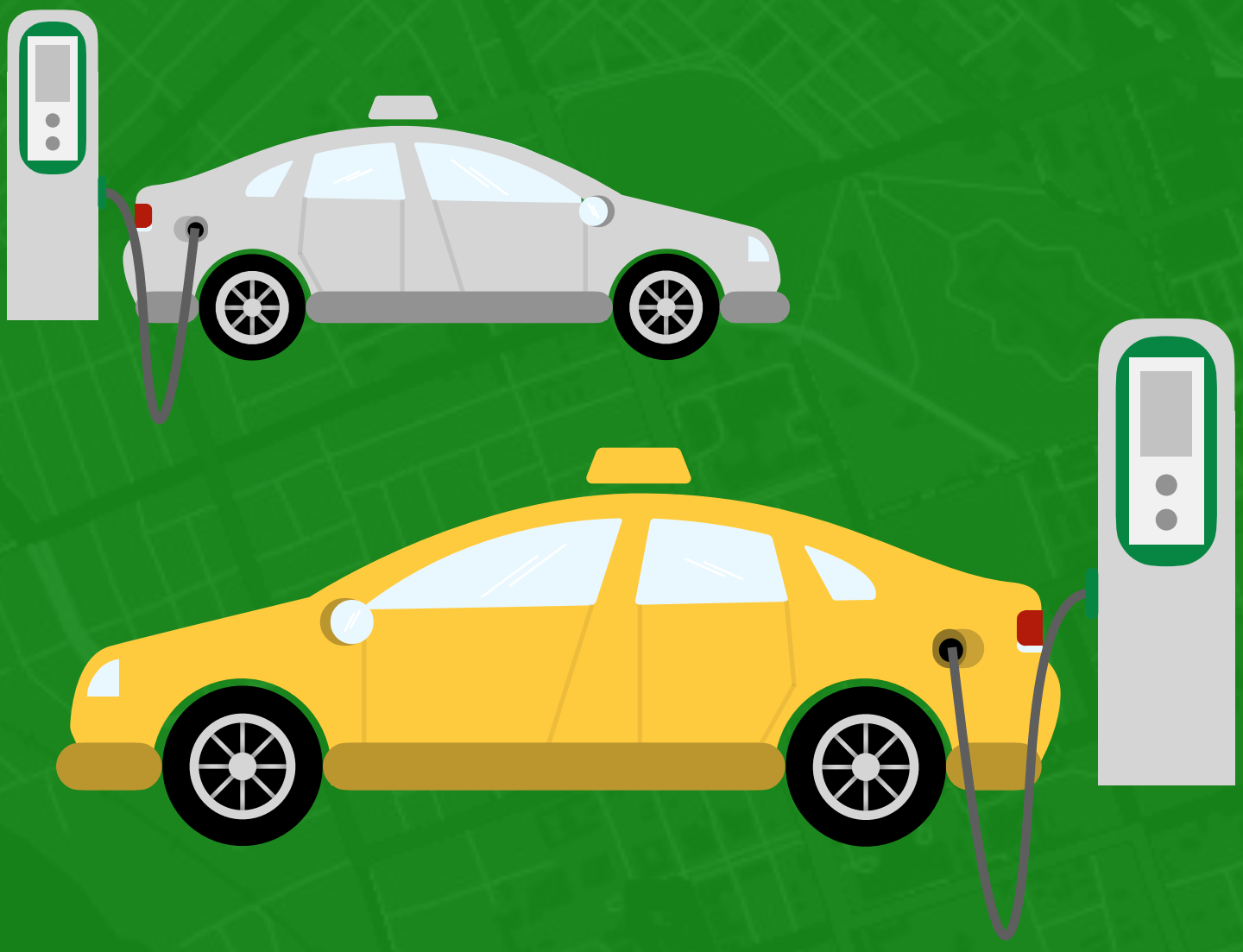
DALHOUSIE UNIVERSITY

Prepared By:
Office of Sustainability

ELECTRIC VEHICLE

Infrastructure Management Guide

Fall 2019



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GLOSSARY

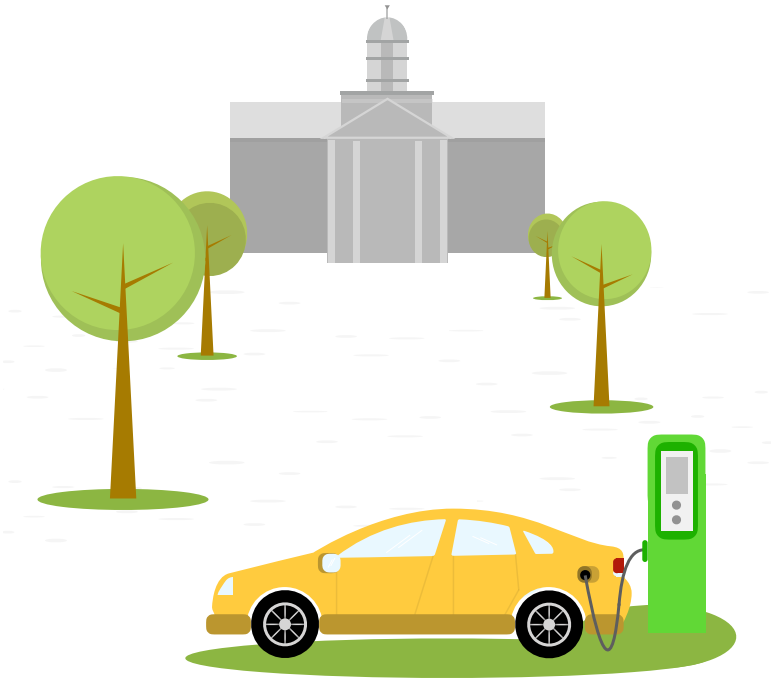
AC	Alternating Current
BEV	Battery electric vehicles, rely solely on the built-in battery as an energy source
Charging Stations	An element of infrastructure supplying electric energy for the recharging of plug-in electric vehicles (PEVs) and battery electric vehicles (BEVs)
DC	Direct Current
EV	Consists of plug-in electric vehicles (PEVs) and battery electric vehicles (BEVs)
EVSE	Electric vehicle supply equipment, otherwise known as a charging station
ICE	Internal Combustion Engine
PEV	Plug-in electric vehicles, is any vehicle that can be recharged from an external source of electricity
PHEV	Plug-in hybrid electric vehicles, contain a smaller battery pack than BEV's without any assistance of the internal combustion engine
ZEV	Zero-emission vehicles, they have the potential to produce no tailpipe emissions to operate e.g. BEVs, PEVs, plug-in hybrids, and hydrogen fuel cell vehicles

EXECUTIVE SUMMARY

An increase in plug-in Electric Vehicle (EV) ownership is resulting in a growing network of Electric Vehicle Supply Equipment (EVSE) infrastructure, otherwise known as EV charging stations (New West Technologies, 2015). The integration of EV infrastructure poses new technical, economic, and regulatory challenges for institutional and commercial sectors (Abbad et al., 2011).

A growth in EV ownership is having an impact on transportation infrastructure, predominately with parking lots where they are poised to become the new gas station (Delphi Group, 2019). Atlantic Canada and the Prairies have yet to experience a significant increase in ZEV ownership, though once the market grows to be more prominent, whether through domestic or commercial uses, new demands will be faced through aspects of parking, such as the adoption of EV infrastructure (Pollution Probe and The Delphi Group, 2018). Parking lot owners (Delphi Group, 2019) should adopt an overarching strategy for EV and ZEV infrastructure, as a call to action for these newfound infrastructure demands.

This management guide is intended to assist Dalhousie University and other institutions to explore the management of existing and new EVSEs (charging stations) for employees, students, and visitors. This guide provides information on cost and location considerations for commercial ESVEs in addition to long-term planning strategies for growth and maintenance.



