Joint Office of Energy and Transportation

TECHNICAL ASSISTANCE HELP SHEET

Cold Weather Impacts on Electric School Buses

School bus fleets considering electric buses can start here to learn about cold weather impacts and considerations for optimizing bus performance when temperatures drop.

Electric school buses are proven to operate effectively in cold weather; however, cold temperatures will impact their range and efficiency. School bus fleets can effectively manage these impacts by considering effective safeguards during deployment.

Cold Weather Impacts

Electric buses operate at peak performance in ideal weather conditions—between 55°F and 60°F air temperature. In this temperature range, electric buses can use all or most of the stored energy for propulsion, which in turn maximizes bus range.

Cold weather reduces range because energy from the high-voltage batteries is required to maintain cabin and battery temperatures. When the temperature drops, so does bus range—more battery power is required to warm the cabin in cold weather, reducing the energy available for propulsion. A 2022 study from the National Renewable Energy Laboratory (NREL) found that electric transit bus range decreased by 33% when air temperature was 25°F, a 30-degree decrease from its ideal conditions of 55°F–60°F.[1] Cold temperatures slow down the chemical processes in the battery system, which reduces the available power and energy.

Electric school buses are typically equipped with a battery thermal management system (BTMS). The BTMS draws energy from the batteries while the bus is idling or charging in order to warm up the battery. This system enables the batteries to optimally perform in all conditions.

Battery-electric school bus in Massachusetts.
Photo from Brian Foulds, Concord-Carlisle Regional School District, NREL 60242

To minimize cold weather impacts, the Joint Office of Energy and Transportation (Joint Office) recommends the approaches outlined below to optimize bus performance and maximize range.

Cold Weather Considerations

- **Perform battery and cabin preconditioning.**
  - Preconditioning is the act of warming up the battery and cabin to optimal temperatures while plugged in to the charger to take advantage of grid energy and reserve battery power for on-route needs. Preconditioning for electric school buses can typically be done during the bus pre-trip routine. Demand charges can occur if charging happens during peak electric rate times. The additional load from charging a bus during these high demand rate periods may cause electricity rates to increase. If subject to demand charges, be sure to account for preconditioning as most buses will perform pre-trip routines at the same general time.

[1] Matthew Jeffers, Leslie Eudy, Erik Bigelow, Greg Olberding, and Amy Posner. 2022. *Duluth Transit Authority Battery-Electric Bus Evaluation*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5400-83038. https://www.nrel.gov/docs/fy22osti/83038.pdf

- **Store electric school buses indoors overnight.**
  - Parking the bus indoors overnight protects the vehicle from cold outdoor air and helps to keep it warmer. The BTMS will not need to work as hard to regulate battery temperature. This in turn improves heater efficiency on the route and requires less power for preconditioning. If indoor storage is not possible, storing the bus in areas with sunshine during the day helps to keep the battery warmer. The BTMS will then not have to work as hard to maintain battery temperature while the bus is operating on afternoon routes.
- **Charge upon returning from a route.**
  - Charging an electric bus when it returns from its route is ideal as the battery will already be at optimal temperature. This will allow for energy from a charger to be primarily directed toward replenishing bus range. Ensure that this charging time does not have negative impacts on time-of-use or demand charges.
- **Add insulation and minimize door opening.**
  - Work with the electric bus manufacturer to see if there are additional insulation options available for the buses. Reducing or minimizing the amount of time the bus doors are open can also help to maintain a warmer cabin temperature.
- **Add heated driver seats.**
  - Heating a driver's seat requires much less power than heating the cabin air. A bus operator with a heated seat may be able to turn off or lower the cabin heat and keep just as warm when students exit the bus, which will conserve the battery and extend range.
- **Train and retrain your drivers.**
  - Ensure that drivers understand how to use the specified equipment for the bus and employ best methods to heat the cabin while preserving the vehicle's range. It is critical to work with the distributor to ensure that drivers have the best training possible to maximize vehicle capabilities.
- **Consider the impacts of climate conditions.**
  - Consult with local electric school bus fleets on their experience with climate and range and ask for efficiency data. Before purchasing, it is important to know what strategies and methods are working for those fleets, and if those fleets have experienced cold weather-related issues that could be avoided.
- **Evaluate worst-case cold weather impacts when performing route analysis.**
  - Ensure that the electric school bus can perform routes in worst-case cold weather with reduced range. Consider larger battery options in certain cases, though this may result in significant cost increases. Alternatively, consider driving the bus on various routes during its first cold weather season, starting with the shortest, least demanding route. There are publicly available tools to assist with identifying optimal routes—the Electric School Bus Route Analysis Tool from the Joint Office can predict route energy consumption based on temperature and other factors.
- **In extreme cases, consider auxiliary heaters.**
  - There are also supplemental heat sources, such as fuel-fired heaters, that can add heat to the vehicle while only using minimal electric resources for heat output. These are available on most electric school bus models but can negatively impact emissions reduction goals. To mitigate their negative effects, they can be set to operate only in extreme cold conditions such as 20°F or below. Consider reaching out to other local electric bus fleets, who can advise on best practices for maintaining and operating buses in that area's climate.

The Joint Office provides technical assistance on planning and implementation of a national network of electric vehicle chargers and zero-emission fueling infrastructure, as well as zero-emission transit and school buses.

For more technical assistance resources, please review DriveElectric.gov/school-districts. If you would like detailed help or assistance, please contact the Clean School Bus Technical Assistance team at DriveElectric.gov/contact.

Joint Office of Energy and Transportation

About the Joint Office of Energy and Transportation
The Joint Office provides technical assistance and expertise to a multitude of stakeholders and programs that seek to deploy a network of EV chargers, zero-emission fueling infrastructure, and zero-emission transit and school buses. Contact us at **DriveElectric.gov/contact**.

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