ELECTRIC SCHOOL BUSES

A PATH FORWARD FOR RURAL MAINE

Rural places are often left behind when it comes to new technology, especially when it comes to transportation. Electric vehicles are no different, where adoption in urban areas has far outpaced adoption rural areas. While rural areas present different challenges for vehicle electrification, the advantages such as lower operational cost and emissions still can provide significant benefit in the right rural context. School buses are one of these ideal rural applications because they offer predictable routes and important health benefits for children.

In the summer of 2021, Mount Desert Island High School (MDIHS) purchased and deployed the first electric school bus (ESB) in Maine. This bus served as a test of this emerging technology in a rural Maine setting. The funding for the project was secured through a federal program and MDIHS partnered with a local resiliency non-profit, A Climate to Thrive, for support on equipment specifications and implementation. This project set out to evaluate ESB viability with on the following metrics:

- **Operational performance:**
  - Route coverage on rural routes
  - Cold weather performance
- **Operational savings:**
  - Cost savings – fuel, maintenance, reliability
  - Emissions reduction

The ESB was assigned to two routes and supported them for the full study period without any route modifications for weather or ESB performance. Additionally, the electric drive proved to be reliable with no downtime attributed to drivetrain-related issues. MDIHS has been satisfied by the performance of the ESB and is actively working to expand their ESB fleet.

About the Project

MDIHS is part of the Mount Desert Island Regional School System and provides secondary education to the communities on Mount Desert Island (MDI) as well as some surrounding islands and communities on the mainland, an area of over 130 square miles. With a year-round population of roughly 11,500 people within the towns served, the population density is comparable to that of other rural Maine counties. As the home of Acadia National Park, environmental issues are important to the communities in and around MDI.

The MDIHS project was born from a desire within the community to benefit from the advantages of ESBs. Early champions of the project were bus driver Doug Van Gorder and local climate resiliency organization, A Climate to Thrive. Three years ago, Van Gorder learned of ESBs from ACTT; however, at the time the cost of acquisition was prohibitive. In 2020, the issue of cost was solved with a grant from Maine Department of Environmental protection through a diesel emissions reduction program.

The Bus and the Route

MDIHS purchased a Lion C bus with the mid-level battery pack providing a factory-rated 125 miles of range. Lion is an electric vehicle manufacturer based in the US and Canada that specializes in commercial electric vehicles. This type C school bus is just over 39 feet long and can carry up to 77 passengers. The bus came equipped with a Level 2 charge port and diesel-fueled auxiliary cabin heaters and has a top speed of 60 miles per hour. The bus is equipped with a thermal management system for

