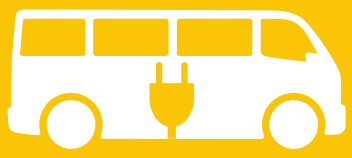


TRANSIT AND SCHOOL BUSES

TRANSIT AND SCHOOL BUSES

Transit and school bus electrification is important for communities working to reduce GHG emissions, eliminate harmful air pollutants from diesel fleets, or showcase their commitment to sustainability. Electric buses are a great opportunity for a high-visibility pilot project, with driving routes and distances typically well suited for electrification. And because most school buses have long breaks between morning and afternoon transport, they are good candidates for distributed charging and vehicle-to-grid applications, providing even more cost and sustainability benefits.

Battery electric transit buses (BEBs) and electric school buses (ESBs) are relatively new to the market compared to light-duty electric vehicles (EVs) but were some of the earliest-available technologies in the medium- and heavy-duty categories. Although BEBs and ESBs require a significant capital investment for both the vehicles and charging infrastructure, there are numerous grant and other funding opportunities to support these efforts. Still, a cost-effective transition will require concerted planning, bringing together transit managers, school district fleet managers and other stakeholders to make informed decisions about investing in an electric fleet. This section offers lessons learned and resources from fleets that are already transitioning to BEBs and ESBs, and outlines strategies for a targeted electric bus planning effort.

Electric Bus Leaders

- Montgomery County Public Schools, the largest school district in Maryland, announced it will lease 326 electric school buses over the next four years. This is the largest local government bus purchase in the U.S. to date.
- The Antelope Valley Transit Authority's Board of Directors set a goal to become the first all-electric transit fleet in the U.S. by 2018. They have largely achieved this goal and have provided lessons learned to other transit agencies seeking to electrify.
- The Federal Transit Administration has been funding transit agencies to adopt electric buses through its Low or No Emission Vehicle program since 2016. The FTA's program site includes information on grantees and where projects have been funded throughout the U.S.
- The World Resources Institute has gathered information on where electric school buses are currently being deployed in the US.

Who to Involve in Transit and School Bus Planning?

- Transit agencies
  - Drivers
  - Maintenance staff
  - IT personnel
  - Facilities staff
  - Decision makers (e.g., general managers, transit boards)
- School districts and supervisory unions
  - Drivers
  - Maintenance staff
  - IT personnel
  - Facilities and/or fleet managers
  - Decision makers (e.g., superintendents, school boards)
  - School bus contractors
- Colleges and universities
- Nonprofits and other community organizations operating buses and/or providing community-based transportation services

Key Takeaways

- Battery electric bus and electric school bus models are readily available in the marketplace from multiple manufacturers
- Electric buses offer significant emissions benefits and reduce the impact of harmful air pollutants for passengers and communities served.
- Electric buses are quieter, benefiting passengers and communities served.
- If charging is managed properly, electric buses have increased efficiency and the potential for reduced and more consistent fuel costs than diesel buses.
- Electric buses have the potential to reduce maintenance costs, although evaluation of buses in long-term service is needed to confirm the scale of potential savings.
- Federal and state funding sources are available to help with procurement of vehicles and charging equipment, and installation of chargers.
- While there are questions about performance, including winter operations, recent pilots have shown vehicles can effectively operate in cold weather conditions.

Typical Barriers

- Electric buses are more expensive to purchase than diesel or other alternatively fueled buses.
- Buses have a relatively low turnover rate. The useful life of a full-size transit bus is 10 years; school buses can operate longer.
- Facilities may lack adequate space and/or electric capacity to support the charging infrastructure required to charge buses.
- Staff often need assistance to determine the ideal locations for chargers as well as to select chargers and manage installation.
- Electric buses may not be able to support all routes with only overnight charging. Some operations may require on-route fast charging which requires careful planning and additional expense for chargers.
- Cold weather and heating implications may affect performance.
- Route profile may affect fuel efficiency.
- Cost-effectively charging electric buses requires careful planning and coordination with Xcel Energy. Fleet managers may even consider "charging as a service."
- Transit and school buses are essential services for vulnerable populations, so it is important to develop strategies to provide back-up power to fully electrified bus fleets.

