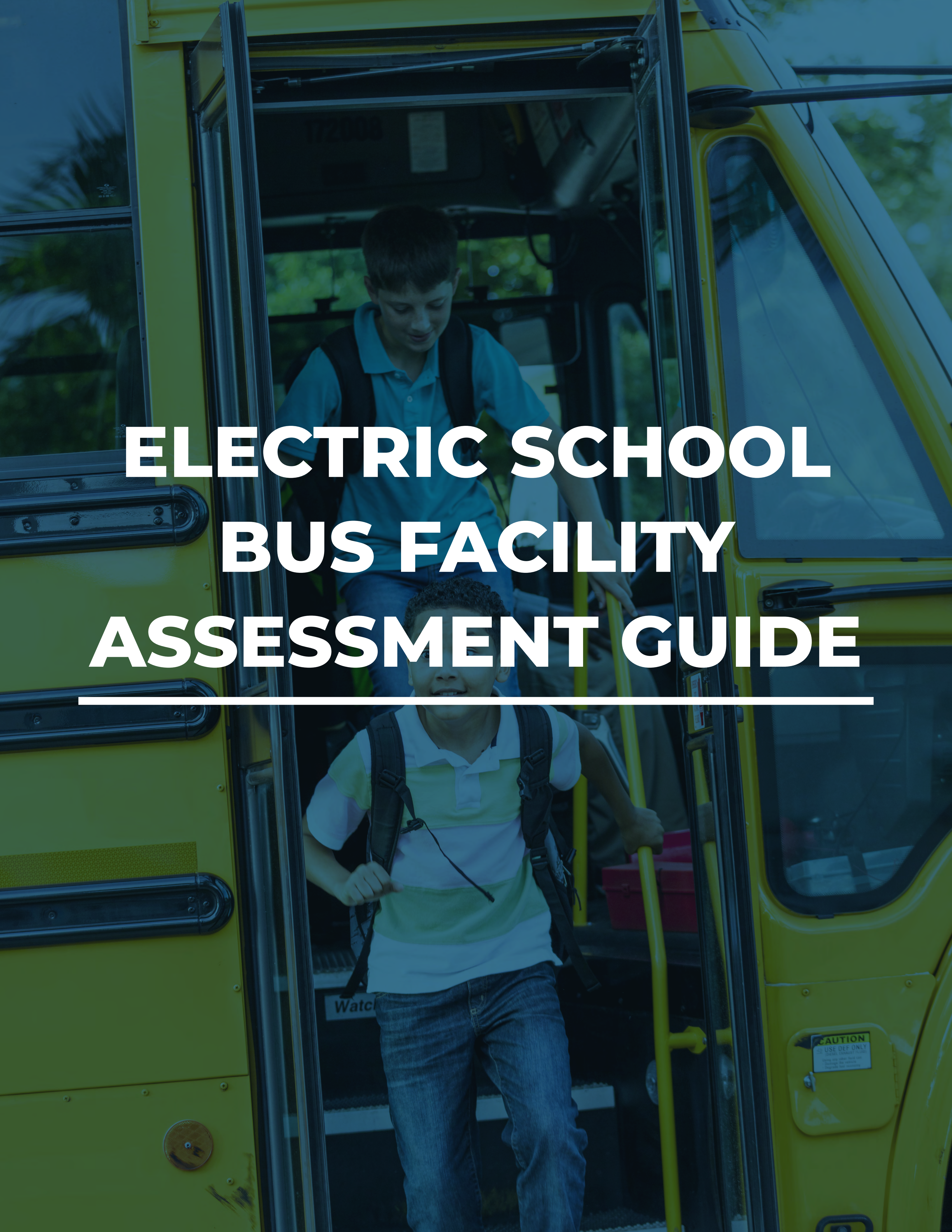
ELECTRIC SCHOOL BUS FACILITY ASSESSMENT GUIDE



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About VEIC

VEIC is a sustainable energy organization on a mission to generate the energy solutions the world needs. For over 35 years, VEIC has been working with governments, utilities, foundations, and businesses across North America to develop and deploy clean-energy services that provide immediate and lasting change. VEIC has expertise in energy efficiency, building decarbonization, transportation electrification, and demand management for a clean and flexible grid. We design innovative solutions that meet clients' goals, while reducing greenhouse gas emissions. VEIC is nationally recognized for programs and pilots that optimize energy use, reduce energy burdens for low-income customers, and advance emerging technologies and innovative program models.

