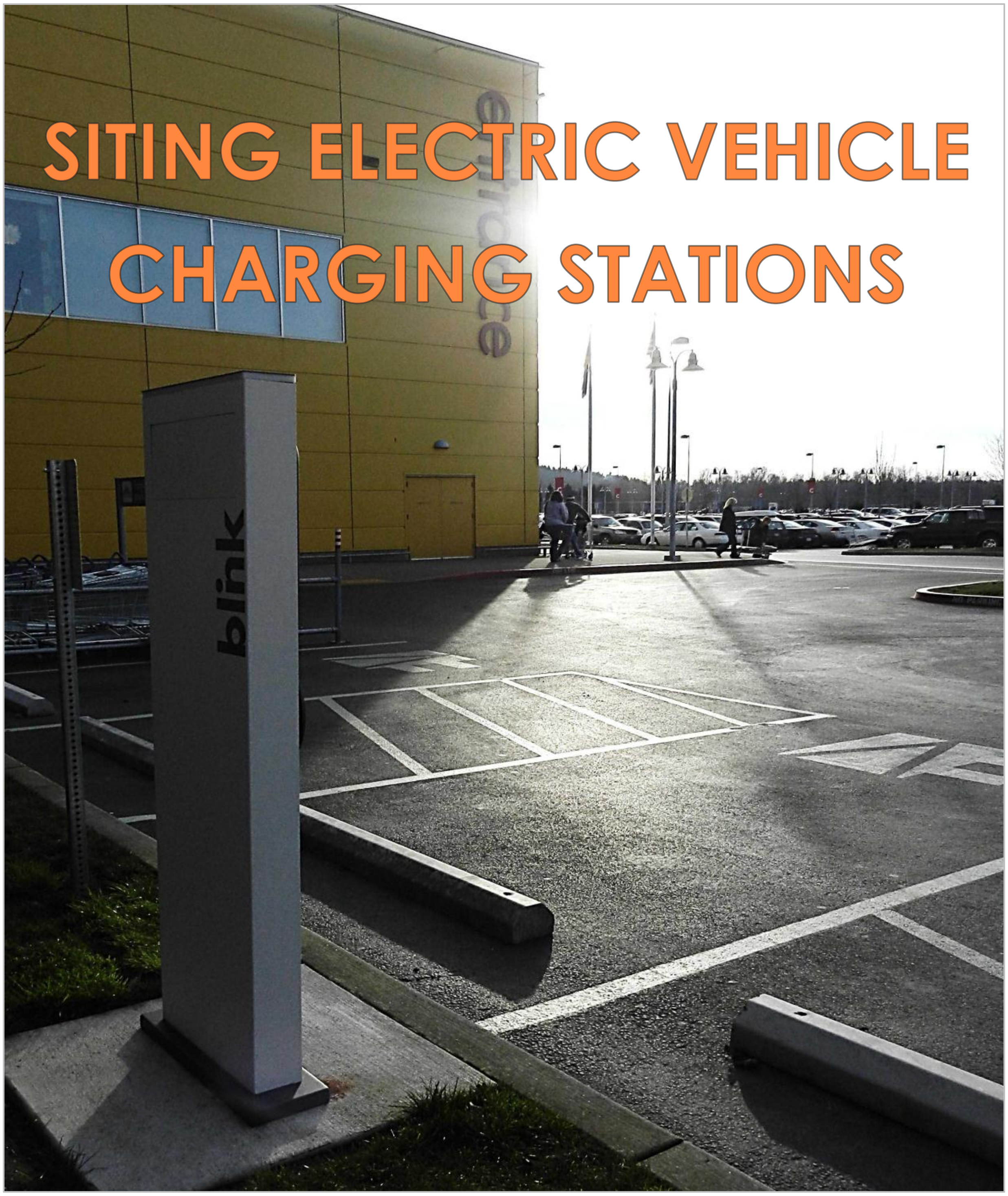
SITING ELECTRIC VEHICLE CHARGING STATIONS



CleanFuelsOhio

Virginia Clean Cities

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SITING ELECTRIC VEHICLE CHARGING STATIONS

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Prepared by: **Sustainable Transportation Strategies**

Author: David Mayfield

Editor: Carlotta Collette

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1.1 SUMMARY

Conventional vehicles have a wide network of gas stations to keep fueled. What do electric vehicles (EVs) need to ensure comparable predictability? This reports offers guidance on how and where to install equipment to keep electric vehicles powered up and running reliably. The report describes three levels of equipment that will be used to charge battery-powered electric vehicles. All three levels – from simple, low-cost Level 1 electric vehicle supply equipment (EVSE) to DC fast chargers – will be installed to help deploy the range of vehicles that are being introduced.

Most attention over the past few years has focused on electric automobiles. This report acknowledges the need to provide charging equipment for the other EVs that are under design or being manufactured, including electric-assisted bicycles, personal mobility devices, buses, vans and trucks.

The majority of people that drive EVs will recharge their vehicle overnight. Nonetheless, studies show that almost half of the population does not park at home near a source of electricity. The lack of available electricity is most prevalent for those that live in multi-unit housing. This report discusses a range of options that will improve EV charging options at multi-unit housing and in nearby neighborhood settings. It also explains how charging opportunities at the workplace and in public locations can support the rollout of electric vehicles.

Land use types and travel patterns will determine the most effective mix of EV supply equipment. Average trip lengths can be supported with Level 1 and Level 2 EV supply equipment, while DC fast chargers will become especially important along intercity routes and at regional destinations.

Lastly, this report considers common factors to consider while siting a charging station on a specific property, such as connecting to electrical power, power capacity, network communications, integrating with existing and new infrastructure, and environmental conditions.

1.2 ELECTRIC VEHICLES AND THEIR SUPPLY EQUIPMENT

Most people in the United States are at least vaguely aware of the electric car because of media coverage. Fewer people know that almost every kind of vehicle produced over the past 20 years now has a plug-in electric version – including electric-assisted bicycles, personal mobility devices, automobiles, vans, buses and trucks (see Figure 1).

This range of battery-powered electric vehicles serves many applications at industrial sites, business and educational campuses, within neighborhoods, and at citywide or intercity levels.

FIGURE 1: ELECTRIC TRUCK AT EV CHARGING STATION

Plug-in hybrid electric vehicles (PHEVs) that utilize both electric and internal combustion engines are also commercially available. The siting of charging facilities needs to take into account this wide range of vehicles needing access to electricity.