VEHICLES

Electric Transit Buses

All major transit vehicle manufacturers now produce electric transit buses. This includes the primary manufacturers of diesel vehicles: Gillig, New Flyer, Nova Bus, and COBUS Industries; and manufacturers that entered the market specifically to make electric transit buses: Proterra, Build Your Dreams (BYD), and GreenPower Bus. The Colorado Energy Office compiled a list of current electric buses announced, to date, as an appendix of a 2021 study. The electric transit market is relatively mature, with many transit agencies across the country having made small initial purchases of electric buses, and an increasing number of transit agencies making a commitment to switch to an all-electric fleet. Electric bus models are available in a range of sizes, from smaller "cutaways" to the largest articulated buses.

Battery range of buses can be tailored to meet the needs of transit operations. Short-range buses have smaller batteries with ranges of up to 70 miles and can be recharged with fast chargers during daily service operations. Extended-range buses have larger batteries with ranges that can reach up to 350 miles before needing to be recharged (McCutcheon-Schour & Whitaker, 2017). Extended-range buses typically operate on routes during the day and are charged overnight. Typical ranges and charging times for electric bus models are included in the table on the next page.

Transit buses typically drive enough miles over the lifetime of the vehicle that much of the incremental up-front cost of the buses can be recovered in fuel and maintenance savings, particularly when funding programs help lower the initial purchase cost.

Electric School Buses

All major manufacturers of diesel school buses — including Blue Bird, Thomas, IC Bus, Collins, Starcraft and Ford — already produce electric school buses or have announced plans to begin producing them. Other electric-only manufacturers include Lion Bus, Motiv Power Systems, and GreenPower Bus. Trans Tech produces Type A (small) buses exclusively and has an electric model. The Vermont Energy Investment Corporation compiled a list of all-electric school bus models available on the market.

The electric school bus market is growing due to increased interest and awareness sparked by the Volkswagen Settlement Funds available, as well as by an increase in purchases from school districts, particularly in California, where financial incentives are available. The entry of turnkey fleet providers, such as Highland Electric Fleets, into the market is also making it easier for school districts to adopt electric school buses.

School buses are strong candidates for electrification because of their predictable and relatively short routes, significant down time which allows for overnight or midday charging (potentially expensive fast-charging is not typically needed), and the significant health benefits to children who ride the bus and are no longer are exposed to diesel exhaust fumes. This is also an important sector to electrify as school buses outnumber transit buses roughly five to one (Smith, 2019). However, up-front cost of the vehicles is still a significant barrier for cash-strapped school districts. At current price points, the lifetime cost savings offered by electric school buses are not enough to make up for the additional up-front cost, primarily because school buses tend to have low overall mileage.

CHARGING

Two types of charging systems are currently used to support electric transit buses: 1) depot chargers that charge overnight, where vehicles are parked, after regular service operations and 2) on-route fast chargers that may be needed to support transportation operations during the day. ESBs primarily use depot chargers to top off during the day between morning and afternoon runs, and recharge overnight. However, some manufacturers exclusively offer DC fast chargers to power their vehicles.

Cost-effectively electrifying buses will require early planning and coordination. Fleet managers will need to coordinate with Xcel Energy to understand the capacity of electrical infrastructure at desired charging sites and any potential upgrades necessary to meet charging demand and explore rate options to keep charging costs low. Utility upgrades can range from $5,000 for secondary distribution upgrades to $9 million for substation upgrades. Fleet managers may also consider leveraging solar and even explore charging services to keep charging costs low. The table below summarizes typical charging characteristics for various bus types.

