ELECTRIC VEHICLE KNOWLEDGE GUIDE

June 2022

This knowledge guide provides an overview of the benefits of electric vehicles, an introduction to the different types of charging stations, electric vehicle policies, best practices, available vehicles, and funding for municipalities in Alberta.

Municipal Climate Change Action Centre

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1.0 OVERVIEW

Current trends predict that as the world shifts to a lower carbon economy, electric vehicle adoption will grow. Electric vehicles (EVs) are relatively new technologies to Alberta with less than 1% of vehicle owners driving one[1]. Like the adoption of any new technology, there are many benefits and challenges to consider. This document explains the benefits of fleet vehicle electrification, answers frequently asked questions about EVs, and shares information about vehicle types, funding, and policies.

2.0 GLOSSARY OF TERMS

- **AC (Alternating Current):** A charge of electricity that regularly changes direction. This is the most common type of power supplied to homes and businesses.
- **DC (Direct Current):** A charge of electricity that flows in one direction. This is the type of power supplied by a battery.
- **EV (Electric Vehicle) or "Battery Electric Vehicle" (BEV):** These vehicles are solely powered by the electricity stored in batteries – no fossil fuel emissions are released during operation! These vehicles are highly efficient as the electric motors convert 85-90% of the energy into turning the wheels.
- **GHG (Greenhouse Gas):** Greenhouse gases trap heat in the atmosphere by absorbing and re-radiating the longwave thermal radiation emitted by the sun. This process, referred to as the greenhouse effect, causes the atmosphere's temperature to increase, consequently increasing the temperature of the Earth. Common GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), water vapor (H_2O), ozone (O_3), and fluorinated gases.
- **HEV (Hybrid Electric Vehicle) or "Hybrid":** Hybrids are powered by an internal combustion engine and an electric motor. Each power source can take turns powering the vehicle as needed leading to improved efficiency. The electric motor is powered by a small battery charged by both the engine and the regenerative braking system. Hybrid vehicle batteries cannot be plugged in and are not charged like EV or PHEVs.
- **ICE (Internal Combustion Engine):** A fossil fuel-powered engine that ignites hydrocarbon fuel to release energy. ICE vehicles are only about 25% efficient at utilizing the stored energy in the fuel to move the vehicle, meaning that roughly 75% of the energy is lost in the form of heat and noise.
- **kW (Kilowatt):** A unit of electric power.
- **kWh (Kilowatt-hour):** A unit of electric energy. The amount of electric energy stored in an EV battery is typically measured in kilowatt-hours.
- **Level 1 Charging:** Charging an EV using a common household outlet up to 120 volts. This is the slowest method of charging and can take up to 9-12 hours or more to fully charge an EV.
- **Level 2 Charging:** Charging your EV using an installed charging station at 240 volts. Level 2 charging stations are what most EV manufacturers recommend to EV owners when charging the vehicle. Depending on the vehicle and charger, Level 2 charging can fully charge an EV within 5-10 hours for BEVs, and 2-4 hours for PHEVs, which works great for overnight charging.
- **Level 3 Charging:** Also known as "DC fast charging" or "DCFC", this is the fastest method of charging for all EVs as it uses more power and a higher voltage than Level 2. Level 3 charging can charge an EV battery to

80% in about 30 minutes or less. Level 3 charging currently only works with specific types of EVs and are uncommon considering that they're more expensive and require more power than Level 2 charging. Level 3 charging helps charge EVs quickly during road trips that exceed an EV's total range.

- **Networked Charging Stations:** EV charging stations with the ability to communicate to other stations and/or to a server or the cloud through a cellular or wireless signal to report or usage, display real-time charging status, allow for remote troubleshooting, facilitate pay-for-use charging, and more.
- **PHEV (Plug-in Hybrid Electric Vehicle):** PHEVs are like HEVs but have larger batteries that can be plugged in for recharging. Most PHEVs can function as a BEV for short commutes between 25-75 kilometres before the ICE turns on to provide additional range. Some PHEVs have a large enough battery to complete most trips on electricity only.
- **Regenerative Braking:** Regenerative braking is a method that slows a moving EV by capturing and storing kinetic energy as electrical energy. As a result, regenerative braking extends the EV driving range and reduces brake wear leading to less frequent and less costly maintenance repairs. In typical ICE vehicles, this energy is wasted in the form of friction and heat.

3.0 BENEFITS

3.1 Vehicle of the future

The demand for EVs is growing. In Canada, approximately 74,000 new EVs hit the road in 2021. EVs made up 3.79% of all new vehicle registrations in 2021, a 51% increase in registrations compared to 2020 [2]. EV adoption also plays an important role in addressing climate change on a measurable scale. Governments around the world are implementing more EV incentives to encourage drivers to make the switch to electric, some even banning the sale of internal combustion engines by 2040[3]. To prepare for the growth of the EVs, charging infrastructure should be factored into any new building.

3.2 Funding available

In Alberta, municipalities can receive rebates for both Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs) through the Electric Vehicles for Municipalities (EVM) program. Municipalities can also stack the EVM rebate with electric vehicle rebates offered by the Government of Canada. Through the incentives for Zero-Emission Vehicles (iZEV) program applied at the point of sale, an additional incentive of $2,500 to $5,000 per vehicle is available. When combined, municipalities can receive EV rebates of up to $19,000 toward applicable passenger vehicles. See Section 7.0 for more information about the EV incentive programs available.

3.3 Eligible vehicle types

A wide variety of vehicle types can receive rebates through the EVM program, including passenger vehicles, heavy-duty vehicles like garbage trucks, non-road vehicles like ice resurfacers, ATVs, UTVs, golf carts, and more. See Section 6 for more examples of eligible vehicles. Vehicles purchased though the EVM program must either replace a fossil fuel-powered vehicle or be a new addition to the existing fleet.

3.4 Operational and environmental benefits

Lower operating costs

Operating costs for electricity and maintenance are significantly lower in EVs compared to their ICE vehicle counterparts. In Alberta, operating an EV over an ICE vehicle[4] could reduce annual fuel and maintenance costs up to 72% depending on vehicle type and the cost of fuel/electricity. To learn more about the savings associated with electric passenger vehicles, see the EV Savings Calculator.

Lower maintenance costs

Typical EV drivetrains have 90% fewer moving parts, which reduces the amount of regular maintenance required. These drivetrains use regenerative braking, which saves energy and extends the useful life of the vehicle's brake pads[5]. Over time the reduced costs for maintenance can offset an EV's higher purchase price (EVM program funding also helps to reduce the upfront costs for EV purchases). In Alberta, annual maintenance costs can be reduced up to 48% with a EV compared to an ICE vehicle[4].

Environmentally friendly

EVs are more environmentally friendly than ICE vehicles. BEVs do not produce emissions when in operation, and PHEVs only produce emissions when operating in fuel mode. Despite the prevalence of fossil fuels in Alberta's electricity grid, studies demonstrate that EVs are still less greenhouse gas (GHG) intensive. As the Alberta electricity grid adds more renewable energy[6], fewer GHGs will be produced as a result of driving an EV.

Over the lifetime of their use, EVs produce less overall GHG emissions (roughly half) than their ICE counterparts, despite the carbon-intensive manufacturing of EVs[19]. In fact, BEVs typically offset their excess manufacturing emissions within the first 6-16 months of operation due to the absence of tailpipe emissions[20]. Figure 1 below compare the lifetime tonnes of CO_2-equivalent of a new and existing conventional ICE vehicle to a 2019 Nissan Leaf, demonstrating an EV's relatively short carbon debt payback period[19].

