, insurance cost, and resale, salvage value. The Business case did not include any GHG emissions analysis. The results show that by purchasing an EV (Nissan Leaf), the Fraser Valley Regional District would save more than $3,000 from reduced fuel and maintenance costs, compared to the current fleet vehicles they had in 2014 (Ford Escape hybrid, and Toyota Prius hybrid).

Parameters

TABLE 12: OPERATIONAL PARAMETERS

		NOTES
EXPECTED SERVICE LIFE	7 YEARS	Based on fleet review.
AVERAGE TRIP LENGTH	12.2KM	Using trip data collected for ten months (2014).
AVERAGE ANNUAL MILEAGE	13,000KM	This number is based on a 2008 fleet review.
GASOLINE PRICE	$1.35/L	This is intermediate price between summer 2014 and October 2014 in the region.
ELECTRICITY PRICE	$0.0748/kWh	In October 2014, BC Hydro General Service Conservation Rate, is a $0.1010/kWh for the first 14,800 kWh consumed, and $0.0486/kWh for additional electricity. FVRD's office's historical BC Hydro bills were approximately 14,800 kWh/ month (averaged between the highest and lower rate).

FIGURE 4: ***FORD ESCAPE S FWD- HYBRID (2015); TOYOTA PRIUS- HYBRID (2015); FORD FOCUS SE (2014); TOYOTA COROLLA (2015); NISSAN LEAF S EV (2015); FORD FOCUS EV (2014)***

(Source: Autotrader.ca)

TABLE 13: VEHICLE PARAMETERS

PARAMETERS	FORD ESCAPE S FWD HYBRID (2015)	TOYOTA PRIUS HYBRID (2015)	FORD FOCUS SE (2014)	TOYOTA COROLLA (2015)	NISSAN LEAF S EV (2015)	FORD FOCUS EV (2014)	NOTES
MANUFACTURER SELLING PRICE	$23,499	$26,155	$19,699	$15,995	$33,788	$36,199	Prices were found on the retailer website on September 30, 2014.
INSURANCE (ANNUAL)	$1458.9	$1921.6	$1612.0	$1725.6	$1651.1	$1801.6	Derived from British Columbia Automobile Association (BCAA) online calculator.
INCENTIVES	N/A	N/A	N/A	N/A	N/A	N/A	Not available.
BATTERY					24kWh	33.5kWh	
RANGE					135km	123km	
FUEL ECONOMY (L/100KM)	9.5	4.7	5.9	7.4			US DOE figures for city-highway combined driving.
MAINTENANCE COST PER YEAR	$684.89	$684.89	$684.89	$684.89	$278.75	$278.75	See Appendix A.
CARBON INTENSITY OF FUEL / ELECTRICITY (CO_2/L OR CO_2 kWh)							Not included.
DEPRECIATE / RESALE COST (LIFETIME)	$4,229	$4,707	$3,545	$2,878	$6,081	$6,515	Estimated at 18% of the purchase price after 7 years for ICEV and EVs.
CARBON TAX							Not included.

TABLE 14: SUMMARY AND COMPARISON OF TOTAL COST OF OWNERSHIP (ANALYSIS CAN BE FOUND IN APPENDIX A)

	FORD ESCAPE S FWD HYBRID (2015)	TOYOTA PRIUS HYBRID (2015)	FORD FOCUS SE (2014)	TOYOTA COROLLA (2015)	NISSAN LEAF S EV (2015)	FORD FOCUS EV (2014)
SELLING PRICE	**$23,499**	**$26,155**	**$19,699**	**$15,995**	**$33,788**	**$36,199**
TOTAL FUEL COST	$11,669	$5,775	$7,252	$9,093	$ 1,310	$ 1,967
TOTAL MAINTENANCE COST	$4,794	$4,794	$4,794	$4,794	$ 1,951	$ 1,951
RESALE / SALVAGE VALUE (AFTER 7 YEARS)	$4,229	$4,707	$3,545	$2,878	$6,081	$6,515
TOTAL COST OF OWNERSHIP	$35,733	$32,017	$28,200	$27,004	$30,968	$33,602
INSURANCE (ANNUAL)	**$1458.9**	**$1921.6**	**$1612.0**	**$1725.6**	**$1651.1**	**$1801.6**
INSURANCE (LIFETIME)	10,212	13,451	11,284	12,079	11,558	12,611
TOTAL COST	**45,945**	**45,468**	**39,484**	**39,083**	**42,526**	**46,213**