About World Resource Institute's Electric School Bus Initiative

Established in partnership with the Bezos Earth Fund, WRI's Electric School Bus Initiative aims to collaborate with partners and communities to build unstoppable momentum toward an equitable transition of the U.S. school bus fleet to electric by 2030, bringing health, climate, and economic benefits to children and families across the country and normalizing electric mobility for an entire generation.

NAVIGATION

How To Use This Guide

The purpose of this guide is to help you determine the readiness of your facility to support the number of electric school buses (ESBs) you wish to deploy. This guide contains two worksheets - one to help define a project scope and another to help navigate an onsite assessment - as well as a glossary of terms and a "Charging 101" section. This guide provides step-by-step instructions, from project ideation to initial facility assessment, to help make your ESB facility implementation a success.

Completing this initial assessment will help you:

1. Understand your facility's readiness to support ESB chargers, and what upgrades might be needed
2. Assess the feasibility and order-of-magnitude costs of any required facility upgrades
3. Gather information needed to begin developing plans for upgrades and installation

Facility considerations come into play at every stage of ESB adoption, from the first point of considering whether to adopt electric buses to planning for a full fleet conversion to electric buses. This resource provides suggested guidance on how to conduct a facility assessment at the beginning stages of any ESB project.

Planning ESB facility upgrades can involve many complex and interrelated factors. For this reason, throughout your process you may wish to occasionally review and revisit previous assumptions or decisions to ensure that your plans are still in alignment, and adjust as needed.

CONVENE AN INTERNAL PROJECT TEAM

Convene an Internal Project Team

The first step in conducting a facility assessment is to convene key stakeholders to discuss the project scale and charger options. This typically includes the project champion, fleet transportation manager, and facilities manager, but often includes other staff members whose knowledge or participation will be especially helpful. The team can use Worksheet 1, below, as a guide to facilitate these initial discussions.

Worksheet 1: Project Scale

Generally, the scale of the project will determine the facility requirements. Is your goal partial fleet electrification? Full fleet electrification? Other objectives, such as vehicle-to-grid (V2G, see glossary) integration, may also play a role in determining the scale of the project.

If your team is unsure of how large to make your initial deployment of ESBs, an initial facility assessment can help you determine your options and make an informed decision.

Sometimes the constraints of the facility and the cost to upgrade or expand electrical service will effectively determine the scale of the initial project. For example, your facility's existing electrical service may be able to accommodate 4 ESBs now with only minor upgrades, but anything beyond that will require a major service and transformer upgrade at much greater cost.

Before proceeding, answer the following questions:

1. What are the primary goals for this electrification project (e.g., comply with a city or state mandate, test a new technology, reduce operating costs, transition off fossil-fuels for the health of children and operators, etc.)?

2. What is the desired timeline for this initial ESB deployment?

3. Approximately how many total buses are served by the facility you are considering for this project?

4. Following your initial ESB deployment, do you expect to add more ESBs and chargers in the future?

Charging Options

The type and quantity of chargers that you decide to purchase are the primary drivers of your electrical infrastructure requirements and any facility upgrades that you might need to make. This section will help you conduct an assessment of the range of feasible charger options for your ESB project.

There are a large, and growing, number of high-quality ESB chargers available in the marketplace. ESB chargers can be grouped into 3 main categories based on their power output and charging speed, as shown below. You can review the "Electric School Bus Charging 101"at the end of this document to learn more.

1. High-power Level 2 charger
2. Medium-power Direct Current (DC) charger
3. High-power Direct Current (DC) charger

Many factors will influence your final decision on selecting a charger for your project. However, at this initial step, it will be most helpful to consider basic charging strategies involving each of the 3 types of chargers. While other configurations are possible, each ESB in your initial deployment will likely benefit from a dedicated charger port. The following tables will guide you in preparing scenarios involving different quantities of chargers and approximating the power demand required by each scenario. This information will be the starting point for determining your facility's electrical infrastructure needs and your overall charging strategy. If some of these terms are unfamiliar to you, definitions can be found in the glossary.