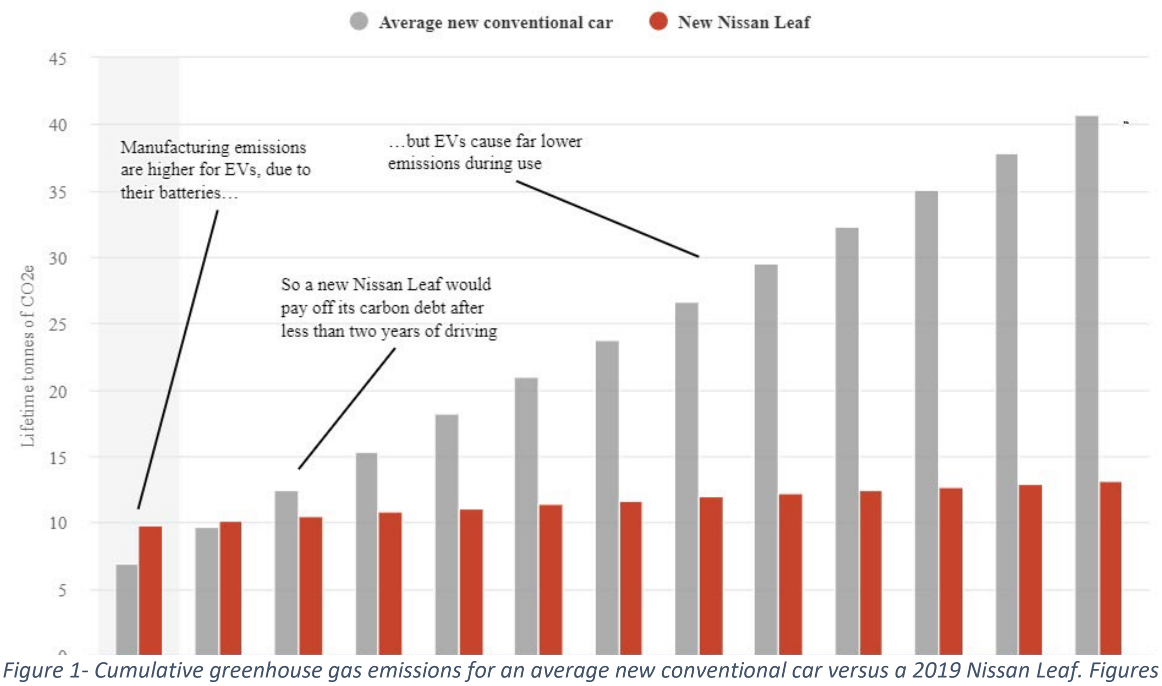


Figure 1- Cumulative greenhouse gas emissions for an average new conventional car versus a 2019 Nissan Leaf. Figures are in lifetime tonnes of CO_2-equivalent, assuming 150,000 kilometers driven over a 12-year lifetime. By year 12, a 2019 Nissan Leaf EV will pay back manufacturing emissions after less than 2 years and will emit three times less CO_2 in its lifetime than a conventional ICE vehicle in the UK. (Source: Carbon Brief)

EV batteries are another typical point of concern when it comes to their end-of-life disposal procedure. However, manufacturers recognize the need for an environmentally friendly solution to the expanding supply of used batteries. If the battery were to be replaced, they are not dumped into landfills (it is illegal to do so). Instead, they are repurposed in second-life applications such as renewable energy storage (solar and wind energy) and battery backup systems for approximately another 10 years[21]. At the end of their life, the batteries are recycled, and their reusable raw materials are harvested[22]. The recyclability of EV batteries prolongs their useable lifespan and offsets the need to mine more rare earth metals that make up the batteries.

4.0 FREQUENTLY ASKED QUESTIONS

4.1 Can EVs travel far distances?

EVs have enough battery life to meet the average distance daily Albertan commuter's needs[9]. New BEVs can travel up to 400+ km on a single charge[7]. Driving range continues to improve on newer EV models, making "range anxiety", a fear of the past.

4.2 How long do EV batteries last?

Typically, EV batteries will last longer than the life expectancy of the vehicle before needing to be replaced. A recent study on EV use in the United States found that the average battery cycling capacity loss over a 10-year timeframe was about 1% per year[10]. However, battery degradation is contingent upon several factors such as driving behaviour and frequency of use, meaning that the timeframe for battery replacement can vary between users.

Studies show that the retirement of an EV battery should occur when the battery no longer satisfies the daily travel needs of a driver (ie. the battery would be depleted before completing a driver's daily travel activity), rather than a specific or pre-determined timeframe. As shown in Figure 2, as battery capacity declines over time, the existing capacity still satisfies the majority of driving needs[23]. For example, at 80% battery storage capacity, less than 5% of daily driver needs are no longer met, indicating that less than 5% of batteries may need to be replaced at that level.

EV drivers can take the

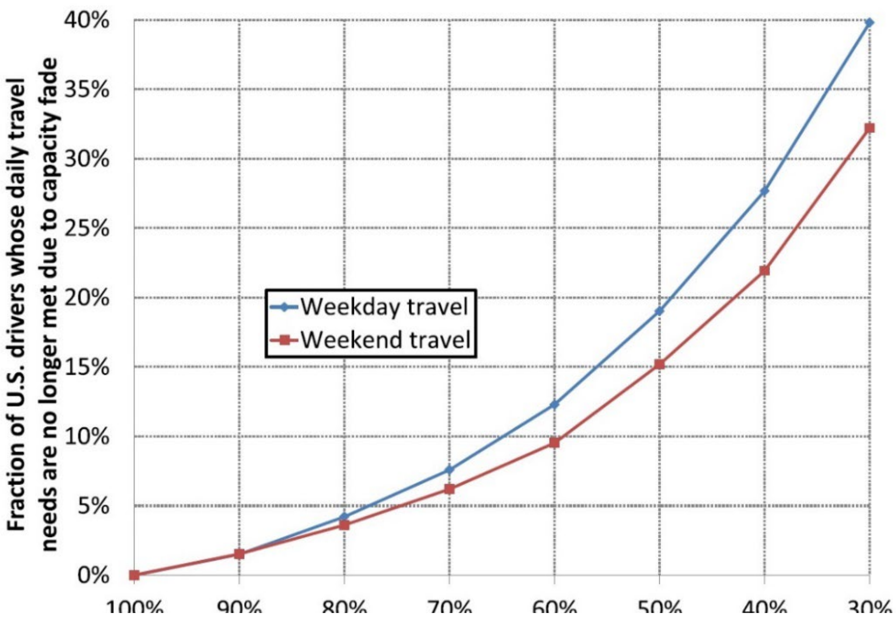


Figure 2- The fraction of drivers in the United States whose daily commuting needs are no longer satisfied as a result of battery capacity depletion to 30%. The vehicle simulated in this study was designed with specifications resembling a Nissan Leaf. (Source: Science Direct: Journal of Power Sources)

following actions to care for their battery and prevent premature battery degradation [11]:

- Limit the amount of vehicle use during very high ambient temperatures and avoid parking an EV in direct sun for long periods during hot summer days
- Limit the frequency of deep battery discharges where most of the battery capacity is drained
- Limit aggressive driving behaviours
- Only use Level 3 charging when necessary

4.3 What kind of maintenance is required?

For a traditional ICE vehicle, maintenance is required on parts such as the brakes, electric motor, tires, brake fluid, and coolant levels. But with an EV, there is very little maintenance involved. This is because there are very few moving parts in an EV. There are no oil changes or spark plugs replacements needed. This low amount of maintenance means more financial savings with an EV, compared to an ICE vehicle.

