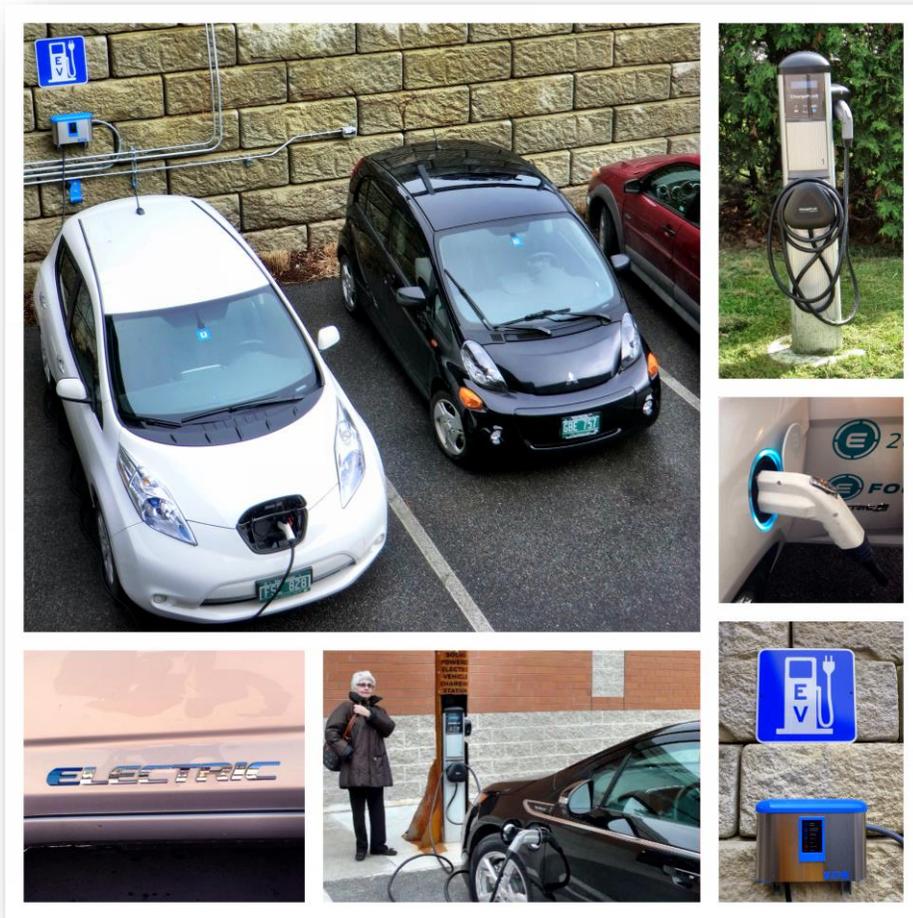


Electric Vehicle Charging Station Guidebook

Planning for Installation and Operation



June 2014



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Executive Summary

The Chittenden County Regional Planning Commission (CCRPC) has established goals to reduce greenhouse gas emissions from the transportation sector and increase the energy efficiency of Vermont's motor vehicle fleet. This is an important factor in realizing energy efficiency improvements and greenhouse gas reductions detailed in the 2013 Chittenden County ECOS Plan¹ and the Chittenden County Climate Action guide; as well as climate action and energy plans across all levels of government in Vermont. The Chittenden County Climate Action guide prioritizes the promotion of electric vehicle infrastructure for electric vehicle charging as a key action to meeting greenhouse gas reduction targets established by the State legislature. Electric vehicle (EV) technology supports these goals by providing low carbon, highly efficient and cost effective transportation.

The technology, data and costs documented in this guide reflect the most current information available at the time of publication. However, potential owners and installers of charging equipment should expect the information and recommendations in this guide will change as the EV industry matures.

The Need for Electric Vehicle Charging Equipment

As of April 2014, there were 630 plug-in passenger cars in the state, a small but quickly growing fraction of the overall fleet. Approximately 1/3 of these are registered in Chittenden County. Most EV owners are able to charge their vehicles at home during overnight hours, but charging opportunities away from home are needed to allow longer trips and increase the confidence of potential car buyers considering EV purchases. CCRPC has developed this guidebook to detail the process for installing charging equipment for property owners, businesses and EV owners as part of a broad effort to promote the benefits of EVs and increase availability of public charging.

Priority locations for publicly available EV charging equipment (often referred to as electric vehicle supply equipment, or EVSE) include areas with concentrations of retail, recreation, and public services. These destinations commonly have parking durations long enough to create opportunities for charging. CCRPC's EV Charging Equipment Location Prioritization Technical Report has additional information on criteria for siting EV charging².

Businesses should consider providing charging suitable for both employees and customers. Current research indicates the presence of charging stations at a commercial business will bring in new customers and drive repeat traffic. Providing charging opportunities for employees provides a valuable amenity and demonstrates environmental leadership. In some cases, municipalities or state permitting may require the addition of EV charging to development proposals under their jurisdiction.

Figure ES.1 below shows the current locations of the 14 existing and planned public electric vehicle charging locations in Chittenden County, most of which are clustered in the greater Burlington area. A map of all EV charging stations in Vermont is available on the Drive Electric Vermont Website³. Many of

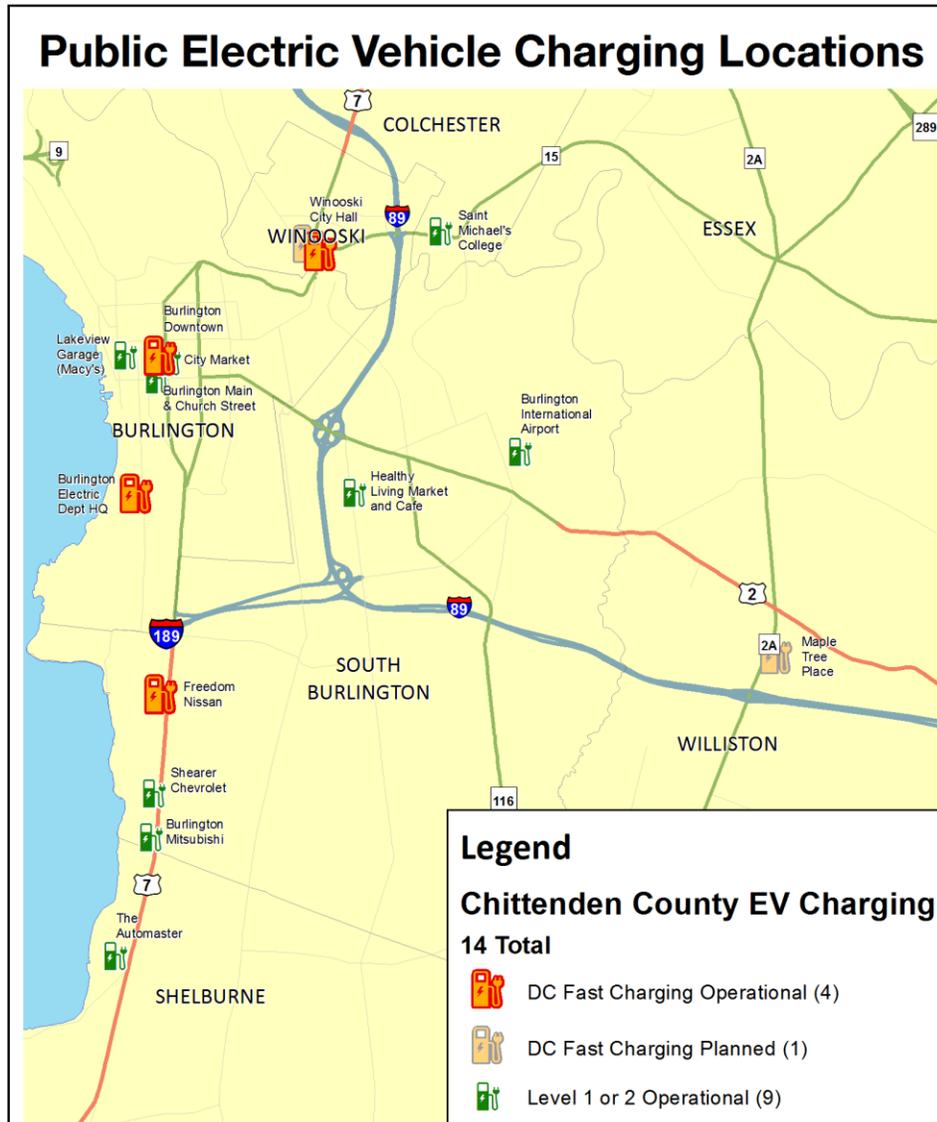
¹ <http://ecosproject.com/>

² <http://driveelectricvt.com/benefits-for-vermont/reports-resources>

³ <http://driveelectricvt.com/charging-stations/public-charging-map>

these locations are at auto dealerships with restricted hours of operation, further reinforcing the need to develop a more robust network of workplace and public charging locations.