One key to creating a significant market for EVs will be provision of adequate charging facilities. Battery charging must be reliable and convenient. Technological improvements to Lithium-Ion (Li-Ion) batteries have advanced electric propulsion over the past decade. The marketplace still supports the use of Nickel Metal Hydride and Sealed Lead Acid batteries, but mostly for PHEVs and lightweight EVs such as electric-assisted bicycles and scooters. Battery designs trade off cost, energy storage, power, weight, longevity, and safety. Li-Ion batteries provide relatively good power performance, energy storage density, rapid charge capability and a long life span, but are also relatively expensive.

EV charging standards are being developed for three levels of alternating current (AC) and three levels of direct current (DC).[1]

In the near term, EVs will use the following three categories of EV supply equipment classified according to power levels and circuit requirements:

- AC Level 1, up to 120-volt single-phase circuit with either 15-ampere (amp) or 20-amp configuration.
- AC Level 2, 208-volt to 240-volt single-phase circuit with an 80-amp maximum but often using 40-amp rated circuits (see Figure 2).
- DC fast charger, converts AC power levels rated at 208 volts to 480 volts (3-phase) to DC power to deliver up to 50 kilowatts at the EV's battery voltage (see Figure 2).

Both Level 1 and Level 2 EV supply equipment are sometimes misidentified as being EV chargers. The EV supply equipment's main purpose is to deliver power to a manufacturer-provided charging module, or charger. Chargers are supplied on board electric cars. Some lightweight EVs have external chargers attached to a power cable while others have an on-board charger similar to electric cars. The chargers convert AC to DC and deliver power to the battery according to manufacturer-specified rates (typically expressed as kilowatts). In contrast, DC fast chargers bypass the manufacturer-provided chargers to directly deliver power to the vehicle's battery.

FIGURE 2: LEVEL 2 EV SUPPLY EQUIPMENT (LEFT) AND DC FAST CHARGER (RIGHT)

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[1] Francfort, Jim. (2010, December). Electric Vehicle Charging Levels and Requirements Overview; Clean Cities Webinar; Idaho National Laboratory.

Level 1 EV supply equipment can recharge the battery of an electric car within 4 to 6 hours if it is driven less than 30 miles per day. Level 1 charging is also suitable for charging the small batteries of EVs such as The Segway® Personal Transporter (see Figure 3).

For Level 1 charging, vehicles plug into a typical electrical outlet (NEMA 5-15R or 20R) using a portable cable set supplied by the vehicle manufacturer. Most automobile manufacturers provide Level 1 cables outfitted with a J1772 connector, the same standard utilized for Level 2 charging. Since 120-volt circuits are so ubiquitous, Level 1 EV supply equipment is the easiest and least expensive type to install.

FIGURE 3: SEGWAY® PERSONAL TRANSPORTER

Photo courtesy of Segway Inc.

Level 1 charging is inconvenient for completely recharging large battery packs found in trucks and many electric cars. Fully depleted, a 24-kilowatt-hour battery could require 15 to 20 hours to charge using Level 1 EV supply equipment.[2] Level 2 EV supply equipment can fully recharge the same battery in less than 4 hours.[3]

Level 2 EV supply equipment operates on circuits with a capacity similar to those that run appliances, such as electric ovens and clothes dryers. Some Level 2 equipment used at commercial sites runs on circuits rated at up to 80 amps. Level 2 EV supply equipment and DC fast chargers have the charging cable and connecter permanently affixed, as shown in Figure 2.

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[2] Electric Transportation Engineering Corporation. (2010, April). Electric Vehicle Charging Infrastructure Deployment Guidelines for the Oregon I-5 Metro Areas of Portland, Salem, Corvallis and Eugene.

[3] This assumes the battery is connected to a charging module using a 6.5-kilowatt rate

The Society of Automotive Engineers' J1772 connecter that attaches the Level 2 charging station to the vehicle is the U.S. national standard (see Figure 4). Almost all automobile manufacturers selling cars in the U.S. support it.

FIGURE 4: J1772 CONNECTOR

DC fast chargers will be important to drivers who need to quickly recharge their depleted batteries. Using fast chargers, most vehicles will recharge up to 80 percent of capacity in a ½ hour or less.

DC fast charging is just beginning to become available to consumers in the U.S. Currently two car companies offer fast charging inlets as an option on their vehicles imported to the United States: Nissan and Mitsubishi. Both use the Japanese CHAdeMO connector. The Society of Automotive Engineers has not yet ruled on what will become the connector standard for fast charging in the U.S. The lack of a U.S. standard is likely affecting the rollout of vehicles that use fast charging technology.

DC fast chargers create substantially more power demand than Level 2 EV supply equipment. However, a battery buffer combined with a DC fast charger can help reduce power demand. By using a battery buffer, a DC fast charger can deliver up to 50 kilowatts to an EV while maintaining a 20-kilowatt draw from the grid.[4]

Many brands of EV supply equipment include advanced electrical metering and communication network connections. Networked EV supply equipment with meters can perform a number of services including "smart grid" applications. As an example, utilities can send signals that reduce the rate of EV charging when grid loads are high or initiate charging when electricity costs are low. Better control of electrical flow by location and time is likely to make smart grid applications profitable for both utilities and consumers.

[4] Buffer Battery 50 KW DC Fast Charger Specifications. (2012, March). Found at www.evcollective.com/charger/BB50KW.html.

1.3 EV CHARGING: USER NEEDS

Battery electric vehicles rely on recharging equipment placed at homes, employment centers, and parking facilities at public places. A large majority of EV drivers recharge their vehicles during the night. This coincides with the greatest electrical grid capacity. Those who cannot depend only on home-based charging are: 1) people who have inadequate access to overnight charging, 2) those who are traveling near or beyond range of the vehicle, and 3) commercial vehicles that have daytime work-related charging needs.

RESIDENTIAL

As of December 2011, the federally funded EV Project reported that 96 percent of all charge events on Blink network EV charging equipment occurred at residential locations. [5] A 2010 web-based study of 152 EV drivers indicated a lower number – 81 percent – charging at home.[6] Future studies are likely to validate that most recharging will occur at home even with a more complete public charging station network in place. But many residences do not have adequate facilities for charging EVs. A survey of more than 2,000 new vehicle buyers in the U.S. concluded that almost half do not have access to an electrical connection (110-volt service or greater) within 25 feet of where they park at home (including single unit and multi-unit dwellings).[7]

Studies of electrical vehicle charging behavior in the U.S. show that the majority of people who use home charging do so during evening hours, with highest plug-in rates between midnight and 6 a.m.[8] The EV Project reported that as of December 2011, study participants plugged their cars into Level 2 EV supply equipment an average of about 7 hours per day. However, the actual charging duration was low, averaging less than 2 ½ hours per day.[9] This indicates a low need for Level 2 charging. EV owners who drive less than 30 or 40 miles per day may find that Level 1 EV supply equipment is sufficient for charging vehicles overnight at their residence.