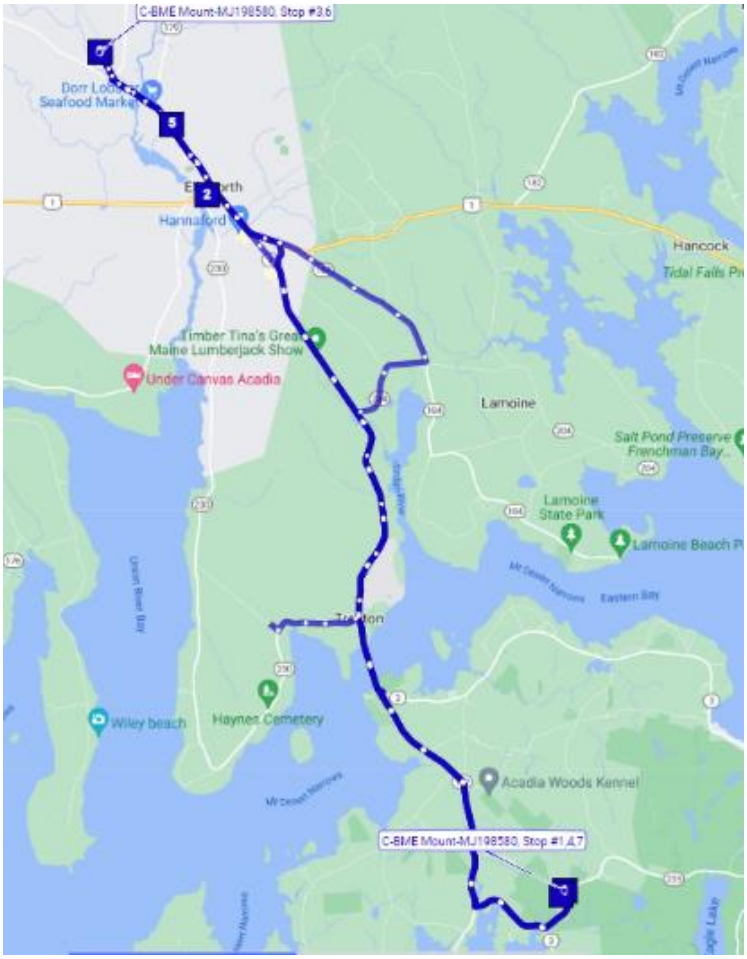

Figure 1: MDIHS to Tech Center in Ellsworth

the battery pack, allowing for outdoor storage year-round, and an audio warning system to alert pedestrians to the bus when in motion. One particularly attractive feature of this bus model is the use of corrosion resistant composite and alloy materials in locations that are particularly rust prone such as steps and skirting.

MDIHS followed the bus manufacturer's recommendation and purchased a Clipper Creek brand charging station (also called an Electric Vehicle Supply Equipment or EVSE). The CS-100 is an outdoor-rated Level 2 charging station with an 80A/19.2kW maximum charging capacity and a 25-foot-long charging cable. This unit is fully weatherproof, so the school chose to mount it on the outside of a storage building adjacent to the bus parking spot. While this charger offers more power than an average Level 2 charger, it does not have network or "smart" capability and will charge the vehicle at the highest permissible power until the vehicle is fully charged, regardless of utility rates. A full charge can be accomplished overnight.

TAKE CHARGE OF YOUR CHARGING

Understanding the charging needs of your ESB are key to making the deployment successful. There are three factors that go into making your charging plan success: route needs, bus battery size, and charging speed.

The needs of the route will dictate how big of a battery your bus will need. Longer routes or routes with sustained highway speeds will need a larger battery. Depending on the route schedule, mid-day "top off" charging can help cover longer routes that would be challenging to cover with a single charge. Most type C ESBs available offer 100-150 miles of range depending on manufacturer and model. Allow for a buffer between the route miles between charging sessions and rated range when choosing the battery size.

ESBs typically can be equipped to support level 2 AC charging or level 3 DC fast charging. Level 2 AC charging typically requires 240 Volt AC supply from your electrical panel and can fully recharge an ESB overnight. Each bus will typically need a dedicated charging station if level 2 charging is chosen. Level 3 DC fast charging offers significantly faster charging speeds, as short as a few hours for a full charge, but requires more power from your electric service and costs significantly more to install than level 2. Due to faster charging speeds, multiple buses might be able to share the same level 3 charging station.

In the case of MDIHS, they chose to use a level 2 charging station because it reduced project cost for the bus, charging station, and charging station installation, but still provided sufficiently fast charging for their needs.

