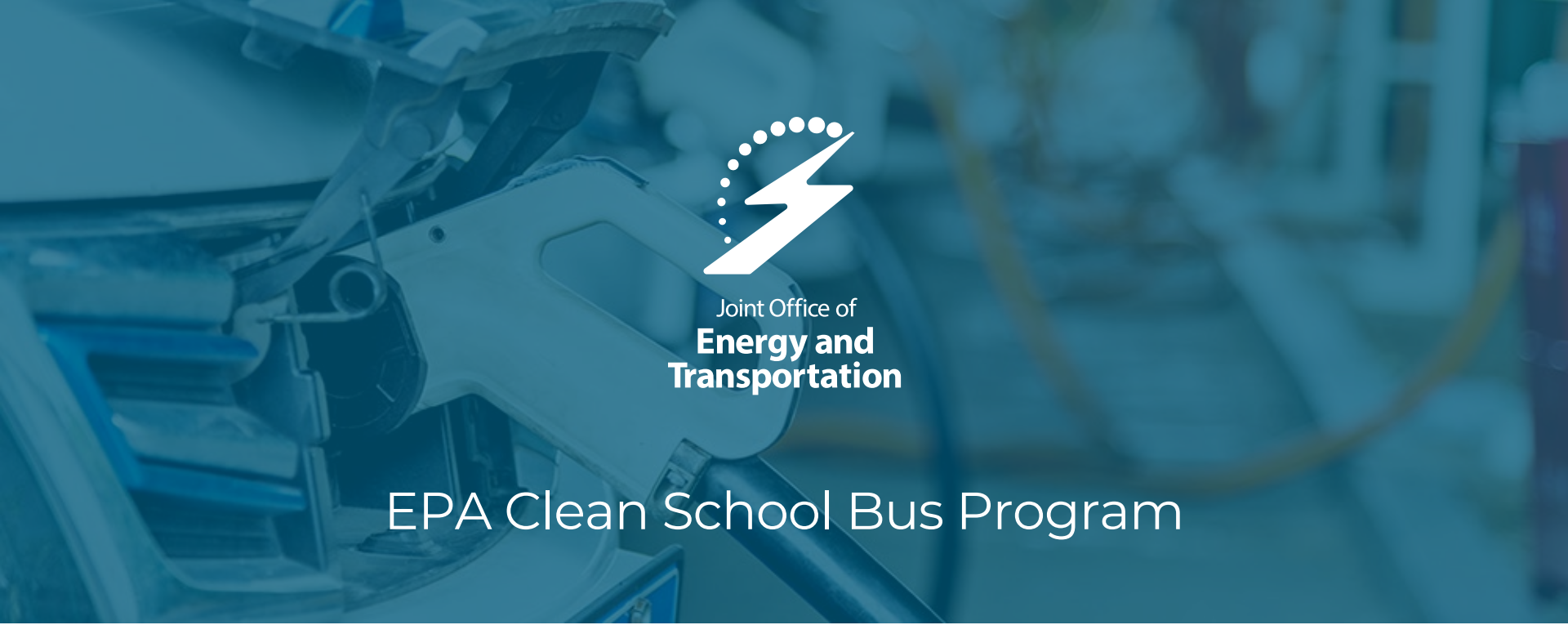


Joint Office of
Energy and
Transportation

EPA Clean School Bus Program

Cold Weather Considerations for Electric School Buses

April 19, 2023

driveelectric.gov

Basics: Electric School Bus (ESB) Cold Weather Operation

- ESB high-voltage (HV) batteries operate most efficiently around 70°F, making temperature regulation a critical consideration.
  - HV battery temperature is regulated by a battery thermal management system (BTMS).
- An electric on-board cabin heater is the largest load on HV batteries outside of propulsion.
- HV battery charging and discharging generates heat.
- HV batteries are generally at an optimal charging temperature after returning from routes.
  - If parked for long periods in the cold, the charger will need to utilize a portion of the power to regulate the HV battery temperature.

ESB Cold Weather Best Practices

Pre-condition the bus prior to each route

- Regulates the HV battery and cabin temperature while the bus is plugged in to the charger
- Conserves HV battery for on-route energy
- Can be done during driver's pre-trip routine

Turn off or lower cabin heat when students exit the bus

- Conserves HV battery and extends range
- Consider heated driver's seats during procurement

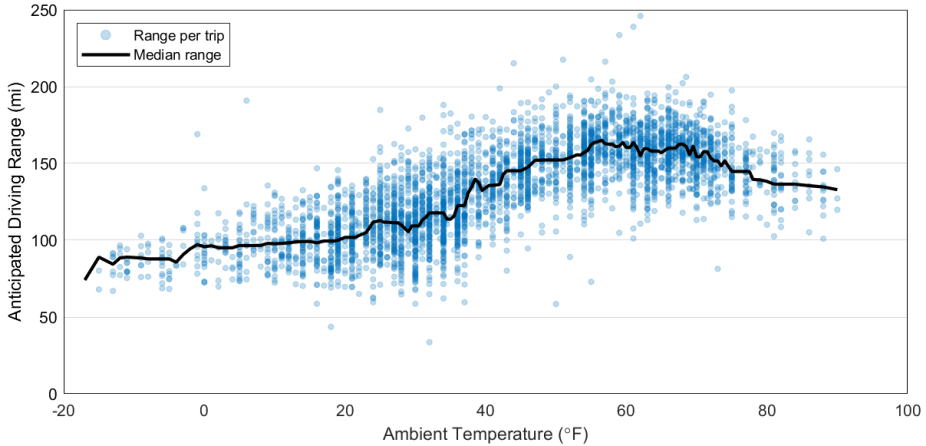
If possible, charge indoors in a temperature-controlled environment.

- Will reduce power needed to regulate temperature
- Will improve heater efficiency

Real World Cold Weather Examples: ESB and Battery Electric Bus (BEB) Fleets

Duluth Transit Authority – Duluth, MN

- 2019-21 study saw a range decrease of approximately 33% for a temperature decrease of 30°F. (https://www.nrel.gov/docs/fy22osti/83038.pdf)
- BEBs are approximately 3x as energy efficient as the diesel fleet
- BEBs utilize auxiliary cabin heaters in colder weather.



Tok Transportation – Tok, AK

- Has operated one Type C ESB since 2020 with only electric heat.
- Successfully completing routes under -35° F
- Experiences an efficiency decrease of 20-25% for every temperature decrease of 30°F, which maxes out around 55% efficiency decrease at negative 10-20°F.
- Bus is stored and charged inside.
- Utilizes 25kW DC fast charger.

Additional Considerations for Mitigating Cold Weather Impacts

Consult similar ESB fleets on their experience

- Climate, bus size, battery size, route distances, storage location, etc. will all affect cold weather operations. It is important to know what ESB fleets with similar use cases are experiencing to make the right decisions.

Consider larger HV battery options

- Evaluate worst-case cold weather when doing route analysis

Consider auxiliary heaters in extreme cases

- Available on most ESB models
- Negatively impacts emission reduction goals

Cold Weather Concerns?

Contact cleanschoolbusTA@nrel.gov for assistance with:

- Evaluating specific cold weather concerns and options
- Completing route analysis
- Incorporating utility or infrastructure considerations
- Connecting with local fleets or Clean Cities Coalitions
- More information on ESB and BEB data logging studies and real-world examples.

Image: *Battery electric school bus in Massachusetts*
Photo by Brian Foulds /Concord-Carlisle Regional School District; NREL Image Gallery