Scenario 1:

Charging Station Type	3-Phase Power Required?	Value A: Number of Stations Planned (from Project Scale Q1)	Value B: Approximate Power per Station	Approximate Total Power Demand (Value A x Value B)
High-Power Level 2	No		20 kW	kW
Med-Power DC	Optional		25 kW	kW
High-Power DC	Yes		50-125 kW	kW (low) to kW (high)
Total				kW (low) to kW (high)

Follow these instructions to complete the information in table above:

1. In the first row, fill in the number of chargers planned (Value A).
2. If you are considering a charger with multiple ports, this value should reflect the number of chargers, not the number of ports. As noted above, it's recommended to plan for one charging port per bus.
3. Multiply Value A by the approximate power per charger (Value B). Write the result in Value C. This is the approximate power demand for this charging type.
4. Repeat this process for the remaining rows.
5. In the row for 'High-Power DC chargers', multiply Value A by both 50 kW and 150 kW to determine the 'high' and 'low' entries for Value C in that row.
6. Add up all the Value C numbers for your total power demand. If you are considering high-power DC chargers, this will be a range of values representing the available power options.
7. Note if you have any stations that require 3- phase power. These attributes will be key to assessing whether electrical infrastructure upgrades will be required.

If you are considering more than one scenario, you may also complete additional tables below, using the same instructions listed above. Some facilities may be able to accommodate multiple charger scenarios. For example, you may be able to support an ESB fleet with dedicated Level 2 chargers for each vehicle just as easily as with shared High-power DC chargers and a few Level 2 chargers for overnight charging.

Scenario 2:

Charging Station Type	3-Phase Power Required?	Value A: Number of Stations Planned (from Project Scale Q1)	Value B: Approximate Power per Station	Approximate Total Power Demand (Value A x Value B)
High-Power Level 2	No		20 kW	kW
Med-Power DC	Optional		25 kW	kW
High-Power DC	Yes		50-125 kW	kW (low) to kW (high)
Total				kW (low) to kW (high)

Scenario 3:

Charging Station Type	3-Phase Power Required?	Value A: Number of Stations Planned (from Project Scale Q1)	Value B: Approximate Power per Station	Approximate Total Power Demand (Value A x Value B)
High-Power Level 2	No		20 kW	kW
Med-Power DC	Optional		25 kW	kW
High-Power DC	Yes		50-125 kW	kW (low) to kW (high)
Total				kW (low) to kW (high)

CONDUCT A SITE VISIT

Conduct A Site Visit

After you have determined your target number of ESBs and chargers, the next step is to do a site visit of your bus depot. An in-person site visit with key facility, fleet, utility, and subject-matter experts will enable you to gather the information necessary to zero in on a draft plan for charger selection, installation, and any necessary facility electrical infrastructure upgrades.

Recommended Participants

From the school/school bus contractor:

- [ ] Facilities manager ____________________
- [ ] Electrician or electrical professional ____________________
- [ ] Fleet/transportation manager ____________________
- [ ] School maintenance or bus ____________________

From the utility:

- [ ] Account manager ____________________

From school board or community:

- [ ] Project champion ____________________

If you have never participated in a school bus or other fleet electrification effort, you may want to seek additional technical support from a local, regional, or national expert, for example, from local government or public transportation staff, a regional electrification group like a Clean Cities Coalition, or national experts like VEIC or WRI.

What to Bring:

Printed copies for each participant:

- [ ] Completed Step One worksheet
- [ ] Blank Step Two worksheet and instructions
- [ ] A map of your school bus facility, including bus parking locations
- [ ] A screenshot from a satellite view (such as from Google Maps or similar service) are often best, because they can show the locations of vehicle parking and existing electrical utility poles and/or ground-mounted transformers