Figure ES.1: Chittenden County Existing and Known Planned EV Charging Locations



Electric Vehicle Charging Equipment Installation

There are a variety of options available for EV charging equipment installations. EVs arrive from auto manufacturers with portable chargers which can be plugged into standard 120 volt household outlets. This is often adequate for home or workplace charging locations with long parking durations and provides charging opportunities at minimal cost.

Specialized charging equipment is available with higher power flows to reduce the amount of time it takes to charge EVs. This equipment ranges in cost from \$500 to \$20,000 or more depending on the

capabilities and amount of power provided. Higher powered “fast charging” units are available which can reduce charging times from several hours to 30 minutes or less.

This installation guidebook contains best practices for locating new charging stations on properties, equipment specifications for various applications, and navigating state and community permitting processes. The use of licensed electricians to install charging equipment is required for public facilities and is recommended for homeowners as well.

1 Electric Vehicle Technology and Charging Equipment Overview

1.1 Electric Vehicles

Electric vehicles (EVs) use electric motors powered by electrical energy stored in a battery for propulsion. These vehicles are available in a variety of models with varying ranges and capabilities and are plugged in to a source of electrical power to recharge.

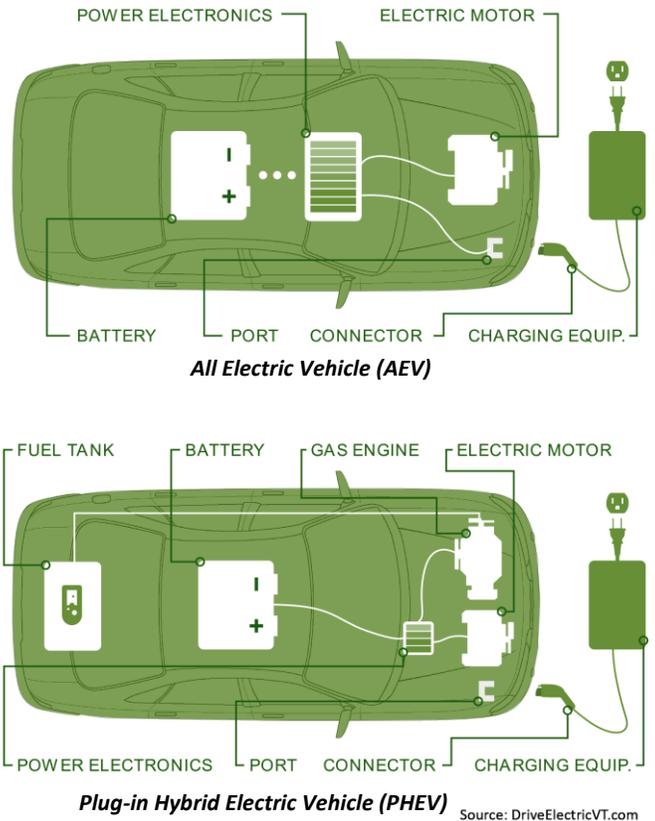
The terminology associated with EV technology is evolving. Many of the fundamental EV design concepts actually predate gasoline internal combustion engines. In the early 1900's there were more EVs on our nation's roads than gasoline fueled vehicles. Today, there are several models for sale at Vermont auto dealers and their presence is expected to significantly grow over the next 20 years. Advances in battery storage technology, lightweight vehicle construction, electric grid automation and other factors will increase the attractiveness of EVs for consumers, businesses and government agencies and support long term shifts to more efficient transportation options.

There are two basic types of EVs:

1. **All Electric Vehicles (AEVs)** are powered solely by energy stored in the vehicle's battery system. There is no backup power generation in the vehicle, so when the battery runs out of charge it requires recharging before operating again. The Mitsubishi i-MiEV, Nissan Leaf, Tesla Model S and Ford Focus Electric are examples of AEVs currently registered in Vermont.
2. **Plug-in Hybrid Electric Vehicles (PHEVs)** are capable of operating solely on electric energy for a certain distance after which an auxiliary internal combustion engine is engaged to offer additional range. PHEV's are often categorized according to their range in electric mode. The battery of a PHEV-10, such as the Toyota Prius Plug-in, has approximately a ten mile electric range while a PHEV-40, like the Chevrolet Volt, has approximately a forty mile electric range. The Chevrolet Volt, Ford C-Max and Fusion Energis and Toyota Prius Plug-in are examples of PHEVs currently registered in Vermont.

In Vermont, the average distance a vehicle travels in a day is around 33 miles⁴, making EVs capable of meeting the mobility needs of the majority of Vermonters on most days. Despite their ability to

Figure 1.1 Types of Plug-in EVs



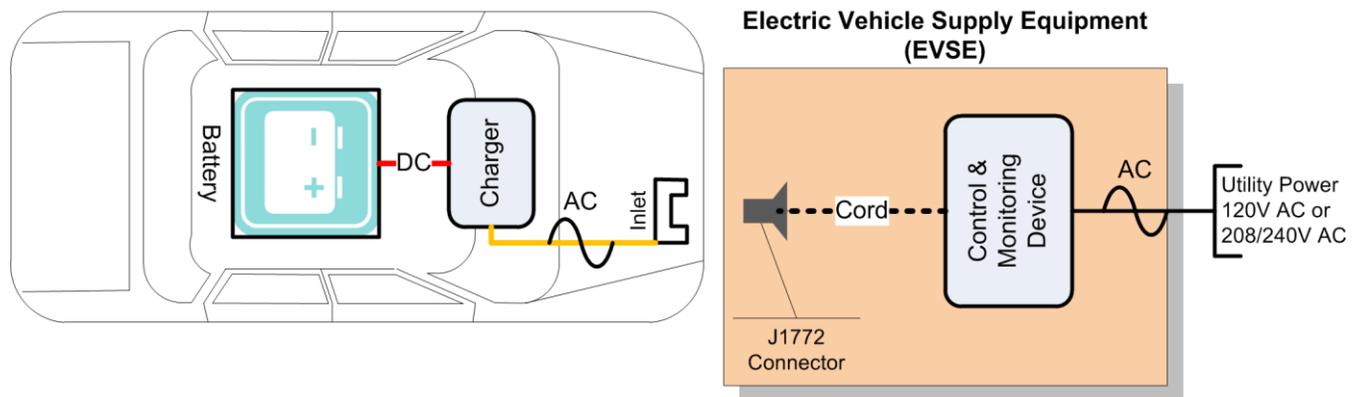
⁴ National Household Travel Survey, 2009. www.nhts.ornl.gov.

accommodate normal travel patterns, the lower range and lack of charging infrastructure compared to gasoline vehicle fueling can affect the range confidence of prospective EV owners, particularly for all electric vehicles.

Recharging EVs is accomplished through connections to electric vehicle charging equipment, also referred to as Electric Vehicle Supply Equipment (EVSE). This is a protective system which communicates with the vehicle and monitors electrical activity to ensure safe charging. While the actual “charger” is contained in the vehicle, the appliance commonly referred to as a charging station or EVSE is the conduit, control, and monitoring device which connect the vehicle to the electric grid. Figure 1.2 is a diagram of the overall charging energy flow from the power grid, through the EVSE (shaded in orange) and into the vehicle through the industry standard J1772 port connector. With alternating current (AC) EVSE, charger electronics within the vehicle invert the AC power supplied by the EVSE into direct current (DC) for storage in the battery. Fast charging DC EVSE delivers high voltage (typically over 400 V) direct current straight to an electric vehicle’s battery system.

With the EVSE safety features built-in to all new vehicles and charging equipment, EVs can be operated and recharged in all types of indoor/outdoor conditions, such as rain, snow, low temperatures and other harsh environments drivers may encounter in Vermont.