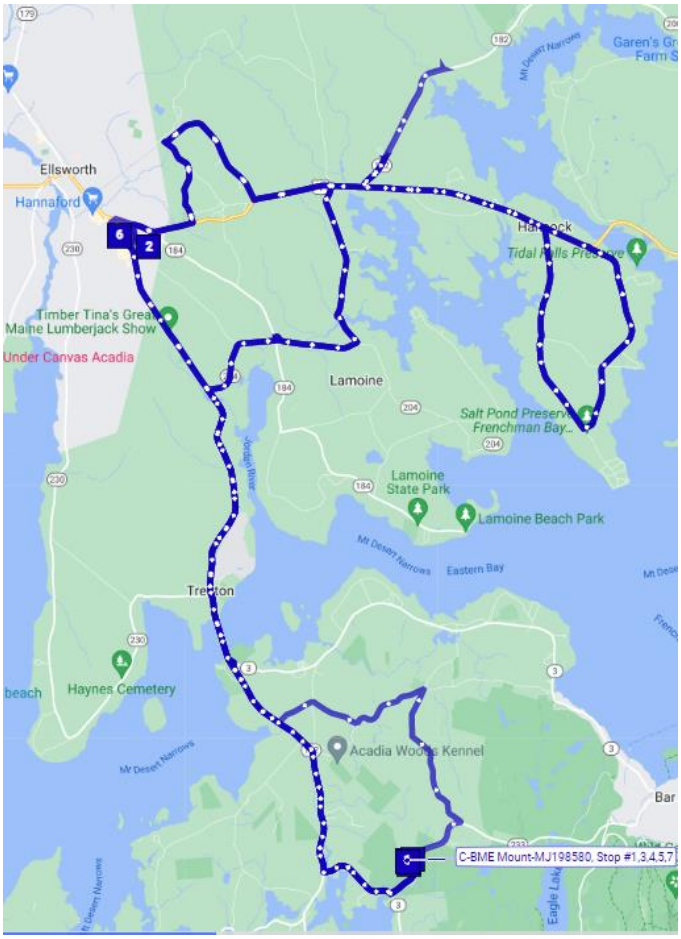

Figure 2: MDIHS Student Commuter Route

The ESB had two routes that it ran on a regular basis. One route brought students from MDI High School to the Hancock County Technical center in Ellsworth twice per day (Figure 1) and did not require the bus to recharge during the middle of the day. The length of this route is approximately 40 miles round trip or 80 miles for a whole day. The other route brought students from off island to MDI High School and returned them home (Figure 2). This route is approximately 57 miles per run or 114 miles for a whole day. This route required a midday "top off" charge for an additional range buffer. The bus was able to complete both routes year-round regardless of weather.

Operational Performance

The data collected (Figure 3) showed that over the 3 months (January, February, March) when the average daily temperature was at or below freezing, the average estimated available range of the ESB dropped by 22% to 118 miles. The estimated available range was at or above the factory range for the six months where average temperatures were above freezing. One driver noted that, "If there's a reduction in range during cold weather it's negligible." This underscores that the ESB range was sufficient for the routes assigned. Over the course of the study, the daily average miles driven was only 70% of the estimated available range.

ESBs offer better working environments for staff as well as reductions in local air pollution. The experience of operating an ESB is generally like a diesel bus while offering better acceleration and significant noise reduction. Of course, as there are no direct tailpipe emissions from the drivetrain, the ESB has significantly lower emissions compared to a diesel bus. This is especially important considering diesel buses spend a significant amount of time idling to provide cabin heat at the expense of noise and tailpipe emissions.

The MDIHS drivers and third-party mechanic interviewed reported that the electric bus is more enjoyable to use than diesel buses. These benefits included the absence of smell

