MBTA Approach to Overcoming Winter Range Challenges with Battery Electric Buses

The MBTA is undertaking an ambitious plan to introduce Battery Electric Buses (BEBs) into service in 2024 and 2025 with the opening of the new Quincy facility and the addition of charging equipment to the North Cambridge facility. It then anticipates rolling out BEBs in many Boston neighborhoods and southwestern suburbs in 2027 and 2028 with the targeted completion of the new Arborway facility. This effort solidifies the MBTA as a leader nationally in the transition to zero emissions vehicles.

To adhere to this accelerated timeline and ensure a smooth transition operationally, the MBTA has determined that it must supplement the electric heating system on the first generation of BEBs with auxiliary heaters to ensure buses can maintain enough charge to complete service on cold days. This conclusion is based on experience running the five 60-Foot Silver Line BEBs and analyses modelling BEB performance on the North Cambridge, Quincy, and Arborway routes.

Context: BEBs and Vehicle Heating

Buses require energy to power operation (driving), heat or cool their interior space to maintain customer comfort, and operate any electronic functions. BEBs therefore must have enough battery charge, or an alternate energy source, to cover these needs for the entirety of service. Interior heating and cooling can be particularly energy intensive because the bus doors open and close frequently to let passenger board and alight. In spring and fall conditions, the relatively moderate outdoor air temperatures mean that the vehicles do not need to expend significant energy to heat or cool the interior space. Therefore, the vehicles expend the majority of their battery's charge on operation. However, in the summer and in the winter, more battery capacity is required to heat and cool the interior space, meaning the vehicle cannot run as many miles on a single charge. This situation is most challenging on very cold winter days, where a significant amount of energy is required to heat the bus. For many routes, the batteries simply cannot heat the bus adequately and operate their scheduled service.

To ensure service reliability and be able to build consistent schedules, it is important for the MBTA to overcome the inconsistency in battery mileage range. There are four approaches to resolving this challenge:

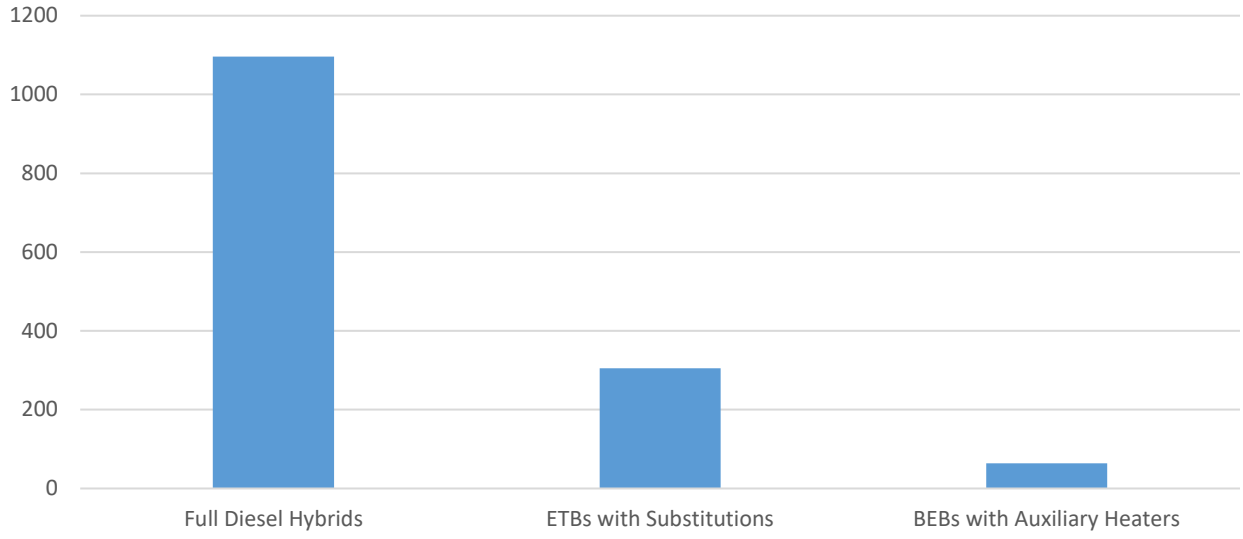
1. **Rework the schedule to accommodate the "coldest day":** Creating vehicle service schedules ("blocks") that accommodate the lowest common denominator would require significantly more buses to operate the same revenue service, which would come with additional capital cost (for the vehicles and the space to store them) and operating cost (labor for operators, electricity for charging, maintenance, etc.).
2. **Use a larger battery:** The market for BEBs mostly uses 450KWh batteries, with a few new options for larger batteries. While the MBTA can create a specification requiring a larger battery, it must consider both the competitiveness given the buses on the market and the weight and space required for a larger battery. The weight of larger batteries adversely reduces the passenger carrying capability, affecting axle / structure loading limitations. However, looking ahead, the MBTA expects batteries will become more efficient and provide for a longer range at a similar weight to the current batteries.