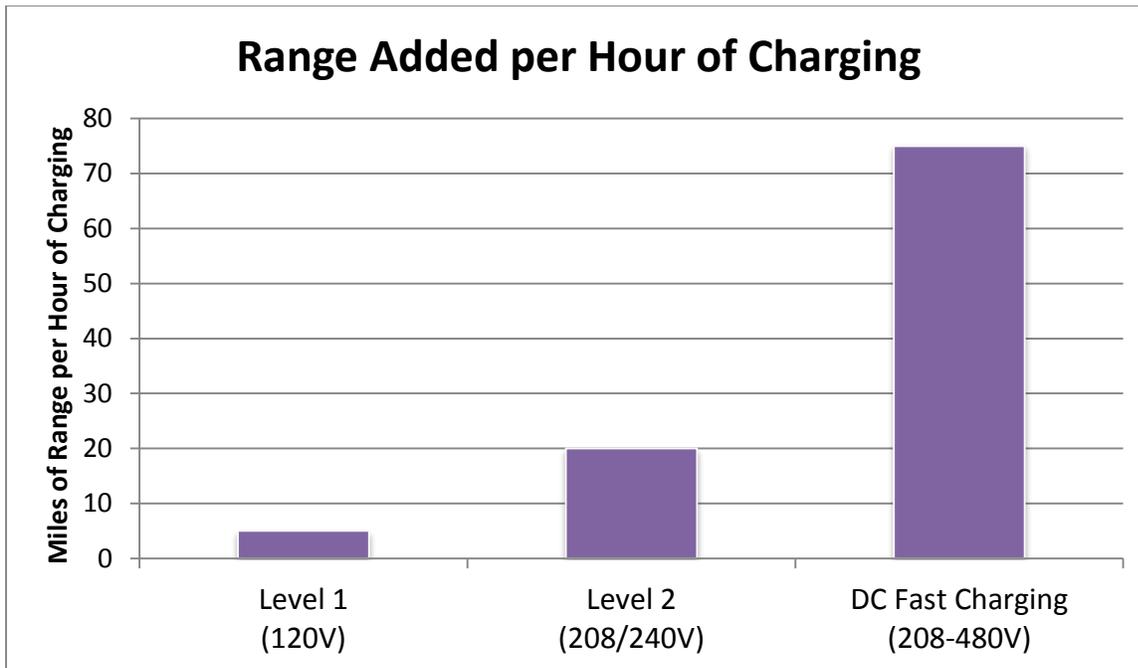
Figure 1.2: Electric Vehicle AC Charging Equipment Diagram



1.2 Electric Vehicle Charging

There are three levels commonly used to describe the charging power of EVSE: Level 1, Level 2 and DC Fast Charging. The amount of range provided for each of these is shown in Figure 1.3 below with additional details in the following sections.

Figure 1.3: Charging Range Added per Hour of Charging



1.2.1 Level 1, 120 Volt Charging

This simplest form of charging uses a 120V AC connection to a standard residential/commercial electrical outlet capable of supplying 15-20 amps of current, for a power draw usually around 1.4 kW when charging.

EVs come equipped from the manufacturers with portable Level 1 chargers, such as the one shown in Figure 1.4. AEVs with 60-80 miles of range will require 10-14 hours for a full charge using Level 1 EVSE. At Vermont's average residential electric rate of \$0.16/kWh⁵, one hour of Level 1 charging costs about \$0.25.

Advantages

- Low installation cost
- Low impact on electric utility peak demand charges which are often applied to commercial accounts

Disadvantages

- Charging is slow - around 3 or 5 miles of range added per hour of charging

⁵ <http://www.eia.gov/electricity/state/vermont/>

1.2.2 Level 2, 208/240 Volt Charging

Level 2 charging requires a 208/240V AC power connection and significantly reduces charging time. Home users commonly use 240 V power for electric clothes dryer appliances and many commercial customers have 3 phase electric service with 208 V power. Either voltage works well for “Level 2” charging. The J1772 standard connector used by most EVs can theoretically provide up to 80 amps of current (19.2 kW), although most vehicles presently available only use up to 30 amps for 3.3 to 6.6 kW⁶ charging.

AEVs with 60-80 miles of range will usually require 3-7 hours for a full charge using Level 2 equipment, depending on the capacity of the EVSE and the vehicle charging system. EVs with smaller batteries, such as a PHEV with 10 miles of range (e.g. Toyota Prius Plug-in) may require less than an hour to reach a full charge. Figure 1.4 includes one model of a Level 2 charger and a J1772 connector. At Vermont’s average residential electric rate of \$0.16/kWh, one hour of Level 2 charging costs \$0.50-\$1.00.

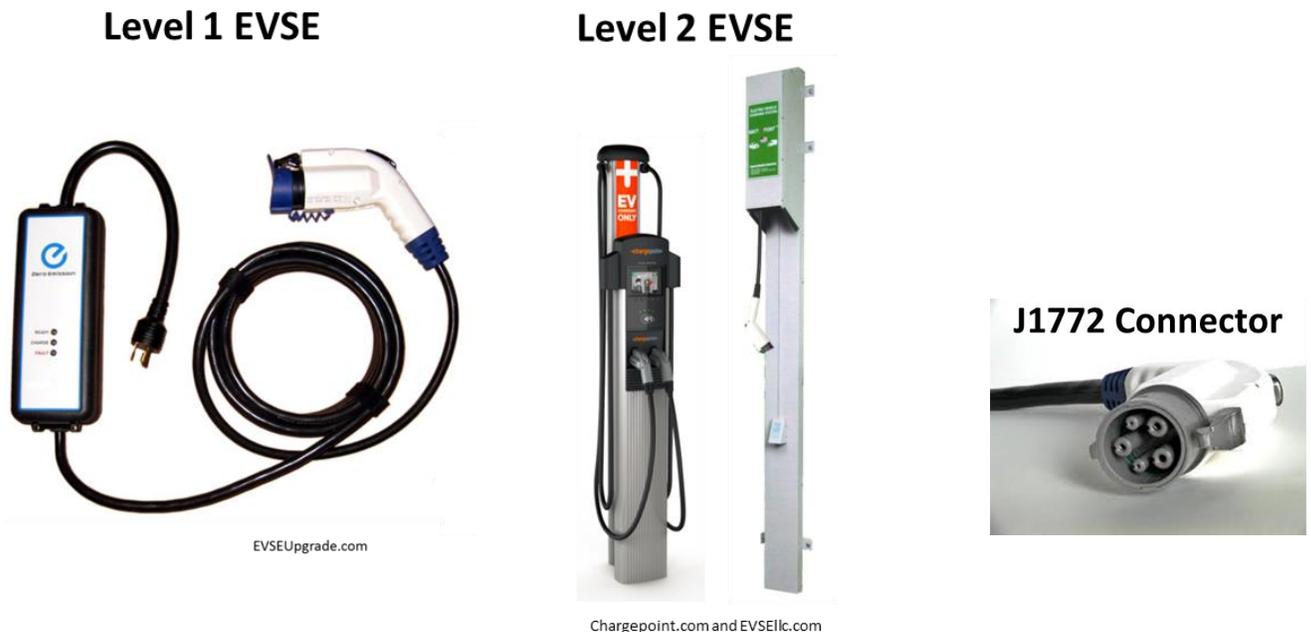
Advantages

- Charge time is significantly faster than Level 1. EVs will get between 10 and 20 miles of range per hour of charge
- More energy efficient than Level 1 for short duration charge events less than one hour
- Variety of manufacturers provides differentiated products for distinct markets and requirements

Disadvantages

- Installation costs are higher than Level 1 and are highly variable depending on equipment and installation issues
- Potentially higher impact on electric utility peak demand charges

Figure 1.4: Level 1 and Level 2 EVSE Equipment and J1772 Connector



⁶ Tesla vehicles can be configured with charging capacity up to 20 kW

1.2.3 DC Fast Charging

Sometimes referred to as Level 3, DC fast charging equipment delivers high power directly into an EV's battery system, enabling rapid charging. Typically, an 80% charge can be provided in 30 minutes or less for many all electric vehicles. This equipment is deployed in various locations around the U.S. including an extensive network along the West Coast of the U.S. in Oregon and Washington State, allowing for long distance travel. As of February 2014, there is one DC fast charger in Vermont at the Freedom Nissan auto dealer in South Burlington, with several additional units expected to become operational over the next six months.

DC fast charging does not use the same J1772 plug connectors as Level 2. There are three distinct connectors for fast charging equipment by various manufacturers:

1. CHAdeMO used by Nissan, Mitsubishi and Kia;
2. SAE Combo used by American and European makes, such as Chevrolet, BMW and Mercedes-Benz; and
3. Tesla's Supercharger used exclusively on Tesla Model S and later vehicles. Tesla has also announced an adapter allowing their owners to use CHAdeMO equipment.

Figure 1.5 shows examples of the equipment and connectors. These various standards may coexist for many years, since Nissan and Mitsubishi plan to continue using the CHAdeMO while several American and European manufacturers are beginning to use the SAE standard. Many EVSE manufacturers are developing equipment with both connector types in response to this situation.

Operating costs for fast charging are highly variable as many electric utilities charge "demand fees" based on peak electric use (kW) in addition to kWh rates most residential consumers are familiar with. If the charging station use coincides with the peak usage for other uses on the same utility meter, then demand fees may be assessed. Several Vermont utilities have or are investigating tariffs which would reduce demand charge costs for EV charging under certain conditions.