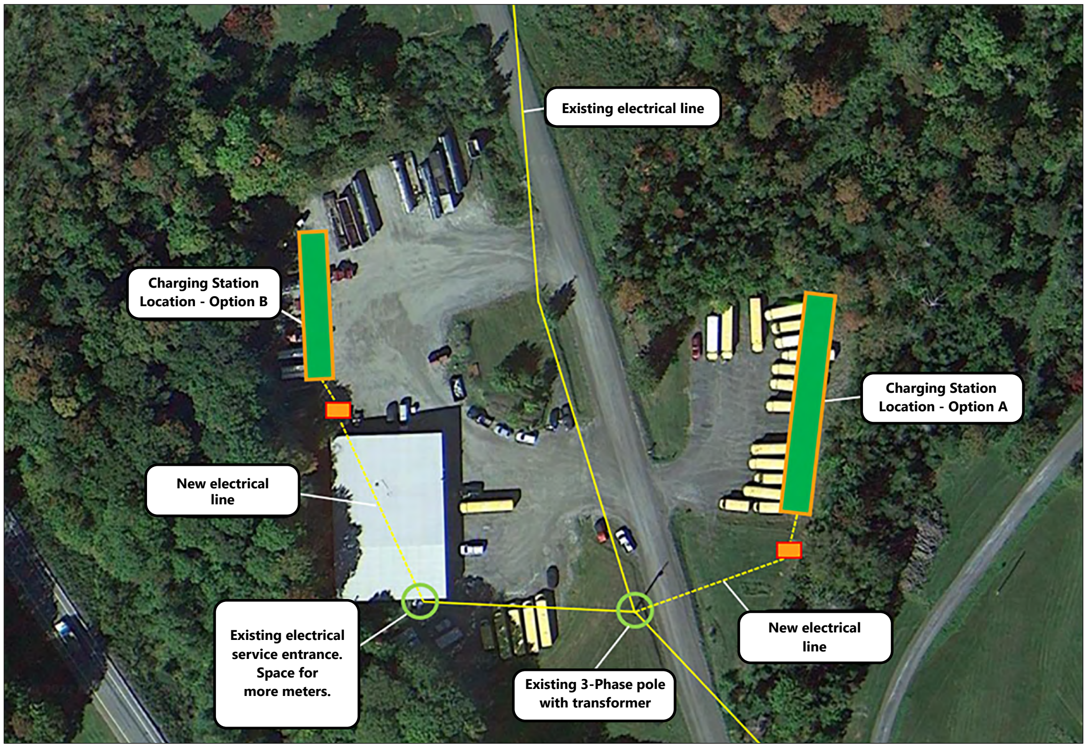
Device for taking photos (camera or phone)

Optional:

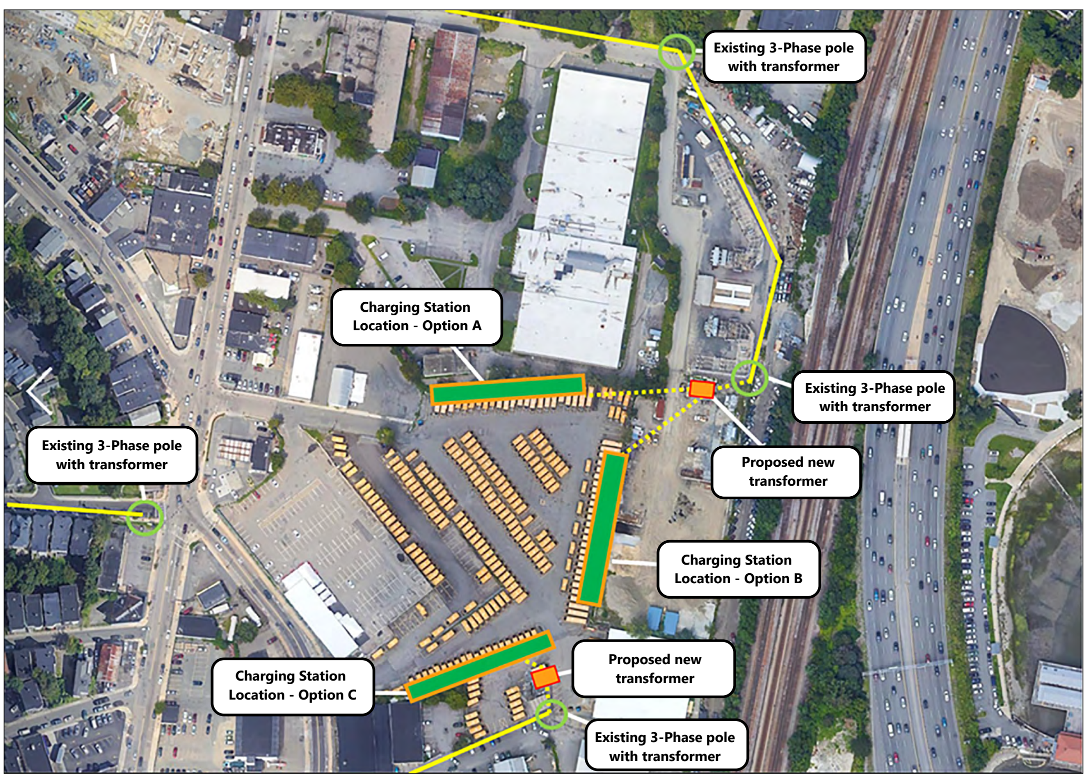
- [ ] Clipboards
- [ ] Pens/markers
- [ ] Tape Measure

