ST. LAWRENCE COLLEGE
SUSTAINABLE ENERGY
APPLIED RESEARCH CENTRE

Investigation of Electric Vehicle Service Equipment Installation and Connection Process: Best Practices and Cost Recovery Model

To

LDC Tomorrow Fund

St. Lawrence College's
Sustainable Energy Applied
Research Centre (SEARC)
Kingston, Ontario

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Index

Abbreviations

AC: Alternating Current

AODA: Accessibility for Ontarians with Disability Act

BEV: Battery Electric Vehicle

CAA: Canadian Automobile Association

CARB: California Air Resources Board

CDMA: Code Division Multiple Access

CEC: Canadian Electrical Code

DC: Direct Current

DCFC: Direct Current Fast Charging

ESA: Electrical Safety Authority

EV: Electric Vehicle

EVSE: Electric Vehicle Supply Equipment

FIT: Feed-In Tariff

GM: General Motors

GPS: Global Positioning System

HEV: Hybrid Electric Vehicle

HOV Lane: High Occupancy Vehicle Lane

Hz: Hertz

IBC: Insurance Bureau Canada

kW: Kilowatt

kWh: Kilowatt Hour

LDC: Local Distribution Company

LED: Light Emitting Diode

LEED: Leadership in Environmental and Energy Design

LPI: Large Paddle Inductive

LSEV: Low Speed Electric Vehicle

NEMA: National Electrical Manufacturers Association

OCCP: Open Charge Point Protocol

OPA: Ontario Power Authority

PHEV: Plug-in Electric Vehicles

QR Code: Quick Response Code

RFID: Radio Frequency Identification Device

SAE: Society of Automotive Engineers

SEARC: Sustainable Energy Applied Research Centre

SPI: Small Paddle Inductive

V2G: Vehicle to Grid

VAC: Volts Alternating Current

List of Figures

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i.

Executive Summary

The Sustainable Energy Applied Research Centre (SEARC) is delighted to submit this report, *Investigation of Electric Vehicle Service Equipment Installation and Connection Process: Best Practices and Cost Recovery Model*, to the LDC Tomorrow Fund and The Natural Sciences and Engineering Research Council (NSERC).

SEARC has collaborated with Utilities Kingston, Siemens Canada, PlugnDrive, Sun Country Highway and ChargePoint to investigate the Electric Vehicle Service Equipment (EVSE) connection, installation and permitting processes, requirements and costs in different jurisdictions, to share best practices and to recommend a standard process for local utilities in Ontario.

Building on the findings of SEARC's preliminary Electric Vehicle (EV) project titled "The Kingston Electric Vehicle Readiness Project", which investigated the barriers to the adoption of Electric Vehicles in the Kingston region, this report documents the installation of three Level 2 EV charging stations, one on each St. Lawrence College campus. The three St. Lawrence campuses are located in Kingston, Cornwall, and Brockville. The process of the three installations was documented to help simplify the process of installing electric vehicle charging stations in similar public locations, both for host site owners and their local distribution companies. The electrical usage and the physical use of the EVSE parking spaces at each campus have also been analyzed to gain greater insight into the logistical, financial and technical impact of the technology, including developing preliminary cost-recovery model proposals.

Key findings include the need for research into potential user numbers and habits at prospective sites, physical layout guidelines for pedestal mounted EVSE that meet both accessibility and equipment protection needs, and connection request standards for Ontario local distribution companies (LDCs).

1. Introduction

1.1 Preface

As the need and desire to reduce carbon emissions and dependancy on non-domestic petroleum products increases, electric vehicles are expected to enter the North American market in mass quantities. An important early step towards the successful adoption of electric vehicles in Ontario is establishing electric vehicle infrastructure guidelines. The guidelines contained in this report are not intended as a complete installation manual for any given electric vehicle charging station, or as a replacement for approved codes and standards. Rather, they are proposed as best practices for the installation of electric vehicle charging stations.

1.2 Purpose

This guide is directed towards the general public, municipalities, local distribution companies, vendors, owners and operators interested in installing electric vehicle infrastructure and will address the best practices for installing EV charging stations.

2. Electric Vehicles

An Electric Vehicle (EV) is propelled by one or more electric motors. Defined below are four of the categories of electric vehicles.

2.1 Hybrid Electric Vehicle (HEV)

Hybrid electric vehicles use two or more distinct power sources to propel the vehicle. HEV's use a combination of an internal combustion engine and one or more electric motors. HEV battery storage is typically low-capacity, limiting their range and top speed in electric mode. HEV batteries cannot be charged from the grid.

2.2 Plug-in Hybrid Electric Vehicle (PHEV)

A PHEV is a hybrid EV that can be plugged into the grid for battery recharging. PHEVs share similar characteristics with Hybrid Electric Vehicles.

2.3 Battery Electric Vehicle (BEV)

A BEVis an electric vehicle that uses chemical energy stored in rechargeable battery packs to propel the vehicle. A BEV uses an electric motor and motor controllers instead of an internal combustion engine. BEV's derive all their power from the battery packs and therefore create zero carbon emissions during operation.

2.4 Low Speed Electric Vehicles (LSEV)

Low speed electric vehicles are powered by an electric power train and on paved level surface can travel up to 40 km/h. All low speed electric vehicles must travel on four wheels and weigh less than 1361 kg. They are designed for use primarily on streets and roads where the use of other vehicle classes are controlled by law or agreement as they do not meet the safety standards required by larger motor vehicles (Transport Canada, 2013). Feel Good Cars of Toronto manufactures the Zero Emission No Noise (ZENN) which is a fully enclosed, three door hatchback LSEV. At the time of writing, low speed electric vehicles are not permitted on the roads of Ontario, with the exception of roadways within provincial or municipal parks and conservation areas (Government of Ontario, 2010).

2.5 Electric vehicle adoption

The adoption rate for EVs is increasing quickly. Figure 1 represents U.S. increase in sales of both electric and plug in hybrid cars from 2010 projected through 2013. As these vehicles continue to gain popularity, local utilities will need to plan for and deal with the impact that their charging will have on the grid.

Green Car Reports has collated Canadian EV sales and lease data for 2013 that shows almost 3000 new EVs on Canadian roads, an increase of 50% on 2012 figures. (Green Car Reports, 2014)

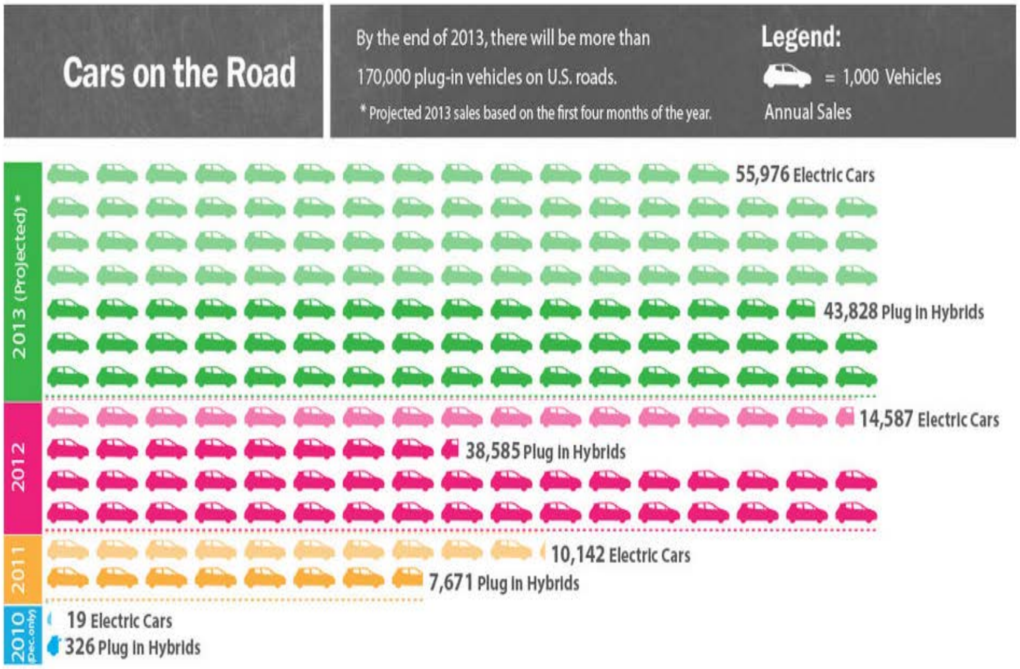


Figure 1: Projected 2013 EV Sales in U.S @ Copyright 2013 Recargo, Inc. (Recargo)

3. Charging Stations

Electric Vehicle charging stations are devices or stations used to provide power to recharge the batteries onboard an electric vehicle. Each station contains a connector that is inserted in the electric vehicle inlet. Once properly connected, the station will deliver the electrical energy needed to power the vehicle.

3.1 Station Level Options

Charging time depends on the following factors:

- The capacity of the battery versus its current level of charge.
- The voltage and maximum current level of the charging unit.
- The vehicle's on-board charge circuitry.