4.4 Do they work in the winter?

EVs perform very well in the winter in two ways:

1. On Alberta's coldest days, an ICE vehicle may not start because the oil becomes too cold and thick to run in a combustion engine. With an EV, there is no oil or combustion engine, meaning that the battery will always be able to start the vehicle because it does not have an ignition source hindered by cold temperatures.
2. EVs warm up fast by using resistance heating, generating heat nearly instantly without the need to idle. While this does consume some battery life (in some cases, upwards of 30 to 40%), EVs can still easily handle the Canadian average daily commute[9].

To get a sense of how cold weather can affect EV driving, Geotab has created a Temperature Tool for EV Range to map out the impact temperature has on day-to-day EV range following an analysis of 4,200 connected EVs and 5.2 million trips. Cold weather impacts on range reduction becomes even less of an issue as new EV models have increased battery capacity meaning there will be little impact on most daily trip needs, and charging infrastructure continues to expand for that occasional road trip. The larger batteries in the next generation of EVs will provide an increased range, making the impact of winter range loss minimal (even for drivers that greatly exceed daily driving averages). Winter commuting countries are also adopting EVs. For example, in March 2019, almost 60% of all new cars sold in Norway, a country with winter climate conditions comparable to Alberta, 14 were fully electric, according to the Norwegian Road Federation[15].

There are many ways to maximize an EV's cold-weather operating range. Here are a few examples[27]:

- Keep your EV stored in a garage (ideally heated)
- Plug in the EV when not in use
- Limit the use of the heater while driving
- Use "eco-mode" to adjust performance parameters (and thereby preserving battery usage)

4.5 How does driving an EV in Alberta reduce greenhouse gas emissions?

Alberta's electricity is derived from a variety of sources including: coal, natural gas, solar, wind, and hydroelectric. Even with an electricity grid powered primarily by fossil fuels, switching to an EV is still less GHG intensive. A study completed by the Simon Fraser University found that charging an EV on Alberta's electricity grid can reduce fleet average GHG emissions intensity by 41%[13]. As the electricity grid continues to incorporate more renewable energy, this reduction in GHGs due to driving an EV will only increase over time.

4.6 How do EVs compare to HEV and ICEV environmentally?

EVs are noticeably more environmentally friendly than HEVs and ICE vehicles. EVs utilize only electricity which is significantly less carbon intensive than fossil fuels [28]. Figure 3 outlines the estimated kilograms of CO_2 emitted from 10,000 kilometers of use from a 2022 Hyundai Kona EV, a 2022 Hyundai Tucson ICEV, and a 2022 Hyundai Tucson HEV. Using the 2019 Alberta electrical grid carbon intensity the Kona EV emits roughly 40% less GHG emission compared to the ICE Tucson [29]. Furthermore, the carbon intensity of the electrical grid is projected to decrease significantly by 2030 in which case EVs may emit up to 85% less GHG emissions compared to ICEVs [30].

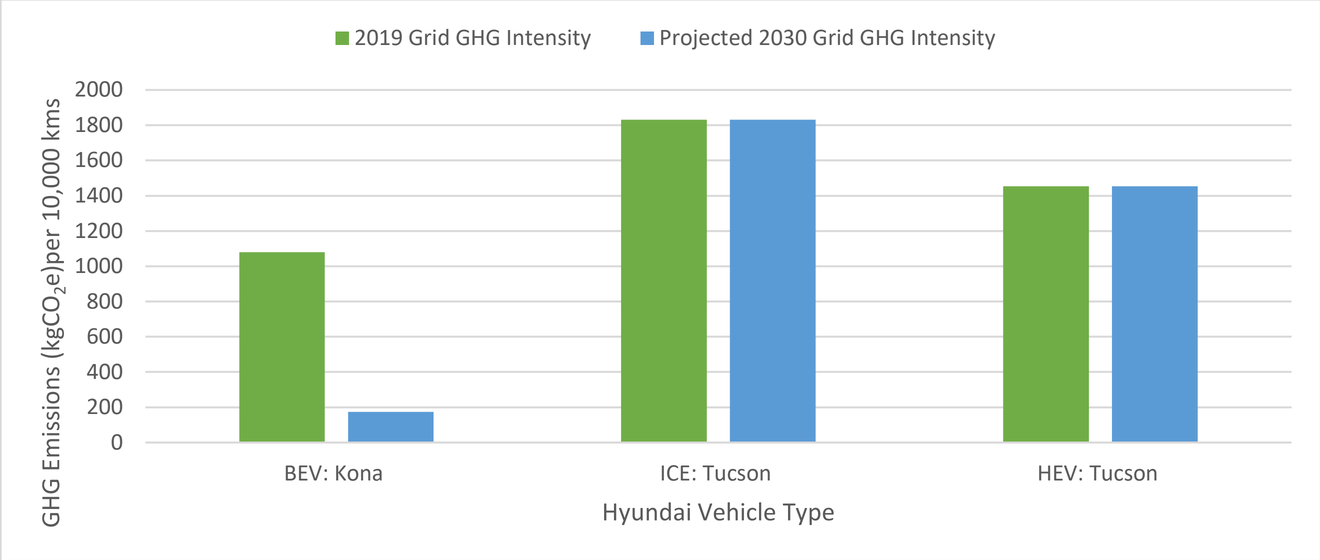


Figure 3 – Estimated GHG emissions per 10,000 kilometers of a 2022 Hyundai Kona EV, Hyundai Tucson ICEV and Hyundai. The Kona emits roughly 40% less GHG emissions compared to the ICE Tucson. (Source: Fuel Ecconomy.gov)

4.6 What impact does lithium ion battery manufacturing have on the environment?

EVs present different environmental impacts compared to conventional ICEV due to their usage of large-scale lithium ion batteries. However, when assessing the environmental impact of an EV compared to an ICE vehicle it is important to consider both the vehicles manufacturing phase and use phase. While the manufacturing of lithium ion batteries relies on a variety of rare-earth metals, around half of the associated GHG emissions of battery manufacturing comes from the electricity used [19]. Therefore, as renewable energy generation continues to expand the associated GHG emissions will continue to decrease.

Figure 4 outlines the associated grams of CO_2e per kilometer of a conventional ICE vehicle, a 2019 Toyota Prius Eco hybrid and a 2019 Nissan Leaf EV. As seen below the GHG emissions associated with the use phase (tailpipe) of the ICE vehicle is far greater than the GHG emissions emitted from the battery manufacturing and electricity utilization of the Nissan Leaf EV. Using the U.S electricity mix the Nissan Leaf EV emits roughly 50% less gCO2e per kilometer compared to the conventional ICE when accounting for the use and manufacturing phases [19].

