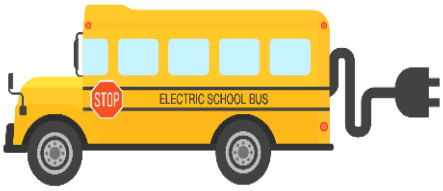
Electric School Bus Charging Equipment Installation Guide



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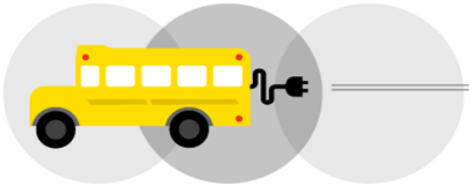

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About Us

VEIC is a national leader on electrified transportation and well-versed on electric school bus technology. We completed a feasibility analysis of electric school buses in Vermont in 2016, documenting the challenges and opportunities of operating these vehicles in a cold weather environment. In 2015 we began managing a pilot implementation of three electric school buses in Massachusetts. For this pilot VEIC provided the schools with technical assistance and guidance as they purchased buses, installed charging equipment, and planned routes.

VEIC has also designed and implemented electric school bus workshops with stakeholders in the Northeast to build awareness about the technology and lessons learned from the Massachusetts pilot project.

Introduction

The following is a guide that covers the main considerations associated with installing charging equipment for electric school buses. VEIC repared this guide as a resource for school districts installing charging stations. It is intended only as a guide, not the definitive document on electric vehicle installation.

This guide is a part of a larger set of resources for schools interested in electric school buses including –

- Electric School Bus Overview and Deployment Strategies
- Sample School Bus Specifications
- Electric School Bus Models Available for Purchase (August 2017)
- Understanding Your School's Utility Bill

All of these resources can be found on VEIC's website www.veic.org/eschoolbuses.

Charging Station Types

There are three levels of Electric Vehicle Supply Equipment (EVSE), often referred to as a "charging station" available on the market: Level 1, Level 2, and DC fast charging. The main difference between the different types of charging is the speed of the charge (how long it takes to charge the vehicle) and the power requirements at the host site or power source. Level 1 is the slowest charging setup and DC fast charging is the fastest. There are also other differences between charging station equipment, including cost.

Level 2 chargers are the most common type of public EVSE station. Currently, the majority of all-electric school buses utilize Level 2 stations, though Level 2 stations for buses must have a higher amperage (100/80 Amp) then a typical public station(see Table 1). Therefore, this guide focuses on the installation requirements associated with Level 2 chargers. There is a possibility that a school would install a DC Fast charger so more information on DC Fast Chargers are included as Appendix A.

Table 1 - Level 2 General Specifications for a Bus

Voltage	208/240V
Amperage	100/80Amp
Charging Power	19.2 kW max
Bus range per hour of charging	15 miles

Level 2 EVSE Installation

Getting Started

Prior to installing a charging station it is advised that schools consult with their local electricity provider.

In some cases, schools may want to collect electricity usage data and/or audit the site's energy footprint **prior to installing a charging station**. An audit can identify opportunities for energy savings in your facility, and these savings could be used to offset the increased electricity load associated with adding a charging station. An audit may also help ensure that school districts' charging station is coordinated with the facility's energy system and charging is scheduled to avoid demand charges.

This can also be an ideal time to discuss the electric school bus pilot project with your electricity provider. Your utility can most likely help you better understand your electricity usage, how an electric school bus will impact your energy bills, and what type of infrastructure upgrades maybe required at your school.

In addition, conferring with your utility creates an opportunity to discuss rates and/or potential for "smart-charging" programs where utilities may be interested in sharing control over the charging schedule for grid-stabilization purposes in exchange for lower prices. This strategy will be discussed more as part of the pilot project.

Installation Location – Reducing Costs

The cost of a Level 2 EVSE installation can vary widely depending on site characteristics, and the quantity and type of equipment (see Table 2). However, there are two primary considerations that drive the cost of the charging equipment installation:

1. The distance from the power source to the charging station.
2. The type of charging station – wall mounted unit or stand-alone unit.