3. **Charge more frequently throughout the service day:** The MBTA can populate in-route charging stations at key points in the network to allow buses to charge during mid-block layover periods. In the long-term, the MBTA anticipates incorporating this approach.
4. **Supplement heating with Auxiliary Heaters**: On the coldest days, the MBTA can employ auxiliary diesel-fueled heaters on the buses to reserve a consistent amount of charge for vehicle operation. The MBTA is using this approach in the near-term, to ensure it can have BEBs in service as soon as feasible.

Short Term Approach – Auxiliary Heaters

The MBTA plans to supplement the electric heaters on the first generation of BEBs with diesel-fueled auxiliary heaters to use during extreme winter temperatures to maintain operator and customer comfort. Designing the bus so the auxiliary heaters will only kick on during the coldest days, rather than using them for all heating needs, means the MBTA is targeting their use to the conditions when the battery is under the most strain to heat the bus. While this approach does not eliminate fossil fuels entirely from operation, it provides a pathway for the MBTA to accelerate the deployment of BEBs, ensure reliability, and limit the emissions.

Service simulations help estimate the amount of diesel fuel and costs anticipated with this approach. For routes 71 and 73 out of North Cambridge, the MBTA estimates it can deliver service using the same bus blocks as today with an estimated 6,250 gallons (approximately $14,400) of diesel fuel for the heaters per year, based on historical temperatures. This approach results in net fewer emissions than today's conditions even with the fully electric trolleybuses, as the trolleybuses often require substitution with diesel hybrids due to roadwork, wire problems, and other incidents. These current day substitutions result in an average of nearly 30,000 gallons of diesel, costing approximately $69,000 per year. As compared to diesel hybrid service, the delta is even greater.



Comparison of Average Annual Tons of CO_2 Emissions for Routes 71 +73 Operated with 100% diesel hybrids, ETBs with diesel hybrid substitutions (planned and unplanned), and BEBs using auxiliary heaters in extreme temperatures.

Long-term Vision – In-Route Charging and Technology Improvements

As the MBTA constructs more facilities to accommodate BEBs and rolls out the vehicles on more routes over the next decade, it anticipates also constructing additional charging facilities at key points in the network where buses layover. This includes MBTA rapid transit stations with large busways, as well as potentially other locations that the MBTA does not own. Making these investments in additional charging facilities will take time and resources to design, fund, coordinate with right of way owners, and integrate into operating procedures. For this reason, the MBTA sees the integration of in-route charging as a long-term effort that would slow the initial plans for BEB rollout, should we not rely on diesel heaters in the interim.

The MBTA also expects the technology for BEBs and batteries specifically will continue to evolve and improve. The MBTA is continually evaluating the market to understand how the newest capabilities can make our transition to BEBs smoother and most cost effective.