



School Decarbonization Strategy Spotlight: Electric School Buses

Today, 32% of school districts are in states that have adopted the Advanced Clean Transport (ACT) rule, have set a zero-emissions school bus target, or have a zero-emissions school bus mandate in place.¹ With nearly a third of school buses required to be electric in the near future, the transition to electric school buses is picking up momentum. This resource guide spotlights electrifying school buses and incorporating electric vehicle charging infrastructure in schools and districts.

Electric School Buses Offer Health, Economic, and Climate Benefits to Students and Communities

Exhaust from traditional diesel-burning school buses is unsafe, with proven links to serious physical health issues² as well as cognitive development impacts,³ putting students' health and academic achievement at risk. Communities of color and low-income communities are exposed to disproportionately high levels of air pollution and its resulting health effects, and this can be especially damaging for children whose lungs and brains are still developing. In addition to these high pollution levels, older diesel buses can be more expensive to maintain.⁴ Electric school buses are safe, reliable, and quiet, can provide a range of benefits to school districts:

Improved Air Quality and Health

- ✓ Electric school buses (ESB) are the only school bus option with no tailpipe emissions. This decreases exposure to harmful pollutants like nitrogen oxides, which contribute to respiratory and heart disease and lung inflammation.

Reduced Greenhouse Gas Emissions⁵

- ✓ ESBs have less than half of the greenhouse gas emissions of any other school bus type, even when accounting for emissions from the generation of electric power.
- ✓ ESB greenhouse gas emissions will only improve as the grid continues to decarbonize.

Cost Savings⁶

- ✓ Compared to diesel, a new electric school bus can save an average of \$6,000 every year on operational expenditures and over \$100,000 over the lifetime of the bus, depending on circumstances.
- ✓ Charging costs are 40-75% lower than diesel fuel costs.
- ✓ Maintenance savings of up to 60% over diesel school buses.

Increased Resiliency⁷

- ✓ Potential to serve as a backup generator during electricity outages.
 - ✓ Provides benefits to the local electric grid.
-

Fleet Electrification Technologies

By December 2022, 49 states have committed to the use of electric school buses, with deliveries completed or buses actively in service in 38 states. With 24 electric school bus models currently available, this growing market offers solutions for many district scenarios.⁸ Before selecting a specific ESB model(s), planning teams will need to consider which standard bus types and charging equipment levels will be most appropriate for their project and operational needs. Because these technology details impact the infrastructure planning and cost, understanding technology options is a key early step in the Roadmap to ESB adoption.

Types of Buses

School buses manufactured today are categorized into three types: Type A, C, and D. Electric options are available for each type, with Type C being the most common bus school districts purchase and therefore having the most electric models available by most manufacturers. Type B buses do exist but are a rare sight on roads these days and are not currently an option for electric school buses.

TYPE A	TYPE C	TYPE D
		
A small conversion bus using a cutaway front section with a left-side vehicle driver's door.	A large school bus but with the entrance door being behind the front wheels. It is also known as a conventional-style school bus.	A large bus with the entrance door located ahead of the front wheels and is also known as a rear engine or front engine transit style school bus.
Source: GAO presentation of 2015 National School Transportation Specifications and Procedures . Artwork by Nicole Kelner		

Newly manufactured electric buses can be purchased just like any new electric vehicle, or buses can be “repowered” by removing the internal combustion engine components and replacing them with a new electric powertrain and high-voltage battery. A fleet can consist of both repowered and newly manufactured buses, as both use the same charging infrastructure. A deeper dive into the ESB market and available offerings can be found here: [All About Types of Electric School Buses | Electric School Bus Initiative](#).