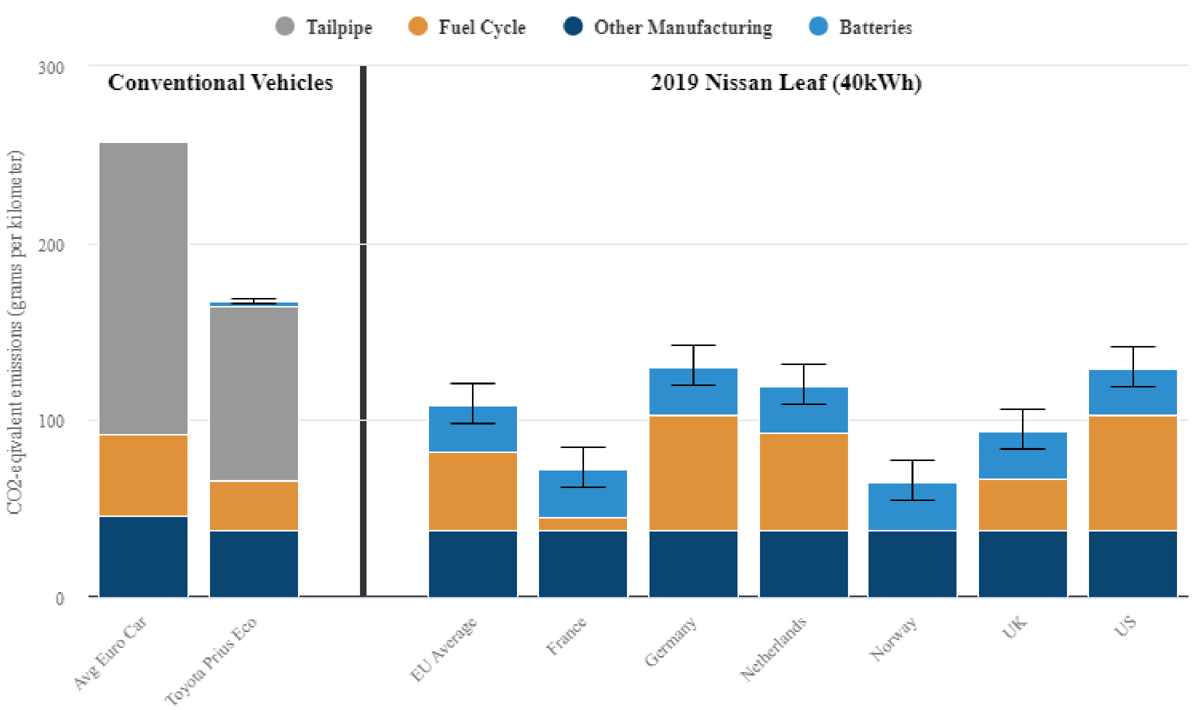


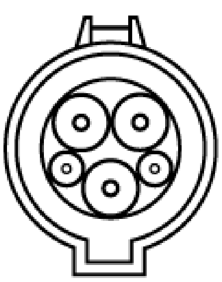
Figure 4: Lifecycle greenhouse gas emission for a conventional ICE vehicle, 2019 Toyota Prius Eco hybrid and 2019 Nissan Lead EV in grams of CO2 equivalence per kilometer, by country based upon 150,000 kilometers travelled. Does not included emission associated with end of life or disposal phase (Source: Carbon Brief)

5.0 CHARGING 101

5.1 Types of charging connectors

There are several different charging connector types available depending on the level of charger required. Here is a short list of connector types for Level 2 or 3 charging stations provided by ChargeHub[12]:

Connector types

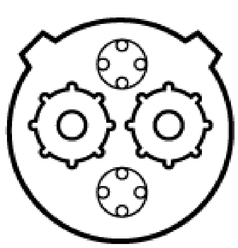


Connector: Port J1772

Level: 1 and 2

Compatibility: 100% of electric cars

Tesla: With adapter

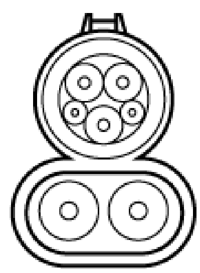


Connector: CHAdeMO

Level: 3

Compatibility: Check specifications of your EV

Tesla: With adapter

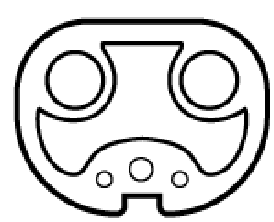


Connector: SAE Combo CCS

Level: 3

Compatibility: Check specifications of your EV

Tesla: No



Connector: Tesla supercharger

Level: 3

Compatibility: Only Tesla

Tesla: Yes

5.2 Types of chargers

EVs require a charging station to replenish their batteries. Different EVs will require different types of charging stations and connector types. Depending on the type of charger, EVs can recharge their battery within a timeframe that meets the needs of the average driver. Here are the different types of charging stations currently available and most commonly used with passenger EVs:

Level 1 chargers

A Level 1 charger is a regular 120-volt household plug that utilizes an adapter to charge an electric vehicle. Most PHEVs can be recharged overnight using a Level 1 charger[8]. However, this is the slowest type of charger and can take upwards of 9-12 hours (or 5-8km/hour) to fully charge a battery. In the absence of a Level 2 charger or for short daily commutes, this type of charger may be enough to replenish the battery. Level 1 chargers typically come with the purchase of a passenger EV.

Level 2 chargers

A Level 2 charger uses a 240 volt plug to quickly charge an EV. These charging stations can fully charge an EV in 5-10 hours (or 30-90km/hour). This style of charger utilizes a standard connector (SAE J1772 plug) adopted by Canadian and American electric vehicle manufacturers for cross-compatibility. Public charging stations in Canada and the US will typically use this common plug-type and can they be installed for use at work and home[8]. Level 2 charging stations plug into the same 240V outlet that a clothes dryer or oven would use and deliver more power than a Level 1 charger, charging an EV battery much quicker. When using a charging station at home or at work, it is recommended that a Level 2 charging station is used in place of a Level 1 adapter to maximize the EV's full potential[12].

Level 3 chargers

Level 3 chargers are the fastest charging option for EVs, making long-distance commutes easier. Using high voltages to charge the batteries, EVs can be topped up to 80% battery life in as little as half an hour (or 1,600 km/hour)[8]. This type of charger utilizes the CHAdeMO and SAE Combo CCS (combined charging system) plugs. Older EVs may not be designed to handle fast charging but fast charging capabilities are becoming more common with newer models.

Figure 4- Typical 120 volt plug with an electric vehicle charging adapter. This is considered a Level 1 charger.

Figure 5 - A 240-volt Level 2 charging station can be installed at home or at work to charge an electric vehicle.

Figure 6 – Level 3 charging station is the fastest method of charging an electric vehicle.

5.3 Locating charging stations

Before driving to a charging station or planning a trip, it is important to check your vehicle's compatibility with the charging station connector available. Some vehicles, like the Chevrolet Volt (a PHEV), are not compatible with Level 3 stations. View PlugShare's charging station map to see available charging station networks in Alberta and across North America.

5.4 Networked charging stations

Networked charging stations (occasionally referred to as "connected" charging stations) can communicate with other stations and the internet via cellular or wireless signals. Networked charging stations offer multiple benefits when compared with non-networked stations.