Results

Results showed that in the most likely scenario, based on driving patterns of FVRD vehicles for 2014 — travelling 13,000km/year and disposal of vehicles after 7 years, an all-electric Nissan Leaf would save more than $3,000 from reduced fuel and maintenance costs, compared to the current fleet vehicles they had in 2014 (Ford Escape hybrid, and Toyota Prius hybrid). However, the analysis included two additional types of ICEV, where the Toyota Corolla is the lowest cost fleet vehicle considering the total cost of ownership of all 6 models. It should be noted that the analysis was conducted in 2014. With current government incentives, current carbon tax, and reduced EVs prices, it is probable that EVs would outperform ICEVs on total cost of ownership.

3.3 | CITY OF LONDON ELECTRIC ICE RESURFACERS

As part of the *2019–2023 Strategic Plan*, London Municipal Council has recognized the importance of Fleet Services and its role in GHG reduction and energy conservation. A ***Corporate Energy Conservation & Demand Management Plan*** was adopted to pursue opportunities to achieve corporate net-zero GHG emissions before 2050. One of the actions in the Plan is the electrification of the ice resurfacing fleet. This business case[25] was developed to support that acquisition in early 2020.

The City operates a fleet of fourteen (14) self-propelled natural gas ice resurfacers to service 18 ice pads in municipal arenas and one skating trail. Fleet Services has forecasted that all current Zamboni Model 445 natural gas units will reach or exceed their 10-year optimal life over the next four years and proposed replacing all 14 ice resurfacers with electrical units from 2020–2023. This business case compared the total cost of ownership and total CO_2 emissions between natural gas and electrical ice resurfacer units.

The results show that an electric ice resurfacer will be around $30,000/unit (includes charger, but not infrastructure cost) more expensive than gas units with a positive benefit-cost ratio. Replacing all 14 ice resurfacers with electric units will reduce GHG emissions by 212 tonnes/annually.

FIGURE 5: ZAMBONI MODEL 450 ELECTRIC ICE RESURFACER

(Source: City of London, RFP Electric Ice Resurfacers)

Parameters

TABLE 15: OPERATIONAL AND VEHICLE PARAMETERS

PARAMETERS	ELECTRIC ZAMBONI	GAS ZAMBONI
MANUFACTURER SELLING PRICE	$125,375	$94,675
EXPECTED SERVICE LIFE	8–10 years	10 years
INCENTIVES	N/A	N/A
MAINTENANCE COST	$3,750/year	$5,815/year

TABLE 16: OPERATIONAL SAVINGS PER UNIT

	ELECTRIC ZAMBONI	GAS ZAMBONI	NOTES
AVERAGE OPERATING COST / YEAR	$3,750	$5,815	The estimates are based on current electricity and natural gas rates and the expected maintenance / service / repair cost estimates supplied by the preferred proponent. Operation savings per contract year are based on the full-time operation of 11 ice resurfacers and three spares / standby.
OPERATING COSTS FOR 10 YEARS	$37,510	$58,145	
TOTAL OPERATING SAVINGS	$20,635		

TABLE 17: OPERATIONAL SAVINGS PER CONTRACT YEAR

YEAR	ELECTRIC UNITS IN SERVICE	SAVINGS	NOTES
2020	3	$3,955	For reference, estimates from Arena Guide Canada (an initiative supported by Natural Resources Canada) that monitor 4,500 ice arenas in Canada show that propane fuel for a year costs about $5,000 compared to electricity cost about $1,000. Maintenance for the internal combustion engine is about $5,000, where for the electric, it can run to about $3,000.
2021	6	$8,825	
2022	10	$16,240	
2023	14	$24,790	
TOTAL OPERATIONAL SAVINGS: 2020–2023		**$53,810**	