Charging stations are available in three characterized levels that offer various charging rates.The sub-sections below describe each charging level in further detail. The electrical specifications of the three levels of charging are outlined in the following table:

Table 1: Electrical Requirements

Level	Voltage	Type of Current	Maximum current (amps)	Maximum power (kW)	AC voltage phase	Frequency (Hertz)
1	120	AC	12	1.44	Single	60
2	208 / 240	AC	80	16.7/19.2	3/Split	60
3	480	DC	400	192	Three	60

3.1.1 Level 1Charging

Figure 2: Standard House Outlet (Falwell)

Level 1 charging typically takes place overnightat the home of the EV owner. A full charge from a level 1 station requires 8-14 hours, subject to the EV and battery type. Level 1 stations use a standard 3-prong grounded electrical outlet (NEMA 5-15R/20R) for charging,thus avoiding the need for the type of electrical modification required by level 2 and level 3, which minimizes the cost of the infrastructure. Level 1 charging is also able to accommodate any type of EV. Of the three levels of charging, level 1 requires the most time to replenish the batteries to a full charge.

3.1.2 Level 2 Charging

Level 2 stations are equipped to charge the vehicle at a faster rate than level 1, typically 4-8 hours. For level 2 stations, charging capacity may be restricted by the onboard charger or battery condition, thus increasing charge time. During the charging process, heat is produced within the battery, and although current EVs are built to manage this heat using liquid cooling and fans, it will inevitably shorten the battery life over the years.

Level 2 charging stations use a Society of Automotive Engineers (SAE) standard connector SAE J1772 for insertion to the vehicle inlet. The SAE has approved this connector to be the new standard that EVs and PHEVs will use to recharge. No energy is supplied to the connector until a safe connection is established. All primary vehicle and charging station manufacturers support this standard.

Level 2 charging stations are currently the most common type used for public charging facilities. More than 40 public level 2 stations were listed on the PlugShare website in eastern Ontario (from Belleville north and east to the Quebec border) as of late April 2014 (Plugshare, 2014).

3.1.3 Level 3 Charging

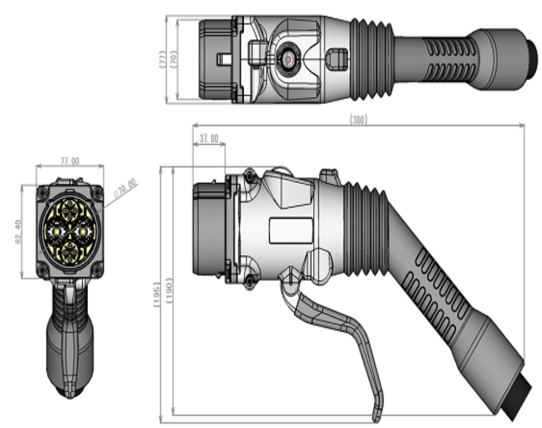


Figure 3: CHAdeMO Connector (Chademo, 2010)

Level 3 charging, also known as “DC Fast Charging” (DCFC), is most commonly used in public and commercial applications. Level 3 charging stations use high voltage (up to 480V) and current (up to 400A) to recharge the batteries onboard an EV in as little as 20-30 minutes, depending on the battery type. DC fast charging stations bypass the on-board charger, so the size of the on-board charger doesn’t affect refill time. Level 3 chargers generally convert grid AC power to DC by using an off-board inverter. The on-board battery management system controls the off-board charger (ELECTRIC TRANSPORTATION ENGINEERING CORPORATION, 2010).

In Japan, the standard connector used for “DC fast charging” is the CHAdeMO charger. The U.S. Department of Energy states in its Plug-in Electric Vehicle Handbook for Public Charging Stations states“SAE International is also working on a “hybrid connector” standard for fast charging that adds high-voltage DC power contact pins to the J1772 connector, enabling use of the same receptacle for all levels of charging” (U.S. Department of Energy, 2012). Some manufacturers in the North American market have now adopted both connectors (SAE and CHAdeMO) on their Level 3 DC Fast Charger units.

A search on the PlugShare website in April 2014 showed only one level 3 charging station open to the public in Ontario, located in Toronto (Plugshare, 2014). Tesla’s website states that the company plans to have a string of its superchargers installed along the 401 corridor by the end of 2014 (Tesla Motors, 2014).

3.1.4 Multiple Connector Stations

Stations with more than one connector can feature the ability to provide more than one level of charging, therefore there are several sub-categories to address. There are multi-connector charging stations, which include two or more connectors providing the ability to charge more than one vehicle at a time. Multi-connector stations provide the same level of charging through each connector. There are also multi-standard charging stations which feature the ability to provide a different level of charging through each connector based on the needs of the user. Multi-standard stations most commonly offer level 2 AC charging and level 3 DC fast charging,

Figure 4: Multi-Connector Station (Aerovironment, 2013)

Figure 5: Multi-Standard Station (ABB)

Multiple Connector stations, whether they are multi-connector or multi-standard, have many advantages over single connector stations for the purpose of public/commercial/fleet installation. To minimize installation costs of the stations, it is best to plan for multiple connector stations over multiple single connector stations. The installation cost of two single connector stations will be significantly more than the installation of one dual connector station.

3.2 Charging Technologies

At the present time, there are two types of charging technologies used to charge the batteries onboard the vehicle. Most commonly used in today's charging station technology is conductive charging, although inductive technology is making its way back onto the market as charging efficiencies are increased.

3.2.1 Conductive Charging

Conductive charging requires physically connecting contacts. This means the user must physically insert the connector into the vehicle for charging to take place. This method is used by many common appliances and is most commonly used by most on-board chargers in electric vehicles. The Society of Automotive Engineers (SAE) has developed a set of standards for conductive charging equipment that is to be followed by charging station manufacturers.

3.2.2 Inductive Charging

Unlike conductive charging, inductive charging requires no direct electrical contact to charge the batteries. Old style inductive charging technology was used by sliding a paddle into an opening at the front of the vehicle. For new inductive charging technology, EV drivers simply drive over the charging pad located in the parking space. The charger magnetically transfers ac power on-board the vehicle, where it is converted to dc power. This method of charging is not common at this point in time because the technology is less efficient than the conductive chargers that are already available.

Figure 6: Paddle Type Charger (Witzenburg, 2012)

When inductive charging technology started to appear on the market there were two types of inductive paddles, Small Paddle Inductive (SPI) and Large Paddle Inductive (LPI). In the early 1990s, a charger called the MagneCharge 220V inductive type charging plug was used for the GM EV1, Toyota RAV4, Ford Ranger, and the Chevrolet S10 EV (Bindon & Stroud, 2013). The large and small paddle chargers are not compatible with each other. An adapter was created for the small paddle chargers equipping them to charge a vehicle designed for a large paddle. On the contrary, a large paddle could not be used in place of a small paddle as it would not physically fit in the space. Shortly after, it was decided the small paddle inductive would replace the large paddle inductive. Midway through the transition from small large paddle to small paddle the California Air Resources Board (CARB) decided to support only the conductive standard of charging (Ballew, 2011).

Figure 7: Plugless Power Charging Pad (BOSCH, 2013)

In 2010, it was rumoured that Evatran was producing the first commercially available floor mounted inductive charging station. Three years later, Evatran partnered with Bosch Automotive Solutions to introduce the Plugless Level 2 EV charging system to make that vision a reality (MacKenzie, 2013). At the time of writing, the charging pad is compatible with the Nissan Leaf and the Chevy Volt, with retrofits for other vehicle models coming soon. Plugless Power claims the charging pad delivers power at over 90% efficiency. This device has not yet been authorized as required by the rules of the US Federal Communications Commission. This device is not, and may not be, offered for sale or lease, or sold or leased, until authorization is obtained (Evatran Group, 2013).

3.3 Station Mount Type

Electric Vehicle charging equipment can come in several different mounting options. Each mounting option is designed to meet the owner's specific needs. The four main mounting options offered by most charging equipment suppliers are portable, wall mount, pole mount, and pedestal/bollard mount. It is important to determine which of these mounting options will best fit the installation need before purchasing the equipment. In all scenarios, the closer the station is to the electrical supply, the cheaper the installation. The following sub-sections will address these mounting options in further detail.

3.3.1 Portable Charging Cord

Most, if not all, EVs sold in the market today include a standard 110/120V (level 1) portable charging cord. The current lack of public charging infrastructure raises concern among EV drivers of being stranded without the necessary means of charging. This is commonly known as “range anxiety”. Although a portable charging cord is not recommended as the primary source of charging, it alleviates some of the range anxiety that most new EV owners are faced with. Anecdotally, it appears some EV owners are reluctant to use their own portable cords in public places, due to a perceived risk of theft or vandalism.

3.3.2 Wall Mount Charging Station

Most wall mount installations are typically done in the EV owner’s garage or on an outside wall of their home. Public and commercial wall mount installations can also be commonly found because the installation minimizes the impact on existing infrastructure. Wall mount installations are the cheapest of the three fixed mounting options because they require the least amount of excess equipment during installation.

The Electric Transportation Engineering Corporation stated in the Electric Vehicle Charging Infrastructure Deployment Guidelines for BC Hydro that “installation of the EVSE in a residential garage typically consists of installing a dedicated branch circuit from an existing house distribution panel to an EV outlet receptacle (125 VAC, 20 A) in the case of Level 1 charging or an EVSE (operating at 240 VAC, 40 A) for Level 2 charging. If the garage is built with the conduit or raceway already installed from the panel to the garage, the task is greatly simplified” (Electric Transportation Engineering Corporation, 2009).

3.3.3. Pole Mount Charging Station

Pole mount installations are more commonly found in public charging areas. When planning an installation, it is preferable to design for a wall or pole mount installation when possible, as they require no trenching or excavation prior to the installation. Pole mounting options are typically most suitable where an existing hydro-connected pole – such as a lamp post – can be used.