Advantages

- Charge time is reduced drastically – typically 30 minutes for an 80% charge

Figure 1.5: DC Fast Charging EVSE and SAE / CHAdeMO Connectors



Disadvantages

- Equipment and installation costs are higher than level 1 and level 2 charging, \$20,000-\$100,000 depending on equipment and power availability at site
- Potential for increased peak power demand charges from electric utility
- Competing standards are confusing to EV buyers and charging station operators
- Potential issues with cold weather operation requiring increased charging time

2 EV Charging Location Selection

2.1 Location Selection Criteria

Optimal locations for EV charging installations will change according to the type of equipment in use. For example, long duration Level 1 charging may be a good match for home or workplace locations, but is generally not recommended for shorter duration parking areas, such as grocery stores.

Table 2.1 below evaluates desirable location characteristics for public installations of level 1, level 2 and DC fast charging.

Table 2.1: Location Attributes for EV Charging

	Level 1 (120V)	Level 2 (208/240V)	DC Fast Charging
Typical Duration of Charge Event	6-10 hours	1-3 hours	30 minutes
Range per hour of charging	5 miles	10-20 miles	75+ miles
Typical Users/Uses	<ul style="list-style-type: none"> ▪ Home use ▪ Employee parking during the work day ▪ Long term (8+ hours) parking at a commuter lot, charging while on a carpool, walking or transit trip 	<ul style="list-style-type: none"> ▪ Home use for EV owners wanting a faster charge ▪ Charging in a commercial area while shopping or doing business ▪ Parking at a commuter lot and charging while on a carpool, walking or transit trip 	<ul style="list-style-type: none"> ▪ Fast charging while on a long trip in order to reach a destination or extend the length of a trip
Desirable Characteristics	<ul style="list-style-type: none"> ▪ Workplaces ▪ Lit, safe area ▪ Pedestrian and transit connections 	<ul style="list-style-type: none"> ▪ Shopping, dining, restrooms etc. within walking distance ▪ Transit service ▪ Pedestrian facilities ▪ Lit, safe area 	<ul style="list-style-type: none"> ▪ Amenities at the charging site (food, coffee, Wi-Fi) ▪ Lit, safe area
Priority Locations	<ul style="list-style-type: none"> ▪ Employee parking areas ▪ Long term customer/visitor parking ▪ Park and ride lots 	<ul style="list-style-type: none"> ▪ Municipal or private parking lots in downtowns, village centers, growth centers or shopping centers. 	<ul style="list-style-type: none"> ▪ Near high volume roadway access points

2.2 Property Siting Considerations

The process for installing EV charging at a particular location will depend on the property ownership and type of land use. Several primary factors relevant to siting EV charging installations within a property are listed below, followed by more detailed information on the process for installing a charging station.

2.2.1 General Siting Issues

- Availability of power – Proximity to electric power service is often the key factor in determining installation cost. Placing charging equipment near existing power service will reduce cost and installation time, particularly if there is reserve capacity available to reduce any upgrade costs. Property owners may want to consider investing in efficiency improvements for other power consumption on the property to reduce ongoing power expenses and free up service capacity in constrained situations. In some situations it may be more cost effective to install a new service drop and meter from a utility distribution transformer if that would result in a shorter power run to the preferred site for the charging station installation.
- Constructability – As stated above, placing equipment near power sources will reduce the extent of trenching needed for conduit runs. Many installations will still require some amount of trenching and in these situations it is best to go through softer features, such as grass medians, rather than sidewalks, asphalt or areas with extensive landscape features.
- Mounting – Wall mount units generally have lower capital and installation costs, so this option is often preferred if the site has a suitable wall area. Dual mount options for charging equipment may also help reduce overall installation costs as the incremental cost of adding another port is frequently much lower than installation an additional single port unit.
- Environmental protection – Charging equipment exposure to the elements should be minimized as much as possible. Areas prone to flooding or standing water should be avoided as much as possible.

2.2.2 Residential Charging Station Installations

Charging at home is by far the most popular option for EV owners. Convenience is high for homeowners who charge overnight when their vehicles are not in use and their electricity costs are much lower than comparable gasoline vehicle fuel expenses.

Many homes have ready access to power connections which reduces EVSE installation expenses. There are generally no concerns about availability or blocking other EV owners from charging, although multifamily residents living in condominiums or apartments may encounter unique issues in getting charging equipment installed, particularly if they do not have access to dedicated parking in proximity to power connections.

Existing 120V outlets can be used for Level 1 charging with the equipment supplied by the vehicle manufacturers which generally recommend the use of a dedicated 15 amp circuit with GFCI protection.

A summary of the rationale and process for residential charging stations is included in Table 2.2 below.

Table 2.2: Residential Charging Overview

	Single Family Home Owners	Multi-Family Home Owners and Tenants
Why do it?	<ul style="list-style-type: none"> • Faster and more convenient charging for EV owners 	<ul style="list-style-type: none"> • Allow homeowners/tenants to charge their EVs at home
How does it work?	<ul style="list-style-type: none"> • May be able to use an existing outlet • Usually just need one charging station in garage or driveway area on your property • EV charging is treated just like an electric appliance 	<ul style="list-style-type: none"> • Allow charging stations in parking areas reserved for homeowner use • Treated just like an electric appliance • Configuring a separate meter from power company is the most straightforward means to charge costs back to EV owners • Or, use charging equipment with built-in metering and set up agreements to recover costs
Installation Plan	<ul style="list-style-type: none"> • Select a location, ideally close to existing power supplies. Existing outlets with suitable specifications can be used with no additional wiring needed. • Select equipment or work with contractor to choose • Check municipal permit requirements [see Appendix] • Hire electrical contractor or complete the installation yourself 	<ul style="list-style-type: none"> • Survey residents to estimate demand • Select location(s), ideally close to power source • Select equipment or work with contractor to choose • Receive approval from property owner, condo association, etc • Check municipal permit requirements [see Appendix] • Hire electrical contractor to complete installation

2.2.3 Workplace / Commercial Locations

After home, workplaces are the second most common location for electric vehicle charging. An increasing number of businesses in Vermont are providing EVSE for employees, visitors and/or customers. Several additional siting factors should be considered for these areas.

- Parking capacity – Vehicles need to dwell for up to several hours while charging. Placing charging equipment in areas with excess parking capacity and restricting EV charging spaces will reduce potential conflicts with internal combustion engine vehicles.
- Proximity to employment / destinations – Since EV charging can require significant time, it is advantageous to co-locate charging at areas with services, such as shopping, restrooms, food and other workplace facilities which provides EV owners with a range of activities to pursue while their vehicle is plugged in.

- Modal Connections – Locating charging in areas with linkages to other modes of transportation, such as sidewalks, bus stops, and park & rides provides owners with access to additional destinations and opportunities.

Table 2.3: Commercial Location Installation Overview

Commercial Locations	
Why do it?	<ul style="list-style-type: none"> • Provide an amenity for your employees • Provide a valuable service for customers and visitors with EVs • Demonstrate leadership on energy efficiency and greenhouse gas reductions • Allow corporate fleet vehicles to charge at your facility
How does it work?	<ul style="list-style-type: none"> • A mix of Level 1 and Level 2 units is often recommended to provide adequate equipment to meet different users at the lowest overall cost • May consider DC fast charging in high traffic locations • Determine whether access will include employees, visitors/customers and/or the general public • Equipment owner can charge fee for use to recover costs, absorb costs or property owner can include power expense in tenant fees • Free charging will reduce capital and operating expenses through lower cost equipment and no networking service costs, but may require review of employee taxable benefit determination. • If you do not own the parking property, then discuss with property owner to determine next steps
Installation Plan	<ul style="list-style-type: none"> • Survey employees on interest in EV charging. Use results to help determine number of charging stations needed • Select location(s), ideally close to power source • Select equipment or work with contractor to choose • Receive approval from property owner • Check municipal permit requirements [see Appendix] • Hire electrical contractor to complete installation

2.2.4 Public Locations

Public EV charging locations generally require the same considerations as Workplace / Commercial locations (above). Factors particularly relevant to public locations include wayfinding signage to direct users to the charging equipment, parking restrictions to increase the availability of charging installations, and fee collection mechanisms to recover costs.

3 Charging Station Planning and Design

3.1 Charging Equipment Overview

There are currently over 50 vendors of EV charging equipment selling hundreds of models of equipment⁷. ChargePoint equipment is used in many of the current public EVSE installations in Vermont, but many other vendors offer high quality options, including Aerovironment, Clipper Creek, Eaton, EVSE LLC, General Electric, Leviton, SemaConnect, Siemens and others.

In some cases installation can be greatly simplified if there are existing 240 volt outlets like those used for electric clothes dryers and welding equipment. Several vendors have Level 2 EVSE units which can plug directly into these receptacles as shown in Figure 3.1 below.

Figure 3.1: Pluggable Level 2 EV Charging Equipment (NEMA 6-50 outlet)



Workplace and public charging equipment may benefit from the use of networking connection from the charging equipment to services which monitor usage and allow owners to collect fees for use of the equipment. The networking capability generally increases the up-front cost for the equipment and frequently requires monthly or annual fees to maintain the network services portal. Networking service capabilities, maximum power handling and cable management are the primary differentiators of the various vendor offerings.