TABLE 18: OPERATIONAL GHG SAVINGS PER CONTRACT YEAR

YEAR	ACCUMULATED GHG REDUCTION (TCO_2/YEAR)	NUMBER OF UNITS SWITCHED TO ELECTRIC	% OF CDM TARGET (900 TONNES GHG ANNUALLY)
2020	3	58	6%
2021	3	114	13%
2022	4	190	21%
2023	4	212	24%

TABLE 19: SUMMARY OF SAVINGS OF ELECTRIC ZAMBONI OPTION

	ELECTRIC ZAMBONI
TOTAL OPERATION SAVINGS	$53,810
TOTAL GHG EMISSIONS	19TCO_2

Results

The electric ice resurfacers cost 32% more than the natural gas-powered machines based on 2020 replacement cost estimates. The estimated operational savings for all 14 units are $53,810 for the 2020–2023 period. Following the conversion of the entire fleet to battery-electric, operational units will mitigate 212 tonnes of GHG emissions annually and contribute about 25% of the City's overall corporate GHG curtailment target of 900 tonnes annually.

4.0 | CONCLUSION AND NEXT STEPS

4.0 | CONCLUSION AND NEXT STEPS

With continued improvements in vehicle and battery technology, and more widespread charging infrastructure availability, fleet electrification barriers are falling away. Bolstered by positive business cases demonstrating that EVs are less costly to own and maintain than their ICE counterparts, the role of EVs in future emissions reduction is projected to grow exponentially. Fleet electrification achieves municipal GHG reduction commitments, providing economic, social and environmental benefits.

This report reviewed EV business case examples and highlighted key considerations that fleet managers can include in their EV business case development. A next step would be for municipalities to test this methodology in real-world circumstances. This will not only allow for improvement of municipal EV business case methods but will also produce objective and reliable information on actual TCO, ROI, and GHG reductions. We encourage municipalities to share their EV business cases through the Clean Air Council network. Coupled with regulatory and incentive support from higher orders of government, this sharing is key to the advancement of municipal fleet electrification.

REFERENCES

1. Canada Energy Regulator, ***Provincial and Territorial Energy Profiles – Ontario***, 2019, Canada

2. Environmental Defence, Ontario Public Health Association, ***CLEARING THE AIR: How Electric Vehicles and Cleaner Trucks Can Help Reduce Pollution, Improve Health and Save Lives in the Greater Toronto and Hamilton Area***, 2020, Toronto, Canada

3. FleetCarma, 2016, ***Electric Vehicle Sales in Canada: 2015 Final Numbers***, *https://www.fleetcarma.com/ev-sales-canada-2015*

4. Plug'n Drive, 2020, ***Electric Vehicles Available in Canada***, Toronto, Canada *https://www.plugndrive.ca/electric-cars-available-in-canada*

5. BC Hydro Power Smart, ***EV Consideration and Range Comparison***, 2019, BC, Canada

6. Charlotte Argue, 2020, ***To what degree does temperature impact EV range?*** Published on May 25, 2020 in GEOTAB Electric Vehicles, Oakville, Ontario, Canada

7. American Automobile Association, 2019, ***AAA Electric Vehicle Range Testing Report***, 2019, USA

8. Laboratory for Alternative Energy Conversion, Plug-in BC, 2018, ***Environmental Life Cycle Assessment of Electric Vehicles in Canada***, BC, Canada

9. R. Logtenberg and B. Saxifrage, 2017, ***Comparing Global Warming Impacts of Electric and Gas Powered Vehicles by Electrical Region***, 2 Degree Institute, Canada

10. Na Jiao, (2018, Aug 28th) ***What can we do with 100GWh of retired electric vehicle batteries?***, IDTechEX, UK, *https://www.idtechex.com/en/research-article/what-can-we-do-with-100gwh-of-retired-electric-vehicle-batteries/15229*