3.3.4 Pedestal Mount Charging Station

Pedestal mount installations are the primary charging station used for public, commercial, and fleet use. A pedestal mount charging station has the advantage of greater station visibility, and can also be used in conjunction with on-site advertising, which increases potential revenue streams. Installation of a pedestal mount charging station typically requires trenching for buried cable, and excavation for the pouring of a concrete pad, which can add a significant amount to the overall installation cost.

3.4 Project Experience & Recommendations

On each of the three campuses, a location was sought that would satisfy as many of the following criteria as possible:

- Reasonably high profile locations – high drive-by traffic areas
- Reasonably accessible – near campus entrances;
- Reasonably well-placed for access to campus buildings;
- Reasonably close to 240V electrical infrastructure;
- Not already required for use by other vehicle types (e.g. emergency vehicles)

3.4.1 Kingston Campus

The location on Kingston campus which met the largest number of the above criteria was a 2-space area near the western entrance to campus off Country Club Drive, near Entrance E17. This location was also happily close to the SEARC office and other research facilities within the Faculty of Applied Science and Computing.

This location did not have a readily available pole to install a pole mounted station – all lamp posts in the parking lot run on 120V, and thus were unsuitable for a level 2 charging station. Wall-mounting was also made more difficult by there being a strip of grass between the parking spaces and the building wall – this area can become saturated and/or muddy at times, and was not considered suitable for what had to be a four-season-accessible EVSE site. Given that this is a research project and would later be advertised throughout and beyond the college, a pedestal station was considered more visible and appealing to the public.

3.4.2 Cornwall Campus

The location chosen on Cornwall campus showed a similar combination of qualities and drawbacks as the Kingston location. The station is located in the smallest parking lot, at almost the southern-most point of campus. It is locatable on digital map sources, is reasonably close to main college entrances, and is reasonably close to an internal load panel from which a 240V branch circuit could be run. A pedestal mount was considered most suitable for this location for the same reasons as in Kingston, and a pedestal-mount charging station was donated to the project that was ideally suited for this location.

3.4.3 Brockville Campus

The location chosen on Brockville campus is relatively high-profile, very close to the main front entrance of the college, with one adjoining EVSE-accessible space also being a blue-painted handicapped parking space. This location required a much longer electric cable trench, and again presented the pedestal mount as the most suitable type of EVSE to install.

Where it is possible, a wall-mount or pole mounted station is recommended, as it is typically a less expensive option.

For pedestal and new-pole mount options, there seems to be a lack of established guidelines for installation. Questions raised during the project included the most appropriate;

- Concrete pad dimensions
- Concrete mix type
- Required drainage under concrete pad
- Depth of concrete pour relating to depth of frost line for charger pad and protective bollards

These questions will be discussed in greater detail in the Station Installation section of this document.

4. System Software

4.1 Communication Software

4.1.1 "Dumb Station"

An EV charging station without communications beyond those to the car being charged is referred to as a dumb station. This type of charging station is typically found in residential installations or commercial installations where online visibility of station availability is not required and the station is not required to process payments.

Communications particular to the charging protocol i.e. communicating with the car to control charging are still required in a dumb station.

4.1.2 "Smart Station"

A smart charging station includes communication capabilities that add to the feature set of the station. Communications can be to data loggers, web or corporate servers, and other charging stations. The method of communications varies among stations. Some of the common methods of communication found are;

- Internet via Ethernet cable or Wi-Fi
- Cellular
- Zigbee (short distance radio communications often used to link local charging stations together at a single area of installation).

A common method of linking a group of charging stations to web servers is to use one charging station as a "gateway" unit that is connected to the internet. Other charging stations at the same location will use Zigbee to communicate with the gateway which can in turn handle all internet traffic for the non-gateway units.

The additional features enabled by using smart stations vary by manufacturer and model as well as the network provider (see section 4.2 to 4.6). Common features found are:

- Payment processing
- Online charging station status and reservations
- Data logging

- Smartphone App to charging station communication and control
- Charging station activation using RFID cards
- Remote station management

4.2 Access to Data

In a typical commercial installation of a smart charging station, a network provider is contracted to handle communications from the outside world to the station. The provider's central system gives station owners and administrators access to data accumulated from the station.

Some charging stations will only allow a specific network provider to be used due to the communications protocol used. For example a ChargePoint enabled station may be required to connect to the ChargePoint network to access data.

4.3 Open Charge Point Protocol

The Open Charge Point Protocol (OCPP) is an open communications standard. It was developed with the intent of allowing charging stations and central systems from varying manufacturers to communicate with each other.

Being an open source protocol means that the OCPP standard may be used free of charge by station manufacturers and network providers.

For more information on OCPP visit http://www.ocpp.nl/node/5

4.4 Access Control

Depending on the charger hardware, and configuration, EVSEs may need to be authorized for use before a charging session begins. This may be done through the following means;

- RFID card linked to an authorized account
- Credit card
- Smart phone App

EVSEs may also be open for use without authorization. Users of these stations simply need to plug the EVSE's wand into the car to start charging.

4.5 Network Visibility

For the context of this report, network visibility is referred to as the capability of users to view the location and accessibility of the station from an online application. Web accessible and mobile network applications have become increasingly popular as a means of real-time status notification. Providing real-time charging status will allow users to make and cancel reservations. Being able to see the availability of the stations will prevent users from driving to a spot that does not have available charging. At the time of writing this report there were several network providers available in Canada (i.e. ChargePoint, Circuit Électrique, VERnetwork by AddÉnergie, Greenlots). All network providers offer their own web and mobile applications complete with their own specific features.

4.6 Mobile Applications

There are many online maps to help drivers locate public charging areas. Registering one's charging station through a mobile network can offer many benefits to both EV drivers and charging station owners. ChargePoint, PlugShare, CarStations and Greenlots offer mobile apps available for Android and iPhone. The applications show a map of all the public charging stations by tapping into the device's GPS, locating the nearest stations, and providing directions. Some maps also include residentially owned stations that allow registered users to contact the owner for permission to use the charging facility. Mobile applications may offer the ability to reserve a station, or verify that the station is not currently in use. Drivers may wish to use these apps when planning a long trip.

4.7 Project Experience & Recommendations

For the purpose of this project, EVSEs were chosen with varying communication schemes and feature sets among the three campuses.

4.7.1 ChargePoint enabled charger - Cornwall campus installation

The charging station at the Cornwall campus is a ChargePoint enabled station connected to the ChargePoint network via a 2G CDMA cellular connection. The connection to the ChargePoint network allows for the following features;

- Remote station management
- Visibility of station status and prices for use through web browsers and the ChargePoint Mobile App
- Payment processing and station reservations (both not used for this installation)

As part of an agreement with ChargePoint, this station will have free access to the ChargePoint network for one year.

Figure 8: Screenshot of the Charge Point Mobile App (ChargePoint Inc., 2013)

This charging station requires authorization to initiate a charge. Authorization is accomplished using a ChargePoint RFID card registered with rights to charge using that charger. This system gives the Cornwall campus the option of controlling access to the station by providing RFID cards to approved users.

Currently the Cornwall EVSE is free for use and available to the public. To accommodate this, an RFID card for station authorization has been chained to the EVSE. There are concerns about this setup around damage or loss of the RFID card and the downtime that could result. There is currently no way of setting the station to charge without authorization for each charging session.

The installation of a ChargePoint enabled station proved to be quite simple. After the electrical connection, all that was required was a phone call to ChargePoint to get the station configured and functional. ChargePoint is a well-established network provider and the maturity of their systems shows in the installation process.

This type of station is geared toward commercial installations. Considerations that potential commercial EVSE owners may have about ChargePoint stations are;

- Ongoing subscription costs to the ChargePoint network
- Station functionality in the event of the ChargePoint network becoming unavailable at some point in the future.

4.7.2 Open Charge Point Protocol charger - Kingston campus installation

The EVSE installed at the Kingston campus has an Open Charge Point Protocol control system. The decision to install an OCPP charger in Kingston was deliberate in anticipation of the ability to develop in-house software based on OCPP for data collection, web presence, and charger control. Custom software at this level did not fit within the scope of this project but may be investigated in the future.

The Kingston charger is currently connected to the Greenlots network. The connection is made through an internet connection to the station using an Ethernet cable. This cable was buried in the trench made to the station during the installation process.

Greenlots offers similar services and features to ChargePoint.

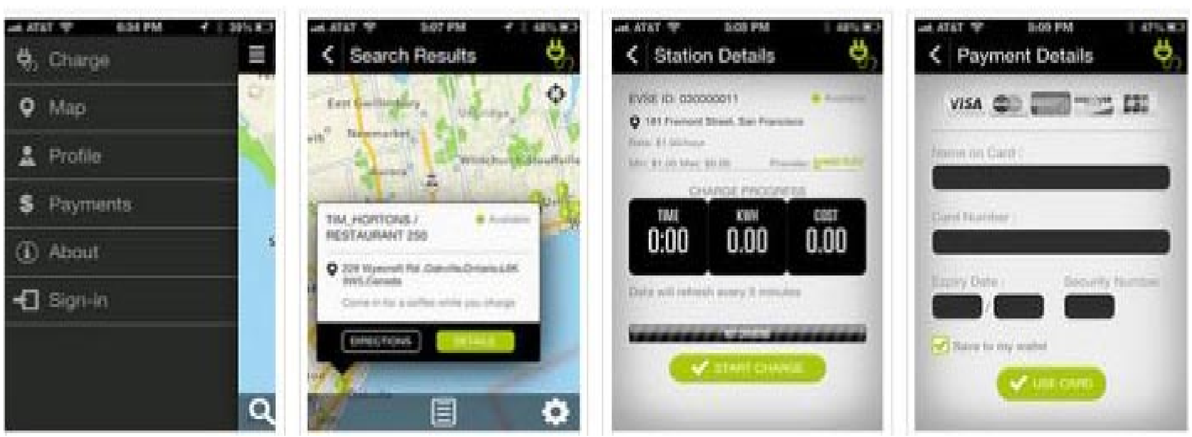


Figure 9: Greenlots Mobile App (Zeco Systems Pte Ltd, 2012)

The station has been configured to not currently require authorization to initiate a charge.