Bus Type	Typical Range (miles)	Charger Type	Charger Use	Charging Time from 0%-100%	Charging Demand (kW)
Short Range Transit	250+	Overhead or Wireless	On-Route	6 min. – 1 hr.	175 - 600
Extended Range Transit	100-250	DC Fast Charger	Depot	2 – 13 hrs.	50 - 150
Electric School Bus	100-150	Level 2 DC DC Fast Charger	Depot Depot Depot/On-Route	5 – 9 hrs. 1.5 – 6.5 hrs. 15 min. – 1 hr.	19 25 – 60 175 - 600
* Battery sizes from 2021 Washington State Procurement (Extended Range Transit), 2021 VTrans Cutaway (Short Range Transit), ANR School Bus Procurement (ESB)					

Strategies in this area focus on assisting transit, school bus, and other fleets plan for, purchase, and deploy electric buses as part of their regular transportation services. Other heavy-duty EV options now available include refuse trucks and cargo vehicles, with more options anticipated to enter the market in the next few years.

Charging Options: Electric Transit Bus

In many cases, electric transit buses can be charged overnight at depots with high-powered DC charging systems. This equipment requires access to high voltage three-phase power. Some electric transit bus manufacturers may include the cost of depot equipment in the vehicle's purchase price or will have relationships with preferred charging equipment vendors. Because transit buses often operate all day and for long hours, on-route fast charging may be needed to maintain service operations with BEBs. Two types of on-route chargers are currently available to support BEBs:

1. **Overhead, or pantograph**: These chargers connect to the top of the bus from a pole-mounted system that deploys when the vehicle stops.
2. **Inductive chargers**: These chargers provide power without making a physical connection to the vehicle. Typically, inductive chargers are installed in the pavement, and power is supplied wirelessly to receiving pads on the bus.

On-route fast chargers are expensive systems to purchase and install — in some cases, they can cost as much as half the price of the vehicle itself. Each fast-charging site requires its own custom design process, similar to the process for depot charging. Fast chargers also require additional planning — to understand and mitigate demand charges that may be incurred if buses charge during peak events, or at times of the day when electric demand is high. Therefore, it is important to assess the need for fast chargers and to consider what overall investment commitment the agency is willing to make in electrification.

Charging Options: Electric School Bus

Currently, the majority of electric school buses use standard, Level 2 chargers with a higher amperage (80 amps) than a typical public station (30 amps). With downtime in the middle of the day and at night, school buses are usually good candidates for slower depot charging. DC charging is becoming common as an alternative to AC Level 2 charging and is typically lower powered than DC fast chargers. As school districts adopt more electric school buses or consider full fleet electrification, DC fast chargers may be needed for buses that travel more during the day and exceed the battery charge range.

Managed Charging

Electricity is more costly to generate and deliver at certain times of day, especially during the hottest and coldest months of the year. Transit bus and school bus operators can often cut charging costs in half by managing the times their vehicles charge. The general practice of reducing costs by controlling charging is known as "managed charging."

Managed charging can be achieved by staff (who manually connect vehicles to chargers at times when energy is less costly) or by computer-controlled systems. The manual practice becomes labor-intensive and complex as bus fleets grow. Manually-managed charging may lead to costly errors (e.g., a single vehicle plugged in 15 minutes earlier than scheduled could add thousands of extra dollars to the month's energy bill). Computer-controlled systems can precisely control the timing of vehicle charging. With these systems, vehicles are plugged in at the end of the day, but the computer system prevents power from flowing to the vehicle until the time when energy costs are the lowest. The computer system can also limit the amount of power being consumed at any one time, reducing the need for costly investments in utility service upgrades.

Involve your IT department early in the charging infrastructure planning process to better understand your ability to automate charging equipment. You may also consider exploring "charging as a service" – a service dedicated to ensuring vehicles are charged at the proper locations, as scheduled, to avoid unwanted demand spikes and ensure full batteries when needed.

PHASED STRATEGIES

With a rapidly evolving market for electric buses and EV infrastructure, taking a phased approach can help fleet managers leverage incentives for early adopters while taking the time to learn and explore which technologies will be the best long-term fit to support their transportation services.