11. Holland and Na Jiao, 2020, ***Li-ion Battery Recycling: 2020-2040***, IDTechEX, UK *https://www.idtechex.com/en/research-report/li-ion-battery-recycling-2020-2040/751*

12. Vincentric, 2011, Canadian Total Cost of Ownership, Canada

13. Electric Power Research Institute, 2013, Total Cost of Ownership Model for Plug-in Electric Vehicle, Palo Alto, CA, USA

14. Propfe et al., 2013, Cost analysis of Plug-in Hybrid Electric Vehicles including Maintenance & Repair Costs and Resale Values, LA, CA, USA *https://elib.dlr.de/75697*

15. Peter Gorrie (April 18, 2019), ***Think you can't afford that EV? In a faceoff against gas cars, the numbers say otherwise***. Corporate Knights, 2019, *https://www.corporateknights.com/channels/clean-technology/faceoff-electric-vs-gas-cars-on-cost-15555966*

16. Stephanie Wallcraft (June 23, 2020), ***So you think electric vehicles cost more? A 10-year comparison shows they're actually cheaper***, The Star, 2020, *https://www.thestar.com/business/2020/06/23/so-you-think-electric-vehicles-are-pricier-a-comparison-of-costs-over-ten-years-proves-otherwise.html*

17. World Health Organization, 2016, ***Ambient air pollution: Health impacts***, Geneva, Switzerland

18. Hänninen et al., 2014, ***Environmental Burden of Disease in Europe: Assessing Nine Risk Factors in Six Countries***, *DOI:* *10.1289/ehp.1206154*

19. World Health Organization, 2011, ***Burden of disease from environmental noise***, WHO Regional Office for Europe & JRC

20. Li Bai et al., 2020, ***Exposure to Road Traffic Noise and Incidence of Acute Myocardial Infarction and Congestive Heart Failure: A Population-Based Cohort Study in Toronto***, Environmental Health Perspective, Canada *doi.org/10.1289/EHP5809*

21. Bruitparif 2019, ***Impact Sanitaires Du Bruit Des Transport Dans La Zone Dense De La Region ile-de-France***, Paris, France

22. Jean-François Venne, 2019, ***Municipal electric champions show how it's done, Electric Autonomy***, *https://electricautonomy.ca/2019/06/18/municipal-electric-champions-show-how-its-done*

23. Atmospheric Fund, 2019, ***A Clearer View on Ontario's Emissions: Electricity emissions factors and guidelines***, Toronto, Canada

24. Fraser Valley Regional District, 2015, ***FVRD Electric Vehicle Business Case***, BC, Canada

25. City of London, 7th Meeting of City Council Agenda, April 07, 2020, ***Request for Proposal (RFP) 20-04 Award - Supply and Delivery of Electric Ice Resurfacers***, City of London, ON, Canada *https://pub-london.escribemeetings.com/Meeting.aspx?Id=8450afe8-426d-46ae-8d16-dd204ae53d9f&Agenda=Agenda&lang=English*

APPENDIX A |

FRASER VALLEY REGIONAL DISTRICT EV BUSINESS CASE ANALYSIS

APPENDIX A | FRASER VALLEY REGIONAL DISTRICT EV BUSINESS CASE ANALYSIS

TABLE 1: TOTAL COST OF OWNERSHIP OF *FORD ESCAPE S (2015)*

EXPLANATION	FORMULA	RESULTS
ANNUAL FUEL COST	9.5L/100km × 13,000km/year ***= 1,235L/year*** 1,235L/year × 1.35$/L ***= $1,667/year***	**$1,667/year**
LIFETIME FUEL COST	$1,667/year × 7 years ***= $11,669***	**$11,669**
TOTAL MAINTENANCE COST	$684.89/year × 7 years ***= $4,794***	**$4,794**
DEPRECIATE / RESALE COST (LIFETIME)		**$4,229**
TOTAL COST OF OWNERSHIP	$23,499 + $11,669 + $4,794 - $4,229 ***= $35,733***	**$35,733**