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1 INTRODUCTION

To address issues such as climatic change, the transportation sector is starting to shift from fossil fuel only combustion engines towards electric hybrids, electric vehicles (EV) or some sort of zero-emission vehicle (ZEV)[1]. This transition requires a new type of infrastructure to be implemented and incentivized, known as Electric Vehicle Supply Equipment (EVSE) or EV charging stations.

Modern energy producing infrastructure plays an essential role in the green transportation movement. Canada's energy sector is becoming increasingly prominent in clean energy, though the risks and costs associated with emerging technologies is affecting how and when commercial industries are able to adopt new changes (Government of Canada, 2019-b). The integration of EV infrastructure poses new technical, economic, and regulatory challenges (Abbad et al., 2011). For commercial owners and developers, these challenges are unavoidable given the unfamiliarity that comes from trials and errors of implementing new technology. For organizations to succeed in this new wave of technological implementation, knowledge sharing is important to simply and effectively fund, implement, and manage EV charging infrastructure.

To date, there are three primary levels of EV charging infrastructure:

- Alternating Current (AC) Level 1
- Alternating Current (AC) Level 2
- Direct Current (DC) fast charging Level 3

Each level of EVSE consists of varying models, features, and circuits that result in different charging times and overall cost for implementing and operating (Table 1.)

[1] Government of Canada (2019-A), Canadian Electricity Association (2019), Pollution Probe and The Delphi Group (2018), EVAC (2018), Chen et al. (2016), EMC (2016), New West Technologies (2015), He et al. (2012)

Table 1. Charging Station Unit (EVSE) Levels & Locations

Type (Level)	Circuit	Charging	Unit Cost	Install Cost	Charging Time	Location
AC (Level 1)	120 V 20 amp	1.4kW-1.9kW	≥$1,000	NA - if using existing outlet	12-20 hours	Most common for residential charging, can require 10-20 hours for a full charge
AC (Level 2)	240 V 40 amp	7.7kW	$2,000 - $10,000	$1,000 - $10,000+ (depending on proximity to electrical feed – includes design & contractor fee)	4-8 hours	Most common for commercial sector charging, can require 4-8 hours for a full charge
DC Fast Charging (Level 3)	450 V 200 amp	62.5kW	$30,000+	$5,000+ depending on size and location of electrical feed	30 min - 1 hour	Most common for commercial and public sectors, can require 30 minutes to 1 hour for a full charge

Modified Source: Community Energy Association. (2013, June). Planning for electric vehicle charging infrastructure: a toolkit. Retrieved on July 3, 2019. Information added regarding costing as costs and charge times are changing as the industry matures.

In the commercial sector, Level 2 charging stations are most commonly implemented for workplaces and institutions where employee and visitor vehicles are parked for longer periods at a time[2]. At Dalhousie University, **eight Level 2 stations with 12 charging units** (four units have two charging heads) are currently provided amongst the Halifax campuses (Studley and Sexton campus). Eleven stations are open to the campus with one station reserved for fleet. Future infrastructure plans include adding chargers at the Agricultural and Carleton campus for all campus coverage.

Caption. Level 2 EV station at the Dalplex

[2] EVCA (2018), FLO (2018), New West Technologies (2015), Chen et al. (2015), Community Energy Association (2013)

1.1 Purpose

In 2019, Dalhousie University released its second University Climate Change Plan and Greenhouse Gas (GHG) Inventory Report (Office of Sustainability, 2019). Part of the initiatives in the plan are to reduce the University's scope 1 and 2 GHG emissions by 55% by the year 2030. To date, the University has reduced 20% of scope 1 and 2 emissions. In order to lower GHG levels, further reduction initiatives continue to be planned and implemented. In 2017, 497 GHG (tCO2e) was produced solely through fleet vehicles across all four campuses; less than1% of scope 1 and 2 emissions (Office of Sustainability, 2019). Though fleet represents a small GHG percentage, transportation initiatives that broadly support sustainable commuting options are one of the many components that the University and Office of Sustainability aim to improve to meet the Climate Change and Sustainability Plan goals and visions.