Phase 1: Laying the Groundwork → **Phase 2: Piloting Vehicles** → **Phase 3: Full Fleet Electrification**

Phase 1: Groundwork

Preliminary research and evaluation are important first steps to help guide your bus fleet electrification process. This first phase is intended to position you for success by learning from your peers, building support, assessing your infrastructure, and leveraging funding resources.

Peer Learning

Reach out to regional municipalities, transit agencies and school districts that have purchased electric buses - for information that can help inform decision-making. Be sure to ask about:

- Vehicle performance, especially in local extreme weather conditions
- Procurement insights
- Actual fuel and maintenance costs
- Initial deployment experiences

Successes and lessons learned from early adopters can help streamline the transition to battery electric buses.

Build Staff and Community Support for Electric Buses

Buses are publicly funded so it is important to build stakeholder and community buy-in, particularly as a larger upfront investment in the buses in needed for initial purchases. The following activities will help educate and build support for electric bus purchases.

- Host a ride and drive event with electric bus manufacturers that will demonstrate their buses. Make sure mechanics and drivers get a chance to "kick the tires"; invite stakeholders, the public and the press so people can experience the vehicles firsthand.
- Host electric bus workshops in partnership with Clean Cities Coalitions to educate stakeholders such as school districts and transit agencies about battery electric buses. Content could include an introduction to the technology, benefits to the community and the fleets, charging infrastructure and coordination with Xcel Energy, and sources of funding.

Examples:

- Moms Clean Air Force hosted an electric school bus event in Denver in 2021.
- Wisconsin Clean Cities and Xcel Energy hosted an EV educational session and ride-and-drive event in 2019 that focused on light-duty vehicles but could be adapted for buses.
- Charge Up Midwest launched a four-state electric school bus tour in 2017 to raise awareness about electric school buses and the associated benefits related to air pollution.

Select Pilot Routes

Most transit agencies and school districts have routes that can be supported by electric buses. Routes with daily mileage below the range of base model electric buses are ideal for initial pilot deployments because they can be supported by less expensive depot chargers and overnight charging. On the coldest days, assume up to 50% reduction in range. With this in mind, school bus routes with 50 daily miles or less can be supported by base model electric buses. For transit routes, identify routes with 80 daily miles or less.

Example:

- The Vermont Electric School and Transit Bus pilot selected school districts and a transit agency with routes well under the advertised battery range for electric buses. The longest route proposed for the piloted elected school buses was 63 miles and 120 miles for electric transit buses.

Resource:

- Here's What You Should Know about Electric School Bus Range, Thomas Built Buses

Conduct Site Assessment for Charging Infrastructure

Buses are typically parked at depots overnight; this is where they will most likely be charged. Conduct a site assessment to determine if there is sufficient power to charge buses where they are currently parked or whether electric upgrades will be needed. Details such as whether there is room for chargers and whether buses will be connected to chargers at the front or rear will help in decision-making. A facility electrician or a contractor can provide quotes on the costs to install chargers and upgrade facilities.

Engage Xcel Energy

Be sure to engage Xcel Energy as early as possible to avoid pitfalls like higher-than-expected infrastructure or fuel costs, and to understand available support through Xcel Energy. As soon as you are considering electric buses, set up a preliminary meeting with your Xcel Energy representative to discuss potential scale of cost for infrastructure upgrades to serve the load and available electric rates and programs.

As you go through the planning process, Xcel Energy will be an important partner. Over time it will be important to discuss with them:

- The number of vehicles you anticipate charging and the timeframe for your vehicle purchases
- Amount of power (kWh) vehicles will require for charging
- Time(s) of day vehicles will likely charge
- Site(s) where vehicles will be charged
- If on-route charging will be part of the deployment plan. If yes, what sites are under consideration to host chargers.
- Strategies and technology to manage charging to avoid peak demand.

Track Available Incentives and Grants

Monitor grants, rebates, and other financial incentives for electric buses or EV charging infrastructure - to help inform purchasing decisions and reduce financial obstacles. Maintaining an updated list of actively running group-buy and other purchasing programs in areas near your community will help you keep up to date on new purchasing programs as they become available and will help fleet operators take advantage of opportunities before they expire.

