Joint Office of Energy and Transportation

TECHNICAL ASSISTANCE HELP SHEET

Cold Weather Impacts on Electric School Buses

School bus fleets considering electric school buses (ESBs) can start here to learn how cold weather impacts ESBs and considerations for optimizing bus performance when temperatures drop.

ESBs 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 on ESB operations by considering effective safeguards during deployment planning.

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

Cold Weather Impacts on ESBs

Cold weather reduces ESB range because it requires energy from the high-voltage batteries to maintain cabin temperature and the temperature of the batteries themselves. This contrasts with ideal conditions (55°F–60°F air temperature) where ESBs can utilize all or most of the batteries toward propulsion of the vehicle to achieve peak driving ranges.

The decrease in range is most often due to energy required to create a comfortable cabin temperature in cold weather. The energy used by ESB electric cabin heaters is second only to the energy used to propel the vehicle. This energy need also increases as temperatures drop. A battery-electric transit bus study showed range decreased by 33% when air temperature was 25°F, a 30-degree decrease from its ideal conditions of 55°F–60°F.[1]

ESBs are also equipped with a battery thermal management system (BTMS) that conditions the batteries to operate at their optimal temperature in all conditions. The BTMS draws energy from the batteries both during operation and while idling or charging.

To minimize cold weather impacts for greater energy draw, optimize performance, and maximize ESB range, the Joint Office of Energy and Transportation (Joint Office) recommends the approaches outlined below.

Cold Weather Considerations

Store ESBs indoors overnight.

- Indoor ESB storage reduces the power needed by the BTMS to regulate battery temperature, 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 the bus use less power for cabin heating and the BTMS on afternoon routes.

Utilize 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 use grid power and reserve battery power for on-route needs. ESBs are uniquely positioned to take advantage of this, as it can typically be done during the bus pre-trip routine. If you are subject to demand charges, be sure to account for preconditioning in your charging analysis, 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

Charge when returning from your route.

- By charging your ESB when it returns from its route, you will avoid any extra power required for the BTMS as the battery will already be at optimal temperature. This will allow for energy from a charger to be primarily directed toward replenishing an ESB's 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 your manufacturer and discuss with local ESB fleets to see if there are additional insulation options available for your buses. Also consider if you can reduce or minimize the time the doors are open on the bus.

Add heated driver seats.

- Heating a driver's seat requires much less power than heating the cabin air. By opting for heated drivers' seats, the operator may be able to turn off or lower the cabin heat when students exit the bus, which will conserve the battery and extend range.

Train and retrain your drivers.

- Ensure that your drivers understand how to best utilize the specified equipment for their bus and the best way to heat the cabin while maximizing the vehicle's range. It is critical to work with your distributor to ensure that the drivers have the best training possible to maximize the vehicle's capabilities.

Understand the impacts your climate will have during procurement.

- Consult local ESB fleets on their experience and ask for efficiency data. It is important to know what is working for them and if they have any pitfalls associated with cold weather that can be avoided.

Evaluate worst-case cold weather when performing route analysis.

- It is important to ensure your ESB can perform your routes in cold weather with reduced range. Consider larger battery options in certain cases, though keep in mind that this may result in significant cost increases. Alternatively, consider driving your ESB on various routes during its first season operating in cold weather, starting with the shortest, least demanding route. This will allow for a fleet to monitor its ESB's effective range and determine what route offers the most cost savings.

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 its heat output. These are available on most ESB models but can negatively impact emissions reduction goals. To mitigate their negative effects, they can be set to only operate in extremely cold conditions such as 20°F or below. Some local ESB or transit fleets can advise on best practices for your 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**.

DOE/GO-102023-6112 · November 2023