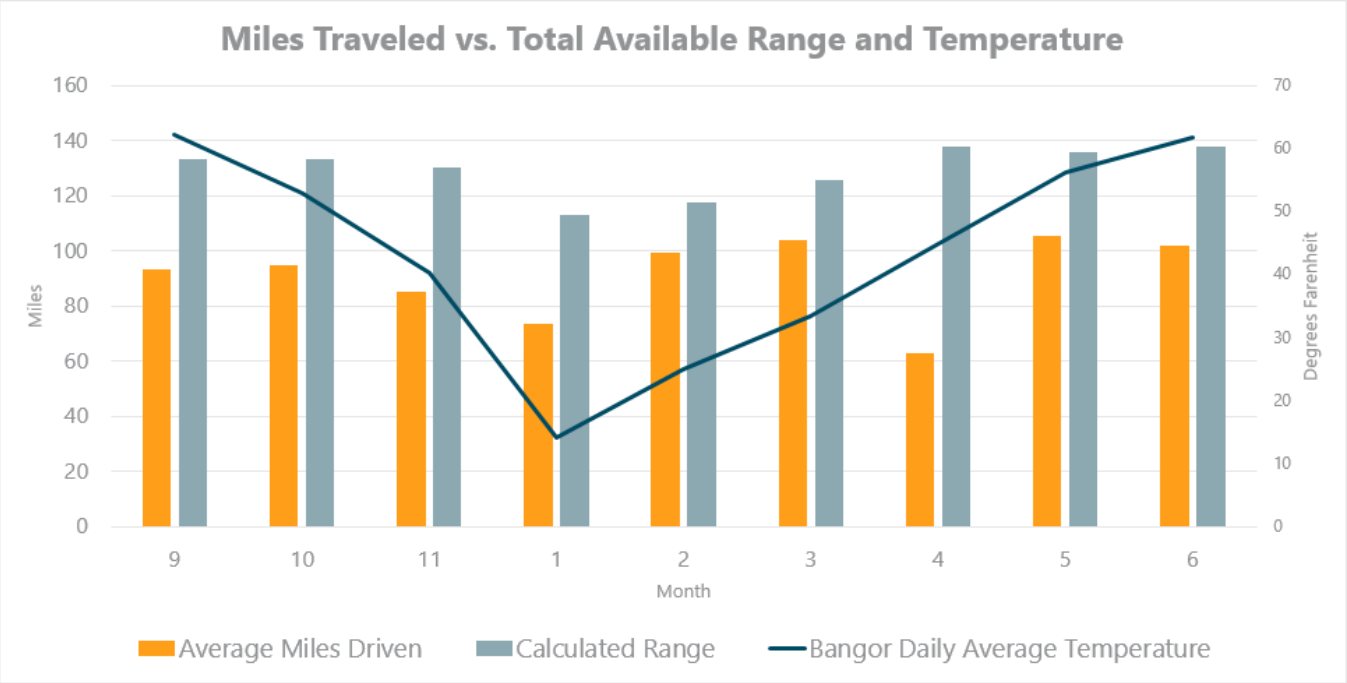

Figure 3

from diesel exhaust and the elimination of engine noise ("The noise and the exhaust fumes you get from a diesel… are nonexistent in an electric bus, which makes it luxurious for me as a driver.") and the perceived health benefits of not inhaling exhaust ("I think it's good… for everybody's health.") One MDIHS staff member discussed these benefits extending to students riding the bus: "The kids seem to like [the electric bus]. Even when you're inside a diesel bus it's so loud whereas an electric bus is quiet." One driver noted that since the main noise from the bus is tire noise, "the kids will stop talking when we get to a stop sign because they don't want other people overhearing."

Operational Savings

ESBs have a significant cost advantage over fossil-fueled school buses due to their superior efficiency and more stable energy cost. On average, the MDIHS ESB provided over 50% savings compared to two similar diesel buses even when electric efficiency dropped during the colder months (Figure 4). Nationally, retail diesel fuel prices saw a dramatic increase during the pilot period, climbing from $3.37 at the start of September of 2021 to $5.78 at the end of June 2022, a 71% percent increase. When asked about what they liked about the ESB, one staff member remarked "Fuel cost savings, especially now a days that diesel is over $6/gallon, I'm feeling a little smug about having this electric bus."

During the study period, comparison diesel bus #6 (2017 Freightliner) had $6,796 of maintenance and repair costs with $2,182 of that due to routine maintenance (fluid and filter changes) and comparison diesel bus #4 (2013 Bluebird) had $8,873 total cost with $2,694 due to routine maintenance. In contrast, Bus #3 was under warranty for