This charger is not equipped with an RFID reader. In the event that SLC decides to require authorization to charge the Greenlots Mobile App can be used to authorize a charging session. The App requires the user to either scan a QR Code, or enter the registered station number. If the user is approved to charge, the charger will then be ready for use. This system may be used to process payments, keep reservations, and alert users of status updates.

4.7.3 "Dumb" station – Brockville campus installation

The charging station installed in Brockville does not have on-board communications. There is no user authorization or payment processing possible at the station level here.

4.7.4 Data Collection and web presence – All campuses

To simplify the process of collecting data and creating a web portal, identical internet connected data loggers were installed at each site. The data loggers measure the voltage and current provided to each charging station. The points of measurement are at the electrical distribution panels feeding the stations.

The Cornwall and Brockville data loggers share their data with the Kingston data logger which in turn communicates with the web server hosting the website. The website located at http://slcevcharging.ca shows measured power and cumulative energy to the stations at each site over given time periods.

This approach was chosen due to the complexity of integrating data from three differing systems.

For more information on the data loggers used see http://www.egauge.net/

4.7.4.1 Extended web presence

All of the stations in this project are registered through a variety of mobile applications. These mobile applications include PlugShare, Recargo, CarStations, CAA, and Greenlots. Each mobile app offers a map showing the location and providing directions to near-by charging stations. Some apps like PlugShare enable users to review, give feedback, and upload photos of the charging station. If choosing to not register through a charging network due to on-going fees, it is recommended to register through a variety of station locating app websites. If the station is not registered through a charging network or location app(s), EV drivers will have great difficulty finding it to plug in. All of the mobile apps and websites made to help EV drivers find charging stations are free to register with and free to download for Android and iPhone users.

Registered Web &Mobile Applications

CAA: http://www.caa.ca/evstations/

PlugShare: http://plugshare.com

Recargo: www.recargo.com/

CarStations: carstations.com

ChargePoint: www.chargepoint.com

Greenlots: http://greenlots.com/ /

5. Station Installation

There are several key factors to address when preparing to install a charging station. The following sub-sections will outline important aspects to consider at this stage.

5.1 Station Location Considerations

Choosing the charging station location is critical to the overall assessment of the installation. Generally speaking, the closer the station is to the electrical supply the less expensive the installation will be. In some cases, if the installation greatly impacts the existing infrastructure, a building permit may be required. Outlined below are some of the general requirements to take into account while planning the location of your electric vehicle charging station:

5.1.1 Public Access Areas

For installations in a publicly accessible area, the following criteria should be taken into consideration:

- Expected use- surrounding traffic, EV adoption, recharge time
- Electrical availability (e.g. 120V / 240V / 208V / 480V)
- Impact on existing parking spaces
- Access to the required communication type (3G cellular, Wi-Fi, or hardwired to a Local Area Network (LAN))
- Potential for impact on pedestrians (e.g. connecting cord obstructing sidewalk)
- Accessibility in winter (snow dumps and snow ploughs)
- Night-time visibility

- Water in proximity to station (avoid low lying/flood-prone areas)
- Protection against impacts and vandalism

5.1.2 Ease of Access

Presently, the most explicit requirement for ease of access can be found in Section 86 of the Canadian Electrical Code stating " Electric vehicle charging equipment shall be located at a height of not less than 450 mm and not more than 1.2 m above the floor level" (Canadian Standards Association, 2012).

Aside from this requirement, there are a few recommendations to follow for installing a user friendly charging station. Sufficient space should be provided around the station for ease of mobility (recommended 3' x 3' standing space). It is important to plan the placement of protective barriers as to not obstruct the path to the station or restrict users from reaching the connector(s). Any barriers around the equipment should still leave adequate space to be easily accessed for inspection and maintenance.

5.1.3 Access to persons with disabilities

Over and above the electrical code requirements, in Ontario the Accessibility for Ontarians with Disabilities Act (AODA) of 2005 and, subsequently, Ontario Regulation 191/11 mandates standards for design of public spaces for new construction and planned redevelopment (Government of Ontario, 2013). Therefore AODA requirements need to be taken into consideration during the installation of electric vehicle charging stations.

The regulation states that in new parking lots with 1-100 spaces, at least four percent should be made accessible parking spaces. Given this guideline, the same considerations should be taken when installing electric vehicle charging stations. For example, a business wishing to install 100 charging stations on their premise should make 4 of those parking spaces wheelchair accessible. A business wishing to install only one charging station on their premises would be required, no later than 2018, to make that space fully accessible for Ontarians with a disability. This report argues that, in order to get ahead of this requirement, *all* new EVSE installations should be made fully accessible.

There are many factors to consider when designing a suitable charging station location that is accessible to all EV drivers. Some of these factors may include cutting curbs, creating accessible parking spaces, considering the height of equipment, and ensuring proper ground levelling. For detailed requirements on designing a site that is accessible for persons with disabilities please refer to the excellent "EV CHARGING FOR PERSONS WITH DISABILITIES" prepared by Sustainable Transportation Strategies in the United States, under the requirements of the Americans with Disabilities Act and ANSI accessibility standards.

Please visit http://www.sustainabletransportationstrategies.com/

5.1.3.1 Project Experience & Recommendations

The installation of all three charging stations for this project followed the basic "accessible protection" parameters discussed above (see also figure 10 below), while fully complying with the Canadian Electrical Code. Figure 10 illustrates the ideal layout for pad-mounted EVSE that deploy protective bollards. All three sites allow sufficient access for wheelchair users and are a short distance from accessible entrances to the college buildings.

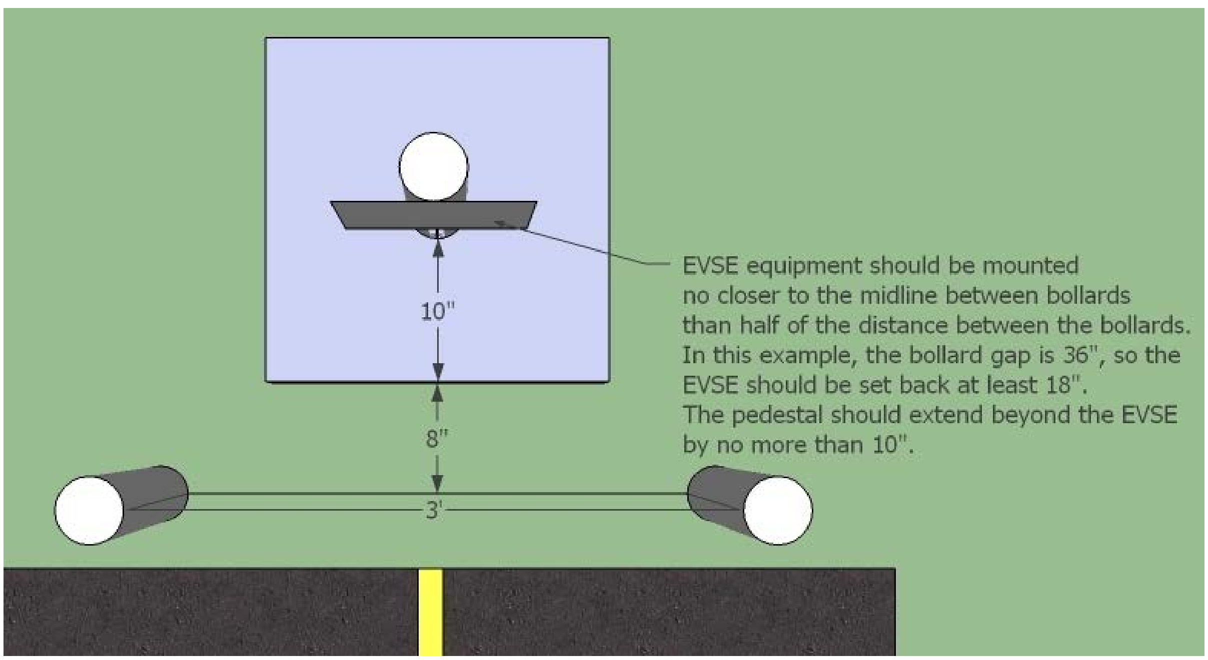


Figure 10: Accessible protection guidelines for pedestal-mounted EVSE

5.1.4 Visibility

For stations with 24-hour public access, adequate lighting should be provided around the area. A well-lit area will reduce the risk of vandalism, theft, and tripping hazards, while increasing the ease of use for the charging station user.

5.1.5 Hazardous Areas

For installations in hazardous areas, please refer to the Canadian Electrical Code (CEC) sections 18 and 20. Any installation within a hazardous location must comply with the applicable codes within those sections. Some examples of hazardous locations include service stations, stations in close proximity to water, and indoor parking garages requiring ventilation.