Firstly, it allows for increased visibility when EV drivers are searching for a charging station. They can do so via a provider's mobile app, third-party websites, or through GPS navigation apps. This is key as not being connected to any network means that a charger will be essentially invisible to drivers. Secondly, it provides an improved driver experience as networked stations can let EV drivers know when a station becomes available. Some services, such as Chargepoint's "waitlist" feature even allow EV drivers to get in a virtual queue so they can charge their vehicle once the vehicle ahead of them has finished[24]. Networked charging stations also allow the owner of the station to monitor usage and set up pay-per-use options. Lastly, there are several cost-saving benefits and flexibility options for networked chargers as well as numerous reporting features that some municipalities and businesses can benefit from. Station owners can receive the latest firmware updates, anticipate problems before they arise, and can control access to ensure turnover between users. The energy and greenhouse gas data collected and reported by networked stations also means that it can be justified as a sustainable investment when applying for grants or engaging with stakeholders.

5.5 Open Source Charging Stations

Of the many factors to consider when purchasing a networked EV charging station, it is important to ensure that charging stations are OCPP compliant. Open Charge Point Protocol or OCPP is a syntax language that is used to communicate with other networked charging stations and a network management system such as ChargePoint[25]. As a free, open source, and easy to use protocol, OCPP ensures that all stations within the EV charging station network are speaking the same language and has thus become a global benchmark for interoperability throughout the EV charging industry[26]. A major advantage to OCPP-compliant charging stations is that it allows the freedom for station owners to choose any network they would like and allow access to more competitive pricing options. This provides additional flexibility and removes fears of a stranded asset should a manufacturer go out of business or being forced to use only the network that the station is compatible with (and all the fees that come along with it). Some restrictions may apply when it comes to OCPP. Contact your distributor for full details around OCPP compatibility.

5.6 Site Selection

There are many considerations to be made when it comes to a charging station's purchase and installation. Site location is one of the most important considerations as it will influence how often the station is used and how easily the station can be accessed. Another consideration is the type of location that the unit will be servicing. This will impact the level of charging station capacity required. If the location will be a site where drivers can spend several hours charging their vehicle, a level 2 charging station may work best (ex. locations near a shopping mall, gym, movie theatre, beach, or park). Fast chargers, on the other hand, may work in locations where the vehicle will only be charging for about 30 minutes (ex. locations near highway rest stops, downtown cafes, etc.). Visibility of the charging station will also need to be a top consideration including the addition of appropriate signage and reserved spaces to park the EV.

5.7 Installation

Once a specific location has been selected, there are a few other on-site considerations to be made regarding the existing electrical infrastructure. Some questions to consider include:

- Where in the parking lot will the charger be mounted?
- Will the charging station be wall-mounted or mounted to a pedestal?
- Is there space to include a charging station within the electrical breaker panel?
- How could EV charging impact demand charges at the desired location?
- Is the site's existing electrical infrastructure capable of supporting the desired level of charging?
- What will the overall installation costs be considering all of the above factors? Are there grants available to help offset these costs?

The answers to the above questions are important to consider. It is always best to speak with a licensed professional, such as an electrical contractor, when considering a charging station install as there may be other factors that could be overlooked. Luckily, there is charging station funding available through the Electric Vehicle Charging Program (EVCP) to aid municipalities in offsetting both equipment and installation costs.

5.8 Charging Station Provider List

The following is a short list of local charging station equipment providers. **Please note that this is not an exhaustive list of every provider on the market, nor is this an EVCP eligible contractor list.** It is recommended to review multiple quotes from various EV charging station equipment and installation providers to properly inform your recruitment process and ensure the station type is eligible for the program.

Provider	Phone Number	Email Address	Website
Chargepoint	408-370-3802	info@chargepoint.com	https://www.chargepoint.com/en-ca/products/sales/
Flo	1-855-543-8356	info@flo.com	https://www.flo.com/en-CA/
Hypercharge	1-888-320-2633	info@hypercharge.com	https://hypercharge.com/
ABB	1-800-435-7365	contact.center@ca.abb.com	https://new.abb.com/ev-charging
Bosch	1-844-317-9525	infoevcharger@ca.bosch.com	https://www.boschevsolutions.com/en-ca
Siemens	905-465-8000	contactus.ca@siemens.com	https://new.siemens.com/global/en/products/
Sun Country	1-866-467-6920	info@suncountryhighway.ca	https://suncountryhighway.ca/

6.0 AVAILABLE ELECTRIC VEHICLES

The following table details the different types of EVs currently available for purchase. Please note that this is not an exhaustive list of every EV on the market as most luxury models are not included, nor is this an eligible vehicle list for the EVM program. More EVs will become available for purchase in the near future that may qualify for EVM program funding, and other EVs that may not be listed could be eligible.

6.1 Passenger Electric Vehicles

Battery Electric Vehicles (BEVs)

Year	Make	Model	kWh/100 km (City/Hwy/Combined)	Battery Size (kWh)	Range (km)	LVL 2 Charge Time from Empty (hrs)	Typical MSRP ($CAD)
2022	Ford	Mach-E	19.0 / 21.8 / 20.3	68	418	8.1	$51,495
2022	Ford	Lightning	27.6 / 34.3 / 30.8	98	370	12	$68,000
2022	Hyundai	Ioniq 5	16.5 / 22.3 / 19.0	58	354	6.3	$47,550
2022	Hyundai	Kona	15.9 / 19.4 / 17.5	64	415	9.5	$46,450
2022	Kia	EV6	15.4 / 20.9 / 17.9	58	373	5.9	$44,995
2022	Kia	Soul	15.5 / 20.5 / 18.0	64	248	6	$42,995
2022	Kia	Niro EV	17.0 / 20.5 / 18.7	64	385	9.5	$44,995
2022	Nissan	Leaf	17.8 / 21.2 / 18.9	40	240	8	$37,498
2022	Nissan	Leaf S Plus	17.7 / 21.6 / 19.4	62	363	11	$40,098
2022	Nissan	SV/SL Plus	18.4 / 22.3 / 20.1	62	346	11	$43,098
2022	Chevrolet	Bolt	16.5 / 19.5 / 17.8	65	417	8.5	$38,198
2022	Chevrolet	Bolt EUV	16.5 / 19.5 / 17.8	65	397	8.5	$40,198
2022	Volkswagen	ID.4	17.3 / 20.5 / 18.7	82	450	7.5	$44,995
2022	Volkswagen	ID.4 AWD Pro	19.8 / 21.8 / 20.7	82	404	7.5	$49,995
2022	Mini Cooper	SE 3 Door	18.2 / 20.9 / 19.4	32	183	4.5	$40,990

Plug-in Hybrid Electric Vehicles (PHEVs)

Year	Make	Model	Combined kWh/100 km	L/100 km (City/Hwy/ Combined)	Battery Size (kWh)	Electric Range (km)	LVL 2 Charge Time from Empty (hrs)	Typical MSRP ($CAD)
2022	Hyundai	Tucson PHEV	26.2	9.1 / 7.1 / 8.2	13.8	53	1.7	$30,454
2022	Hyundai	Santa Fe	27.6	7.1 / 7.9 / 7.4	13.8	50	3.4	$39,354
2022	Ford	Escape PHEV	19.9	5.5 / 6.2 / 5.8	14	60	3.3	$41,199
2022	Kia	Sorento	26.5	2.8 / 3.2 / 3.1	13.8	51	3.4	$36,695
2022	Kia	Niro PHEV	19.9	4.9 / 5.3 / 5.1	8.9	67	2.25	$34,595
2022	Jeep	Wrangler 4xe	49.8	11.6 /11.9 /11.7	17	35	2.4	$54,114
2022	Mini Cooper	SE Countryman	28.6	8.1 / 7.9 / 8.0	10	29	2	$39,790
2022	Chrysler	Pacifica	25.5	8.0 / 7.9 / 8.0	16	51	2	$50,234
2022	Mitsubishi	Outlander	28.3	9.4 / 9.0 / 9.2	13.8	39	4	$44,198
2022	Toyota	Prius Prime	15.7	4.3 / 4.4 / 4.3	8.8	40	2	$33,750