3.2 Equipment specifications

The following specifications are recommended for EV charging equipment purchases. Nearly all vendors currently selling charging equipment in the United States meets the general recommendations for all charging equipment.

⁷ <http://www.pluginrecharge.com/p/electric-vehicle-supply-equipment-evse.html>. Accessed 12 April 2013.

General Recommendations for All Charging Equipment

1. Compliance with Society of Automotive Engineers J-1772 and/or CHAdeMO standard for EV charging plug connector dimensions and operational requirements
2. Nationally Recognized Testing Lab (e.g. Underwriters Laboratories) listed for outdoor use
3. NEMA Type 3R or 4 certification for outdoor electrical enclosures
4. Ability to operate in extreme temperature conditions (-20 to +100 degrees F)
5. Americans with Disabilities Act (ADA) accessible buttons and components
6. Warranty - Minimum 1 Year, longer desired

Additional Recommendations for Public Charging Equipment

7. Charging amperage from 30 to 80 amps to support vehicles with higher charging power capabilities (7.2 – 19.2 kW)
8. Modular Field serviceable parts, particularly for cord and J1772 connector
 - a. Minimum cord length of 20 feet
 - b. Cord management system to keep cord off the ground and comply with National Electric Code (NEC) article 625 as it applies to cord management systems
9. Network monitoring capability for status and fault reporting
 - c. Current status of charging station equipment (in-use, malfunction, etc)
 - d. Reporting on power consumption and usage patterns
10. Fee collection system using credit cards, access codes, phone operation and/or contactless RFID cards from widespread charging network(s) with customer service assistance available 24 hours a day, 7 days a week by phone.

Simple purchases of a small number of EVSE units are readily accomplished through a variety of internet shopping sites and through local retailers, such as Lowes as well as electrical distributors. Large scale implementation of EV charging equipment may achieve significant cost savings through a competitive bid process based on the above specifications and any additional requirements from the owner(s) of the equipment.

Equipment reliability is an important consideration, but unfortunately the relatively young market for EV charging equipment means there is not much experience with many vendors. The ChargePoint, GE and Eaton units in operation around Vermont have been relatively problem-free, but potential purchasers are encouraged to require a one year minimum warranty for new equipment. Some vendors offer longer standard warranties, such as Clipper Creek's three year warranty, or else extended warranties may be available at additional cost.

Table 3.1 below includes a listing of most of the major manufacturers of EV charging equipment, with capabilities for communications and mounting options shown.

Table 3.1: EV Charging Equipment Manufacturers and Capabilities⁸

Manufacturer	Charge type			Communications & Billing Options			Mounting Options			
	Level 1 (120V)	Level 2 (208/240V)	Level 3 (DC Fast Charging)	Network Communications Available	Billing / Payment Interfaces	Billing / Payment Networks	Floor / Ground	Bollard	Wall	Overhead
ABB			•	•	•	•	•			
AddÉnergie		•		•	•	•	•	•	•	
Aerovironment, Inc	•	•	•	•	•	•	•		•	
Andromeda Power			•	•	•	•	•			
Bosch		•					•			
Clipper Creek, Inc	•	•		•	•	•	•		•	
Control Module Industries (EVSE LLC)	•	•		•	•	•	•		•	•
ChargePoint	•	•		•	•	•	•	•	•	
DBT USA		•		•	•	•	•	•	•	
Eaton	•	•	•	•	•	•	•		•	
Fuji Electric			•	•	•	•	•			
General Electric		•		•	•	•	•		•	
Kanematsu			•	•	•	•	•			
Leviton		•		•	•	•	•		•	
Nissan			•	•	•	•	•			
OpConnect	•	•		•	•	•	•		•	
Pep Stations		•		•	•	•	•		•	
Schneider Electric		•	•	•	•	•	•		•	
SemaConnect		•		•	•	•	•	•	•	
Shorepower	•	•		•	•	•	•		•	
Siemens	•	•		•	•	•	•	•	•	
Signet Systems		•	•	•	•	•	•			

⁸ Based on Texas River Cities Plug-in Electric Vehicle Initiative Regional Plan and Final Report. October 2012. http://texasrivercities.com/uploads/TRC-EVI_Report_2012-10-25_FINAL.pdf
 CCRPC EV Charging Installation Guide June 2014

3.3 EVSE Typical Site Plans

There are many possible arrangements and designs for EVSE installations, depending on the parking area layout, availability of power, and other site considerations. General EVSE site plan considerations include:

- Power availability (240V for Level 2, 3 phase for DC fast charging)
- Level parking surface, preferably paved so EVSE spaces can be marked
- Lit, visible area to address security concerns
- Accessibility for disabled users
- Barriers or mounting options to protect EVSE equipment from vehicles
- Signs and pavement markings to designate sites and restrict their use



Making installations accessible for disabled users is covered more detail in Section 3.4.4. There are also options for addressing snow removal reviewed in Section 3.4.5. Figure 3.2 shows several examples of the range of EVSE installations.

Drive Electric Vermont has a condensed installation guidebook and additional information on EV charging technology which is an excellent place to start learning about EV charging and other related issues: <http://driveelectricvt.com/charging-stations/installation-guide>

Advanced Energy's Installation Guidebook has more detailed information on siting considerations, including recommendations to ensure charging is accessible for disabled EV owners: <http://www.advancedenergy.org/portal/ncpev/resources/ESVEHandbook.pdf>

These Northeastern States Transportation and Climate Initiative guidelines may also be useful: http://www.transportationandclimate.org/sites/default/files/EV_Siting_and_Design_Guidelines.pdf

Figure 3.2: Photos of Typical EVSE Stations



3.4 Typical Site Plans

There are many possible arrangements and designs for EVSE installations, depending on the parking area layout, availability of power, and other site considerations. Many EVSE sites use wheel stops to prevent vehicle contact with the charging equipment, but these can be problematic with snow removal. Bollards can also provide protection for EVSE, and are recommended over wheel stops to increase accessibility. With very limited exception, at least one EV charging parking spot should be accessible to individuals with disabilities (refer to section 3.4.4 below for additional information).

3.4.1 Perpendicular Parking Spaces

The majority of workplace and public EV charging will be located in parking lots with perpendicular parking for employees, visitors and customers. Figure 3.3 below is an example of a wall mounted installation, which is typically the most cost effective means of providing charging equipment if the parking area configuration allows for this. Installation costs are reduced by eliminating pedestal mounts and by allowing shorter conduit runs along building walls. The parking configuration shows typical parking stall dimensions of 9 feet wide by 18 feet long. A five foot wide aisle between accessible spaces provides room for disabled users to maneuver. As shown by the cord reach area, this configuration can serve several parking spaces by allowing drivers to park in the appropriate spaces or back in as necessary to provide access to the vehicle charging port.