Potential funding sources include:

- Federal Transit Administration Low or No Emission Vehicle Program: The Low or No Emission Competitive program provides funding to state and local governmental authorities for the purchase or lease of zero-emission and low-emission transit buses as well as acquisition, construction, and leasing of required support facilities.
- Federal Diesel Emissions Reduction Act Program (DERA): U.S. Environmental Protection Agency administers the DERA program, which includes federal funding opportunities to support the purchase of electric school buses.
- State Diesel Emissions Reduction Act Programs: States are also allocated funds from the DERA program and are responsible for selecting and awarding grants for projects, including repowering or replacement of diesel school buses with electric buses.
- Congestion Mitigation & Air Quality Improvement Program (CMAQ): CMAQ is administered by the Federal Highway Administration (FHA) and allocates $2.3 to $2.5 million annually to states to fund projects that reduce congestion and improve air quality in areas that do not meet federal air quality standards. Bus replacements are eligible for funding under this program.
- State Volkswagen Emissions Settlement Program: The Volkswagen Emissions Settlement Program identifies 10 eligible mitigation actions, which generally focus on reducing NOx emissions through repowering or replacing older heavy-duty diesel vehicles with newer, cleaner vehicles (including EVs). Eligible activities include electric transit and school buses. Transit agencies, school districts, and contractors who provide transportation services for school districts are eligible for up to 100% funding, including the cost of charging infrastructure. While states have the flexibility to fully fund electric buses, it is up to each state to determine how the funds are allocated. States may choose to require cost-sharing to help stretch settlement dollars. Each state administers its own application process used to identify and fund programs.

Electrify Paratransit Mobility Pilot

Xcel Energy developed the Electrify Paratransit Mobility Pilot as part of the Transportation Electrification Plan (TEP) in Colorado to study how best to reduce the upfront and operational costs of electrifying medium-duty shuttle busses serving paratransit operators. The pilot will help cover the upfront costs associated with the vehicles, the charging equipment, and infrastructure necessary to support their operation for a set period.

Phase 2: Piloting Vehicles

Design and implement a pilot electric bus demonstration. Electric bus demonstrations have been implemented to build awareness about the technology; to gather information to validate costs, savings, and benefits of the technology; and to test the technology in a range of operating conditions such as cold weather and hilly terrain. A demonstration includes evaluation activities to collect data for a set period and, ideally, is compared with performance data from diesel vehicles in the fleet. Demonstrations can be a good initial activity to build buy-in and support for larger-scale deployments.

Purchase Suitable Technology for Pilot

Using the groundwork completed in Phase 1, and considering requirements from funders, conduct a procurement for vehicles and charging infrastructure. Generally, an existing specification for a diesel vehicle can be altered to create an electric bus specification. Body, chassis, and on-road performance characteristics generally do not need to be updated. All references to engines, fluids, fuel, starting batteries, cooling systems, transmissions, differentials, brakes, exhaust, etc. should be reviewed and removed or altered as necessary. Add any special considerations that come with electric buses.

Considerations when choosing electric buses include:

- **Battery**: The battery is by far the most expensive component in an EV. Battery warranty terms must be carefully specified in your RFP and then compared between manufacturers to avoid costly replacement of a failed battery. Battery leasing could be a good financial model and is offered by some manufacturers. Additionally, many manufacturers provide an extended battery warranty option that would cover expected vehicle life.
- **Charging Infrastructure**: Some manufacturers require proprietary charging systems, while others use off-the-shelf charging equipment. Some charging systems cost more up front but can scale easily to serve many vehicles at a lower cost per additional vehicle. For manufacturers that require proprietary charging equipment, be sure to request itemized costs of mandatory equipment in proposals. If you expect to receive proposals from manufacturers that use off-the-shelf charging systems, either require that they provide a quote for such a system or separately solicit budgetary estimates from charging system manufacturers before comparing vehicle proposals. Different charging systems come with varying degrees of controllability, and some may even come with advanced control software — whether standard or as an add-on. To accurately compare charging systems, carefully evaluate control options.
- **Other EV-specific Components**: Be sure to request specifications and specific warranty terms for other EV-specific components like electric motors, inverters, heating systems, and AC-DC converters.
- **Training and Support**: If maintenance staff do not have experience with electric buses, provide manufacturer safety and diagnostic training. Dealerships may not have electric bus expertise to assist with repairs locally. Some EV-only manufacturers do not have existing dealer networks. Ask questions about exactly how long it will take each manufacturer to get a qualified service technician to your site.
- **Track Records**: Electric buses are becoming a mature technology, but some manufacturers have only been making them for a few years. Weigh each manufacturer's specific experience with electric bus deployments when you consider expected reliability and performance.