Here are two sample facility maps used for ESB planning:

Example of Rural Bus Parking Facility



Example of Urban Bus Parking Facility



Before you begin your tour:

- [ ] Provide everyone with a high-level description of your electric school bus project idea and goals.
- [ ] Review the completed Step One Worksheet to ensure everyone understands how many buses, charging stations and approximate electrical power needs are being considered.

Worksheet 2: Facility Tour

Electrical Power Sources

Your utility account manager, facility manager, and/or electrician will be needed to help you determine answers to the following:

1. Identify all potential electrical power sources that could supply power to your facility:

- [ ] Existing overhead and/or underground distribution lines that are connected to your facility
- [ ] Nearby overhead and/or underground distribution lines that could be connected to your facility
- [ ] Take photos of the distribution lines, including the location around where they enter your site or connect to your facility, for future reference

2. Determine the existing load capacity of electrical transformers:

- [ ] Take photos of any accessible transformer labels for future reference

3. Determine what type of electrical service you have:

- [ ] Voltage (V): ____________________
- [ ] Phase (Single or Three Phase): ____________________

4. Determine the existing electrical panel capacity:

- [ ] Calculate available power (Amp rating of panel main circuit breaker minus total amp ratings of all individual circuits)
- [ ] Note any unused circuit breakers or room for additional circuit breakers
- [ ] Take photos of electrical panels for future reference

5. Identify any potential entrance points and paths for new or upgraded electrical service:

- [ ] If a new power service line needs to be run to your facility (either a building or parking area), which location(s) would be the most desirable to install, and what path would it follow?
- [ ] Tip: Project costs and complexity generally increase the further that power lines need to be run, especially when running underground and trenching is required. Some routes may require an easement if crossing neighboring property which can add legal complexity as well.
- [ ] Mark these on your Facility Map copy

Bus Parking

Your facilities manager and/or fleet/transportation manager should be able to help you determine answers to the questions in this section.

Based on the number of buses you are considering deploying at this initial stage, is there a preferred location where these buses would ideally be parked (and chargers installed)? Are there any alternate options?

For each location, consider the following:

Operations and safety:

1. Are the buses in this location for a specific reason?
2. How are the buses parked? Are they backed in, or driven through?
3. Are they parked so closely together that accessing the front, back or sides of the bus would be difficult?
4. Will the parking arrangement need to be modified during snow events?
5. Are students dropped off near/at your facility? Are there any significant safety considerations (such as student loading/unloading areas, fire zones or applicable regulations) that will impact where chargers can be installed?

Infrastructure:

1. How far (in feet) is this location from existing and/or any new potential electrical service?
2. What options are there for bringing sufficient electrical service to this parking location?
3. Approximately where would charging stations be installed at this location?
4. If adjacent to a building, could charging stations be mounted on the walls of the building?
5. Where would any needed supporting electrical infrastructure be installed (ex. ground mounted transformer, power inverters, switchgear, meter, panel or subpanel, etc.)?

Post-Tour Discussion:

As you complete the tour, discuss and answer the following as a group:

1. How many of each of the following chargers you are considering could you install without significant upgrades to your existing electrical infrastructure?
   a. High-powered Level 2
   b. Medium-powered Level 3 Direct Current (DC) charger
   c. High-powered Level 3 Direct Current (DC) charger
2. What upgrades are likely needed to enable your facility to support the number of buses and types of charging stations desired at this initial stage?
3. Which of these upgrades will be the responsibility of the facility owner ("behind the meter") and which will be the responsibility of the utility ("in front of the meter")?
   a. How long will those upgrades take to complete?
   b. What is the likely order of magnitude cost of those upgrades?
   c. What barriers exist to completing the upgrades?
   d. Is it possible to complete the upgrades in phases?
   e. Are there opportunities to use mobile or modular design to limit construction needs (e.g., using a shipping container to house infrastructure aboveground)?
4. Where are the most promising locations to place these charging stations, in terms of cost-effectiveness, operational safety and ease of deployment?