Figure 3.3: Wall Mounted EVSE Example Site Plan Diagram

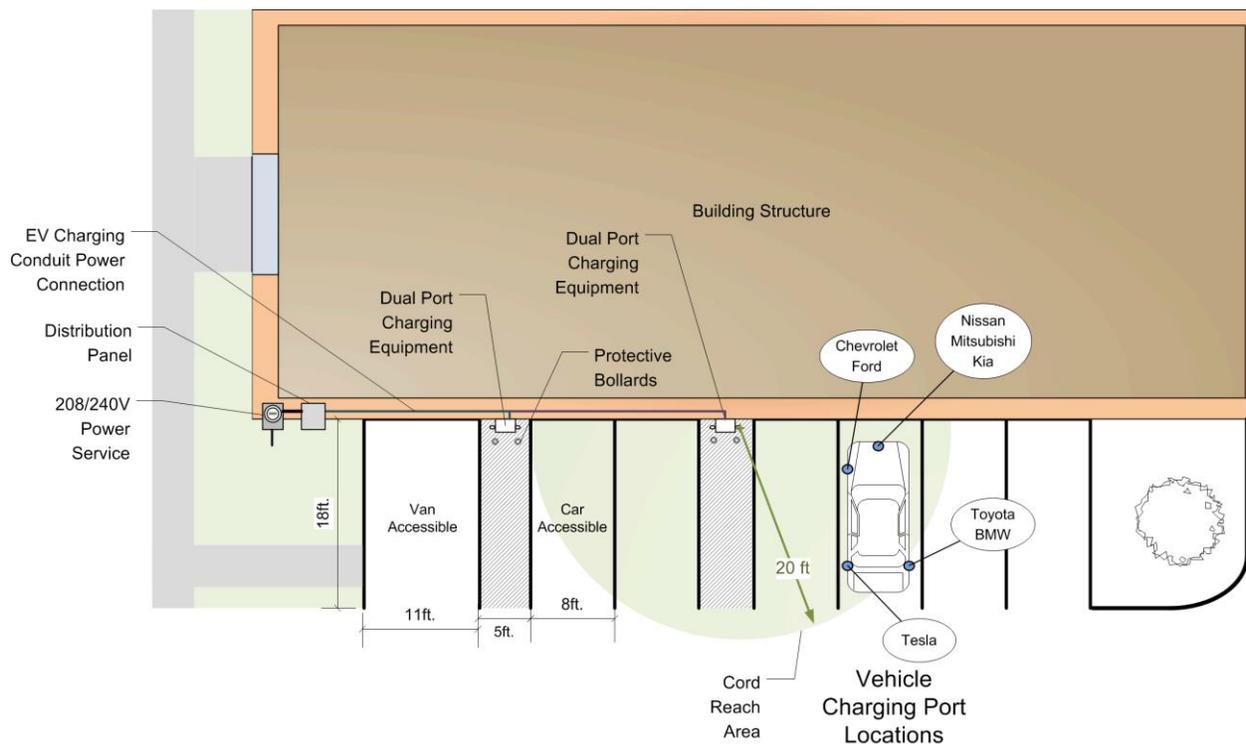
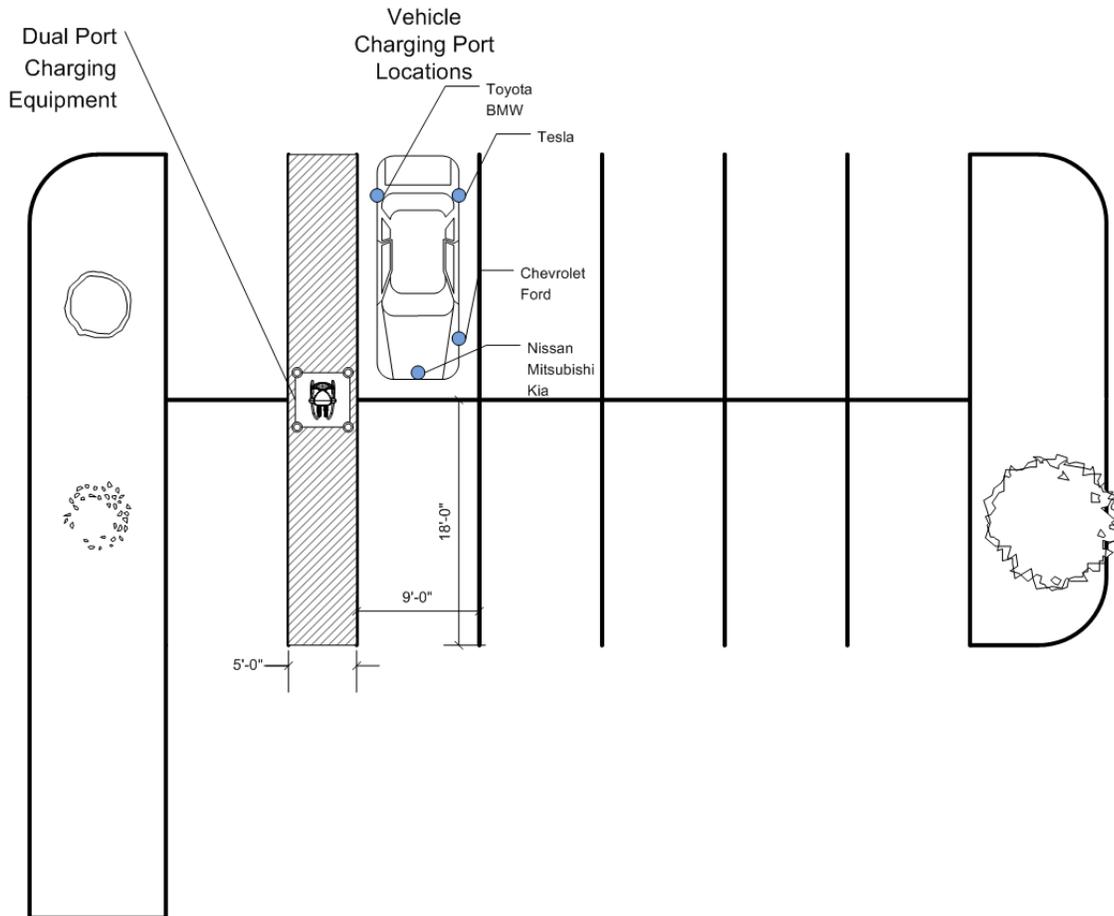


Figure 3.4 below shows an example layout of EV charging centrally located between parking aisles with the same typical parking stall dimensions of 9 feet wide by 18 feet long. This configuration can serve

several parking spaces depending on the length of the charging cord. Charging port locations for several vehicles are shown on the diagram.

Figure 3.4: Perpendicular Parking Lot Site Plan Example



3.4.2 Parallel Parking Spaces

Many suitable locations for EV charging may be located along highway rights-of-way where parallel parking exists or could be added. A number of regions in other parts of the country have installed curbside EVSE in these locations, however this layout is not recommended if other viable options exist since it is difficult to configure in a way that allows the cord to access multiple spaces, the charging inlet ports on the vehicles may be difficult to reach, highway maintenance work may damage the equipment and the cords may be more difficult to configure for save pedestrian access.

If parallel parking EV charging is the only choice, then the guidebook references above provide more information on specific considerations at these locations.

3.4.3 Parking Garages

Parking garages provide excellent opportunities for EVSE, with covered facilities protecting equipment and reducing

Figure 3.5: Parking Garage Example



snow removal needs. In addition, many garages have power available and wall or ceiling mounting options which reduce installation cost. Fees for EV charging can be included in parking costs – some manufacturers offer charging equipment payment systems which can integrate with garage tickets. Other installation considerations as detailed in the perpendicular parking section will generally apply.

3.4.4 ADA Requirements

The Americans with Disabilities Act (ADA) requires public parking areas to be accessible to users in wheelchairs or with other mobility limitations. The US Access Board establishes accessibility standards for public facilities, such as parking areas and fueling stations⁹, but has not yet taken action on specific ADA requirements for EV charging stations. In the absence of specific rules, the general accessibility requirements are expected to apply to EV charging installations.

The most common approach for construction of new EV charging locations is to adapt an existing parking space for use by EV owners. In some very limited cases this may allow EVSE hosts to avoid making the equipment accessible if it would technically infeasible or reconfiguring parking widths would reduce the number of parking spaces at the facility below requirements codified in local bylaws. If there are issues with providing a fully-accessible location, then components of ADA requirements should be met to the extent possible.

At this time, it should not be necessary to restrict use of accessible EV charging to disabled users only, but the general recommendation is to make the first charging space accessible. Several resources are available with additional resources on accessible charging station designs, including the following:

- <http://www.sustainabletransportationstrategies.com/wp-content/uploads/2012/09/Site-Design-for-EV-Charging-Stations-1.01.pdf>
- <http://www.sustainabletransportationstrategies.com/wp-content/uploads/2012/01/EV-Charging-ADA-Version-1.0.pdf>
- [http://www.theevproject.com/downloads/documents/EV%20Project%20-%20Accessibility%20at%20Public%20EV%20Charging%20Locations%20\(97\).pdf](http://www.theevproject.com/downloads/documents/EV%20Project%20-%20Accessibility%20at%20Public%20EV%20Charging%20Locations%20(97).pdf)

3.4.5 Snow removal considerations

In order to provide accessible operation of EVSE, a 3' by 3' (minimum) handicapped accessible operating area must be kept clear of vehicles and snow between the nose of the vehicle and the EVSE. Strategic placement of bollards, curbing, or wheel stops may be required to protect EVSE from vehicular impacts, while still providing accessibility and reasonably convenient snow removal. Many EVSE plans utilize wheel stops to prevent vehicle contact with the EVSE, but these can be problematic for snow removal, so bollard poles are often a better option in areas where snow may accumulate.

Several options below are presented for consideration to ease the snow removal, while maintaining accessible EVSE operations. While each of the following possibilities could significantly increase installation costs, this could be offset by operational cost savings in reduced maintenance needs.

⁹ <http://www.access-board.gov/guidelines-and-standards/buildings-and-sites/about-the-ada-standards>

Figure 3.6: Solar Photovoltaic EV Charging Canopy

Canopies. Covering the operating area with a roof structure or canopy would keep the operating area clear of snow, and reduce weather-related pavement damage. Canopies also offer large visible areas on which to raise awareness of the EVSE, and also incorporate solar arrays that provide power to the EVSE. There are turn-key solar canopies with built in level – 2 charging units that are currently being installed in other states.