The University has been undergoing major energy efficiency and sustainability improvements across the Halifax Campuses (Studley, Carleton, and Sexton) and Agricultural Campus (AC). Simultaneously, Dalhousie University has invested in EV infrastructure over the past decade throughout the Halifax campuses with plans of further implementation at the AC and Carleton campus.

The focus of EV infrastructure at Dalhousie is to provide extra EV fueling support through charging stations. In 2015, approximately 80% of charging was done at home (EMC, 2016). While residential charging is common, workplace charging infrastructure has become important in reducing driving range anxiety for commuters, as it can nearly double all-electric daily commuting distances[3]. The accommodation of public and workplace charging stations has become an acting influencer on vehicle users switching over to an EV (Electric Vehicle Charging Association, 2018). The existing and future infrastructure at Dalhousie improves the convenience for existing and future ZEV owners. Through the provision of top-off stations, EVSE infrastructure provides a secure way of getting home for employees and students who utilize EVs as a form of commuting. It also creates infrastructure for fleet EV vehicles.

This management guide is designed to assist Dalhousie University and other commercial institutions looking to implement and manage charging infrastructure. This guide provides information regarding cost and location considerations for commercial charging stations in addition to long term planning strategies for growth and maintenance.

[3] Pollution Probe and The Delphi Group 2018, New West Technologies 2015

1.2 Background

1.2.1 Permits & Parking

There are six types of parking permits at Dalhousie – Reserved, General (Unreserved), Short-term metered parking (individual meters and pay and display - $2 an hour), Ride Share and Accessible. Presently, EV charge stations are available at general (unreserved lots) and in metered parking locations providing access to campus and community members.

1.2.2 EV Parking Locations

Current EV stations are located on Studley and Sexton campus. One station is set-up for fleet vehicles and the rest of the 11 charge units are open to campus and community members as outlined on the University Facilities Management Website.

1.2.3 Existing Challenges

In 2018, the transportation sector was the second largest source of GHG emissions. EVs produce low local GHG emissions and while Canada overall generates a large percentage of non-fossil fuel electricity, Nova Scotia's energy is still dominated by coal (EMC, 2016). In 2021, legislated renewable energy targets are planned to reduce the NS emissions factor so that EVs will have a lower footprint than hybrid cars. Currently EVs produce less emissions than a full combustion engine but slightly more than a hybrid (Thorne and Hughes, 2019).

Most NS charging stations that have been installed are Level 2 and are not network-enabled, meaning that the opportunity to collect data on usage patterns is limited (Pollution Probe and The Delphi Group, 2018, p 4). For Dalhousie University and other commercial owners installing, monitoring, and maintaining EV infrastructure is new territory within a rapidly changing field.

Caption. EV charge Station, Sexton campus

2 IMPLEMENTATION

A number of steps are involved in the implementation of an EV charging station program, including:

1. Identify vision, goals and objectives;
2. Identify responsible departments for implementation, management, and promotion;
3. Identify parking management structure (permit type, rules, and relevant payment methods) signage and spot design, and costs.
4. Select potential charging locations based on goals, objectives, and opportunity (e.g. new building);
5. Development of infrastructure site and hardware and software tender requirements;
6. Purchase charging station meeting tender requirements;
7. Purchase contactor services to install and commission charger based on design details;
8. Review of software services legal agreement; and
9. Identify process and program for on-going maintenance, management, and renewal.

2.1 Vision, Goals and Objectives

Establishing visions, goals and objectives helps to articulate the rationale and approach for establishing and maintaining organizational EV charging stations. Motivations for establishing workplace charging may relate to sustainability and green building goals, enhancements to parking service for employees and visitors, research, etc. Some examples of statements include:

Vision

We as a community are moving towards a future that will allow us to continue to evolve through our actions of becoming a low-carbon to eventually carbon-neutral workplace. Supporting EV infrastructure at each location is one of the many supports we are working towards.