Table 2 – Approximate Installation Costs of a Level 2 Charger

Equipment Price	$2,200 – 9,000
Installation	$2,000 – 12,000+
Total	$4,200 – 21,000+

Distance between the Power Source and the Charging Station

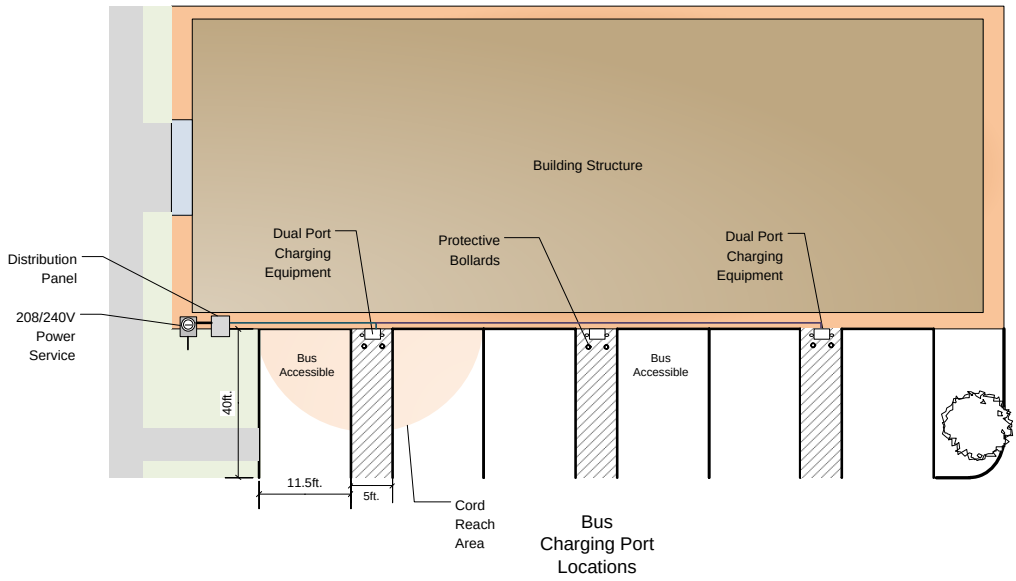
Costs associated with connecting a charging station to the power source can account for 40% or more of the installation cost. One of the simplest ways to reduce installation costs, therefore, is to install the station as close as possible to an existing power source that has sufficient capacity to avoid service upgrades. Longer distances between the EVSE location and power source increase installation costs by requiring more electric circuit components and conduit-runs.

Additionally, connecting the EVSE to a power source normally requires trenching or linear drilling for underground conduit. Trenching can be particularly expensive when it requires digging up pavement or concrete. Trenching or linear drilling can be minimized by selecting a site close to a power source. Where digging is required it is best to go through softer features, such as grass, rather than sidewalks, asphalt or areas with extensive landscape features. If a large amount of trenching will be required, schools should discuss with their local utility the cost of installing a new service drop and meter to allow shorter power runs to charging sites.

Charging Station Type

The type of charging station – whether it is a wall or pole mounted – also drives installation costs. Wall mount EVSE units are generally less expensive to purchase because they do not need a post or stand and installation costs are reduced because no trenching is required to connect the EVSE to the power source. Wall mounts also avoid costs associated with setting up a standalone unit. Whether wall mount units can work for a school bus depends on the location and position of bus parking relative to the building. Many bus models have charging plugs at the front of the vehicle which make this option feasible. Figure 1 below demonstrates locations optimized for low-cost installation by being mounted to a building and close to a power supply.

Figure 1 - EVSE Site Diagram



Other Installation Considerations

Snow Removal

Snow plows are one of the most common ways charging equipment is damaged. To avoid damaging the charging stations, schools should consider how the EVSE will be cleared of snow without being damaged by plows.

It is suggested that a 3' by 3' (minimum) area be kept clear of snow between the nose of the vehicle and the EVSE. This will insure that the stations are accessible for both individuals with disabilities and make it easier for others to reach the equipment. Best practices also call for the placement of bollards, curbing, or wheel stops in front of the EVSE to protect the equipment 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.

Other options that can ease snow removal, while maintaining accessibility include

a. Retractable cables can be utilized to give access to the EV charging equipment cable with minimal snow removal. Many EV charging that require manually winding and replacing the cable after use are challenging in cold weather when the cable can become stiff. Experience suggests users may place the cables on the ground, which increased potential for damage. This issue is addressed when the charging equipment is purchased rather than installation.
b. Canopies or roofs to keep the operating area clear of snow and reduce weather-related damage.

Ventilation, Hazards and Safety

Most school buses are parked outside and will be well ventilated. However, if an electric school bus will be parked and charged in a covered area, there may be some requirements for ventilation. The need for ventilation should be discussed with the vehicle manufacturer.

Electric vehicle charging stations are designed to be used in rain and in wet conditions. However, charging stations should be installed in areas not prone to flooding.

Vandalism

Experience suggests that vandalism is not a recurring problem with electric school buses. Strategies to help avoid vandalism including locating the EVSE in a well-lit and in a visible area. The most common forms of vandalism with EVSE's is graffiti and cord damage. Units with a retractable cable will help detract vandalism of the cord.