5.1.6 Connector Safety

Applicable codes stated in the Canadian Electrical Code are outlined below:

“20-114 Electric Vehicle Charging

(1) Flexible cords used for charging shall be the extra-hard-usage type.
(2) Connectors shall have a rating not less than the ampacity of the cord and in no case less than 50 A.
(3) Connectors shall be designed and installed so that they will break apart readily at any position of the charging cable, and live parts shall be guarded from accidental contact
(4) No connector shall be located within a hazardous area as defined in Rule 20-102.
(5) Where plugs are provided for direct connection to the vehicles, the point of connection shall not be within a hazardous area as defined in Rule 20-102.
(6) Where a cord is suspended from overhead, it shall be arranged so that the lowest point of sag is at least 150 mm above the floor

Most vehicles charging software protocols are designed to prevent the driver from attempting to drive the vehicle while the vehicle is plugged in. It is therefore unlikely that a driver will forget to unplug before leaving the charging station, damaging the equipment. Station owners should take precautions in winter months to minimise the risk of damage from snowploughs. If the previous driver who used the station doesn’t hang the cable properly, it can become entangled with a snowplough, causing costly repairs or even replacements. Additionally, ploughed snow should be directed away from any EVSE, whether wall- or pedestal-mounted, so as to maintain access year-round and minimise the risk of damage from ice or snow accumulation.

5.1.6.1 Project Experience & Recommendations

Station owners who are worried about damaged cables and connectors may wish to place additional signage near the equipment reminding users to properly hang the wand and cable after charging their vehicle.

An option that was explored with the installations at St. Lawrence College campuses was to purchase charging stations with retractable cords. This operates in a similar manner to the hose on a gasoline pump. This option adds a greatly improved mechanism of cable management, but also adds around $600 to the cost of the charging station. Moreover, the unit cannot easily be installed with a pedestal-mounted charging station, and as such was not selected.

5.2 Electrical Requirements

5.2.1 Proximity to Electrical Services

Whether the installation is residential, public, or in a single/multi-unit dwelling, the proximity of the station to a suitable electrical supply will greatly impact the overall cost of the installation. If planning for future expansion, extra conduit, electrical capacity, and extra circuits should be considered during the initial installation. Level 2 EVSE requires a 240V branch circuit and a distribution panel with sufficient amperage capacity and room for a new circuit breaker. Considering this potentially significant upgrade cost, EVSE hosts would be advised to consider whether Level 1 charging would be sufficient for the site and user needs.

The Canadian Electrical Code contains a dedicated section – section 86 – referring to electric vehicle charging systems. Therein, rule 86-300 indicates “Electric vehicle charging equipment shall be supplied by a separate branch circuit that supplies no other loads except ventilation equipment intended for use with the electric vehicle supply equipment” (Canadian Standards Association, 2012, p. 298).

5.2.2 Input Current Requirements

Applicable codes stated in the Canadian Electrical Code are outlined below:

8-104 Maximum circuit loading

(1) The ampere rating of a consumer's service, feeder, or branch circuit shall be the ampere rating of the overcurrent device protecting the circuit or the ampacity of the conductors, whichever is less.
(2) The calculated load in a circuit shall not exceed the ampere rating of the circuit.
(3) The calculated load in a consumer's circuit service, feeder, or branch circuit shall be considered a continuous load unless it can be shown that in a normal operation it will not persist for
    (a) a total of more than 1 h in any two-hour period if the load does not exceed 225 A; or
    (b) a total of more than 3 h in any six-hour period if the load exceeds 225 A (Canadian Standards Association, 2012, p. 32)

86-302 Connected load

The total connected load of a branch circuit supplying electric vehicle charging equipment and the ventilation equipment permitted by Rule 86-300 shall be considered continuous for the purposes of Rule 8-104 (Canadian Standards Association, 2012, p. 298)

5.2.3 Project Experience & Recommendations

The factors of electrical distribution point capacity and distance to parking played a large role in the locations chosen for the charging stations.

In all campuses an electrician very familiar with the campus electrical services was contracted for the installation. The electricians provided consultation regarding which load centers had available capacity for the stations. They also were able to aid in finding suitable parking spots with minimal distance and obstructions to electrical distribution.

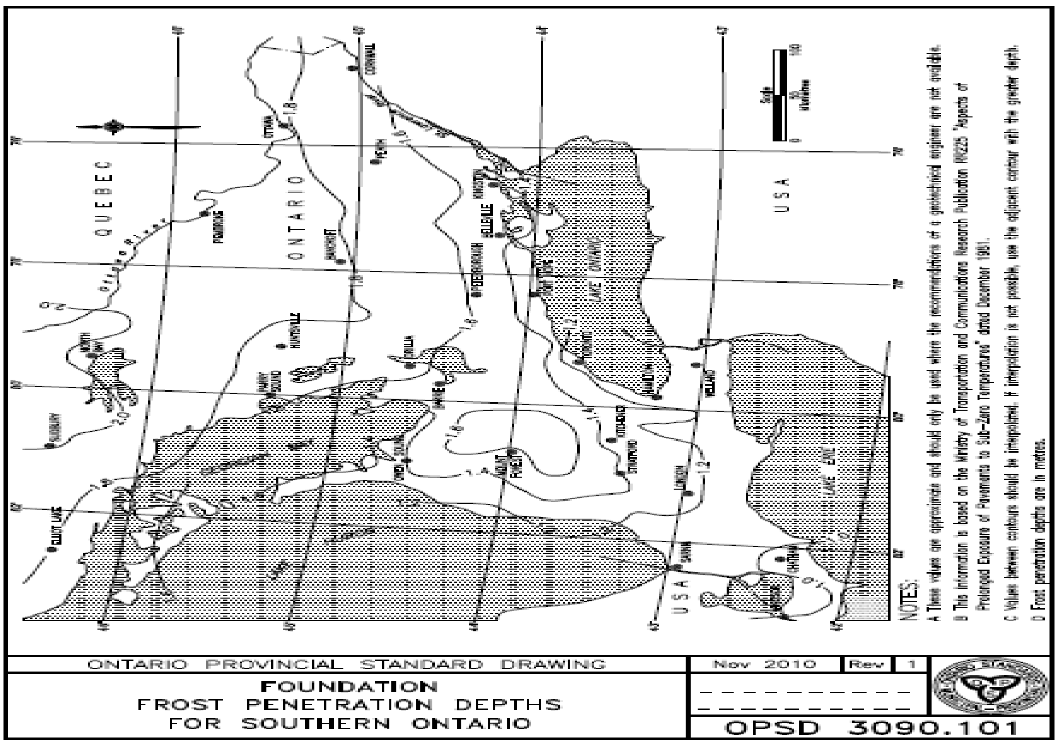
5.3 Mounting Requirements

To ensure satisfaction for all EV owners and users, there are a few general mounting requirements to follow while installing a charging station. Outlined below are some of the requirements and recommendations for making a charging station user friendly.The recommendations below are not intended to replace the installation manual provided by the charging station vendor.

5.3.1 Frost Line Depth

In all cases, the concrete pad should be poured to below the frost line in the installation area to ensure no movement of the pad. Contact your local municipality to determine the frost line depth in your area. Frost line depths for Southern Ontario can also be found graphically on the Ministry of Transportation's website.

Figure 11: Frost Penetration Depths



5.3.2 Concrete Pad Preparation

Prior to excavation, Ontario One Call must be notified to ensure no underground wiring is disturbed during the installation. A free locate will be provided by Ontario One Call within 5 business days of the request. At this point in time, there is no standard concrete pad sizing for charging station installations. Currently, each vendor supplies a recommendation for concrete pad sizing within their installation manuals.

5.3.3 Project Experience & Recommendations

Prior to excavation, Ontario One Call cleared the area free of all underground wires. Proper locates were carried out and results were passed on to the electrical and civil contractors working on the project.

College faculty from the Civil Engineering Technology department was used as a resource to determine the frost line depth for the proposed locations. College Civil Engineering Technology faculty also aided in design of the concrete pads. This was an area of the project where there seems to be a lack of readily available regulations or guidelines.

Two differing pad designs were used. In all cases, a 12" diameter Sonotube was installed to below the frost line and filled with concrete. The determining factor of the design used was if the footprint of the charging station would fit within the Sonotube diameter. The following is a description of each design strategy:

5.3.3.1 Pad design 1 – Station footprint does not fit within Sonotube diameter

This is the situation at the Brockville and Kingston installations. The manufacturer of the Sun Country Highway station recommends an 18" x 18" x 18" or greater pad (with the top just slightly above ground level) for mounting the pedestal with no mention of pouring concrete to below the frost line.

The issue found here is that constructing the 18" pad attached to a smaller cylinder (the Sonotube) going below the frost line will create points where water could freeze under the portions of pad not connected to the deeper concrete structure and either break or heave the pad.

To resolve this issue, the 18" pad depth was changed to 8" and an additional 6" deep section of B size aggregate was placed under the vulnerable portions of the pad. This is to provide sufficient drainage protecting the pad and station from damage due to water freezing.

It should be noted here that the protection bollards installed here are separate from the charger pad structure.

5.3.3.2 Pad design 2 – Station footprint fits within Sonotube diameter

The Cornwall installation is such that the charger installed has a footprint small enough to fit within a 12” diameter Sonotube. This means that the charger can bolt directly to the 12” diameter concrete pour and not face the issue of ice expansion under the pad.

For this installation the cylindrical concrete forms penetrating the frost line for the charger and the two bollards were contained within but not attached to a 7.5" deep "floating" pad. This was done to improve the aesthetics of the installation and make lawn maintenance around the installation easier.