Goals

We will successfully implement and monitor existing and new EV infrastructure to support and encourage EV commuting. We will share our learnings with other workplaces in establishing EV charging stations.

Objectives

We aim to provide access to EV charging stations to support top up services for campus members and visitors. Our five-year target is to have EV stations available on all campuses.

2.2 Roles and Responsibilities

Identification of employers, consultants, licensed electrical contractors, construction contractors, vendors, employees or visitors' roles helps with smoother implementation. A number of organizations created workplace policies that identify workplace goals, managing department roles, outline user etiquette, and fee structures.

The Clean Air Partnership (2018) Workplace EV Charging Policy Guide highlights a number of examples of workplace roles including long-term planning, day-to-day operations and maintenance, legal agreement and policy review. Consultants may play a role in providing hardware and siting design, contractors in installing and commissioning stations, vendors in providing hardware and software products and troubleshooting, along with help line services.

2.3 Parking Management Structure and Costs

Management of EV parking spots can provide additional challenges with access to stations being blocked by non EV vehicles and sharing of EV charging resources amongst EV users. Clear signage and symbols, permit facilitation and parking rules provide structure for use of the spaces.

"Based on the experience gained with public charging stations, it is found that one of the most effective ways to prevent gas-powered vehicles from parking in front of a charging station is to simply paint the entire parking space green. The parking space should also be clearly identified by a sign that explicitly states the main usage rules so that users of the charging stations are aware of requirements, such as hours of operation and any reservation requirements."

(FLO, 2019 p.19)

The cost for a person to use a charging station is usually administered through a charged flat rate that can be incorporated in an existing parking fee or permit, a time-based rate (e.g. hourly), or a blended rate where the consumer is billed for parking in addition to the time-based charge (Government of Canada, 2018). Fees for stations that are based on time are currently exempt from inspection or any intervention by

Measurement Canada, although if the fees are based on energy or power measurements, then an approved and inspected meter must be utilized.

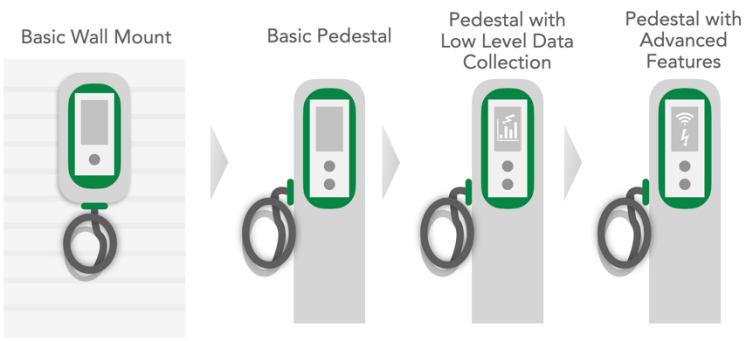
In 2018, The Office of Sustainability staff conducted a scan of nine universities in Canada and the US. Most had a mix of metered fees, fees based on electricity usage and maintenance/replacement charge, and/or no additional fees. At Dalhousie, some stations are available at no additional fee other than a parking pass requirement and some have fees related to the short-term metered spot. For short-term metered spots electricity charges are not calculated; a $2 hour short-term metered spot rate is collected similar to other short-term metered spots. Money is collected through networked EV charge stations – i.e. software services engaged on a charge station collects funding through a vendor card or credit card and non-networked units where a parking meter or pay and display unit is installed. The charging stations on campus provide electricity through building electrical systems that are powered by Nova Scotia power (NSPI). EV signage and pavement markings, costs, and management information is found on the Facilities Management website.

A number of one-time and ongoing costs have been identified by organizations (RMI, 2019) including Dalhousie. These include:

- Site assessment and tender drawings;
- Infrastructure costs - connection of conduit and control of electricity services (metering);
- Software and payment services for networked units (often annual);
- Contract development and management set up;
- Grid hosting;
- Charger hardware purchase, installation and commissioning;
- Payment systems:
- Standards compliance;
- Permitting process;
- Easements;
- Maintenance and management; and
- Renewal.