5. Are there opportunities to incorporate "future-proofing" concepts, like trenching a larger area than initially needed and placing additional electrical conduit, to reduce costs for future ESB deployments?

6. Next steps
    a. What information and/or approval is necessary for the school fleet to move forward to the next (detailed Facility Planning) stage?
    b. What information do stakeholders and decision-makers need to understand the scale of the project and to support planning?
    c. What support can utility staff offer moving forward, in terms of facility planning, electrical rate review, etc.?
    d. What specific tasks are each of the group members responsible for completing and reporting back on following today's meeting?

Name	Task	Due Date

GLOSSARY

Glossary

ESB Charging Terms and Definitions:

Capacity: The amount of power available for output from the electric grid at a given time.

Charger: The equipment that connects to your ESB to deliver power to the battery.

Charger Port: The component of a charger that physically plugs into the ESB. Some chargers have multiple ports, allowing them to be connected to multiple ESBs at the same time.

Charging Infrastructure: The electrical equipment and components that are required to install and operate a charger, such as switchgear and transformers. Often, these components need to be upgraded to accommodate ESBs.

Circuit Breaker: essential safety devices found inside electrical panels, intended to prevent fires. Circuit breakers are switches that interrupt electricity flow in the event of an overload or short.

Demand: The average amount of power that is pulled from the electric grid by one or more sites for a specific 15-minute period.

Demand Charge: A type of utility charge that's based on the highest amount of power drawn during the month. Demand charges are intended to cover the cost of maintaining the electric utility's infrastructure. Your utility will have more information on the specifics of your demand charge rate.

Electrical Panel: Also called a breaker panel, breaker box, or service panel. A metal box that contains all of the circuit breakers that deliver power to different components of your building, as well as the main circuit breaker. Information such as the amp rating and devices or building area controlled by each circuit breaker are usually found written on the panel door or on the circuit breakers themselves.

A typical wall-mounted electrical panel:

ESB: Electric School Bus.

EVSE: Electric Vehicle Supply Equipment. In addition to chargers, this also includes all the supporting infrastructure such as mounting, charge cords and connectors, and protection features. These can be installed as freestanding units or mounted to walls.

Wall-mounted:

Freestanding:

Single-Phase Power: Also known as split-phase. The typical service level provided to homes and small businesses, this service has two 'poles' or 'legs' each capable of providing 120V power separately, or 240V power when combined using a double-breaker – such as for a clothes dryer or electric stovetop.

Three-Phase Power: A higher power electrical service that is typically utilized in commercial and industrial settings. Three lines supply power to the site, each out of phase with the others, typically providing 208V or 480V service which allows for much greater total power draws. One telltale sign of three-phase power is the presence of a 3-pole circuit breaker inside an electrical panel (three circuit breakers linked with a bar on the handle).

3-pole circuit breaker usually indicates three-phase power:

Power Inverter (or Converter): A device that converts electrical current from Alternating Current (AC) to Direct Current (DC).

Switchgear: A centralized collection of circuit breakers, fuses and switches (circuit protection devices) that function to protect, control and isolate electrical equipment for relatively large EV charger installations.

Transformer: Transforms electric power from one voltage to another. For EV charging projects, transformers are typically used to reduce the voltage of the electrical power coming from the grid to the voltage needed for the chargers (such as 240V or 480V). Transformers are typically sized in terms of kilovolt-amps (kVA). These can be either mounted on utility poles, or mounted on cement pads or vaults in the ground.

Pole Mounted:

Ground mounted:

Electric Current: Current is the rate at which electric charge flows past a point in a circuit. Circuits with larger currents can support faster charging speeds (and/or more chargers). Measured in Amperes or "Amps" and denoted with an "A".

Electricity can flow in either **Alternating Current** (abbreviated "**AC**") which is the form used in the electric grid, or **Direct Current** (abbreviated "**DC**") which is the form used in electric vehicle batteries.