Foam was wrapped around the bollards and charger mounting form to prevent these items from bonding with the floating pad during the concrete pour. A 4" layer of aggregate was installed below the floating pad for drainage and rebar incorporated into the pad for added strength.


Electric
Vehicle
Charging
Station

5.4 Signage

The following sub-sections will address the recommended signage for the parking space and the charging equipment.

5.4.1 Parking Space Signage

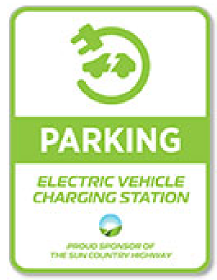


Figure 13: EV Parking Sign (Sun Country Highway, 2012)

Figure 12: Charge Point Station with EV parking sign ((Stevens, 2010))

It is recommended to have a designated sign specifying that the parking spot is dedicated to electric vehicle charging. Many jurisdictions have already adopted their own signage dedicated to EV charging spaces. Some charging station vendors feature their own parking signs you can purchase at an additional price. Smaller institutions with limited parking may not wish to designate the parking space to “EVs Only”.

5.4.2 Painted Ground Markings

Figure 14: Painted ground markings (Loveday, 2013)

Painted ground markings in the parking space are another option to distinguish the parking space from primary parking. Ground markings are recommended for indoor use. Outdoor use of painted ground markings is not recommended since the markings will not be visible during winter seasons. Additionally, snow plows clearing the parking space will inevitably damage the paint which can result in costly on-going repairs.

5.4.3 Additional Signage

If desired, extra signage specifying the space as handicapped parking in addition to EV charging may be placed.

In addition to providing signs designating the parking spaces as “Electric Vehicle Parking”, it is recommended to provide signs directing EV drivers to the parking spaces if they are not easily visible.

5.4.4 Project Experience & Recommendations

Figure 14: Parking Space Signage by SEARC

On commissioning of the charging station at St. Lawrence College Kingston, the demand for use was low. The parking space was not initially limited to EV Parking Only. Instead signs simply labeled the space as an electric vehicle charging station but did not prohibit non-electric vehicles from parking there. Since installation the demand for the station has increased due to SLC staff purchases. Signage has now been placed at the station specifying it as “EV Only Parking”.

5.5 Protection

In most cases, where the charging station is mounted directly in front of the parking space, protection of the station will be desired. Protection of the station can be provided by one or more solutions such as wheel stops, bollards, or wall-mounted barriers.

5.5.1 Wheel Stop Barrier


Figure 15: Wheel stop barrier (Border Lifting & Safety, 2011)

When choosing protection for the station, it is important to leave sufficient space around the station. If planning for a wheel stop barrier, it is recommended to leave 5 feet clearance between the wheel stops for wheelchair turnaround space. The center base of the station should be a minimum 1 foot behind the wheel stop to ensure the station is not in danger to a vehicle overhanging the wheel stop. In some cases, existing wheel stops may need to be removed or replaced to provide ease of access to the station. While these barriers are cost effective to install, they may require additional maintenance such as sweeping or shoveling to avoid tripping hazards.

5.5.2 Bollards

Another form of protection is to place bollards in front of the station. It is recommended to leave a minimum of 3 feet and a maximum of 5 feet between the bollards for wheelchair turnaround space. The front of the EVSE should be set back from the midline between bollards by at least half the distance between the bollards, to ensure that vehicle corners or snow-plough blades cannot damage the equipment (see figure 10) . Using bollards as protection will require excavation or even cutting through pavement depending on the area of installation. In turn, this will increase the cost of the installation.

Bollards should be installed so that they penetrate the ground past the frost line to avoid heaving/shifting in winter.

Figure 16: Bollard Protection (PRWeb, 2013)

5.5.3 Wall Mounted Barrier

Lastly, the least expensive form of protection, although only practical for wall mount installations, is a wall mounted barrier. This barrier is most practical because it does not obstruct the path to the station or restrict the connector from reaching the vehicle.

Figure 17: Wall mounted barrier (Sustainable Transportation Strategies, 2012)

5.5.4 Project Experience and Recommendations

At St. Lawrence College, it was decided to offer maximum protection to the charging stations. There was a consensus among the project team that a car could potentially drive over a wheel stop barrier and cause damage to the station. Bollards were therefore installed in front of each charging station. To maintain an appealing appearance, once the bollards were placed in the ground they were painted green and finalized with a black bollard cap.

Figure 18: Painted Bollard with cap

6. Point of Sale Options

Owners and operators of publicly-accessible charging stations may choose to charge a fee for charging to offset the cost of electrical usage from EV drivers. As stated in section 144 (1) of the Ontario Electricity Act,1998, a facility may not directly charge for the electrical usage unless they are a registered regulated retailer. Electricity retailers contract for wholesale electricity and retail this energy to customers under a binding agreement between parties. It is because of this constraint that charging station owners have turned to charging for parking spaces in attempt to recover the costs. There are currently several different ways of charging for use of equipment and recovering costs.

6.1 Unregistered Retailer

The main point of sale options for unregistered retailers are described in further detail below:

- Free parking & free charging: EV drivers will park and charge for free. This option is used to attract new clientele to a business and help promote the adoption of electric vehicles.
- Paid parking & free charging: EV drivers will pay per hour for the parking space that includes use of electric vehicle charging equipment.
- Charging fee at a flat rate: EV drivers will pay a flat rate to be provided unlimited charging.

Another way to recuperate costs is registering the station through a network that provides a pay per session payment plan. Some charging stations provide the option of paying with a credit card or a RFID that is registered with the network.

At this time, most charging stations are free to use – including all Level 2 stations in Kingston. However, with electric vehicles entering the market in mass quantity, it is possible that unregistered retailers may eventually need a more appropriate way of charging for the energy use of these facilities (U.S Department of Energy, 2013).

6.2 Registered Retailer

Metered Charging: EV drivers are charged per kWh of electricity consumed. This option depends on the regulation of utilities in the area of the charging station.

As stated above, electricity retailers are subject to regulations regarding their methods of selling the electricity . All registered electricity retailers must integrate a Measurement Canada-approved meter. Measurement Canada states that any equipment used for measuring electricity must meet stringent requirements to be approved. If a multi-unit residential building has another company providing sub-metering, it may be possible to use that sub-meter company, which is already registered, to bill by energy consumed. Given the additional costs incurred by this process, it is unlikely under the current regulatory regime in Ontario that there will be any EVSE installed using this form of energy cost recovery.

6.3 Additional Revenue Streams

Some charging stations provide additional space to support advertising on the station. Several charging stations provide an extra LED screen to stream advertisements. If the option of an LED screen is not available then placing stick-on logos on the station is also possible to create advertising revenue options. Charging local businesses to place advertisements on the charging station will help offset the cost of running the equipment.

6.4 Electric Vehicle Charging Stations Open Access Act

One of the biggest accomplishments surrounding point of sale options for electric vehicles took the lead in California. Hoping to increase the use of charging stations California is passing a bill prohibiting the requirement for a person requesting the use of an electric vehicle charging station to have to join a membership, association, or any organization charging a subscription fee for use. The bill titled Electric Vehicle Charging Stations Open Access Act (SB 454) is progressing to become law in California, and is expected to become widespread across the U.S. and other countries. Making the stations accessible to everyone, without limitations such as needing a subscription or RFID, should make the switch to electric vehicles much easier for drivers. Removing these barriers and adopting an Open Access Act will help effectively promote and advance the use of electric vehicles by making charging stations more easily accessible, while simultaneously alleviating range anxiety.

6.5 Project Experience and Recommendations

St. Lawrence College is in discussion with Greenlots with a view to using its EVSE management system in order to facilitate an equitable energy cost recovery structure. EV owners on staff at the college will likely have the option of paying per use as a regular member of the public or of paying for an additional annual parking fee that covers the cost of the energy that their EVs consume. The Greenlots software will also allow for greater utilisation of the Kingston EVSE, which is now serving potentially three staff EVs in addition to campus visitors. Owners will be prompted to move their now-charged EVs to allow others to use the station.

Cost recovery for a typical station – including purchase, installation and energy cost – is addressed below in more detail in section 9.

7. Permitting

Due to the fact that electric vehicle charging stations can require extensive electrical and civil engineering work, suitably qualified contractors must be selected for the installation. Prior to the installation, a licensed electrical contractor must obtain a permit from the Electrical Safety Authority. The contractor should be aware of the relevant codes and regulations pertaining to the installation and obtain approval from all appropriate authorities prior to any excavation. Building permits are not currently required for EV installation.

7.1 Project Experience and Recommendations

The permitting process of this project was extremely minimal and took no effort on SEARC's behalf. As required in this case by the Electrical Safety Authority (ESA), a licensed contractor was used for all electrical work. The only permit that was required for this project was obtained from the ESA by the electrical contractor.

Additionally, under Ontario regulation it is against the law to dig without having natural gas line locates conducted. To prevent undesired consequences, service disruptions, or costly fines and repair costs, locates were conducted prior to any excavation.

8. Incentives

In an effort to promote the adoption of electric vehicles, the Ontario government currently offers several different rebates to incentivize new potential drivers. Currently there are rebates offered on electric vehicles and electric vehicle charging stations, along with other incentives described below.