Comparing and predicting EVSE installation costs vary from project to project and also depend on the specific needs and constraints of the users and station itself (New West Technologies, 2015). Level 2 chargers are preferred for vehicles parked 4-8 hours at a time and are available in wall-mounted and pedestal applications. Wall mounted EVSEs are connected to a building's electrical system which helps to reduce installation costs, typically costing between $1,000-3,000 CAD per station. Pedestal charging stations have a higher installation cost due to trenching, asphalt, and concrete work required to

connect the building's electrical system, typically costing between $3,000-10,000+ CAD per station (FLO, 2018).



Caption: Varying Level 2 Charging Station Models

2.4 Siting

Implementing EVSE requires a site plan for successful implementation. The best practices identified by the Community Energy Association (2013) for creating a planning framework should include:

i. Measurement of the potential site, this ensures that the site can accommodate the planned number of vehicles and charging equipment. Consider requirements for flood-prone or future flood-vulnerable areas
ii. Review and evaluation of electrical conduits near the site, measure their distance from the site
iii. Site plan illustrating the proposed orientation and location of the charging equipment for the parking site
iv. Cost estimate for bringing electrical power to the site in addition to other installation costs
v. Location of the main electrical panel(s), branch circuits, and conduits
vi. Location of hazardous materials (if any)
vii. Location of existing charging stations
viii. Existing lighting and proposed lighting (if any)
ix. Traffic flow

In addition, the Community Energy Association, identified criteria for site planning (Table 2.)

Table 2. Criteria for Charging Infrastructure on Sites

Site Characteristics	Description
Visible	The selected site should maximize visibility for potential users.
Secure	The site should be well lit and visible to help enforce crime prevention through environmental design principles.
Nearby power source	Existing light fixtures and power poles can reduce installation costs, eliminating the need for trenching onsite through existing concrete or pavement. The construction required for extending electrical conduits is reduced as a result.
Topography	The site should not be on a hill due to vehicle rolling risks. Locating a station on a decline may result in rainwater or snow to gather in the area.
Availability	The site should be accessible any time during the day or at a minimum, during business hours.
Access & EGRESS	Above ground locations are often more spatially flexible. There must be ample room to accommodate the number of vehicles planned without obstruction for the user and other vehicle parking spaces.
Shelter & Ventilation	This improves the charging experience regarding the safety and comfort of the user.

Source: Community Energy Association. (2013, June). Planning for electric vehicle charging infrastructure: a toolkit. Retrieved on July 3, 2019.

2.5 Hardware and Software Tender Considerations

EV charging station tender specifications include specific technical requirements beyond standard tender specifics of costs, experience, and warranty. Technical requirements include items such as model type – number of heads, wall or ground mounted, incoming voltage, connector type, cord length and type, weather resiliency demands, safety controls and trip features, reporting features, payment features, network requirements, and data security. Hiring a consultant to advise and prepare tender document may aid in the procurement process.

2.6 Charging Stations

Current EV charging station technology consists of the equipment required to supply electricity from a source to the battery in an EV or a plug-in hybrid vehicle (New West Technologies, 2015). When plugged in, the EV charging station communicates with the

EV or plug-in hybrid to ensure that the vehicle is properly plugged in before supplying a charge.

As previously mentioned, there are three primary levels of EVSE charging infrastructure:

- Alternating Current (AC) Level 1
- Alternating Current (AC) Level 2
- Direct Current (DC) fast charging Level 3

Level 1 and Level 2 EV charging station's provide alternating currents (AC) to the onboard charging equipment of an EV or PHEV. Direct Charge (DC) Level 3 stations charge at a faster rate since the electrical charge travels directly to the vehicle's battery, skipping the current conversion process. Most of the physical components are similar between an AC and DC EVSE though the main difference is that the DC fast charging EVSE uses a charger located off-board from the vehicle instead of the built-in charger that exists in EVs and PHEVs (New West Technologies, 2015).

