Joint Office of
Energy and Transportation

TECHNICAL ASSISTANCE HELP SHEET

Hot Weather Impacts on Battery-Electric Transit Buses

Transit fleets considering integrating battery-electric buses (BEBs) can start by examining the impact of hot weather on BEBs and identifying key factors to optimize bus performance in high temperatures. While BEBs have proven effective in operating under hot weather conditions, elevated temperatures can influence BEB range and overall efficiency. To mitigate these effects, transit fleets should proactively incorporate relevant precautions during the deployment planning process.

Hot Weather Impacts

The effects of hot weather can be noticed at any point beyond 70°F, intensifying as temperature increases. This will vary according to service area climate and cabin comfort settings. The main impact to BEBs from hot weather is the reduced range due to increased power used by the heating, ventilation, and air-conditioning (HVAC) system.

Hot Weather Considerations

- **Consider battery-electric transit bus air conditioning.**
  The air-conditioning systems in BEBs are very similar to those of internal combustion engine (ICE) buses, blowing air over a cooled evaporator. One key difference in BEB air conditioning is that the air-conditioning compressor uses high-voltage power, rather than being belt driven like an ICE. BEBs also have the added challenge of additional cooling loops for BEB-specific components, including the battery thermal management systems and high-voltage power electronics.

- **Plan for worst-case scenarios.**
  When planning for deployment, transit agencies should prepare for their most energy-intensive or strenuous day of operation to ensure reliable service. Some climates can easily determine the more strenuous season, like those that regularly experience temperatures below 0°F or above 100°F. Agencies experiencing both extremes will want to determine which season reflects the larger deviation from the minimum HVAC load, typically occurring around 70°F. For locations experiencing a more energy-intensive summer than winter, the most strenuous use case would reflect the hottest day of the year. More humid climates will

also require higher HVAC system use to maintain interior comfort; the higher the dew point, the harder the system will have to work.

- **Understand range impacts.**
The best performance of a BEB will often occur within temperatures from 50°F to 70°F. BEBs experience more significant decreases in fuel economy and range when colder than this band, as cooling is more efficient than heating with the electric systems onboard. **Range will also decrease when temperatures are warmer**, with some agencies in hot climates achieving only 75% of typical range. This is primarily due to increased cooling loads, but BEB range can also be dependent on other factors like battery capacity, weight, driver behavior, route topography, and average speed. Ensure your drivers are properly trained on efficient BEB driving habits to minimize the non-HVAC-related range effects. Bus manufacturers should offer driver training upon delivery of your buses.

- **Provide cover and shade for bus storage and charging.**
To minimize HVAC energy use, keep the battery at optimal temperature, and maintain lower temperatures at the charger, consider storing BEBs in covered or shaded areas, where available, after pulling in or during layovers in hot climates. For chargers exposed to the outdoor environment, fleet management staff need to know the designed operating ambient temperature and local temperature trends to ensure year-round reliable charging of BEBs. For example, a charger may be designed to operate in ambient temperatures from 31°F to 113°F. Some charger performance will derate at higher temperatures. Hotter climates may even experience charger inoperability or downtime during temperatures near or exceeding rated temperatures. Consult with your charging equipment supplier for optimal range and strategies to improve performance.

An outdoor canopy providing shaded areas is an alternative. Pantographs or hose reels can be installed on the canopy, with the added advantage of allowing photovoltaic panels on top to provide solar energy that can offset energy from the electric grid. Canopies designed to support solar panels are readily available as preengineered solutions and can provide shade and power generation.

- **Utilize battery preconditioning.**
A transit agency should explore preconditioning capabilities and measure the effects on operating schedules and cost. Preconditioning allows preheating or precooling of a BEB prior to service or charging, though it does require additional energy and extends the charge time. Availability of preconditioning will vary according to bus model, charging infrastructure, and any third-party charge management software. Preconditioning should always be done while plugged in to reserve the high-voltage battery for on-route usage.

- **Consult other fleets.**
Transit agencies can learn how to prepare for deployment by reaching out to other agencies that have introduced BEBs. Agencies that experience 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 of Energy and Transportation (Joint Office) also offers technical assistance at RideElectric.gov.

- **Plan for resiliency.**
Planning and operating staff should explore resiliency measures to mitigate the risk of power outages in extreme weather. Some agencies may have additional energy storage measures (such as solar with battery storage), temporary generators, or pantograph chargers that may be installed on separate substations from the depot. Agencies should also consider resiliency by design when planning for BEB deployment to help mitigate loss in range and charging time during extreme temperatures.

- **Plan for future higher temperatures.**
When making long-term capital purchases, agencies should consider the potential for increasing temperatures over time when evaluating equipment options. This can include planning for higher-capacity cooling, upper operating temperature limits for chargers, and control systems that allow for remote precooling.

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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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