Voltage: The electrical potential of a charge measured in terms of Volts (V). Equivalent to pressure in a water pipe, it is a measure of how much 'push' the service has. Higher voltage typically results in faster charging speeds.

Power: Measured in terms of kilowatts (kW). Higher power results in faster charging speeds. Power is a function of voltage and amperage. Increasing one allows you to decrease the other and get the same amount of power. A certain size conductor will have a maximum safe amperage rating but increasing the voltage can allow for more power to be delivered.

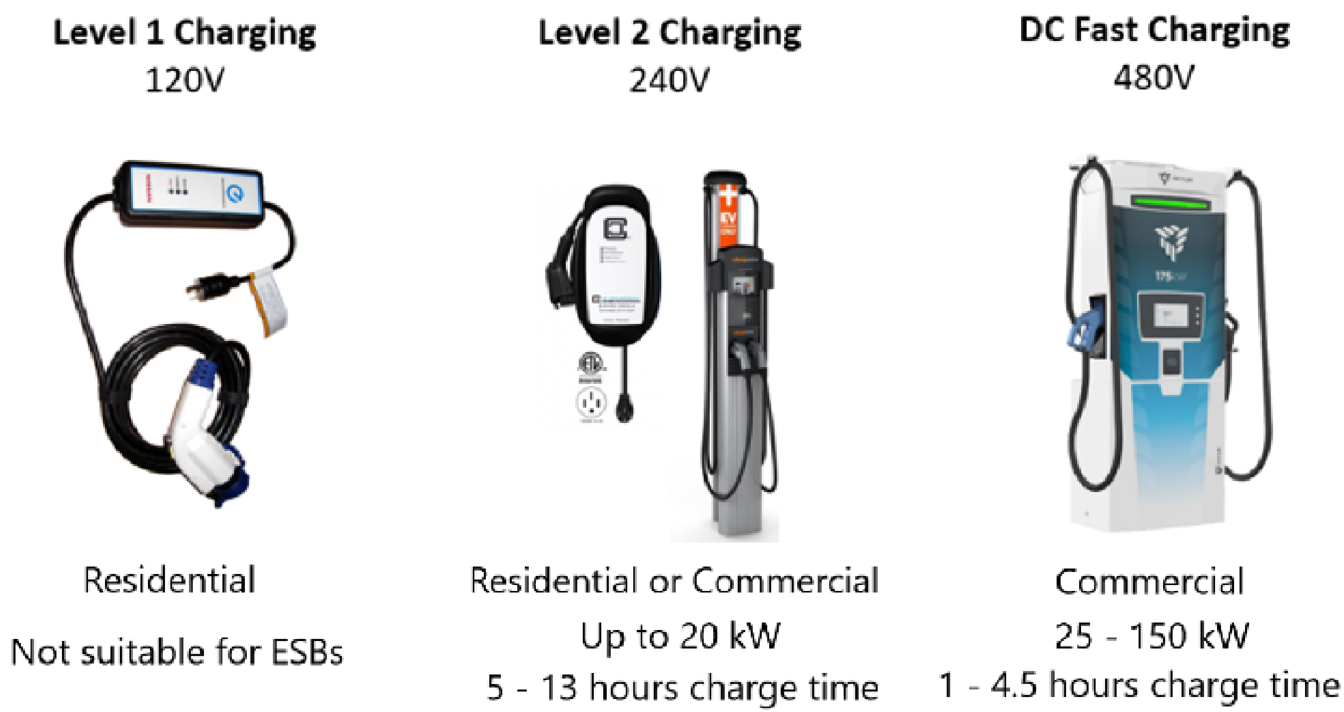
ELECTRIC SCHOOL BUS CHARGING 101

Electric School Bus Charging 101

Here's a quick overview of the types of electric school bus (ESB) chargers and considerations for selecting the right option for your fleet.

Charger Types: There are three levels of chargers (also commonly referred to as "Electric Vehicle Charging Equipment", "EVSE", or "chargers") available on the market: Level 1, Level 2 and DC fast charging. The main difference is how quickly they can charge your bus, and their power requirements at your facility.

Level 1 charger are compatible with standard electrical outlets, but are not suitable for ESBs because of their slow charging speeds. Many ESBs can be effectively charged by either a high-power Level 2 chargers (19 kW, 240 volts Alternating Current (AC)) or a medium-power direct current (DC) chargers (commonly 25 kW, 480 volts DC). Many ESBs may also charge at high-power DC fast chargers (commonly 50-150 kW, 480 volts DC).