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[5] ECOtality NA. (2012). The EV Project Q4 2011 Report.

[6] Plug in America. (2010, May). Memorandum to Puget Sound Regional Council and Washington State Dept. of Commerce. Appendix D of Electric Vehicle Infrastructure: A Guide for Local Governments in Washington State.

[7] Axsen, Jonn and Ken Kurani. (2008, August). The Early U.S. Market for PHEVs: Anticipating Consumer Awareness, Recharge Potential, Design Priorities and Energy Impacts. Institute of Transportation Studies, University of California at Davis.

[8] Smart, John et al. (2010). Electricity Demand of PHEVs Operated by Private Households and Commercial Fleets: Effects of Driving and Charging Behavior, 25th World Battery, Hybrid and Fuel Cell Electric Vehicle Symposium & Exhibition, 2010.

[9] ECOtality NA. (2012). The EV Project Q4 2011 Report.

SINGLE UNIT DWELLINGS

A web-based survey conducted of new vehicle buyers found that about 46 percent live in a single unit dwelling and park within 25 feet of an electrical outlet.[10] In this survey, the highest number of new vehicle buyers who could recharge at home had attached garages.

Many of the electrical circuits near parking supply up to 120 volts, a rate that is only adequate for Level 1 charging. Use of a 120-volt outlet requires no special EV supply equipment. EV owners plug a cord set into a NEMA 5-15R or NEMA 5-20R outlet. Circuits often have multiple outlets. Charging an electric car could use most of a circuit's capacity, leading to overload when other devices are also operating on the same circuit. The charging of small EVs like electric bicycles, however, can share a circuit with other uses.

EV drivers that regularly travel long distances and have high capacity batteries likely will install a Level 2 charging station. Installation costs can easily exceed the cost of the Level 2 EV supply equipment itself.

Many states require Level 2 EV supply equipment to be hard wired directly to an electrical panel. However, some Level 2 EV supply equipment is designed to be plugged into a receptacle on a dedicated 240-volt circuit. Renters that own EVs may favor this style because the equipment can be unplugged and moved at end of lease. If a hard-wired circuit to the EV supply equipment is required, renters might be able to amend their lease to allow for installation and removal of the equipment.

Some utilities are starting smart grid projects. Single unit dwellings are easy to incorporate into smart grids for EV owners that wish to participate because:

- Each house is individually metered.
- Single families usually own or rent each house.
- EVs can remain plugged in for many hours beyond what is needed for recharging.

MULTI-UNIT DWELLINGS

Incorporating EV supply equipment in multi-unit dwellings is more complicated than in single unit homes. Few parking places at multi-unit dwellings have available electrical outlets. A recent survey reports that only 17 percent of new car buyers who live in apartments park their car near an electrical outlet.[11] Most of the parking at multi-unit dwellings with available electricity only has access to 120-volt power; this is only suitable for Level 1 charging.

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[10] Axsen, Jonn & Kurani, Ken. (2008, August). The Early U.S. Market for PHEVs: Anticipating Consumer Awareness, Recharge Potential, Design Priorities and Energy Impacts. Institute of Transportation Studies, University of California, Davis.

[11] Smart, John et al. (2010) Electricity Demand of PHEVs Operated by Private Households and Commercial Fleets: Effects of Driving and Charging Behavior. Idaho National Laboratory.

Non-resident owners may have few incentives to justify potentially expensive installations. Property managers and residents may lack the authority to approve equipment installations.

Assigned parking is typical at multi-unit dwellings. Even in densely populated New York City about half of all cars use assigned residential parking.[12] This presents a problem since assigned parking is usually not near the car owner's electrical meter and electrical panel.

Some buildings have more flexibility than others to exchange parking places. Parking in multi-unit dwellings comes either bundled (cost included in with the dwelling) or unbundled. Some condominiums attach a specific parking place to the condominium owner's deed. All this affects siting choices for siting EV charging stations and methods of cost accounting.

Adding the first one or two EV charging stations at multi-unit dwellings may utilize much of the existing electrical capacity. Future installations would then encounter higher costs to upgrade the infrastructure. Property owners and condominium associations need to fairly assign costs to EV owners because retrofitting electrical panels and conduit can be expensive. Providing charging stations for residents of older multi-unit dwellings generally proves most difficult. Older buildings typically were built with few off-street parking spaces – and by today's standards, little electrical capacity.

Multi-unit dwellings have main electrical panels and meters for customers clustered in centralized locations. Adding sub-meters and panels near already crowded equipment may be difficult (see Figure 5).

FIGURE 5: TYPICAL ARRAY OF METERS AT A MULTI-UNIT DWELLING

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12 New York City, Mayor's Office of Long-Term Planning and Sustainability. (2010, January). Exploring Electric Vehicle Adoption in New York City.

These issues can be resolved by dispersing locations of new sub-panels, and utilizing EV supply equipment that includes sub-metering. Another approach would be to not use existing meters and install one or more new meters and electrical panels connected directly to utility-owned transformers that are on the property or on adjacent public right-of-way.

The following potential solutions are offered to help provide charging capabilities to residents of multi-unit dwellings:

- Get professional advice or utilize educational materials to assist both property owners and residents in understanding the legal barriers and solutions to installing charging stations and fairly assigning costs. Your local Clean Cities coordinator may be able to help (for more information, visit www.cleancities.energy.gov).
- If parking can be reassigned, locate the EV parking in clusters where installation is least expensive.
- Prioritize 120-volt service to assigned parking where cost of installation is relatively low.
- Place Level 2 charging stations at unassigned parking that will be shared. A number of sharing models will develop including networks to attribute costs and schedule appointments.
- For shared EV charging stations, use a service that charges hourly rates while the vehicle is plugged in. This will encourage moving the vehicle after charging and allowing another EV user to park and charge.
- Install Level 2 charging stations where the cable can reach more than one parking place.
- Run a new service from the electrical utility nearest parking and install EV supply equipment with the capability of tracking costs for each user.
- Consider off-site locations in the neighborhood for EV charging (see Neighborhood Charging below for more information).