8.1 Electric Vehicle Rebate

Government rebates and incentives have become increasingly popular to help encourage drivers to make their next vehicle an electrically-propelled vehicle. In July 2012, the Ontario Government launched the Electric Vehicle Incentive Program. As stated by the Ministry of Transportation, this program offers Ontario consumers an incentive ranging from $5,000 to $8,500 for the purchase or lease of a new plug-in hybrid or battery electric vehicle. Incentives can be received for up to five vehicles per applicant each year (Ontario Ministry of Transportation, 2013).

Individuals, municipalities, non-government organizations, and non-profit organizations purchasing or leasing an eligible vehicle registered and plated in Ontario can apply for rebates from the Electric Vehicle Incentive Program. The program is open to plug-in electric and battery electric vehicles that are highway-capable and purchased or leased after July 1, 2010. The incentive is not available to low speed vehicles. The rebate value is based on the vehicle's battery capacity and, if applicable, the term of the lease (Ontario Ministry of Transportation, 2012).

For more information on which vehicles are eligible for the electric vehicle rebate please visit http://www.mto.gov.on.ca/english/dandv/vehicle/electric/electric-vehicles.shtml

8.2 Charging Station Rebate

Persons eligible for the provincial electric vehicle rebate and have/are planning to install a charging station may apply for a rebate of up to $1,000 or 50% of the installation costs, whichever is lower (Ontario Ministry of Transportation, 2013).

If applying for an electric vehicle charging station rebate, an applicant must first have applied to and received the electric vehicle rebate. For every electric vehicle rebate received, the recipient is eligible for one electric vehicle charging station rebate. The charging station installation rebate will be granted once the proper documentation has been provided. Documents required include, but are not limited to, proof of purchase from a Canadian EVSE supplier and an ESA inspection certificate.

For more information on which charging stations are eligible for the electric vehicle charging rebate please visit
http://www.mto.gov.on.ca/english/dandv/vehicle/electric/ev-charging.shtml

8.3 Access to HOV Lanes

As an extra incentive, EV drivers may choose to purchase special green license plates for qualifying plug-in hybrid and battery electric vehicles. The plates can be obtained through the regular plating process through Service Ontario locations for the standard vehicle plate fee of $20.00. Currently, personalized plates are not available. Until June 2015, EV drivers who are eligible and choose to purchase green plates for their vehicle will have access to high occupancy vehicle (HOV) lanes on 400-series highways (Ontario Ministry of Transportation, 2011).

Figure 19: Green License Plate (Ontario Ministry of Transportation, 2011)

The owner of any vehicle eligible for the electric vehicle incentive program is eligible to purchase green plates for their PHEV or BEV.

8.4 Reduced Car Insurance Premiums

Along with the government incentives mentioned above, another benefit to going green may be cheaper car insurance. Some insurance companies, such as TD, will offer a discount on the total premium if the hybrid or electric vehicle is recognized by the Insurance Bureau of Canada (IBC) (Meloche Monnex Inc., 2014).

8.5 LEED Building Certification

As a building owner, installing a charging station offers more benefits than just attracting new 'green' clientele. Installing electric vehicle charging stations can help a facility qualify for a LEED point. To find out more about LEED points and certification please visit the Canada Green Building Council web site at www.cagbc.org

9. Installation Costs

Much of the cost difference between EVSE units hinges on whether or not the charging station has communication and data storing abilities. For the St. Lawrence College projects, a device called an e-gauge was selected and installed to collect data from the stations. The e-gauge uses current transducers to detect when the stations are using power, in turn allowing the station owner to know when a vehicle is charging at the station. Additionally, two of the three stations have built-in digital communications provided at no cost for one year. The College will decide whether the costs of these communications can be recuperated through the charging stations before registering to continue the service. The following sub-sections will show the cost comparison of a charging station with communications to one without communications assuming a commercial installation with a pedestal mounted charger.

"Smart" EVSE installation with averaged costs

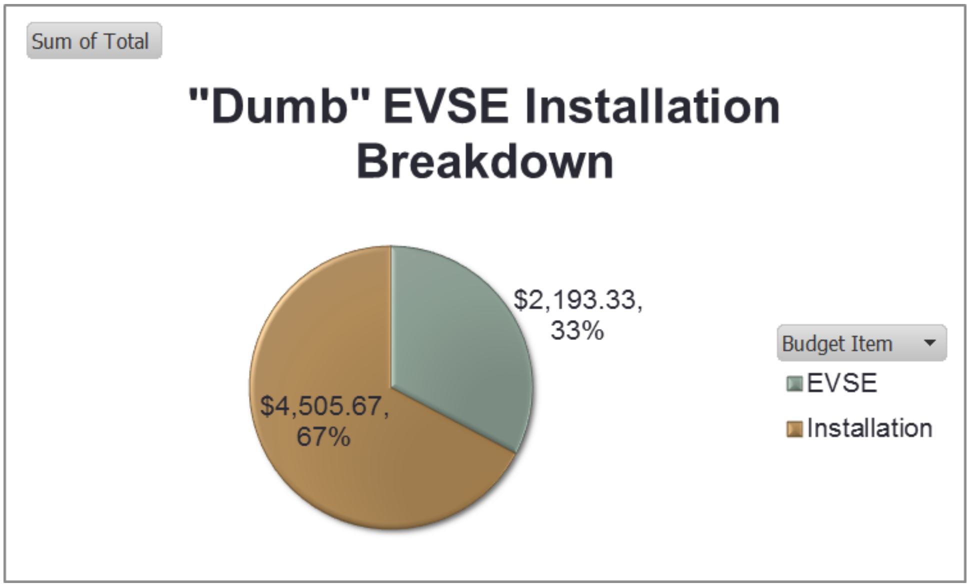
Item description	Budget Item	Budget Sub-Item	Cost	Taxes	Total
Charging station	EVSE	EVSE	$3,690.00	$479.70	$4,169.70
Electrical	Installation	Labour/Material	$2,240.00	$291.20	$2,531.20
Pad/Bollards install	Installation	Labour/Material	$1,480.00	$192.40	$1,672.40
Signage	Installation	Signage	$56.37	$8.42	$64.79
Misc Materials	Installation	Materials	$71.04	$10.61	$81.65
Steel bollard tubes	Installation	Materials	$135.40	$20.23	$155.63
				Total	$8,675.37

Notes

- EVSE price average of five single wand Level 2 smart stations quoted in project
- Average cost of electrical installation over three campuses
- Pads/bollards cost is from Brockville installation as work at other campuses performed in house.

"Dumb" EVSE installation with averaged costs

Item description	Budget Item	Budget Sub-Item	Cost	Taxes	Total
Charging station	EVSE	EVSE	$1,941.00	$252.33	$2,193.33
Electrical	Installation	Labour/Material	$2,240.00	$291.20	$2,531.20
Pad/Bollards install	Installation	Labour/Material	$1,480.00	$192.40	$1,672.40
Signage	Installation	Signage	$56.37	$8.42	$64.79
Misc Materials	Installation	Materials	$71.04	$10.61	$81.65
Steel bollard tubes	Installation	Materials	$135.40	$20.23	$155.63
				Total	$6,699.00



Notes

- EVSE price average of three single wand Level 2 dumb stations quoted in project
- Average cost of electrical installation over three campuses
- Pads/bollards cost is from Brockville installation as work at other campuses performed in house.

Another factor that can significantly affect the cost of installation is the mounting type. Consider that a wall mounted level 2 charger without communications is available for under $900 before taxes. Wall mounting eliminates the cost of pad construction, and probably bollard installation and material cost. The electrical installation would most likely be less expensive as trenching would probably not be required.

Anecdotally speaking, a faculty member of St. Lawrence College installed a residential EVSE during the time frame of this project. The total cost of installation including the EVSE, hardware and labour was $1955.

10. EVSE usage on St. Lawrence College campuses

St. Lawrence College now has around 7 months of EVSE usage data, which will be used to inform the cost-recovery model for the college energy and system management costs. The college can probably also be used as a fair comparator for institutions of similar size and nature, and as such, its findings will be informative for many site owners considering EVSE installation.

When the stations were first installed, there were no EV owners on staff at any campus, but shortly after commissioning, two full-time members of staff purchased EVs and both have begun to use the EVSE at Kingston campus on a regular basis. A third staff member bought an EV in the week prior to this report's completion. Members of the public have been seen using the station as well.

Brockville campus has seen 4 charging visits since installation. All of these user visits are assumed to have been made by members of the public as there are no EV owners on staff in Brockville. The station in Cornwall has yet to be used, again mainly due to there being no EV owners on staff.

Campus EVSE usage – essentially, the use of the 2-wand Kingston charging station – has increased steadily since installation in late August 2013, with regular users beginning in October 2013. As can be seen in table 2, there has been a marked uptick in the 7 weeks prior to this report's completion that has seen visit frequency increase by 75% and the average energy delivery increase by 55%.

Table 2: EVSE usage on St. Lawrence College campus, 2013-2014

Period	# of days	# of visits	Total energy drawn	# of visits per working week	Avg. draw per visit
August 26 – March 7	193	116	341kWh	4.6	2.94kWh
March 8 – April 28	51	56	255kWh	8	4.55kWh

In addition to the data collection, the research team has interviewed the EV owners on staff at the college, to learn more about their patterns of EVSE use. One key finding so far is that for most charging events, level 1 charging would be sufficient to meet their needs. The EVs are typically parked on campus for periods of 6 hours or more per day, which is enough time to fully charge the batteries. This has implications for the future use of the level 2 facility, in that it may mean greater numbers of EVs can be supported on campus at a lower installation cost, provided that suitably accessible level 1 charging locations can be identified.