2022	Toyota	RAV4 Prime	22.3	5.7 / 6.4 / 6.0	18	68	4.5	$44,990

Source: https://www.plugndrive.ca/electric-cars-available-in-canada/

6.2 Medium/Heavy Duty Electric Vehicles

Vehicle Type	Make	Model	Battery Size (kWh)	Range (km)	Typical MSRP ($CAD)
Cargo Van	Ford	E Transit	68	200	$63,570
Cargo Truck	Lion Electric Co.	Lion 8	336	270	Contact Provider
Cargo Truck	Mitsubishi Fuso	eCanter	82.8	100-125	Contact Provider
Cargo Truck	Motiv Power Systems	EPIC E-450 Box	106/127	170	Contact Provider
Cargo/Refuse	DAF	CF Electric	315	200	Contact Provider
Cargo/Refuse	DAF	LF Electric	260	280	Contact Provider
Refuse Truck	BYD	6R (Class 6)	211	N/A	Contact Provider
Refuse Truck	BYD	8R (Class 8)	281	90	Contact Provider
Refuse Truck	Lion Electric Co.	Lion 8 Garbage Side Loader (with Boivin Evolution electric Hopper and Arm)	336	270	Contact Provider
Refuse Truck	Lion Electric Co.	Lion 8 Garbage Rear Loader	336	270	Contact Provider
Refuse Truck	Mack Trucks	LR Electric	N/A	N/A	Contact Provider
Work Truck	Motiv Power Systems	EPIC E-450 Work	106/127	161	Contact Provider

6.3 Low Speed/Non-Road Electric Vehicles

Ice Resurfacers

Make	Model	Battery Size (kWh)	Typical MSRP ($CAD)
Engo	170SX	N/A	Contact Provider
Engo	Ice Tiger	64	Contact Provider
Engo	Wolf Electric	64	Contact Provider
Olympia	Ice Bear Electric	53	Contact Provider
Olympia	Millennium E	62	Contact Provider
Olympia	Mini E	14	Contact Provider
Phaneuf International	Phaneuf 4.0	N/A	Contact Provider
WM	Compact Electric	26	Contact Provider
WM	EVO2 E	50	Contact Provider
WM	Mammoth Electric	36	Contact Provider
WM	Shira Electric	36	Contact Provider
Zamboni	650 Electric	62	Contact Provider

Zamboni	Model 450	22	Contact Provider
Zamboni	Model 552 AC	41	Contact Provider
Zamboni	Model 552 AC Li	25	Contact Provider
Zamboni	Model 650	N/A	Contact Provider
Zamboni	IZO Model 612	50+	Contact Provider
Zamboni	IZO Model 712	31	Contact Provider

Various Non-Road Vehicle Types

Vehicle Type	Make	Model	Battery Size (kWh)	Range (km)	Typical MSRP ($CAD)
Electric Tractor	Soletrac	eUtility	26	N/A	Contact Provider
Golf Cart	FTR Golf Canada	Model 1	N/A	70-90	Contact Provider
Golf Cart	Club Car	Onward Electric	N/A	N/A	$12,900
Off Road Work Vehicle	Canadian EV Ltd.	Might-E Truck	16	80	Contact Provider
Parkade Sweeper	Proterra	5130 Battery	19	N/A	$53,000
Passenger/UTV	Polaris	GEM e2	N/A	Up to 157	$13,400
Riding Mower	Greenworks	Lithium Z GZ 60R	N/A	N/A	Contact Provider
Riding Mower	Mean Green Mowers	CXR-60"	N/A	N/A	Contact Provider
Riding Mower	Gravely	Pro-Turn 60"	16	N/A	Contact Provider
Skidsteers/Loaders	Sherpa	100 ECO Mini-Loader	8.6	N/A	Contact Provider
Skidsteers/Loaders	Wacker Neuson	WL20e	11	N/A	Contact Provider
Skidsteers/Loaders	MultiOne	8 Series	N/A	N/A	Contact Provider
Skidsteers/Loaders	Bobcat	E10e Compact Excavator	12.7	N/A	Contact Provider
Street Sweeper	Dulevo International	D.zero2	N/A	N/A	Contact Provider
Street Sweeper	Tennant	500ze	N/A	N/A	Contact Provider
Utility Task Vehicle	Alke'	ATX320E	9	75	Contact Provider
Utility Task Vehicle	Club Car	Carryall 500	N/A	N/A	$14,279
Utility Task Vehicle	Hisun	Sector E1	N/A	60	$13,400
Utility Task Vehicle	John Deere	TE 4x2 Electric	N/A	N/A	$15,000
Utility Task Vehicle	KarGo	KarGo	N/A	N/A	Contact Provider
Utility Task Vehicle	Polaris	Ranger EV	11.7	80	$14,000
Utility Task Vehicle	Taylor-Dunn	Bigfoot 3000	12.4	64	Contact Provider
Utility Task Vehicle	Textron	Prowler EV iS	N/A	N/A	$17,500
Snow Removal Vehicle	Claes Equipment	Multi-Function Truck	N/A	N/A	Contact Provider
Snow Removal Vehicle	Claes Equipment	BR Rotary Broom	N/A	N/A	Contact Provider

Snow Removal Vehicle	Claes Equipment	FBB High-Power Snow Blower	N/A	N/A	Contact Provider
Snow Removal Vehicle	Claes Equipment	TBT Tow Behind Truck	N/A	N/A	Contact Provider

7.0 OTHER AVAILABLE EV INCENTIVE PROGRAMS

There are several other funding programs currently available for EVs and charging infrastructure:

7.1 iZEV (Zero-Emission Vehicle) Program

Effective May 1st, 2019, the federal government launched a point-of-sale incentive for consumers, businesses, and provincial/municipal governments who purchase or lease a new eligible electric vehicle (i.e., vehicles that have not been plated before). Rebates for BEVs, and longer-range plug-in hybrid vehicles are eligible for a $5,000 incentive. Shorter-range PHEVs are eligible for an incentive of $2,500. This incentive is applied in addition to any provincial zero-emission vehicles incentive offered and municipalities can stack this rebate with the EVM program rebate. Municipal governments can receive up to 10 incentives under the iZEV program per calendar year.

7.2 Green Municipal Fund: Green Fleets Pilot Projects

The Federation of Canadian Municipalities (FCM) offers a pilot project for reducing fossil fuel usage in municipal fleets through the Green Municipal Fund. Pilot projects can include a variety of EVs, EV infrastructure, autonomous vehicles, and more. Municipalities can receive up to 50% of eligible costs to a maximum of $500,000. Smaller municipalities below a population of 20,000 receive even more support and may qualify for up to 80% of eligible costs. Funding from this pilot project is stackable with EVM program funding.