PUBLIC LOCATIONS

Publicly available EV charging stations are located on a variety of properties owned by private, public, or nonprofit entities. EV owners seek to charge at public locations for the following reasons:

- As a primary or secondary charging source for those with inadequate home charging capabilities.
- To provide a quick recharge for people who have depleted their battery and need to return from a trip.
- To boost the battery charge for the driver who is planning ahead and does not immediately need the extra range.

Level 1, Level 2, and DC fast charging equipment are all relevant for specific public charging needs. Siting of Level 1 and Level 2 EV supply equipment differs from DC fast charging because of substantial difference in charging duration. For Level 1 and Level 2 charging, a driver typically will leave the charging station for 1 to 3 hours. Level 1 and Level 2 EV supply equipment should be located near a destination where activities appropriately fit the waiting period, such as:

- Shopping centers
- Sports stadiums
- Conference centers
- Casinos
- Schools
- Museums
- Theaters
- Restaurants and bars
- Tourist attractions
- Offices
- Hotels
- Parks

Planners are encouraged to combine Level 1 and Level 2 EV supply equipment at public charging stations as shown in Figure 6. This provides a back-up "trickle charge" option for electric vehicle drivers who arrive at the station and find the Level 2 EV supply equipment in use. It also increases the number and diversity of vehicles that are likely to use the station.

Drivers who use DC fast chargers will plug in for approximately 10 minutes to 30 minutes and likely will stay at or near the vehicle. Planners should locate fast chargers along major highways and also within a few miles of regional destinations at places with available grid capacity with at least a 480-volt AC three-phase circuit. The most convenient sites will accommodate indoor waiting during fast charging. Potential locations include coffee shops, restaurants, and convenience stores. Sites would benefit by having staff to assist persons with disabilities who cannot lift the cable and connector.

FIGURE 6: EV CHARGING STATION WITH LEVEL 2 AND LEVEL 1 EV SUPPLY EQUIPMENT

Photo courtesy of Virginia Clean Cities

Commercial charging network providers will seek to install EV supply equipment at high-usage locations that are likely to prove profitable, such as the large retail store shown in Figure 7.

FIGURE 7: DC FAST CHARGER AT RETAIL STORE

Charging stations in the public right-of-way can access electricity where utilities have power lines and transformers. Connecting via the utility's infrastructure usually necessitates a new meter and panel – and potentially adding a new transformer.

Parking that is angled or perpendicular to the traveled way provides the best protection to the charging equipment and the public (see Figure 8). Parallel parking along the street poses safety issues unless the parking is inset into a curbed area that separates the vehicle from the traveled way. EV manufacturers have not standardized which side of the vehicle has the recharging inlet. With parallel parking, the J1772 connector can be exposed to traffic. The cable could pose a risk to passing bicycles or pedestrians on the street side of the vehicle.

FIGURE 8: LEVEL 2 EV CHARGING STATION AT ANGLED PARKING IN RIGHT-OF-WAY

Information to help EV drivers locate charging stations remains insufficient. Drivers are reported to have difficulty locating public charging stations and, if they are not adequately signed, are unsure if they are available for public use.[13] Some communities have improved this situation. For instance, advocates of EVs have placed signage and mapped availability of Level 1 charging stations in Olympia, Washington (see Figure 9). However, some of these stations remain difficult to find due to the lack of way-finding signage.

FIGURE 9: LEVEL 1 CHARGING STATION WITH SIGNAGE

[13] Smart, John et al. (2010). Electricity Demand of PHEVs Operated by Private Households and Commercial Fleets: Effects of Driving and Charging Behavior. Idaho National Laboratory.

The federal government now maintains a web site showing locations of all levels of publicly available EV supply equipment.[14] Smart phone mapping applications also help drivers locate nearby charging stations. Regardless of these internet tools, additional signage to guide drivers to EV charging stations is needed.

The EV Project helped standardize public charging station use by issuing deployment guidelines.[15] The Guidelines recommend that publicly available Level 2 EV charging stations be signed "No Parking Except for Electrical Vehicle Charging." However, compliance is limited without having the support of local ordinances and enforcement (see Figure 10).

Much still needs to be learned about actual needs and behavior of EV drivers. Public charging stations, still few in number, are in the process of initial rollout. Early results from the EV Project show that only 4 percent of charging events associated with that project occur at public locations.[16]

FIGURE 10: UNAUTHORIZED USE OF EV CHARGING STATION

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[14] See http://www.afdc.energy.gov/afdc/locator/stations

[15] Electric Transportation Engineering Corporation. (2010, April). Electric Vehicle Charging Infrastructure Deployment Guidelines for the Oregon I-5 Metro Areas of Portland, Salem, Corvallis and Eugene.

[16] ECOtality NA. (2012). The EV Project Q4 2011 Report.

REGIONAL TRIPS, REGIONAL DESTINATIONS

Some EV advocates believe that the success of EVs rests in their ability to conveniently conduct regional trips where drivers tend to travel longer than average daily distances. Data show that most people take long-distance trips for pleasure (56 percent), business (16 percent) and commuting (13 percent).[17] The majority of these trips go to regional destinations that offer services, goods, and experiences that attract visitors from other cities, regions, and states.

Many EVs entering the market are suitable for regional trips. Their drivers will utilize Level 2 EV supply equipment or DC fast chargers to recharge for the return trip. Needs for long-distance drivers could be met by a network of DC fast chargers located at major destinations and also along high-volume roads like interstate freeways and state highways. Recent installations by Oregon Department of Transportation along Interstate 5 serve as the beginning of such a network.

Planners of EV charging stations at regional destinations have many siting choices. Finding sites near electrical panels, existing conduit, transformers, and utility-owned service lines is typically not difficult and not likely to conflict with issues like the safety and comfort of charging station users.

As a consideration to the general public, most studies recommend not placing EV charging stations in the most high-demand parking spaces within parking facilities until there is a significant rise in number of EVs. This will reduce resentment caused when EV charging stations remain empty while surrounding parking is completely full. As an exception, EV charging for persons with disabilities needs to be located near an entrance to the destination.