A number of companies provide EV charging stations. Some provide charging stations, software, and payments services (Table 3). The landscape is rapidly evolving, an example of this can be seen at Dalhousie, as one of the charger units is now no longer supported by the parent company.

Table 3. - North American EV CHARGING STATION Network & Operators

Network/Operator	Region	Website
Aerovironment	USA	http://www.evsolutions.com/
Astria Technologies	USA, Canada	http://www.astriatechnologies.com
Blink	USA, Canada	http://www.blinknetwork.com/
ChargePoint	USA, Canada	https://www.chargepoint.com/
Electric Circuit	Quebec	https://lecircuitelectrique.com/welcome
FLO	Canada	https://www.flo.com/en-CA/
GE WattStation	USA, Canada	https://www.gewattstation.com/connect/
Greenlots	USA, Canada	http://greenlots.com/
NRG eVgo	USA	https://www.nrgevgo.com/
OP Connect	USA	http://www.opconnect.com/press/
SemaConnect/SemaCharge	USA, Canada	http://www.semaconnect.com/
Sun Country Highway	USA, Canada	http://suncountryhighway.com/

Tesla (Supercharges and Destination)	USA, Canada	https://www.tesla.com/en_CA/supercharger
Volta	USA	www.voltacharging.com

Source: Charge Hub. (2019). Charging networks. Retrieved from https://chargehub.com/en/networks.html on July 16, 2019.

Natural Resources Canada and other partners keep a website updated with publicly available EV charge station locations.

2.7 Installing and Commissioning Charger

After an EVSE is installed, a commissioning process is conducted to verify the safety and effective operations of the hardware and software. Licensed electrical contractors need to certify the safety of the Unit and have secured the approximate paperwork (i.e. permit). The EVSE vendors authorized service technicians will perform visual, mechanical/electrical inspections, prepare reports, and register the unit on the network if it is connected. The responsible workplace authority will need to connect to charger software for payment and analytics or set-up non-metering method of payment.

2.8 Review of Legal Agreement

EV charger vendors have standard legal agreements for warranty issues, network devices and payment structures, data privacy, etc. Depending on the organization and details in the agreement, the legal department may need to review the document.

2.9 Ongoing Maintenance, Management and Renewal

Identifying an ongoing process to fund and maintain equipment, respond to inquiries, and renew assets is important to consider as assets come to end of life.

3 POLICIES AND PROGRAMS

3.1 Policies and Guidelines

Support for EV fleet and commuting initiatives is often in green building, greening fleet and climate change plans and policies. At Dalhousie, goals in the 2019 Climate Change Plan highlight reducing greenhouse gases through the objective of low emission and renewable sources for energy and transportation (Office of Sustainability, 2019).

References for low emission vehicles are seen in the following plans and guidelines.

- Climate Change Plan (2019)
- Vehicle Share & Green Fleet Guidelines
- Sustainable Building Policy

Dalhousie has a sustainable building policy set in place for new construction to reach LEED Gold certified or higher (Office of Sustainability, 2019). Green Fleet guidelines focus on new fleet procurement with low carbon emission vehicles which are a suitable size for the performance required. Mini trucks, a hybrid and an electric hybrid have been purchased through the Green Fleet guide (Office of Sustainability, 2019).

Dalhousie University is a Chartered participant of the International Sustainability Tracking, Assessment & Rating System (STARS). Every three years, Dalhousie submits information on over 67 criteria sections related to sustainability operations, curriculum, research and engagement for rating. Dalhousie's current STARS rating is Gold as of 2018.

Every fourth year the University releases a public Sustainability Progress report. Annually, a detailed Greenhouse Gas Inventory is prepared and published. This inventory outlines progress made on climate change goals. (Dalhousie University, 2018).

3.2 Requirements

The installation of EV charge station may connect to requirements from an organization (e.g. EV charger policy); a municipality, the province (e.g. Ontario EVSE regulation) or utility as part of the electrical permit process as for example.