7.3 Zero-Emission Vehicle Infrastructure Program (ZEVIP)

The Federal Government has introduced a program to build reliable EV infrastructure with Level 2 or higher charging stations to coincide with future transportation goals. Cost-sharing contribution agreements may be implemented through this program to install charging stations in multi-unit residential buildings, workplaces, public spaces, on-street locations, and dedicated fleet vehicles. This program is limited to funding 50% of total project costs up to a maximum of $5 million. Depending on the type of charging station, municipalities may access between $5,000 and $50,000 in funding.

8.0 POLICIES

To reduce the environmental impacts of the transportation sector, municipal, provincial, and federal governments across Canada have incorporated plans for vehicle electrification in their policy decisions. The following are examples of how government policies can influence vehicle electrification.

8.1 Municipal Policies

City of Edmonton

The City of Edmonton's Electric Vehicle Strategy includes the following goals that will be tracked and measured through the creation of an environment for EVs to thrive:

- the advancement of Edmonton's knowledge of EVs,
- an increase in the number of charging stations available for public use,
- an introduction of PHEVs into the municipal fleet and,
- an increase in the number of EVs registered in Edmonton.

Opportunities such as education and marketing, installing electric charging infrastructure, and creating EV incentives, regulations, and financial tools are some of the strategic actions they are taking to demonstrate effective leadership in EV advocacy.

City of Calgary

The City of Calgary compiled a Climate Resilience Strategy that includes an Electric Vehicle Strategy designed to:

- respond to the need for the development of EV infrastructure,
- encourage faster adoption of EVs aiding in the reduction of GHGs,
- and increase awareness about EVs amongst the public and industry.

Projects such as the Peaks to Prairies EV Charging Network demonstrate the establishment of an EV-friendly environment, through a collaborative approach between municipalities.

City of Leduc

The City of Leduc developed a 10 year Greenhouse Gas Reduction Action Plan, laying the groundwork for projects that produce cost and GHG savings. This plan includes transportation actions for EVs, ensuring that the charging infrastructure is established throughout the municipality. A noteworthy action item is the bylaws that require EV charging stations in new developments like multi-family dwellings, mixed-use buildings, and parking facilities following a certain ratio of level 2 charging stations.

8.2 Provincial Policies

While the Province of Alberta has yet to implement an EV strategy of its own, other Canadian provinces are implementing the following policies to encourage EV adoption.

British Columbia

Numerous EV policies and rebate incentives have been introduced to encourage and accelerate the adoption of EVs in British Columbia. The Go Electric Incentive program includes funding for point-of-sale BEV and PHEV incentives, investments into EV charging infrastructure, support for municipal fleet vehicle electrification, and investments in research, training, outreach, and economic development. The BC government has also implemented a SCRAP-IT program that offers electric vehicle-specific incentives and qualifying vehicle owners incentives to scrap their older ICE vehicles.

Other noteworthy policy decisions include:

- Allowing electric vehicle users to access high-occupancy vehicle (HOV) lanes regardless of the number of passengers,
- revising the Provincial Building Act to provide local governments greater flexibility when considering EV charging in new developments and,
- a Zero-Emission Vehicles Act requiring automakers to meet an escalating annual percentage of new light-duty ZEV sales and leases; 10% of light-duty vehicle sales by 2025, 30% by 2030, and 100% by 2040 (the first jurisdiction to legislate a 100% zero-emissions vehicle target16).

Quebec

By implementing the 2015-2020 Transportation Electrification Action Plan, Quebec plans to increase the number of BEVs and PHEVs purchased in the province. By providing a rebate program (offering up to $8,000 in EV incentives), discounts of up to $4,000 on used BEVs, and refunds for installing EV charging stations at businesses, municipalities, and organizations, Quebec has set a goal of 100,000 zero-emission vehicles to be registered by the end of 2020.

Other provincial government measures include:

- The expansion of the Electric Circuit, the largest public charging network in Quebec and eastern Ontario,
- allowing EV owners free access to toll bridges, highways, and ferry rides as well as dedicated lanes reserved only for EVs and,
- making electric vehicle acquisition compulsory for fleet vehicles of departments and public institutions including health and education networks.

Quebec has also legislated a Zero-Emission Vehicles Standard, requiring manufacturers to acquire credits by procuring a specific number of EVs for the Quebec market. This will allow Quebec consumers access to a larger number and wider range of EVs for purchase.

8.3 Federal Policies

The Government of Canada has recognized the need for EV adoption to combat climate change and reduce GHGs. As a result, the federal government set ambitious sales targets to encourage EV adoption, including a goal for 10% of all light-duty vehicle sales by 2025, 30% by 2030, and 100% by 2040[17]. Other than the EV incentives mentioned already in Section 7.0, the federal government has considered other strategies to incentivize EV adoption, including:

- Support for provincial and local governments requiring that 100% of residential parking spaces be "EV Ready" (having an energized electrical outlet available to provide Level 2 charging),
- Mechanisms to require that EV charging infrastructure be included in national building codes and zoning law requirements and,
- A Zero-Emission Vehicle Awareness Initiative designed to increase awareness of EVs through education and outreach.

9.0 IMPLEMENTATION

The following section details a 4-step action plan that municipalities can follow to electrify their vehicle fleets:

Step 1. Assess transportation needs

The first step in any effective fleet strategy is to understand the transportation needs of your municipality and implement a long-term approach that leads to a more efficient fleet. A fleet inventory study helps build an understanding of fleet requirements as a baseline and should capture the following detail:

- The types of vehicles included in the fleet inventory study scope, which may include passenger vehicles, non-road vehicles, transit, waste collection, or other fuel consuming vehicles and equipment.
- Frequency of vehicle use, the average distance traveled, amounts of fuel used, fuel costs, maintenance costs, and operational considerations.
- Record mileage and/or installing data loggers can provide valuable information to advise fleet managers.

As a component of the EVM program, municipalities can receive financial support to conduct a feasibility study of incorporating EVs into their fleets based on their existing fleet portfolio. A feasibility study will quantify the potential for cost savings and emission reduction as a result of adding electric vehicles to a municipality's fleet. This study will help inform decisions on determining a long-term path forward to decarbonize fleet vehicles and save operating costs.

Step 2. Build support

Engaging the appropriate stakeholders as early as possible in the process is crucial to gain support for important fleet decisions. Informing key stakeholders and decision-makers of the potential benefits associated with the electrification of the municipal vehicle fleet will help build commitment and support. MCCAC's EV Savings Calculator will help compare savings and present a feasible business case for switching from an ICE vehicle to an EV.

Step 3. Create a plan
Creating a strategic plan of action is crucial to the success of any project. The following components should be considered:

- Establish a vehicle replacement schedule targeting specific groups of vehicles.
- Target areas of the fleet with the most potential for cost savings and emission reduction.
- Investigate and select EV options that meet operational needs while achieving cost savings and emission reduction. Compare the plan to any set targets to ensure the plan will achieve the desired outcomes.
- Identify the funding supports available for vehicles and charging stations.
- Plan for the installation of EV charging infrastructure.
  - Incentives are currently available to reduce capital costs.

Step 4. Implement your plan
After implementing your plan, it's important to manage the transition, communicate the benefits, and highlight the results throughout the organization. The following actions may be considered:

- Continuously monitor the performance of the new fleet vehicles to verify the cost savings and emission reductions align with the expected outcomes.
- Communicate results throughout the municipality to explain the journey and the benefits of the change.
- Provide on-site training to promote fuel-efficient driving behaviour and to inform operators of new operational considerations of driving EVs.