11. Cost Recovery

Should cost recovery be required, the EVSE owner must first decide on the period over which the costs are to be recovered. Sites will have different usage patterns – frequency, duration, time of use and type of user are all likely to be quite site specific – but it is reasonable to expect that use will, generally speaking, increase over time.

Knowing as much as possible about these variables in advance of the project installation will help to determine the most suitable type and level of EVSE to install, to increase cost-effectiveness of the EVSE, and to facilitate the most realistic cost-recovery model for the site. In most cases, some form of electronic system management is likely to result in the most equitable use of both the EVSE and the parking space that it serves, and is recommended by the authors of this report.

An institutional EVSE owner like St. Lawrence College, with some regular EV owners using the facilities (e.g. employees of the college), should be able to determine appropriate rates for these users, while charging different rates for guests, visitors or the general public. As parking on all three campuses is subject to an hourly fee or the purchase of an annual pass, the use of EVSE could be considered a premium service for which additional charges are levied.

As an example, based on the average installed cost of $8675 cited above, and selecting a 5-year simple payback period, a basic equipment cost recovery model could be developed as follows:

- 365 days per year = $4.75/day, average of 2 users per day = $2.40/user visit;
- ~250 workdays/year = $7/day, average of 2 users per day = $3.50/user visit, free weekend charging;

- ~250 workdays/year = $1/hour flat rate, minimum charge 1 hour, average of 7 charging hours per working day, free weekend charging;

To cover the cost of energy being delivered, the host site can opt to levy a fee relative to the approximate amount of electricity used, and can choose to link this fee to the cost incurred by the host or to the cost presumed to be avoided at the user's home.

Based on the historical EVSE user duration numbers in table XXX above, and the commodity charge rates paid by St. Lawrence College (anecdotally, $0.08/kWh) and the current average Ontario residential commodity charge ($0.0955/kWh), the average EVSE visit could then add between $0.25 and $0.43 to an equipment cost recovery user fee in 2014.

12. LDC preparedness – discussion and recommendations

A utility that is able to accurately identify every charging station being added to the grid will be able to take a more strategic approach to avoid potential overloading of its transformers and, it is hoped, will be better able to harness the potential of EVs as nodes in a smarter grid. There are a number of options open to a utility seeking to be pro-active about the monitoring of and planning for EV charging station installation within its service territory.

12.1 Discussion

Toronto law firm Gowling Lafleur Henderson LLP recently compared the potential of a burgeoning EV sector in Ontario with the iPhone market in the US around ten years ago (Timmins, 2014). At this time, mobile data carriers increasingly struggled to cope with rapidly increasing demand for their services due to a very popular consumer product. One can also draw a relevant parallel between the current level of market penetration of level 2 and 3 EVSEs in Ontario and that of small distributed generators in the province around 5-6 years ago. The number of residential and small commercial renewable energy generators began to increase gradually following 2006's Ontario Regulation 541/05 – Net Metering and the introduction of the Renewable Energy Standard Offer Program that same year. The subsequent Green Energy and Economy Act of 2009 ushered in the financially highly attractive Feed-In-Tariff (FIT) and microFIT programs, at which point there was a dramatic increase in participation that saw over 15,000 microFIT renewable energy generation systems connected in three years.

MicroFIT proponents in Ontario will understand these concerns about the fragmented utility sector in Ontario, given the sometimes wildly differing costs and experiences of connecting small renewable energy systems in different LDC territories. Nevertheless, it is fair to say that the utility sector, with the assistance of the Ontario Energy Board, has adopted a reasonably common set of standards, connection request forms and agreements, submission and acceptance of which are now required in order to connect generators in any LDC territory. Anticipation of the demand for the OPA microFIT and FIT programs prompted the province's utilities to develop formal processes that allowed them to track the location and consider the cumulative effect of distributed generators connected to the grid.

SEARC recommends that a similar approach be taken by the province's utilities to develop and implement a unified process for tracking level 2 and level 3 EVSE equipment installation. Not only will this reduce the risk of unforeseen and problematic additional loads on the distribution system, it will allow more EVSE owners to participate in the wider evolution of the Smart Grid in Ontario. Two-way transfer of power between EVs and the grid, as envisioned in a Vehicle-to-Grid (V2G)-enabled future, wherein EV owners allow their vehicles' batteries to participate in grid load management activities by either supplying energy to or modulating their energy withdrawals from the grid in response to signals from the grid operator - has the potential to play a significant role in a smart grid future. For utilities to be able to fully harness this potential, a register of all V2G-capable level 2 and 3 charging stations would be a valuable resource. In this scenario EVs will have the same potential impact on the grid as a distributed generator. Thus it would be prudent for utilities to consider the option of requiring EVSE owners or installers to register their equipment with their local utility company, so that it can plan and be ready for system operation in V2G use as and when market and technological signals combine to incentivize its adoption.

Some utilities in North America are already taking a pro-active approach to tracking EVSE installations in their territory. Pacific Gas and Electricity (PG&E), operating in northern California, where EVs have made greater penetration into the market, has required since 2011 that EV users planning to install EVSEs complete an application form that shows the increased load calculations implied by the EV installation. Using this information, PG&E will, if the customer is installing level 2 charging, determine whether service upgrades are necessary at the customer's location, and can also plan for upstream upgrades based on projected cumulative impacts. The customer can also choose to take advantage of EV-specific low-price off-peak rates for charging, which are geared towards minimizing demand for EV charging during peak periods of grid demand. In this jurisdiction, where peak electricity consumption is discouraged through strong price signals, any level 2 EVSE installation is required to have either a second service meter and/or an upgraded or additional load panel.

12.2 Recommendations to Utilities

Within the current permitting and regulatory framework, an initial, independent and reactive approach would be for a utility staff member to monitor charging station installations using the free online mapping services listed above, cross-referencing with their own grid architecture maps, and then evaluating the grid impact of those mapped systems. This approach is imperfect, however, as not all stations installed are publicly mapped, and not all system information is necessarily available on EVSE mapping websites.

Toronto-based non-profit Plug'n Drive's ChargeMyCar program is a web-based service for new EV owners that encourages them to take the correct steps in installing EVSE. When a level 2 charging station is sold through the Plug'n Drive website, the organization contacts the purchaser's local distribution company to let them know that an EVSE installation is proposed for that customer's address.

SEARC proposes that dealerships and vendors of both EVs and EVSEs be provided with a quick guide pamphlet to inform new EV drivers about the process of installing a charging station. This pamphlet should include contact information for Ontario One Call, information on securing the services of a certified electrician, and a notification form to be forwarded to the local electrical distribution company. At the time of writing, the Plug'n Drive website indicates a network of around 200 auto dealers across the province currently selling mainstream BEVs and/or PHEVs. Given that many EV buyers will purchase their EVSE in a bundle with their EV, having a hard copy of the same Plug'n Drive information included in sales packages may increase the number of EVSE installations being captured by local LDCs.

SEARC also proposes that Ontario LDCs adopt a uniformly similar service request form to be completed by all prospective EVSE owners and installers. This form should be provided to and filled out by the owner of the station, and submitted in advance of the installation, giving the LDC the opportunity to make a site visit to evaluate whether a service upgrade may be required. A copy of the ESA's final inspection should then be sent automatically to the LDC to file with the customer application, so that the LDC knows the EVSE is now "live". An example of such a service request form, modelled on a similar form for generators produced by Kingston Hydro, is shown in appendix A.

APPENDIX A

LDC EVSE Connection Request Application Form

ANYTOWN HYDRO CORPORATION requests that all prospective installers of level 2 or level 3 Electric Vehicle Charging Systems (EVSEs) complete this form and return it prior to having any electrical service work carried out. The information on this form will assist ANYTOWN HYDRO in evaluating whether any upstream service work is required to support the EVSE installation. It will also enable the cumulative tracking of EVSE installations in the ANYTOWN HYDRO service territory, and allow ANYTOWN HYDRO to coordinate future service levels and opportunities, such as off-peak charging rates or Vehicle-to-Grid services.

Date:_________________

1. Customer Information
   a. Name:____
   b. Address:____
   c. Telephone number:_________________________________
   d. Email:____
   e. Utility Load Account number:_______________________

2. EV Charging Station Information
   a. Proposed Charging station make / model (if known):______________________
   b. Charging level (circle): Level 2 / Level 3
   c. Charging station amperage (if known): ____________________________
   d. Communications networks (list all, if known): _____________________

      ____

      ____

      ____

      ____

3. Electrical Service details
   a. Existing load service rating (Amps): ______________________________
   b. Service entrance type (circle): Overhead / Underground
   c. Customer-owned transformer (circle): Yes / No
   d. Customer load analysis and impact calculations
      i. Calculation performed by licensed electrician:

         ____

         ____

         ____

         Contractor name: ______________________________

ESA License number: ____

e. Load service upgrade required (circle): Yes / No

f. Proposed new load service rating (Amps): ____________ / Not applicable

For Office Use Only

EVSE Standards Compliance:

____

Distribution Feeder

- Normal (44kV / 27.6kV) Supply TS and Circuit:

  ____

- Normal Supply DS and Circuit:

  ____

- Number of Phases: _____
- Phase: _______________
- Distribution Transformer Data:
  - Rating _______ kVa
  - Number of Transformer Units:_____
  - Number of Phases: ______
  - Winding Connection and Voltage: _____
  - Oil-filled or Dry-type: _____

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