Heated pavement. Providing sub-surface heating is another option to keep the EVSE operation areas free from snow and ice, as power will be available, easing installation. There are two types of heated pavement: hydronic and electric radiant. Electric radiant employs low-voltage mats installed under the pavement which are heated using electricity. Hydronic systems employ small tubing running underneath the pavement; in which heated water mixed with anti-freeze is circulated (the ambient soil temperature below the frost line is above 50 degrees). Installation and operational cost of these systems will need to be weighed against the savings in maintenance.

Retractable cable. Another option is a retractable cable that provides access to the EVSE cable with minimal snow removal. Many EVSE designs require users to manually wind and replace the cable after use. This may become difficult in cold weather when the cable becomes stiff, and may result in the cable being placed on the ground in or around the operating area. This exposes the cable to potential damage from vehicles and snow plows, and makes use difficult, particularly for disabled users. Figure 3.7 shows retractable cable units from EVSE LLC that are mounted on concrete pedestals and require no additional protection from snow and ice. Retractable cables are also more easily accessible for wheelchair users.

Figure 3.7: Retractable Cable for EVSE



3.5 EVSE Signage

While many EV users will find charging locations through their smart phones or onboard navigation systems, there is still a need for clear roadside signage for EVSE¹⁰. Many users may be visitors to Vermont who are unfamiliar with the area, and signage will help alleviate anxiety about finding a charging location. In addition, while many patrons may be able to find EVSE with their smart phones, cellular service is not uniform across the state, and gaps remain. Signage required for EV users include General Service signs (at interstate exits), “trailblazing” signs to lead the driver from an interstate or major highway to the EVSE, and regulatory signage and pavement marking that will indicate that the parking is restricted to EVs while charging.

With so few EVSE statewide, signage is an important component of EV infrastructure, and guidance is needed to direct patrons to EVSE locations. Policies and guidance for signage should strike a balance between the needs of those who may rely on the signs, and the potential difficult of finding appropriate places to install signs and funds to maintain them.

3.5.1 General Service Signs

The Manual on Uniform Traffic Control Devices (MUTCD) has adopted a standard sign symbol for EV charging stations, shown in Figure 3.8. If signs are desired for locations that only provide Level 1 charging, then a supplemental plaque denoting “Level 1” could be added beneath so drivers are aware of the limitations.

Figure 3.8: MUTCD Approved EVSE Symbol



3.5.2 Regulatory Signs

The final type of signage that is required is a regulatory sign to restrict use of the parking spaces to charging EVs only. The recommended practice in Vermont is to use language restricting parking “Except for Electric Vehicle Charging” to prevent instances of EV owners taking up charging spaces without actually plugging into the equipment. Enforcing this requirement in Vermont may require updates to municipal ordinances governing parking requirements.

Figure 3.9 Recommended Signage for EV Charging



3.5.3 Sign Vendors

There are many vendors offering standard highway signage prescribed by the MUTCD and recommended above. For convenience, two potential sources are listed below.

Stop Signs and More

<http://www.stopsignsandmore.com/p-925-d9-11b-ev-charging-station-symbol-signs-18x18.aspx>

<http://www.stopsignsandmore.com/p-1445-no-parking-symbol-except-for-electric-vehicle-charging-sign-12x18.aspx>

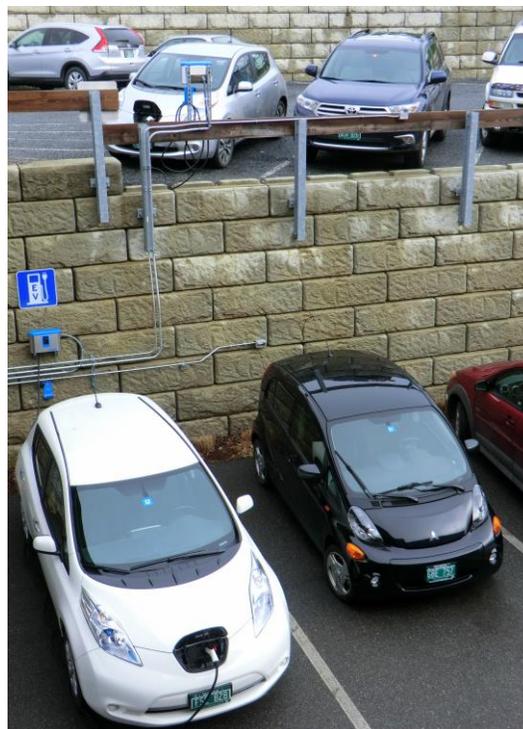
Traffic Sign Store (make sure to get the “alt” version of the sign with the plug showing)

http://store.trafficsignstore.com/merchant2/merchant.mvc?Screen=PROD&Store_Code=trafficsignstore&Product_Code=D9-11b-18EG&Category_Code=

¹⁰ The EV Project, 2012. Lessons Learned – EVSE Signage,

<http://www.theevproject.com/downloads/documents/Signage%20Initial%20Issue%204-20-2012.pdf>

The figure opposite is an example of the EV charging equipment installed at the CCRPC offices in Winooski with level 2 equipment wall mounted along with the standard MUTCD signage.



4 Charging Station Installation and Operating Costs

4.1 EVSE Installation Costs

Costs of EVSE installation vary widely depending on site characteristics and the quantity and type of EVSE being installed. Like any product, price is also influenced by the degree of competition amongst EVSE vendors and the ability of vendors to achieve economies of scale in service delivery. Equipment prices and installation costs are decreasing as EVSE became more prevalent, with particularly rapid cost reductions for Level 3 charging equipment.

Table 4.1 provides estimates of per unit costs for charging equipment. The different components of commercial EVSE costs include the equipment price from the vendor and installation which can include the following items:

- Power connection to the electric grid, including any electric circuit components and conduit runs necessary to reach the equipment;
- Mounting (wall mount generally less expensive than post mounted which require concrete pedestal);
- Protective devices, such as bollards or wheel stops
- Wayfinding signage, parking lot lines and stripes
- Lighting

- Internet connection if cellular data service not available
- Permitting

Table 4.1. EVSE Infrastructure Costs

	Level 1 AC – 1.4 kW	Level 2 AC – 3.3-6.6 kW	DC Fast Charging – 25-50 kW
Equipment Price	\$30-900 ¹¹ : Prices vary with system capability to monitor and charge for use.	\$600 - 9,000	\$15,000 – 60,000 ¹²
Installation	\$200-450	\$2,000-12,000	\$10,000 - 25,000
TOTAL	\$230-1,350	\$2,600-21,000	\$25,000 – 85,000

Installation cost estimates were obtained directly from experienced installers, such as Green Power Technologies and Peck Electric.

4.1.1 Reducing Installation Costs

Providing electrical service to parking spaces for EVSE can account for as much as 40% of installation costs.¹³ Installing EVSE simultaneously with parking lot resurfacing or new construction can reduce the costs of delivering electrical service to EVSE. Installing multiple EVSE simultaneously can also substantially reduce per unit cost of EVSE by nearly a third¹⁴ or more.

4.2 Operating Costs

EVSE operational costs include energy costs for power supplied to EVs, costs for ongoing remote monitoring services as well as maintenance costs for the equipment.

The most common maintenance issue for EVSEs nationwide is damage to the cords and/or J1772 connectors. Most manufacturers have modular equipment designs which allow for swapping out damaged parts, although UL requirements sometimes dictate replacing entire sealed modules rather than individual components to maintain certification after repairs, particularly for EVSE in outdoor environments.

Table 4.2 provides estimated operational costs of EVSE, including:

- Energy – electric utility costs for power supplied,
- Usage monitoring and point of sale systems – optional equipment to meter the amount of use in terms of energy, time charging, number of events, or other measure. This information can be especially useful in determining reasonable fees to recover costs at multifamily or commercial installation locations. The point of sale systems allow equipment owners to charge a fee for use based on credit cards or other payment systems;

¹¹ <http://www.pluginamerica.org/accessories>. Accessed 13 March 2013.

¹² Fuji Electric DC Quick Charger. Web 11 March 2013

<http://www.americas.fujielectric.com/sites/default/files/DC%20Quick%20Charging%20-%20FEA%20Comparison%20Study%20%20%2825kW%20vs%20%2050kW%29%207-3-12.pdf>.

¹³ Per conversation with Kip Myrick at Peck Electric, 19 February 2013.

¹⁴ Ibid.

- Maintenance, snow removal and insurance costs – These costs will be variable depending on the equipment, installation location and amount of use received. In general EVSE equipment requires minimal routine maintenance. Snow removal costs will vary widely depending on the design and need for hand clearing or other special practices. Insurance costs to extend coverage to EVSE will also depend on the owner’s policy and coverage.