CITYWIDE TRIPS

Travel behavior suggests that most trips in the U.S. go to regularly visited destinations near home. U.S. drivers make about 3 trips per day, resulting in a national average daily distance of 29 miles. Trip types include errands and shopping (45 percent), recreation and socializing (27 percent), and commuting (15 percent).[18]

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[17] US Bureau of Transportation Statistics. (accessed 2012, January) National Household Travel Survey Long Distance Travel Quick Facts. Found at: http://www.bts.gov/programs/national_household_travel_survey/long_distance.html

[18] U.S. Bureau of Transportation Statistics. (accessed 2012, January) National Household Travel Survey Long Distance Travel Quick Facts. Found at: http://www.bts.gov/programs/national_household_travel_survey/long_distance.html

Electric cars and plug-in hybrid cars can easily handle these trip lengths. Other types of small, lightweight EVs also have adequate range for citywide trips. These include electric bicycles, urban EVs, and neighborhood EVs such as the one shown in Figure 11.

FIGURE 11: NEIGHBORHOOD EV USING A LEVEL 1 CHARGING STATION

To serve these local, mostly short trips, EV infrastructure planners can focus on Level 2 and Level 1 EV supply equipment. Park-and-Ride lots for carpooling and transit offer an excellent place for a mix of Level 1 and Level 2 charging stations since the length of stay at these locations often lasts 4 or more hours. The lightweight EVs such as electric-assisted bicycles would benefit from having dedicated spaces for public charging that are protected from the weather and offer security from theft.

Assuming that DC fast chargers are planned for regional destinations and major travel corridors, plans for additional DC fast chargers associated with city-level trips should consider gaps in geographic coverage and the special needs of electric delivery vehicles, taxis, vehicle rentals, and car-sharing services.

NEIGHBORHOOD CHARGING

Many people do not have access to electricity where their car is parked at their residence, so they need alternative charging options nearby. A number of options exist.

A survey conducted in New York suggests that people identified as likely early adopters of EVs would be willing to park away from their homes and pay more for assigned parking with charging capabilities. Over half of the early adopter respondents said they would be willing to switch parking to a commercial garage convenient to their home, while less than 37 percent of the general population said they would.[19] EV adoption will be best encouraged by making neighborhood charging as convenient and close to housing as possible.

Property owners can rent spaces to nearby residents for at-will charging. Apartment owners could add the convenience of EV charging as part of the service package (along with fitness centers and laundry facilities) associated with the property. The property owners could utilize one of the existing private networks to handle scheduling of patrons and payments for charging. Similar arrangements for charging station installations could be made with adjacent properties such as:

- Churches
- Public schools
- Libraries
- Government offices
- Parks
- Neighborhood retail and office centers
- Industrial property
- Private parking facilities

These parking places are often underutilized at night. Community leaders could help negotiate such installations.

Finally, EV owners can contribute financially towards the installation a fast charger on-site or in the neighborhood. A user fee structure can be set by the connection/minute.

EMPLOYMENT CENTERS

EMPLOYEE PARKING

Almost half of new vehicle purchasers cannot find available electricity near their home parking. The siting of EV charging stations at employment centers could help resolve this problem except that most parking at work also lacks access to electricity.

[19] New York City, Mayor's Office of Long-Term Planning and Sustainability. (2010, January). Exploring Electric Vehicle Adoption in New York City.

A recent survey of employed, new vehicle purchasers reported that only about 6 percent of the respondents found electrical outlets near parking at work.[20]

Of all U.S. workers, 86 percent commute to work in a car, van, or truck.[21] A 2010 web-based survey related that almost 40 percent of EV drivers would be more likely to commute in their EVs if charging stations were available at the work site.[22] A long commute in an EV might make charging at work a necessity.

A combination of Level 1 and Level 2 charging would meet current needs for employee parking. Since workers usually park vehicles for 8 hours, most of them will find that Level 1 charging is adequate.

Employers and employment center owners may need financial incentive to install EV charging stations for workers. If so, they can contract with a charging station network service that will supply equipment and assign costs to the charging station users.

Charging stations at work can be assigned to specific individuals, or placed at unassigned parking where a reservation system can be employed if necessary. For some sites, it may be appropriate to mix employee and visitor use of unassigned EV charging stations and thereby increase availability and usage.

FLEET VEHICLES

Organizations are beginning to add electric passenger cars, vans and trucks to their fleets. Electric fleet vehicles are especially well adapted for running regular routes where battery capacity can be matched to need.

In 2009, researchers conducted a study of PHEV usage including 153 fleet vehicles distributed to many organizations located primarily in the U.S. The PHEVs were equipped with a 5-kilowatt-hour battery pack and Level 1 charging capabilities. Their research found the following:

- Fleet drivers traveled further than home use counterparts (48 miles per day).
- The fleet vehicles were recharged at multiple locations, contrasting with home charging behavior of individuals. This can partly be explained by vehicles being used by businesses having more than one location.
- Highest power demand occurred weekdays between 2:00 p.m. and 7:00 p.m. [23]

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[20] Axsen, Jonn & Kurani, Ken. (2008, August). The Early U.S. Market for PHEVs: Anticipating Consumer Awareness, Recharge Potential, Design Priorities and Energy Impacts. Institute of Transportation Studies, University of California, Davis.

[21] McKenzie, Brian & Rapino, Melanie. (2011, September). Commuting in the United States: 2009. U.S. Census Bureau.

[22] Plug in America. (2010, May). Memorandum to Puget Sound Regional Council and Washington State Dept. of Commerce. Appendix D of Electric Vehicle Infrastructure: A Guide for Local Governments in Washington State.

[23] Smart, John et al. (2010). Electricity Demand of PHEVs Operated by Private Households and Commercial Fleets: Effects of Driving and Charging Behavior. Idaho National Laboratory.

This conclusion about power demand is consistent with the schedules of many local freight distribution runs that begin before morning rush hour and end by mid-afternoon. Unfortunately, high power demand for vehicle recharging coincides with peak use of electricity for other uses. Whenever feasible, charging for regularly used fleet EVs should occur during off-peak hours (typically overnight) to ensure operational readiness; this can be accomplished using smart EV charging equipment and vehicles that best match routing patterns. Utilities can promote off-peak charging through variable electricity rate schedules.

Installing a cluster of charging stations as shown in Figure 12 can require substantial electrical upgrades including a new transformer.

FIGURE 12: TRUCKS USING LEVEL 2 EV SUPPLY EQUIPMENT

Managers of this Frito-Lay distribution plant, located in an industrial zone, reported no difficulty getting adequate service from the electrical grid to the site. The site employs 20 Clipper Creek EV supply units using 240-volt, 80-amp circuits.

