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TECHNICAL ASSISTANCE HELP SHEET

Cold Weather Impacts on Battery-Electric Transit Buses

Transit fleets exploring the adoption of battery-electric buses (BEBs) can start here to learn about the effects of cold weather and how to enhance bus performance in low temperatures. BEBs can be effective in cold weather conditions, despite effects on range and efficiency. Transit fleets can prepare for expected weather conditions by incorporating appropriate safeguards during the deployment planning phase.

Cold Weather Impacts

Cold weather mainly impacts BEB range because of the heating, ventilation, and air-conditioning (HVAC) system. Whereas an internal combustion engine bus can redirect waste heat from the engine to warm the cabin, BEB heating must use energy from the high-voltage battery. Most BEBs have all-electric heaters for the battery and interior, but they also have the added challenge of additional cooling loops for BEB-specific components like battery cells through the battery thermal management systems. While heat pump systems are expected to increase in popularity, they are currently limited, and the resistive heat has a high power requirement. This means there is a significant draw to power the system, often requiring more energy than cooling in summer and possibly more energy than propelling the vehicle.

Cold Weather Considerations

- **Plan for worst-case scenarios.**
When planning for deployment, transit agencies should prepare for the coldest or most strenuous day of operation to ensure reliable service. Agencies operating in climates routinely experiencing temperatures below 32°F should consider the strategies outlined below. Performing a route analysis based on coldest temperatures will point to optimal battery and charger sizes to complete routes on the most strenuous days. Contact the Joint Office of Energy and Transportation (Joint Office) at DriveElectric.gov/contact for help identifying route analysis resources.

- **Utilize battery preconditioning.**
Some manufacturers do not allow their batteries to provide discharge for propulsion until the battery cell temperature is at 50°F or higher to protect cell life. Preconditioning can avoid this by preheating the battery to a defined target temperature where performance is optimized before entering service , generally around 60°F–75°F, depending

on the original equipment manufacturer. Each manufacturer has a different interface for preconditioning, and options should be explored during procurement. Preconditioning should always be done while plugged in to reserve the vehicle's battery for on-route usage.

- **Store and charge BEBs indoors.**
  Storing buses outside leads to cold batteries and a cold cabin. When the vehicle is ready to start service again, energy stored in the battery must be used to warm the battery up to the target operating temperature and to heat the cabin for passengers. Heating a cold-soaked battery can take up to an hour, and the full vehicle functionality may not be available until this is complete. If this is done while unplugged from a charger, the energy expended is used for heating instead of driving, leading to a reduction in range for that day. If chargers are exposed to the outdoor environment, fleet management staff need to consider the equipment's designed operating temperature range during the procurement step. Installing charging equipment indoors can also eliminate the need for snow and ice removal around chargers.

- **Account for slippery conditions and regenerative braking.**
  Regenerative braking can become less effective or disabled during snowy or slippery conditions as part of the vehicle's traction control response to wheel slip. The effects vary by manufacturer and ultimately could mean lower range than typical conditions where regenerative braking functions normally.

- **Consult other fleets.**
  Agencies experiencing similar conditions of service, climate, technology, and topography can provide best practices and lessons learned. Groups like the American Public Transportation Association's (www.apta.com) Zero Emission Fleet Committee and the Zero Emission Bus Resource Alliance (zebragrp.org) can help connect agencies to share experiences. The Joint Office also offers technical assistance at RideElectric.gov.

- **In extreme cases, consider auxiliary heaters.**
  Some transit agencies in cold climates opt for additional heating systems, typically powered by diesel or electricity, to meet their cabin heating needs. Dual-powered heaters will allocate the load according to operating ambient temperature and can vary across technologies. Auxiliary diesel heaters have the advantage of not requiring a high load from the traction battery for operation, preventing the large range loss that occurs when using electric heaters. While a diesel heater will generate some emissions, currently available BEBs will not be feasible in colder climates without this supplemental heating. At full rated output, a typical auxiliary heater will consume about 1 gallon of diesel per hour—significantly less than diesel bus fuel consumption at around 2–3 gallons per hour. This advantage in diesel consumption, even in the worst case, means transit agencies in cold climates can plan for consistent usable bus range.

- **Consider additional HVAC system mitigations.**
  In addition to auxiliary heaters, other systems can be fitted to increase operator and passenger comfort and extend range. Some windshield defroster systems are powered by an auxiliary heater, and windshields are available with internal resistive heating elements thin enough to be invisible to the operator. Operator seat heaters and dedicated floor heaters can provide additional warmth to the operator without needing to heat the entire cabin. These are often installed by the original equipment manufacturer.

- **Plan for resiliency.**
  Planning and operating staff should explore resiliency measures to mitigate the risk of power outages in extreme weather. Options include energy storage measures (like solar with battery storage), temporary generators, or the use of any plug-in or pantograph chargers that may be installed on separate substations from the depot.

Joint Office of Energy and Transportation

About the Joint Office of Energy and Transportation
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/transit-agencies**. If you would like detailed help or assistance, please contact the Clean School Bus Technical Assistance team at **DriveElectric.gov/contact**.

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