3.2.1 Municipal Requirements

In the Halifax Regional Municipality, Electric Vehicle Charging Stations are highlighted in municipal bylaws.

163 *(1) Electric vehicle charging stations are permitted in all parking areas.*
(2) Where more than 25 parking spaces are provided in association with any parking structure, multi-unit dwelling, office, hotel, or mixed-use building, all parking areas must include wiring conduits to allow the future installation of electric vehicle charging infrastructure.
(3) Where more than 100 parking spaces are provided on a lot, at least 2 electric vehicle charging stations must be provided. (HRM, 2018, p 95)

(70) Electric Vehicle Charging Station means infrastructure that supplies energy for the charging of electric vehicles such as plug-in electric, neighbourhood electric, and hybrid vehicles. (HRM, 2018, p 133)

3.2.2 Organizational Design Requirements

Organizations may have developed specific design standards for on-site EV charge station stations. The US Dept. of Energy and Transportation Climate Initiative (2012) create a best practices document of siting and design guidelines to aid organizations.

3.2.3 Green Building Specifications

Many green building certification programs from LEED® to BOMA BEST® outline credits for alternative transportation including the support for low emitting and ZEVs.

3.3 Incentives

The Government of Canada stated in their 2016-2019 Federal Sustainability Development Strategy Report that $120 million will be invested towards Green Infrastructure Programs for EV and Alternative Fuel Infrastructure from 2018 to 2022 to help reduce greenhouse gas (GHG) levels emitted from transportation (2018). Canada's transportation sector alone accounted for 24% of the national GHG emissions in 2017 (Government of Canada, 2019-c).The Electric Vehicle Infrastructure Demonstration (EVID) Program is working on addressing these barriers to effectively deploy EVSEs so that there is an increased uptake of zero-emission vehicles (ZEVs) (Government of Canada, 2019-a). Projects for new and existing EVSE technology are looking at Level 2, DC fast charging, wireless (induction), and autonomous vehicle charging technologies to encourage developmental growth for EV infrastructure (Government of Canada, 2019-b).

The Government of Canada have released Request for Proposals (RFP) on Public Spaces and On-street applications to encourage ZEV infrastructure deployment (Natural Resources Canada, 2019-a). There have been recent grants for workplace and fleet targets though the program will aim to support EVSEs at workplaces and to support ZEVs dedicated for corporate fleets.

> *"In Atlantic Canada, barriers to ZEV adoption were identified including:*
> - *Lack of incentives and high purchase costs*
> - *Lack of consumer and policy-maker awareness and education about ZEVs and their benefits*
> - *Lack of public charging infrastructure*
> - *Lack of ZEV availability in dealerships*
> - *Lack of available models (e.g., pickup trucks) to meet required vehicle performance specifications for large consumer demographics*
> - *Lack of access to maintenance and repair*
> - *Higher future ZEV deployment would displace revenue from gasoline sales taxes used for road infrastructure*
>
> *Displaced revenue for dealerships from service and repairs for ZEVs Priority opportunities for action identified by Atlantic Canada region stakeholders included:*
>
> - *Incentives for vehicle purchase and charging infrastructure*
> - *Increase charging infrastructure*
> - *Education and awareness campaigns by multiple groups (Government, NGOs, OEMs, etc.) (Pollution Probe and The Delphi Group, 2018). "*

3.3.1 Financial Incentives

Natural Resource of Canada is contributing funds through the ZEV Public Space and On-Street RFP, providing 50% of the total project costs with up to a maximum of $5 million per project. Table 4 – EVSE Funding Program lists the current funding available for ZEV projects.

Table 4 – EVSE Funding Programs

Type of Charging Station/EVSE	Supply Power
AC Level 2 (208 / 240 V)	$5,000 per connector (in order to be eligible for maximum funding per connect, each must be available to charge a vehicle and simultaneously support a parking space)
DC Fast Charging (Level 3) (from 20 kW to <50 kW	$15,000 per station
DC Fast Charging (Level 3) (from 50 kW and above	$50,000 per station

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