10.0 SOURCES

[1]"Climate Change and Transportation." *Alberta.ca*, Government of Alberta, 2020. <www.alberta.ca/climate-change-and-transportation.aspx>.

[2]Haycock, Kate." Over one in 20 new cars registered in Canada in 2021 were EVs." Electric Autonomy, 15 Feb 2022. https://electricautonomy.ca/2022/02/15/ihs-markit-zev-adoption-canada-2021/E

[3]Center for Climate Protection. "Actions by Countries to Phase out Internal Combustion Engines." 2019. <https://Climateprotection.org/Wp-Content/Uploads/2016/06/ccp_logo.Jpg, climateprotection.org /actions-by-countries-phase-out-gas/>.

[4]Logtenberg, Ryan, et al. 2018, *Comparing Fuel and Maintenance Costs of Electric and Gas Powered Vehicles in Canada.* <www.2degreesinstitute.org/reports/comparing_fuel_and_maintenance_costs_of_electric_and_gas_powered_vehicles_in_canada.pdf>.

[5]US Department of Energy. "Plug-In Electric Vehicle Handbook." *Energy Efficiency and Renewable Energy*, Clean Cities Technical Response Service, Apr. 2012. <afdc.energy.gov/files/pdfs/pev_handbook.pdf>.

[6]Bentein, J. (2017, November). "*Why Canada is a top spot for Electric Vehicles to reduce GHGs*". <http://www.jwnenergy.com/article/2017/11/why-canada-top-spot-electric-vehicles-reduce-ghgs>.

[7]City of Vancouver. (2016). *Vancouver's EV Ecosystem Strategy*. <http://vancouver.ca/files/cov/EV-Ecosystem-Strategy.pdf>.

[8]"CAA National." *CAA*, 2019. <www.caa.ca/electric-vehicles/charging-stations/>.

[9]Electric Vehicle Association of Alberta. "FAQ." 2019. <www.albertaev.ca/faqs>.

[10]Yang, F., Xie, Y., Deng, Y. et al. *Predictive modeling of battery degradation and greenhouse gas emissions from U.S. state-level electric vehicle operation*. Nat Commun 9, 2429 (2018) doi:10.1038/s41467-018-04826-0

[11] "Electric Vehicle Battery Life & Warranties." *EnergySage*, 2 Jan. 2019. <www.energysage.com/electric-vehicles/buyers-guide/battery-life-for-top-evs/>.

[12]ChargeHub. "2019 Definitive Guide on How to Charge An Electric Car." *ChargeHub*, 2019. <www.chargehub.com/en/electric-car-charging-guide.html>.

[13]Kamiya, George. "Modelling the Greenhouse Gas Emissions Intensity of Plug-in Electric Vehicles in Canada Using Short-Term and Long-Term Perspectives ." *Simon Fraser University*, 22 Sept. 2015. <www.summit.sfu.ca/system/files/iritems1/16226/etd9404_GKamiya.pdf>.

[14]Shahan , Zachary. "Tesla Model 3 Is #1 Best Selling Vehicle In Norway, #3 In Netherlands, #7 In Switzerland - CleanTechnica Report." *CleanTechnica*, 20 Sept. 2019. <www.cleantechnica.com/2019/09/20/>.

[15]Digges, Charles. "As of Last Month, Nearly 60 Percent of New Cars Sold in Norway Are Electric." *Bellona*, 1 Apr. 2019. <www.bellona.org/news/transport>.

[16]Ministry of Energy. "Zero-Emission Vehicles Act." *Province of British Columbia*, 4 Nov. 2019, <www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/transportation-energies/clean-transportation-policies-programs/zero-emission-vehicles-act>.

[17]Government of Canada. "Zero-Emission Vehicle Infrastructure Program." *Natural Resources Canada*, Government of Canada, 4 Oct. 2019. <www.nrcan.gc.ca/energy-efficiency/energy-efficiency-transportation/zero-emission-vehicle-infrastructure-program/21876>.

[18]Akendi. "Greening Government Fleets: A Helpful Guide to Understanding Best Practices." *Natural Resources Canada*, Government of Canada, May 2018. <www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/pdf/transportation/NRCan_GreeningGovFleets_e.pdf>.

[19]Hausfather, Zeke. "Factcheck: How Electric Vehicles Help to Tackle Climate Change." Carbon Brief: Clear on Climate, European Climate Foundation, 13 May 2019. <www.carbonbrief.org/factcheck-how-electric-vehicles-help-to-tackle-climate-change>.

[20]Nealer, Rachael, et al. "Cleaner Cars from Cradle to Grave." Union of Concerned Scientists, Nov. 2015. <www.ucsusa.org/sites/default/files/attach/2015/11/Cleaner-Cars-from-Cradle-to-Grave-full-report.pdf>.

[21]Ahmadi, L, et al. "A Cascaded Life Cycle: Reuse of Electric Vehicle Lithium-Ion Battery Packs in Energy Storage Systems." Government of Canada, 3 July 2019. <nrc-publications.canada.ca/eng/view/object/?id=0e23acb6-9235-4da9-bb71-34eac02cee12>.

[22] Institute for Energy Research. "The Afterlife of Electric Vehicles: Battery Recycling and Repurposing." *Institute for Energy Research*, 6 May 2019. <www.instituteforenergyresearch.org/renewable/the-afterlife-of-electric-vehicles-battery-recycling-and-repurposing>.

[23] Saxena, Samveg, et al. "Quantifying EV Battery End-of-Life through Analysis of Travel Needs with Vehicle Powertrain Models." *Science Direct*, Elsevier, 14 Jan. 2015. <www.sciencedirect.com/science/article/pii/S0378775315000841#cebib0010>.

[24] Hughes, Michael. "Networked EV Charging: The Smart Solution for Business." Charepoint, 30 Oct 2019 <https://www.chargepoint.com/blog/networked-ev-charging-smart-solution-business-0/>.

[25] "Understanding OCPP" ChargePoint, 2013. <https://www.chargepoint.com/files/OCPP-Fact-Sheet.pdf>.

[26] "Understanding OCPP: Why Interoperability Matters" EVBox, 2021 <https://evbox.com/us-en/understanding-ocpp>.

[27] "How Winter Weather Affects an Electric Car." Edited by Jim Gorzelany. *MYE.* MotorSport Network. 2020. <www.myev.com/research/ev-101/how-winter-weather-affects-an-electric-car>

[28] "AutoSmart: Learn the facts – Fuel consumption and CO2" Natural Resources Canada, 2014. https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/oee/pdf/transportation/fuel-efficient-technologies/autosmart_factsheet_6_e.pdf

[29] "Provincial and Territorial Energy Profiles – Alberta." Canada Energy Regulator, 2022. https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/provincial-territorial-energy-profiles/provincial-territorial-energy-profilesalberta.html#:~:text=The%20greenhouse%20gas%20intensity%20of,kWh)%20electricity%20generated%20in%202019.

[30] Barnard, Michael. "Canada's Carbon Price Will Radically Cut Alberta's Grid Emissions." CleanTechnica, 2020 https://cleantechnica.com/2020/12/20/canadas-carbon-price-will-radically-cut-alberta-grid-emissions/#:~:text=That%20model%20suggested%20that%20grid,150%20grams%20CO2e%20in%202040.