Electric Vehicle Supply Equipment and Infrastructure

Electric vehicle charging equipment includes both hardware and software components that decision-makers will need to evaluate:

- Vehicle charging stations
- Vehicle charging cords and connectors
- Electrical infrastructure (transformers, electrical panel upgrades, electrical meters)
- Software (with graphical user interface or dashboard)

There are currently three charger “levels” available. The levels classify the electricity requirements to run the hardware and electrical output available to charge EVs. Level 1 (L1) chargers are not suitable for ESBs due to the low rate of charge relative to the time it takes to charge the battery. Level 2 and Level 3 (also called Direct Current Fast Chargers or DCFC) charging levels will be applicable to electric buses. Differences in these two levels are summarized in the table below, adapted from the Electric School Bus Initiative.⁹

TABLE 1. KEY CHARACTERISTICS OF CHARGING LEVELS

Characteristics	Level 2 (L2) Single Port	Level 3 / DCFC Single Port
Type of current	Alternating Current	Direct Current
Voltage (volts)	208/240	200-600
Power level (kW)	~7-20	~24-150
ESB recharge time	5.5-13 hours	1-4.5 hours
Charger cost	\$400-\$6,500	\$10,000-\$40,000
Installation cost	\$600-\$12,700	\$4,000-\$51,000
Electrical infrastructure upgrades	Typically minimal	May require new transformers, panel capacity, and meters
Use case	Buses able to charge afternoon and overnight; in rural areas, can be installed at drivers' homes	Overlapping routes; frequent afternoon and nighttime use

Notes: Costs are largely dependent on the power output (kilowatts) of the charger, the degree of control over charging, and other advanced features. Installation costs will be site and geography dependent. Estimates do not include potential grid upgrade costs.

The Importance of Managed Charging

Managed charging software is designed to help fleet operators optimize charging schedules, costs, and bus performance. To get the most out of ESBs and EVSE investments, districts should include managed charging software in their project. Specific applications may include:

- Setting time windows when charging will or will not happen, such as overnight charging when electricity is cheaper



Working With Your Electric Utility

When assessing infrastructure needs, communicating early and often with the electric utility is crucial to understand any regulatory limitations, if additional electric service will be required, panel capacity, and more.

To understand how to work with your electric utility, check out: Electric School Bus Initiative—[All About Working with Your Electric Utility](#).

- Notifications for when charging is complete, to reduce high-demand DCFC equipment use
- Staggering charging start times to avoid large electricity demand costs due to charging all at once

Using ESBs as a Power Source

With the right combination of hardware and software, schools and districts can take advantage of V2X (“vehicle-to-everything”) operations, sometimes referred to as bidirectional charging. The basic premise of V2X is to utilize the significant energy potential of the ESB’s battery system as a mobile power source. This could mean sending energy back to the electric grid or supplying energy to a building from stored energy in the bus battery. There are two main reasons to consider this type of operation: to leverage differences in electricity costs based on time of day, minimizing costs; and to increase electricity resilience by utilizing the stored power of the ESB at times when there are power outages or failures of the electricity grid.¹⁰

Vehicle-to-Grid Success Story: Cajon Valley Union School District

Location: El Cajon, CA

Students Served: 16,000

Technology Summary:

- 5 Type C Lion Electric ESBs with 132 kWh battery, 100 mile range
- 2 Type C Lion Electric ESBs with 169 kWh battery, 120 mile range
- 6 bidirectional fast chargers (60 kW)
- Level 2 wall chargers (used if bidirectional chargers go offline)



Project Summary: After deciding to pursue ESBs to meet their sustainability goals, the school district connected with the local utility, who helped obtain federal and state grant funding to purchase the buses. The utility also paid for the charging infrastructure and associated electrical upgrades to enable Vehicle-to-Grid capability. In exchange, the district discharges power back to the grid when it is needed most through managed charging and provides valuable data to the utility.

Cost Information: Grant funding covered most of the upfront cost for the seven ESBs, bringing the school district expenditure down to approximately \$70,000. The utility paid for over \$1 million in electrical infrastructure upgrades. Utility program participation also provides revenue to the schools.

Lessons Learned/Key Advice: Planning ahead is essential. When considering V2X technology, work with utility to ensure benefits to the grid do not diminish in any way the district’s ability to operate the ESBs efficiently.

Read More About This Project Here: [The Electric School Bus Series: Powering the Grid with Cajon Valley Union School District | Electric School Bus Initiative](#)

The ESB Roadmap

The transition to electric school buses can span multiple years. The five general stages, which often happen concurrently, are outlined below.