- **Range**: Range is extended by increasing the number of battery packs and comes with an extra cost. The routes selected in Phase 1 should inform your range needs. Range is highly dependent on the type of usage. For transit buses, test data from the Federal Transit Administration's bus testing facility in Altoona, PA, can be used to help estimate range under conditions similar to yours. Nearly every battery technology available suffers from reduced range in cold weather. Electric heating systems can cut range by 50% on the coldest days. If you will operate in cold weather, consider a fossil fuel auxiliary heater.

Examples:

- The Roaring Fork Transportation Authority (RFTA) began its BEB pilot project with a scoping workshop with bus vendors to inform its purchase of eight BEBs and four depot chargers.
- Charlotte North Carolina is piloting 18 BEBs for 12-18 months on the way to its long-term goal of 100% electric buses. Their rollout will prioritize "Corridors of Opportunity" to elevate health equity and to introduce BEBs first in areas with the highest pollution.
- Minnesota's Lakeville Independent School District 194 piloted an ESB in 2017 to gather information and prove it can work in a cold climate.

Resource:

- The U.S. Department of Energy sponsors the Alternative Fuels Data Center, which contains various tools and information on the alternative fuel vehicles on the market.

Install Chargers

Focus on installation of chargers as soon as buses have been ordered. It can take time to procure chargers (if they are not being provided by the vehicle manufacturer) and make facility upgrades to support chargers. Contractors will want to know the specifications of your chargers so they can provide appropriate electrical service to the chargers.

Resource:

- The Vermont Energy Investment Corporation compiled an electric school bus charging equipment installation guide in 2017.

Evaluate Pilot Results

An important element of a pilot is data collection. Identify the key metrics you expect to track and where data will come from to support this analysis. In addition, it is important to determine a baseline for a comparable new or replacement diesel bus to compare performance, emissions, and operating costs. Data can come from various sources include utility meters, chargers, vehicle telematics, and even manual logs maintained by drivers and maintenance staff. Interviews or listening sessions with drivers, maintenance staff, passengers and community members can provide insights into vehicle performance and benefits of electric buses.

Key metrics to track include:

- Vehicle performance, including driver experiences operating the buses
- Operational costs including maintenance, repair, and fuel
- Energy use
- Emissions reductions

Establish a performance period for evaluating electric buses. The performance period should capture a range of seasonal weather. Follow your data collection plan and report results to stakeholders on a regular (monthly or quarterly) basis. Regularly pulling data from the vehicles may also flag performance issues, such as higher than expected fuel costs, that can be addressed during deployment. At the end of the performance period compile data, lessons learned, and recommendations for future electric bus procurements into a report or presentation for stakeholders and the community.

Examples:

- Massachusetts Department of Energy Resources summarized the results of its electric school bus project in this report.
- The Vermont Agency of Natural Resources is funding an Electric School and Transit Bus pilot with Volkswagen (VW) Settlement Funds to test performance of buses and inform future allocation of funding to electric bus technology.

Phase 3: Full Fleet Electrification

Use the information you collected in Phase 1 and lessons learned in Phase 2 to plan for electrifying a larger portion of your bus fleet. A full or partial electrification plan will include developing a comprehensive vehicle replacement plan and a charging infrastructure plan. Given the potential for extremely high electricity demands if multiple chargers are sited in one location, site planning, design, and construction are paramount for expanding your bus electrification efforts.