MEETING USER NEEDS

The following summary addresses user needs identified in this section:

1. EV owners should assess the distance that they typically drive to determine if they need Level 2 charging at home. Level 1 EV supply equipment can recharge the battery of an electric car within 4 to 6 hours if it is driven less than 30 miles per day.
2. People who live in multi-unit dwellings are more likely to have difficulty finding a source of electricity near where they park. There are many potential solutions, and these will require collaboration between and among property owners and residents.
3. As an alternative to expensive, multi-unit dwelling installations, consider off-site shared installations. Community leaders could help negotiate placement of neighborhood charging stations for EV owners who cannot recharge at home.
4. All levels of EV supply equipment have value in supporting the range of vehicle types that will use public charging. Over the next few years, Level 1 and Level 2 EV supply equipment will serve most needs.
5. For safety reasons, charging stations located in road right-of-way should be sited where diagonal or perpendicular parking is available (rather than at parallel parking).
6. Focus DC fast charger installation along intercity routes, near regional destinations, and at places frequented by high-use commercial vehicles.
7. EV drivers will use EV charging stations where they work. They may want to charge during the day because of a long commute or if they did not fully recharge overnight or on the weekend.

1.4 FACTORS AFFECTING SITING OF CHARGING STATIONS

Once a property owner or other decision maker determines to install an EV charging station on a specific property, where should it be sited? Several common factors help shape the decision.

CONNECTING TO ELECTRICAL POWER

There are a number of options for how and where to connect EV supply equipment to electrical power. In many cases, the simplest choice is to attach a new dedicated circuit to existing service at an electrical panel on the site. Utilities own the electrical equipment up to and including the meters used to record electrical use. Connecting to the utility meters are one or more electrical panels that distribute electricity to various branch circuits rated according to voltage and amperage. Circuit breakers in the panels ensure safety from circuit overload, short circuit, and ground fault.

EV supply equipment should connect on a dedicated circuit to an electrical panel. This usually involves installation of new conduit from the EV supply equipment to the panel. Costs tend to rise as the distance from the panel to the EV supply equipment increases. If available parking lies more than 50 feet from existing meters and panels, installers should evaluate additional choices. For example, utilities have the potential to bring new service either from existing transformers (Figure 13) found on the site or from a new transformer installed on, or near the property (such as in adjacent right-of-way).

FIGURE 13: EXISTING TRANSFORMER NEAR POTENTIAL EV CHARGING STATION

Near-term installations can maximize use of existing infrastructure to achieve the most benefit for least cost. However, this will likely constrain where EV charging will occur on the site.

Plans to supply fast charge capabilities to a property often require new connections to utility-owned service on or off the property.

POWER CAPACITY

The power load caused by EV charging corresponds to the type of equipment being used and the number of EVs being charged at the site.

Power capacity is usually a minor, localized issue with Level 1 EV supply equipment. Many facilities already have the 120-volt circuits along exterior walls of buildings and in parking lots and landscaping. An electrician should check whether existing circuits can safely support the planned load of EV charging. For electric cars, a dedicated circuit is recommended.

Developed sites have less 208-volt and 240-volt (Level 2) power available compared to 120-volt power. For residences, kitchen and garage areas often have 240-volt circuits. However, the power draw of a 6.6 kilowatt-hour EV charger (such as a Ford Focus EV on-board charger) exceeds most types of home power uses and requires a dedicated branch circuit.

Available space in an existing electrical panel does not ensure that the panel has the electrical load capacity for EV charging. A professional electrician working with the local utility can evaluate the service load and adequacy of existing infrastructure. If the planned electrical load exceeds capacity of the panel, electricians will need to install upgrades such as a new panel and dedicated branch circuits for each new unit of EV supply equipment.

The utility will be able to address the power load on the nearest transformer and feeder. Single EV supply equipment installations typically do not overload utility-owned infrastructure. However, as the number of clustered EV supply equipment increases, so does the risk of overload. Utility policy will determine how the cost of grid upgrades is paid, whether by all utility ratepayers, the charging station installer, or some other approach.

For large properties or campus development, planned grid improvements should be factored into the siting of EV charging stations. As the electrical infrastructure reaches capacity, new infrastructure such as electrical lines, transformers, meters, and electrical panels will be needed. Planning of this new electrical infrastructure along with considering EV charging station needs will lead to a wider range of siting choices.

NETWORK COMMUNICATIONS

Most Level 2 EV supply equipment and DC fast charger stations operating in public contain an advanced electrical meter and link to a communication network in order to track usage, bill customers, and perform other tasks. Many networks use radio frequency identification (RFID) technology to pair individual users with charging events.

Charging station network providers offer bidirectional communications that enable the following activities:

- Display status information for the user,
- Notify network administrators about equipment or transaction failure,
- Update EV supply equipment software,
- Aggregate data for charging station hosts and owners,
- Provide two-way communication as part of a smart grid or site energy management system,
- Remotely check charging station availability or charging status,
- Fee collection, and
- Reserve a charging station.

Charging stations utilize one or more means (for example, Wi-Fi, Ethernet, and cellular) to connect to a network. Some potential installation sites have limited capability to connect to a network. Site alternatives and equipment options need to be reviewed to ensure successful, reliable communication. As an example, basement locations or remote parking structures could lack both Wi-Fi access and good cellular coverage. Instances will occur where sites require a new, separate communications conduit. Even if an installation is planned for equipment that is off-grid, sites should be selected for eventual grid connectivity if feasible.

INTEGRATING WITH EXISTING INFRASTRUCTURE

Developed properties have a mix of buildings, other structures, landscaping, walkways, and parking lots. These elements help define pathways taken by pedestrians at the site. Both formal and informal pedestrian travel patterns should be documented before placing EV charging stations to ensure that charging cables do not create a tripping hazard. The installation shown in Figure 14 is not recommended because using the equipment would block a sidewalk. Tripping hazards caused by charging cables also should be avoided along walking routes in indoor areas such as garages and car ports.

FIGURE 14: CHARGING CABLE USE WILL BLOCK SIDEWALK

While most EV charging stations can be placed away from high-demand parking spaces, at least one charging station should be conveniently located to accommodate persons with disabilities. ADA requires nondiscriminatory access to places that accommodate the general public. Commercial facilities that do not directly serve the public – like office facilities and warehouses – also must meet ADA requirements for new construction and alterations. This includes use of EV charging stations. Accessible charging will likely require increasing the size of the designated parking space. Parking spaces potentially can be restriped to gain extra space needed for the charging station parking. A separate report provides in-depth guidance regarding EV charging for persons with disabilities.[24]

Vandalism and personal safety at EV charging sites vary according to site characteristics. Places with these issues can be evaluated according to quality of existing night lighting, activity areas, and lines of sight – all of which correlate with reduced crime. Charging stations sited in areas perceived as safe receive more utilization.