TABLE 2: TOTAL COST OF OWNERSHIP OF *TOYOTA PRIUS (2015)*

EXPLANATION	FORMULA	RESULTS
ANNUAL FUEL COST	4.7L/100km × 13,000km/year **= *611L/year*** 611L/year × 1.35$/L **= *$824.85/year***	**$825/year**
LIFETIME FUEL COST	$ 825/year × 7 years **= *$5,775***	**$5,775**
TOTAL MAINTENANCE COST	$684.89/year × 7 years **= *$4,794***	**$4,794**
DEPRECIATE / RESALE COST (LIFETIME)		**$4,707**
TOTAL COST OF OWNERSHIP	$26,155 + $5,775 + $4,794 - $4,707 **= *$32,017***	**$32,017**

TABLE 3: TOTAL COST OF OWNERSHIP OF *FORD FOCUS SE (2014)*

EXPLANATION	FORMULA	RESULTS
ANNUAL FUEL COST	5.9L/100km × 13,000km/year **= *767L/year*** 767L/year × 1.35$/L **= *$1,035.45/year***	**$1,036/year**
LIFETIME FUEL COST	$1,036/year × 7 years **= *$7,252***	**$7,252**
TOTAL MAINTENANCE COST	$684.89/year × 7 years **= *$4,794***	**$4,794**
DEPRECIATE / RESALE COST (LIFETIME)		**$3,545**
TOTAL COST OF OWNERSHIP	$19,699 + $7,252 + $4,794 - $3,545 **= *$28,200***	**$28,200**

TABLE 4: TOTAL COST OF OWNERSHIP OF *TOYOTA COROLLA (2015)*

EXPLANATION	FORMULA	RESULTS
ANNUAL FUEL COST	7.4L/100km × 13,000km/year **= *962L/year*** 962L/year × $1.35/L **= *$1,298.7/year***	**$1,299/year**
LIFETIME FUEL COST	$1,299/year × 7 years **= *$9,093***	**$9,093**
TOTAL MAINTENANCE COST	$684.89/year × 7 years **= *$4,794***	**$4,794**
DEPRECIATE / RESALE COST (LIFETIME)		**$2,878**
TOTAL COST OF OWNERSHIP	$15,995 + $9,093 + $4,794 - $2,878 **= *$27,004***	**$27,004**

TABLE 5: TOTAL COST OF OWNERSHIP OF *NISSAN LEAF S EV (2015)*

EXPLANATION	FORMULA	RESULTS
FUEL ECONOMY	Battery capacity / Distance = 24kWh/135km = 0.177kWh/km **= *0.18kWh/km***	**0.18kWh/km**
ANNUAL FUEL COST	0.18kWh/km × 13,000km/year × $0.08/kWh **= *$187.2/year***	**$187/year**
LIFETIME FUEL COST	$187.2/year × 7 years **= *$1,310.4***	**$1,310**
TOTAL MAINTENANCE COST	$278.75/year × 7 years **= *$1,951.25***	**$1,951**
DEPRECIATE / RESALE COST (LIFETIME)		**$6,081**
TOTAL COST OF OWNERSHIP	$33,788 + $1,310 + $1,951 - $6,081 **= *$30,968***	**$30,968**

TABLE 6: TOTAL COST OF OWNERSHIP OF *FORD FOCUS EV (2015)*

EXPLANATION	FORMULA	RESULTS
FUEL ECONOMY	Battery capacity / Distance = 33.5kWh/123km = 0.272 kWh/km **= *0.27kWh/km***	**0.27kWh/km**
ANNUAL FUEL COST	0.27kWh/km × 13,000km/year × $0.08/kWh **= *$280.8/year***	**$281/year**
LIFETIME FUEL COST	$281/year × 7 years **= *$1,967***	**$1,967**
TOTAL MAINTENANCE COST	$278.75/year × 7 years **= *$1,951.25***	**$1,951**
DEPRECIATE / RESALE COST (LIFETIME)		**$6,515**
TOTAL COST OF OWNERSHIP	$36,199 + $1,967 + $1,951 - $6,515 **= *$33,602***	**$33,602**