Develop a Full Vehicle Electrification Plan

Develop a plan for bus electrification that considers replacement schedules and operational needs to serve existing routes. Route lengths and hours of operation are important considerations that will help determine whether existing routes can be served by electric buses on the market, the size of batteries, and whether on-route fast chargers are needed or if buses can be supported with overnight depot charging. Consulting firms are typically engaged to conduct route analyses for transit agencies. Vehicle manufacturers and turnkey fleet electrification companies can also provide some support to transit agencies and school districts considering electric bus purchases.

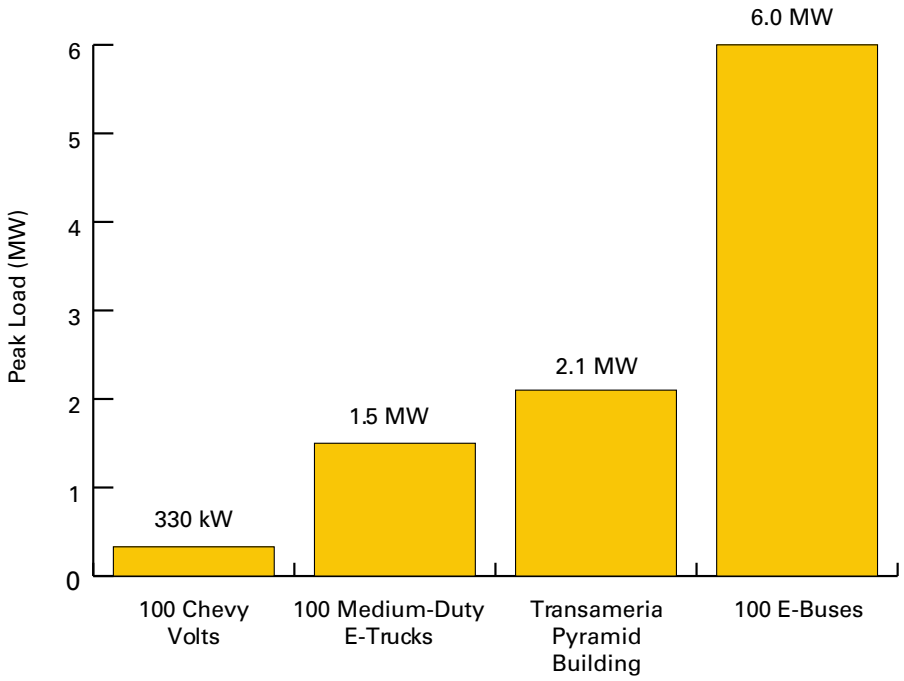
Develop a Charging Infrastructure Plan

As you identify vehicles to replace with electric alternatives, use the results of your analysis to develop a charging infrastructure plan for bus depots (where buses are parked overnight) and if needed, for on-route charging. Then, determine what type of charging levels you will need to support daily operations. In some cases, vehicle manufacturers will offer proprietary charging systems at a certain level. Make sure to consider whether these fit your operational needs, factoring in the cost of the chargers. At the outset, consider how you will stage upgrades to your facilities. Even in the early stages of electric bus adoption, incorporating additional electrical capacity and conduit into the construction of new transportation facilities is significantly less expensive than retrofitting a facility.

Equitable Electric Bus Routes

Because of historical racist housing policies like redlining, low-income neighborhoods and communities of color are often located near highways and arterial roads with high levels of commuter traffic, buses, and heavy-duty vehicles that produce harmful vehicle emissions. As you electrify your bus fleet, prioritize routes in these disproportionately impacted communities.