Cutting, trenching, and drilling to add new conduit for an EV charging station can be very expensive. As an example, the installer might need to drill through a wall and trench into mature vegetation, walkways, and surface parking -- all of which would need repair after installing the conduit. Hardscape surfaces with special finishes and coloration can be expensive to repair or impossible to exactly match. Horizontal boring can reduce the need to cut and trench through special surfaces such as flagstone paving. Drilling through structural concrete can require x-rays to ensure that the structure's integrity is not compromised. The cost of installation can be avoided if existing conduit has adequate capacity to be utilized for new dedicated circuits. Installation costs also can be reduced by installing conduit onto existing surfaces as shown in Figure 15.

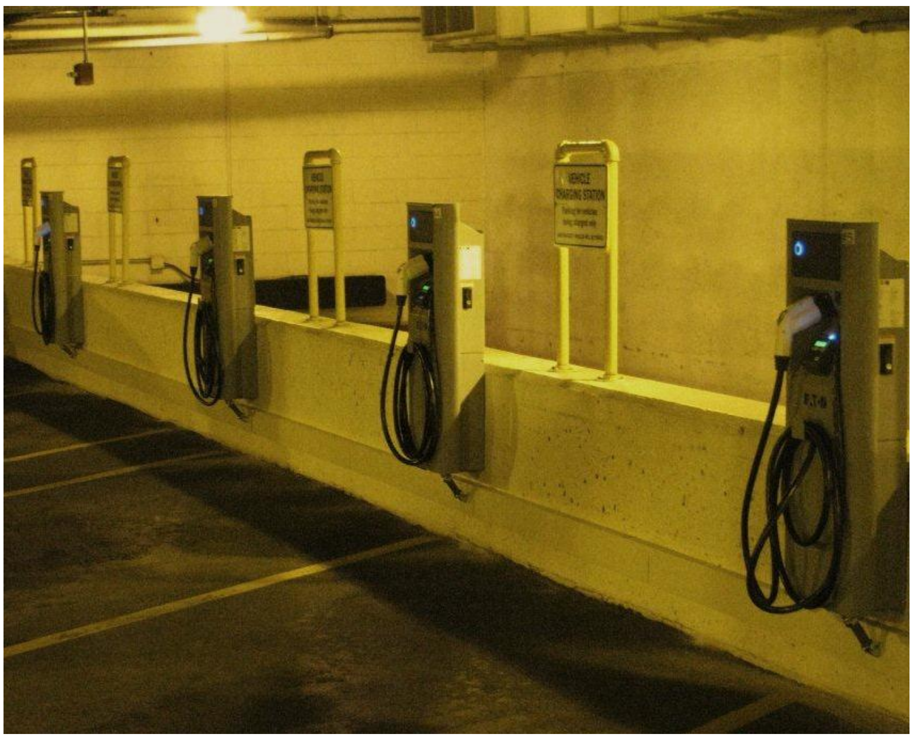

FIGURE 15: SURFACE-MOUNTED CONDUIT BELOW EV SUPPLY EQUIPMENT

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[24] Mayfield, David. (2012, February). EV Charging for Persons with Disabilities. Found at: http://sustainabletransportationstrategies.com

Trenching in landscaping adjacent to parking sometimes can be less damaging than cutting through hard surfaces like asphalt concrete. Figure 16 shows EV supply equipment on new concrete pads set into existing landscaping directly adjacent to parking. The success of this approach depends on the plant material and location of existing underground utilities and irrigation.

FIGURE 16: EV SUPPLY EQUIPMENT PLACED IN LANDSCAPING

NEW CONSTRUCTION

Developers should plan for, and place extra conduit for electric vehicle charging stations even if new EV charging stations are not anticipated as part of that construction. Placing conduit before hard surfaces like pavement are constructed will pay huge dividends by avoiding the costs of trenching, drilling, and repairs when charging stations are later needed. Plan conduit for Level 1 and Level 2 charging in parking areas and consider separate indoor Level 1 facilities for small EVs like electric-assisted bicycles. Locate conduit for DC fast charging to support time-limited parking spaces where the associated traffic does not conflict with other on-site activities.

Likewise, developers should consider placement of conduit for communications regardless of immediate need. This is important for underground or remote parking, or for any other place where networking to future EV supply equipment would require a hard-wired connection.

New construction planning and design provides the best opportunity to site EV charging stations that are convenient, cost effective, and include the needs for persons with disabilities.

ENVIRONMENTAL FACTORS

FLOODING

While charging stations designed for outdoor use operate safely under wet conditions, avoid installations in flood plains to prevent inundation or having standing water come in contact with components of the EV charging station.[25]

The Federal Emergency Management Agency helps determine and map Design Flood Elevations. Permitting issues relative to flood plains and related advice are available through the local jurisdictions.

Wall or pole mounted EV supply equipment should be considered where occasional localized pooling could occur.

LIGHTING

Most EV supply equipment has lit screens that display charging-related information even in the dark. However, area lighting is recommended for parking spaces used at night. For safety, a minimum recommended luminance of 0.2 foot-candles[26] is recommended.[27] Area lighting at higher levels would better illuminate charging cables extended along the ground. It could also reduce vandalism of the EV supply equipment and theft of small EVs such as electric-assisted bicycles.

Codes and standards of many local jurisdictions cover illumination requirements and restrictions on public and private property. Some business practices and ordinances require dimming of area lighting after close of business, so this should be a factor in locating charging stations planned for 24-hour public access. Adding area lighting could be as expensive as installing the EV charging station.

EV supply equipment that utilize vacuum florescent display screens offer readable messaging under almost any condition, including bright sunlight. However, some

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[25] Electric Transportation Engineering Corporation (2010, April). Electric Vehicle Charging Infrastructure Deployment Guidelines for the Oregon I-5 Metro Areas of Portland, Salem, Corvallis and Eugene.

[26] 1 foot-candle is the luminance cast on a 1-foot square surface by 1 lumen (originally defined as the light of one common candle).

[27] Batinsey, John. (2006). Outdoor Lighting Ordinance Guide. Found at http://www.nj.gov/dep/opsc/docs/Sample_Lighting_Ordinance.PDF

charging station screen types cannot easily be read in direct sunlight and should be sited such that they are either facing away from the sunlight or under shade.