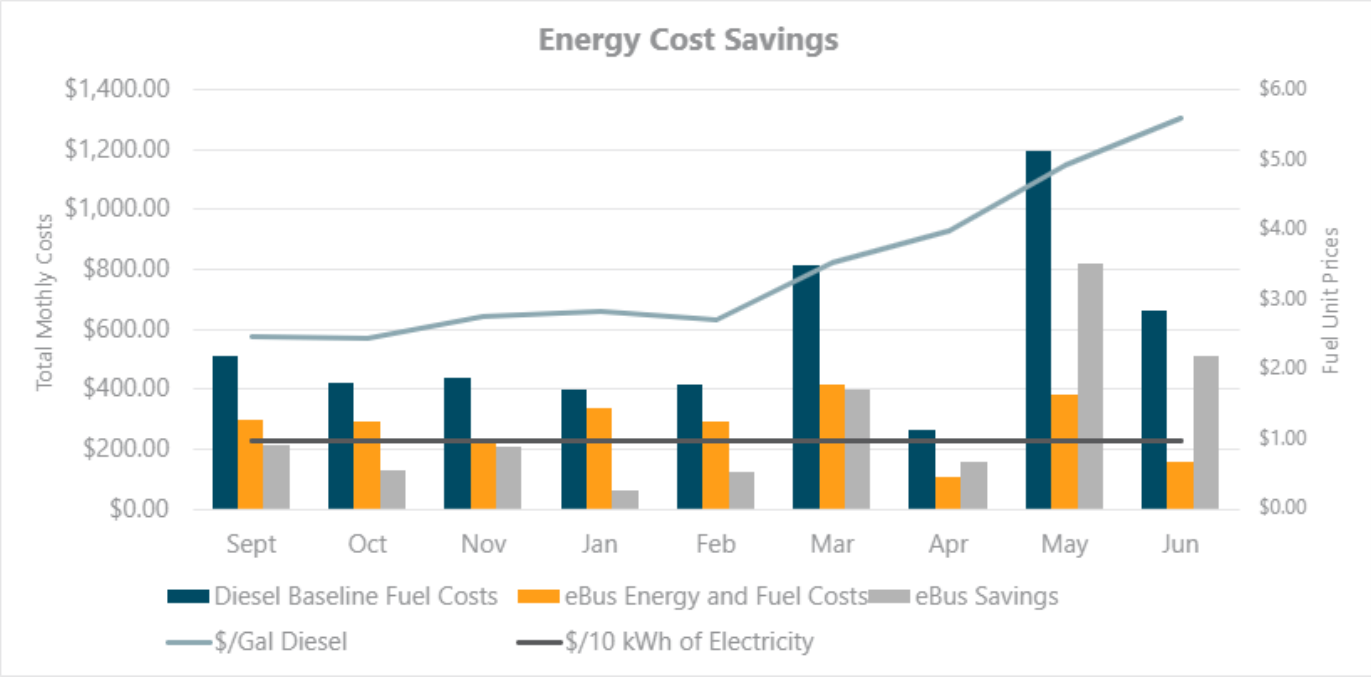

Figure 4

repairs and only required $455 in fluid and filter costs (not including labor) to help diagnose an air-ride suspension compressor issue. While the repair costs of the diesel buses can largely be attributed to repairs needed due to age and the ESB repair costs were covered by the manufacturer's warranty, the diesel buses still had significantly higher routine maintenance costs than the ESB.

Over the course of the study, the electric drivetrain on the bus had flawless reliability with zero downtime. There were a few minor bus-body related warranty claims that were easily resolved. The only notable out-of-service event was due to a fault in the air-ride suspension system in December. Repair time was extended due to slow shipping because of COVID related supply chain interruptions. In response to these challenges, the bus manufacturer has committed to having mobile technicians based in the state to quickly diagnose and repair buses in the field. MDIHS will be ordering buses with traditional spring suspension going forward. Overall, this study highlights the intrinsic reliability of electric drivetrains as they are significantly less complex than their diesel equivalents since they do not require emission control systems, multi-speed transmissions, or diesel engines.

ESBs save more than money. Over the course of the study, the ESB saved nearly its fully loaded weight in carbon emissions. Electric school buses have zero tailpipe emissions and improve the air quality inside and outside the bus. This is important for children, who

spend between 20 minutes to several hours a day on school buses: air pollution levels inside older diesel buses can exceed surrounding areas by 5 – 10 times[1].

MAXIMIZE YOUR SAVINGS

Operating an ESB will likely lead to a noticeable increase in electricity usage. While ESBs are 2-3 times more efficient than their diesel counterparts on an energy basis, the additional energy usage can cause fees on your bill which can reduce your net operational savings.

In 2016 the Massachusetts Department of Energy Resources, in partnership with VEIC, conducted a one-year pilot project to test the performance of electric school buses in urban, suburban, and rural applications. One of the key findings of this early project was the cost savings of the electric buses were offset by additional demand charges from the utility. A demand charge is an additional fee changed by the utility when a large customer draws over a certain amount of power. The purpose of a demand charge is to encourage the consumer to spread their usage throughout the day, so the utility does not have to build oversized infrastructure to handle brief peaks of demand. The nature of how the demand charge is implemented, and the associated cost will vary depending on the utility and specific rate plan. Fortunately, such additional fees can usually be avoided by using managed charging to shift charging sessions to times of day where demand charges do not come into play or by changing to a rate plan that better fits the needs of bus charging.

Summary

The success demonstrated by MDIHS shows that ESBs can provide quality service, in addition to cost savings and emissions reductions, in a rural Maine setting. Over the course of the study, the ESB's significant savings in both maintenance and energy costs combined with superior driving and riding experience made the advantages of ESBs over diesel buses very clear. MDIHS is pleased with the performance and benefits of their ESB and is actively pursuing funding for additional buses including one with a wheelchair lift. Other rural school districts in Maine have following MDIHS's lead and procured or applied for funding for ESBs. Additionally, the State of Maine has set standards for the deployment of electric school buses with the passage of LD 1579 in May of 2022. The new law sets a goal for 75% of school bus acquisitions in the state to be zero emissions by 2035. Nationally, there is rapidly growing support for ESBs from bus manufacturers and the federal government. All major manufacturers now offer electric bus models, and the U.S. Environmental Protection Agency is providing up to $5 billion in Clean School Bus funding over the next five years to help schools to go electric. This study shows that an ESB is a good fit for MDIHS's needs and that ESBs will likely be a beneficial technology for other rural Maine schools.

[1] https://www.slideshare.net/WorldResources/why-electric-school-buses