While DC fast chargers are more expensive compared to high-power Level 2 AC units, they operate more efficiently. Also, some electric bus models only accept DC charging, and others may offer discounts on a bus if they don't need to provide onboard Level 2 charging hardware.

Some chargers come equipped with more than one port, or plug, which allows it to connect to more than one ESB at a time. A charger equipped with multiple ports will still only deliver it's maximum power rating, either split simultaneously between multiple ports or through a single port. For example, a 125 kW charger with 2 ports could deliver 62.5 kW through each port simultaneously, or 125 kW through one port (other configurations that add to 125 kW might also be possible, depending on the specific charger's capabilities).

Costs: High-power Level 2 chargers typically cost between $2,000 and $5,000 for the equipment, and $1,000 to over $10,000 for installation (depending on the complexity). Medium-power DC fast chargers are more expensive ($10,000-$15,000 for more basic equipment to more than $40,000 for larger, more powerful stations, and typically $50,000 or greater for High-power DC fast chargers). They also require a three-phase power supply, so installation costs are typically higher as well – ranging from $4,000 to $15,000 on the lower end to over $50,000 for larger and more complex projects.

The cost of installing one or more chargers can vary widely depending on site characteristics, quantity, and type of charging equipment. That said, there are two primary considerations that drive the cost of installation:

1. **The distance from the power source to the charger.** Costs associated with connecting a charger to the power source can account for 40% or more of the installation cost. If possible, minimize your installation costs by installing the station as close as possible to an existing power source that has sufficient capacity to avoid service upgrades. Longer distances between the charger location and power source increase costs by requiring more electric circuit components and conduit-runs, as well as trenching or linear drilling costs for underground conduit.
2. **Whether the charger is mounted to an existing wall or installed as a free-standing unit.** Wall-mounted chargers are generally less expensive because they don't require a free-standing pedestal (or a concrete pad) or trenching to connect them to a power source. Whether wall-mount units can work for a school bus depends on the location and position of bus parking relative to the building. Note that High-power DC fast chargers typically require freestanding installation due to their size.

Charging Time: A typical Type C ESB with a 150kWh battery pack will be able to charge in 6 to 8 hours overnight using High-power Level 2 chargers. A Medium-power DC fast charger will be able to provide a slightly faster charge (4-6 hours). Some fleets with more-powerful DC fast chargers (50 kW or more) may be able to recharge the same bus in as little as 2 hours. Fleets should evaluate whether they may need midday charging, how much charging time they will have between morning and afternoon shifts, and how much range they will need to recover during that time, as each factor will influence charger type selection.

Networked Chargers: Some chargers are connected on a network so they can be monitored and managed collectively using an online software platform. For school fleets, networked chargers can enable managed charging (see below) and provide real-time charging status for your buses and alerts if there are any charger malfunctions. Networked chargers are typically more expensive than simpler, non-networked chargers, and often require ongoing monthly fees.

Managed Charging: EV charging can increase electricity demand - sometimes significantly in the case of DC fast chargers and/or during midday charging. However, the resulting impact on your electricity demand charges can be minimized if EV charging is managed to occur while other loads are low (such as overnight). Managed charging includes any strategy to control when charging occurs or the amount of charging done at any given time. Generally, managed charging aims to minimize both costs (such as demand charges) and strain on the electric grid, and typically uses software to coordinate charging schedules among multiple networked chargers.

Vehicle-to-Grid (V2G) or Vehicle-to-Building (V2B): Electric utilities are interested in vehicle-to-grid/building configurations of ESBs. V2G/V2B enables a parked ESB to help absorb excess power or supply power in peak power demand times. The ESB accomplishes this by charging or partially discharging its battery at specific times while connected to a specially equipped EVSE. Strategic timing of battery discharge could save money for the utility and still allow for a fully charged vehicle when needed, while potentially providing utility financial incentives to the fleet to help offset the cost of the electric bus. These technologies are still very new, however, and until more trials have been completed school bus operators should not plan on extra cost savings from V2G/V2B (unless these savings are guaranteed through a service contract from a 3rd-party "turnkey" ESB fleet administrator).