- 1. Foundation Setting:** Create your project team, get educated on the technology and process, establish your approaches to centering equity, engage stakeholders and research funding and financing options. Establish the business case by understanding the total cost of ownership.
- 2. Charging Infrastructure and Operations Planning:** Decide how many buses to procure, charger locations and site upgrades, and create operations and infrastructure plans.
- 3. Procurement and Installation:** Procure buses, chargers, and services; upgrade facilities and install electrical infrastructure.
- 4. Training, Testing and Deployment:** Train drivers, maintenance workers, and first responders; test buses and charging equipment; deploy!
- 5. Performance, Benefits and Scaling:** Monitor performance and benefits and look for ways to expand your impact.



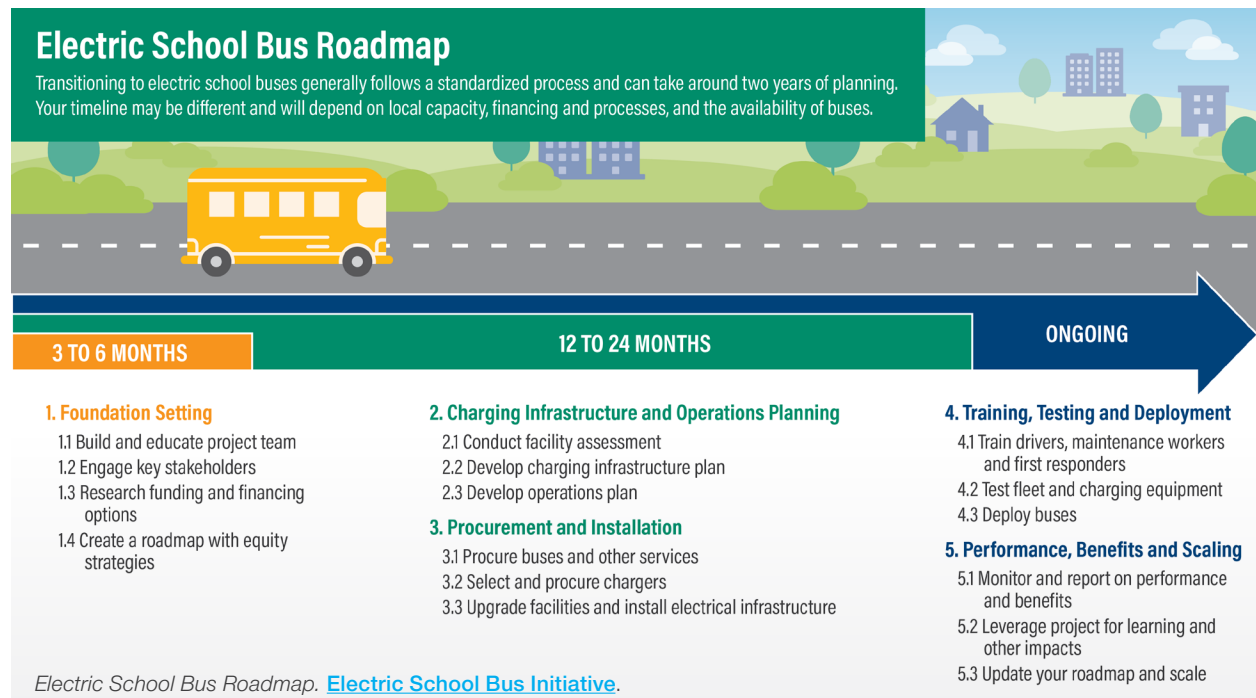
Funding and Financing

As of August 2023, over 300 funding or financing opportunities are available to support the transition to electric school buses. EPA's Clean School Bus Program alone has designated \$5 billion to replace diesel school buses through 2027. With these funding opportunities, the total cost of ownership of electric school buses can be less than half of their diesel equivalents.

For more information about funding opportunities, check out: [All About Funding and Financing Options | Electric School Bus Initiative](#)

Electric School Bus Roadmap

Transitioning to electric school buses generally follows a standardized process and can take around two years of planning. Your timeline may be different and will depend on local capacity, financing and processes, and the availability of buses.