Signage

General Service Signs – The Manual on Uniform Traffic Control Devices (MUTCD) adopted a standard blue service sign symbol for EV charging stations (see Figure 2).

Regulatory Signs –The use of language on signage restricting parking such as "Except for Electric Vehicle Charging" is suggested to prevent unnecessary parking in charging spaces (See Figure 3). Schools may want to include a sign that restricts parking to school bus charging only.

Figure 2: MUTCD Approved EVSE Symbol

Figure 3: Recommended Signage for EV Charging

Networked Units

Charging stations can be networked or non-networked. Networked charging stations are connected to other information systems outside of the charging station. (Non-networked stations communicate with the vehicle but no other external device or system.) EVSE devices will be networked to allow the vehicle and charging station to communicate and provide access control, plus data on usage and costs. Networked stations will also allow the school administrators to view the status of charging station equipment (in-use, malfunctions, etc.). Network stations also collect data on power consumption and usage patterns.

Number of Ports

Charging equipment can come with multiple ports (or plugs) where vehicles can plug in. For this demonstration project, only one port is required, but schools may opt for dual ports. School buses can be equipped with dual charging ports; by doubling the number of connections to the EVSE, charging time can be reduced by 30% to 40%. Installing a dual port station may also help reduce overall installation costs as the incremental cost of adding another port is frequently much lower than installing an additional single port unit. Mounting in locations that allow charging cords to reach multiple parking spaces can help maximize availability of charging equipment.

Operating and Maintenance Costs

The costs of operating a charging unit depends on how often the equipment is used, but maintenance costs are expected to be minimal. Maintenance costs primarily consist of insurance and snow removal, plus, on occasion, damage to the cords or plug connectors. Most manufacturers have modular equipment designs that allow for swapping out damaged parts. However, UL safety requirements sometime dictate replacing entire sealed modules rather than individual components to maintain certification. Insurance and warranty costs to extend coverage to EV charging equipment will depend on the owner's policy and coverage.

Appendix A: DC Fast Charging

Right now all of the electric school buses on the market come standard with Level 2 charging with the option of adding DC Fast Charging for an additional costs. There is a possibility that a school would choose to pay the incremental costs and install a DC Fast charger in order to charge a bus faster.

DC fast chargers come in a range of power capabilities: from ~ 24 kW to 90 kW. Higher the kW rating mean the battery will charge faster. The total time it takes to charge a battery depends on the kW rating of the charger and the size of the battery pack (see Table 1). Note: most of the charging times available through the web are for cars and do not apply to buses. Buses have much bigger batteries and thus, longer charge times.

Table A1 - Charging Time for Buses with a DC Fast Charger

24kW Charger	**~ 4 hours**
90 kW Charger	~ 1 hour

Electricity on the grid is always AC (alternate current) and batteries store DC (direct current) electricity. Most vehicles convert energy from AC to DC on the vehicle and this conversion process slows the charging process. DC fast chargers have more power available and thus, charge vehicles quickly However, DC fast chargers have more hardware and thus are more expensive to both purchase and install. The cost of a DC fast charger starts at ~$20,000 and increase as power ratings increase. DC fast charging units require access to 3-phase power systems; connecting the units to 3-phase power is a primary driver of installation costs.

DC Fast Chargers also have standards for equipment. In 2016, the U.S. has two standards for fast charging systems: CHAdeMO and SAE J1772 standard plugs. CHAdeMO is an international standard developed in Japan. SAE (Society of Automotive Engineers) is the current US standard. These standards set the requirements for the physical connections (the plug) and communication protocols to ensure safe charging. The bus connector must be the same standard as the charger connector. CHAdeMO standard requires a CHAdeMO connector. SAE J1772 standard requires a J1772 connector. SAE J1772 standard offers combo connectors. Combo Connectors can accept SAE J1772 AC level 2 connectors and/or SAE J1772 DC fast charging connectors. VEIC has specified the SAE J1772 standard for electric school buses.

Appendix B: Other Resources

The following resources provide more information about installing electric vehicle charging equipment:

Plug-In Electric Vehicle Handbook for Public Charging Station Hosts:
http://www.afdc.energy.gov/pdfs/51227.pdf

Plug-In Electric Vehicle Handbook for Fleet Managers:
http://www.afdc.energy.gov/pdfs/pev_handbook.pdf

Drive Electric Vermont: Charging Stations Installation Guide:
http://www.driveelectricvt.com/charging-stations/installation-guide