Multiple chargers at one location can significantly increase electricity demand. Coordinate with Xcel Energy early in your planning process to discuss charging considerations, such as whether identified sites have sufficient electric capacity or need upgrades, what charging rate structures are available, and whether there are additional incentives available to bring down upfront infrastructure costs. One report stated that a fleet of 56 buses would require approximately 11 MWh/day and a fleet of 542 could require 109 MWh/day (Black and Veatch, 2019). Another source shares sample peak loads for different electrification scenarios, showing that 50 ESBs could yield a peak demand of 3 MW (see figure below). You may also consider installing onsite renewable energy to offset new electricity demands.



Peak loads for various EV fleets without mitigating grid impacts, based on 2020 ACEE White Paper by Steven Nadel and Eric Junga

Cost-effective charging will require careful coordination with multiple members of your organization. Involve your IT department early in the charging infrastructure planning process to better understand your ability to automate charging equipment. You may also consider exploring "charging as a service" – a third party service dedicated to ensuring vehicles are charged at the proper locations, as scheduled, to avoid unwanted demand spikes and ensure full batteries when needed. Finally, your charging plan should include financial considerations – how will your organizations pay for the chargers and the additional electricity? Which chargers will be purchased and installed first? See the Funding section to begin identifying funding resources to support your vehicle replacement and charging infrastructure plans. What incentives are available to reduce the cost of charging infrastructure.

Example:

- Miami Dade County, Florida partnered with U.S.-based Proterra to install 75 chargers and 42 new buses in a comprehensive plan to electrify, making this fleet one of the largest e-bus fleets in America.

Implement Vehicle Replacement and Charging Infrastructure Plans

Significant lead time is needed to upgrade facilities to support electric bus chargers, so you should start planning for site upgrades as soon as you have completed your vehicle replacement plan. Site plans can be further refined once you have completed your initial vehicle and charger procurements. An electrical engineer will need to be engaged to draw up plans for charging infrastructure at the site and provide quotes for the work. These plans should be submitted to Xcel Energy or the electric utility serving the site. If the initial conversation with Xcel Energy indicates that significant upgrades will be needed to provide energy to your bus fleet, Xcel Energy will not be able to design those upgrades until they receive the plans from the engineer. This means a minimum of several months' work must be done before Xcel Energy can begin its work. The Xcel Energy design process can take several months as well. If Xcel Energy initially indicates that only minimal site upgrades will be needed, it is likely that Xcel Energy will only need to review and approve the engineer's drawings. By including Xcel Energy early in you will not only be able to address potential concerns with energizing your charger but you can incorporate any Xcel Energy programs that may be available to support your bus purchase and charger installation.

Key decisions will need to be made before plans can be drawn up. Will the EV fleet expand in the future? If so, does it make more sense to oversize the electrical infrastructure now, so it does not need to be upgraded later? Where, exactly, will charging stations be located? Where will conduit run? Where will a new transformer be located? Use your vehicle replacement and charging infrastructure plans and work with an electrical engineering firm to answer these questions.

Example:

- Xcel Energy developed a guidance document on the expected steps and timeline for installing EV charging infrastructure.

Consider Resiliency

School and transit buses provide essential services, transporting vulnerable populations and often serving as community resources in emergencies. Therefore, it is essential that public bus fleets have a strategy to fuel buses in the event of a power outage, as part of a full-fleet electrification plan. There are multiple options: to provide a redundant source of power from diesel-powered generators, to retain some fossil-fuel powered vehicles in the fleet, or to install renewably-powered microgrids.

Example:

- Martha's Vineyard Transit Authority (VTA) is fully electrifying its fleet. Because it is located on an island, having a redundant power source is critical to maintain operations in the event of a power outage. As a result, VTA has developed a renewably-powered solar plus storage microgrid to power its buses, manage peak loads and ensure operations can continue in an emergency.

Share Your Leadership

Just as you were learning from others in Phase 1, others can learn from your successes and lessons learned. Participate in peer networks and other sharing opportunities to inspire other transit and school bus fleet managers in the region; continue learning about new innovations that could enhance your fleet electrification efforts. Venues for sharing information include:

- State public transit associations
- State school bus associations
- American Public Transit Association (APTA) conferences and BEB forums
- National Association for Pupil Transportation (NAPT)
- Clean Cities Coalitions