Electric School Bus Roadmap. [Electric School Bus Initiative](#).



Credit: Lincoln Public Schools Sustainability



Additional Fleet Decarbonization Opportunities

Electric school buses are not the only transportation decarbonization strategy; transitioning other district vehicles to electric and installing EV charging for students, parents, staff, and visitors offer additional decarbonization and educational opportunities. For example, Austin Energy offers the EVs for Schools¹¹ program which provides incentives for installing charging stations as well as educational materials.

Installing EV charging stations for passenger vehicles follows similar principles to electric school bus adoption. Reach out to your electric utility early in the process to understand your infrastructure needs and what programs are available to help.

To Learn More:

In addition to the resources provided throughout this document, the following programs and initiatives provide a variety of useful resources for school decision-makers:

- [US Environmental Protection Agency's—Clean School Bus Program](#)
- [Alliance for Electric School Buses](#)
- [World Resources Institute's—Electric School Bus Initiative](#)

References

- 1 Electric School Bus Data Dashboard: <https://electricschoolbusinitiative.org/electric-school-bus-data-dashboard>
- 2 Timothy K.M. Beatty and Jay P. Shimshack, "School buses, diesel emissions, and respiratory health," 2011. <https://www.sciencedirect.com/science/article/abs/pii/S0167629611000701#bib0190>
- 3 West Ausitn, et al, "School bus emissions, student health and academic performance," 2019. <https://www.sciencedirect.com/science/article/abs/pii/S0272775719301530>
- 4 Jesse Boudart, et al, "Key Variables Affecting Decisions of Bus Replacement Age and Total Costs," 2012. <https://journals.sagepub.com/doi/10.3141/2274-12>
- 5 Electric School Bus Initiative, "Why we need to transition to electric school buses," 2022. <https://electricschoolbusinitiative.org/why-we-need-transition-electric-school-buses>
- 6 Electric School Bus Initiative, "'Why Electric School Buses?' Sample Pitch Deck (September 2023)," 2023. <https://electricschoolbusinitiative.org/sites/default/files/2023-09/Why%20Electric%20School%20Buses%20Sample%20Pitch%20Deck%20%28September%202023%29.pptx>
- 7 Electric School Bus Initiative, "'Why Electric School Buses?' Sample Pitch Deck (September 2023)," 2023. <https://electricschoolbusinitiative.org/sites/default/files/2023-09/Why%20Electric%20School%20Buses%20Sample%20Pitch%20Deck%20%28September%202023%29.pptx>
- 8 World Resource Institute, "The state of electric school bus adoption in the US," 2023. <https://www.wri.org/insights/where-electric-school-buses-us>
- 9 Electric School Bus Initiative, "Electric School Bus U.S. Market Study and Buyer's Guide: A Resource for School Bus Operators Pursuing Fleet Electrification," 2022. <https://electricschoolbusinitiative.org/sites/default/files/2022-09/electric-school-bus-us-market-study-buyers-guide.pdf>
- 10 Electric School Bus Initiative, "All About Managed Charging and 'Vehicle-to-Everything' or V2X," 2022. <https://electricschoolbusinitiative.org/all-about-managed-charging-and-vehicle-everything-or-v2x>
- 11 EVs for Schools: <https://austinenergy.com/green-power/plug-in-austin/school-charging>

The [Decarbonization Roadmap Guide for School Building Decision Makers](#)

identifies cost effective strategies and approaches to help school districts achieve healthy, efficient, and decarbonized school facilities. The content for this guide was developed in partnership with WRI and the Electric School Bus Initiative.



WORLD
RESOURCES
INSTITUTE

Electric
School Bus
INITIATIVE

nbi new buildings
institute

New Buildings Institute (NBI) is a nonprofit organization driving better energy performance in buildings to make them better for people and the environment. We work collaboratively with industry market players—governments, utilities, energy efficiency advocates, and building professionals—to promote advanced design practices, innovative technologies, public policies, and programs that improve energy efficiency. Visit the [NBI Getting to Zero in Schools](#) webpage to learn more.