SOLAR ACCESS

Some organizations choose to combine solar generation with the installation of EV charging stations. The needed access to sunlight will guide the siting choices for combined charging station/solar panel installations. The solar array shown in Figure 17 provides shelter for the charging station area.

FIGURE 17: EV CHARGING STATION WITH SOLAR CANOPY

Any organization that wishes to combine solar or any other non-utility owned electricity generation resource with EVSE should ensure that they comply with applicable state laws governing electricity regulation and utility franchise rights, and account for the terms of contractual agreements between electric utilities and governmental entities.

CULTURAL RESOURCES

Federal, state and local governments have lists of historic properties that require protection. Archaeological sites usually must be avoided. Historic buildings and historic districts might require some restrictions on visual appearance, placement and design. Local governments generally know if this is an issue and how to address it.

Where installers are running conduit to charging stations at existing paved parking lots, archaeological resources seldom become an issue. This is because the soil was previously disturbed by grading and placement of fill. Exceptions occur, and if the vicinity is known for archaeological resources, the proposed location should be checked against government records. Trenching in landscaping or in previously undeveloped areas has higher likelihood of requiring review for cultural resources.

Projects that involve federal actions (such as funding or issuance of a permit) require protection of properties listed on the National Register of Historic Places. This can include archaeological sites, structures and historic districts. Trenching in previously undisturbed ground could trigger this federal law, as could visual impacts. Visual impacts could matter if the view of a listed historic structure changes in a way that compromise why it became eligible for the National Register. The surrounding property or landscaping as well as the structure itself could be protected by the listing.

WEATHER

Most brands of EV supply equipment manufactured for public and residential uses are suitable for outdoor use, although some perform better than others in extreme temperatures. Winter weather can impede the operation of EV supply equipment when covered in snow or ice. Cold weather charging is especially problematic while using the charging cable. Snow and ice can encase the cable if it is lying on the ground or otherwise exposed. This can be mitigated with equipment that has a retractable cable which remains flexible in extreme cold conditions (see Figure 18).

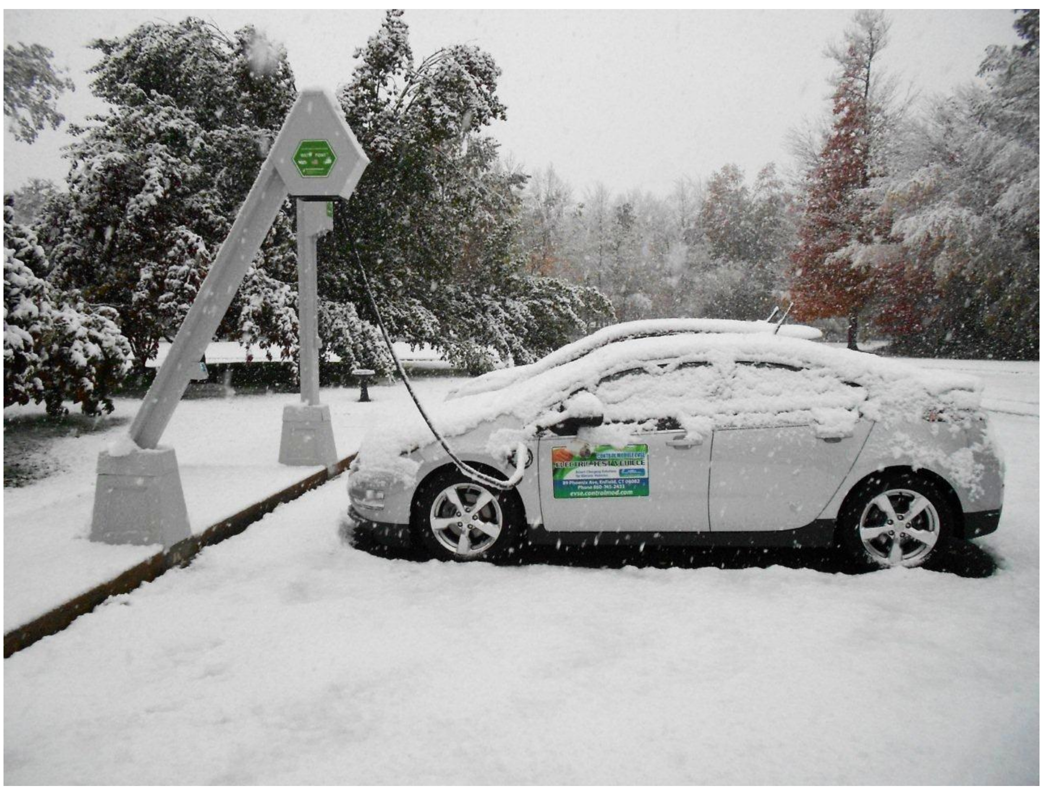

FIGURE 18: CABLE MANAGEMENT SYSTEM MITIGATES FOR COLD WEATHER CONDITIONS

Photo Courtesy of EVSE LLC

Snow banks can interfere with charging station function and snow plow operations could damage the equipment. Bollards are more easily visible in snow than wheel stops and will help protect EV supply equipment obscured by snow.

Siting EV charging stations in enclosed locations offers the best comfort and protection against extreme weather.

SUMMARY OF SITING FACTORS

Considerations for siting EV supply equipment are summarized below:

1. Consider the proximity of planned EV charging stations to existing electrical panels. Ideally, find parking as close as possible to an existing electrical panel with power capacity. For distances greater than 50 feet, consider new connections to utility-owned lines and transformers.
2. Check availability of wireless network connections for siting Level 2 and DC fast chargers.
3. Minimize disturbance to existing infrastructure. The amount and complexity of the installation and surface repairs affects cost.
4. Maximize use of existing electrical capacity and infrastructure on the site. This includes transformers, electrical panels, and conduit.
5. Avoid conflicts between EV supply equipment cables and existing walking routes.
6. Siting for future charging should be considered during design of new construction. Placement of conduit to serve potential sites for EV charging stations will save considerable funds when those stations are constructed.
7. Evaluate siting to consider issues related to light, flooding, cold weather, and moisture.
8. Avoid or minimize impacts to important cultural resources while siting EV charging stations.

ADDITIONAL INFORMATION

For assistance with additional information, please contact:

David Mayfield, Principal, Sustainable Transportation Strategies, via www.sustainabletransportationstrategies.com

Cynthia Maves, Director of Grant Administration, Clean Fuels Ohio at (614) 884-7336.

Alleyn Harned, Executive Director, Virginia Clean Cities at (540) 568-8896.