Table 4.2. Annual EVSE Operational Costs

Cost Category	Level 1 AC – 1.4 kW	Level 2 AC – 3.3-6.6 kW	DC Fast Charging– 25-50 kW
Energy	\$200/year to \$800/year: Energy costs will vary depending on time of use and total use.	\$200/year - \$2,500/year: Energy costs will vary depending on time of use and total use.	Highly variable – depending on use and potential peak demand charges, which could reach \$12,000/year for a 50 kW DC Fast Charger
Usage monitoring and point of sale systems (optional)	\$400: One time cost for a monitoring and payment system device.	\$255/year: per charging port for access to software and network systems	\$255/year: per charging port for access to software and network systems
EVSE Unit Maintenance	\$400/year	\$400/year	\$400/year
Snow Removal	Varies	Varies	Varies
Insurance	Varies	Varies	Varies
Total	\$600+	\$1,200+	\$1,500+

4.3 EV Charging Cost Recovery Models

There are several potential EV charging business models, which are summarized in Table 4.3. Many of the models that allow for more revenue generation also have a larger administrative burden.

Table 4.3: Potential EV Charging Business Models

Business Model	Description
Subscription and/or fee for use	EVSE owner charges for use of individual stations or access to a network of stations for a specified period of time. This could be a one-time use or a monthly subscription.
Advertising based revenue generation	EVSE is designed to allow its owner to lease space for advertising messaging. May require additional review by local jurisdictions.
EVSE Paired with Renewable Energy Generation	Solar Photovoltaic installations can offset energy costs of EV charging through utility net metering arrangements.

4.3.1 Subscription and fee for use

A variety of models exist for generating revenue through billing users of EVSE. Of the models in practice currently, the most common are a membership based model and a pay per use model. Vermont and many other states do not allow unregulated utilities to sell electricity by the kWh, so unless there are changes to state statute, billing would be done based on time spent at an EVSE or through unlimited access for a fixed monthly fee. Examples of membership and pay for use business models include the eVgo Network operated by the private electric vehicle charging service company eVgo and the Plug-in EVerywhere program managed by Texas utility Austin Energy. eVgo offers subscription plans of \$29.99 to \$69.99 per month for a Level 2 charging installation. The operator avoids the upfront costs of the installation as well as the operation and maintenance costs and eVgo earns a return through the charging fees¹⁵. Austin Energy's Plug in EVerywhere program allows utility customers the ability to purchase a membership to a network of publicly accessible EVSE for a fee of \$5 per month or to use EVSE in their public charging network without subscription for \$2 per charge event. Austin Energy also works with private companies to install EVSE, offering to assume the cost of operation, management and energy costs for companies that install Plug-in EVerywhere EVSE on their premises.

4.3.2 Advertising based revenue generation

Vermont's sign law restricts off-premise advertising signs in the highway right of way which limits the potential for sales of advertising space on EVSE wraps to serve as a means of generating revenue through EVSE.¹⁶ However, advertising signage on EVSE that is located out of view of the highway targeted at customers, employees and visitors of a host establishment may be a viable means of generating revenue through EVSE depending on local sign ordinances. Price Chopper has pioneered this model in New York state with what it refers to as "alternative fuel pads", charging stations equipped with a canopy and space for advertisers to promote products within the store or of presumed interest to the supermarket's clientele. The model could function through direct ownership—as in the case of Price Chopper—or third party ownership. In a third-party ownership model, a vendor would install and operate the EVSE on the premises of the host.

4.3.3 Offsetting Energy Costs through Solar Photovoltaic Installations

Daytime charging of EVSE has the potential of increasing demand during hours of peak energy usage, causing strain on the power grid and, in turn, additional costs to utilities which may be passed down to rate payers. This is especially true in summer months which are typically peak usage times for electric power consumption. As EVs become more prevalent, utilities will likely continue developing variable time of use rates, using price signals to encourage charging during off-peak evening hours.

One means to ensure that installation of public EVSE does not result in costly impacts to the power grid is to pair EVSE with solar photovoltaic panels (PV). PV generates electricity during the day while the sun is shining which tends to be the same period of time that energy demand on the power grid reaches its peak and the cost of energy is at its highest. This feature of PV makes it a particularly valuable resource

¹⁵ eVgo Electric Vehicle Charging Solutions. *Charging Plans*. <https://www.evgonetwork.com/charging-plans/>.

¹⁶ Vermont Billboard Law, Title 10 V.S.A. Chapter 21, Section 481-506.
<http://www.leg.state.vt.us/statutes/sections.cfm?Title=10&Chapter=021>.

when connected with the power grid, a value which will be amplified in the years to come if EV charging during daytime increases.

Vermont law allows owners of grid connected photovoltaic systems to generate credit from the production of electricity that can be applied to a utility account. Because of the unique value of PV in mitigating peak demand energy costs, utilities are required by Vermont state law to offer customers a credit for power generated by grid-connected systems covering at the customers current rate plus an additional “solar adder” credit calculated as \$0.20 minus the utility’s highest residential rate.¹⁷ Currently law stipulates that this premium applies for the first 10 years of operation after which point credit will be valued at the utility’s highest residential rate.

The premium paid for PV generated energy accelerates the return on investment and implies the possibility that the value of PV could grow in the future if costs of peak energy demand increase. As widespread daytime use of EVSE may be a cause for increases in peak demand costs, pairing EVSE installations with PV is an ideal means of hedging against any rise in energy costs that may occur in the future.

To further enhance incentives for investing in PV, under current state and federal tax incentives, private companies with sufficient tax appetite can achieve upwards of a 10% return on investment over the course of a PV system’s life in the form of deductions from their utility bills. For non-profits and public sector entities that are not able to capitalize on tax benefits, a number of companies in Vermont offer power purchase agreements that enable hosts of solar arrays to receive compensation for use of roof space or open land by private investors in solar. In such arrangements, the host receives compensation for use of their space—either in the form of offsets to their energy costs, a lease payment or both—and the peace of mind that a substantial portion of the energy they use is offset by clean renewable energy with no upfront costs.

5 Charging Equipment Implementation

Previous chapters covered site selection, equipment recommendations and costs. The final steps to installing a new EV charging station are detailed below, including state and local permitting and installation options. Permitting procedures for EV charging are evolving over time as communities gain experience, so property owners are encouraged to check with local officials for current information before proceeding with installations.

5.1 State of Vermont Permitting

The Vermont Department of Fire Safety’s Division of Fire Safety (<http://firesafety.vermont.gov/professions/electrical>) administers the State Electrical Safety program, which includes Vermont’s electrical code requirements and the permit process for electrical equipment, including EV charging equipment, located on commercial or residential multi-family properties. Single family residential installations are exempted from this permit requirement.

¹⁷ Database of State Incentives for Renewables and Efficiency (DSIRE).
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=VT02R

State environmental permits may be necessary depending on site specific potential environmental impacts such as wetlands disturbances or stream crossings. For erosion or sediment control plans to be necessary, the area of disturbance needs to be 1 acre or greater.

Act 250 permits are usually only be required for large developments. If a property has an existing Act 250 permit, any construction or change triggers the need for an amendment. This process is streamlined for minor amendments - EVSE could be considered minor depending on the level of construction necessary.

A VTrans highway permit may be necessary if the charging station will be located in the state right-of-way or if construction will encroach on the right-of-way:

http://vtransengineering.vermont.gov/sections/right_of_way/utilities_and_permits

State permit specialists are available for guidance on what permits may be required at specific locations:

http://permits.vermont.gov/faq/anr_dec_pslocator

5.2 Municipal Permitting

The Appendix includes summaries of permit requirements for EVSE installations in Chittenden County municipalities. In general most communities do not require permits for EV charging installed inside residential single family garages. Charging stations on the exterior of the house may require a permit depending on the community. Most multi-family and commercial property locations will require a minimum of an administratively processed permit and in cases where new curb cuts or changes to traffic circulation are necessary there may be more significant review requirements needed, such as Development Review Board approval. The Appendix also contains suggested language for municipal bylaw updates intended to streamline future EVSE installation if adopted by the community.

5.3 Installation Checklist

5.3.1 Single Family Home Owners

- State and Local Permitting as Required
- Construction / Implementation Options
 - Have dealership or manufacturer partner take care of everything
 - Hire an electrician contractor to complete installation
 - DIY an option in most Vermont communities
 - Check local permit requirements *[see Appendix]*

5.3.2 Multi Family Home Owners and Tenants Associations

- State and Local Permitting as Required
- Construction / Implementation Options
 - Develop plan and hire an electrician to construct
 - Hire a turnkey service provider to handle installation process
- Complete any applicable local permitting processes
- Install and commission equipment

5.3.3 Public and Private Parking Areas

- State and Local Permitting as Required
- Construction / Implementation Options
 - Develop plan and hire an electrician to construct
 - Hire a turnkey service provider to handle installation process
- Complete local permitting process
- Install and commission equipment
- Notify Drive Electric Vermont¹⁸ of new charging station availability

6 Appendix – Chittenden County Municipal Permitting Requirements

¹⁸ <http://driveelectricvt.com/contact-us>