



GETTING ON BOARD WITH ELECTRIC TRANSIT

The Inflation Reduction Act of 2022 (IRA) is sparking new interest in the market for electric vehicles (EV). Of particular interest is the new Section 45W tax credit for commercial vehicles.

The IRA allows tax exempt organizations, including government agencies, to receive a direct payment (in lieu of a tax credit) for investing in clean energy. This provision, which covers 10 tax years, is accelerating the electrification of transit bus fleets.

The transition to zero emission buses (ZEB) is well underway. The Infrastructure Investment and Jobs Act of 2021 boosted funding for zero-emission projects. In 2022, the Federal Transit Administration (FTA) allocated \$1.6b in Low and No Emission Grants and Bus and Bus Facilities Grants, supporting 150 transit fleets and facilities throughout the United States. California is leading the country with a commitment to phase out all diesel or natural-gas-powered buses by 2040.

As urban populations grow, municipalities increasingly look for ways to increase public transportation ridership. We expect the EV bus to be part of the solution, offering a much quieter and “fume-free” ride for passengers while decreasing carbon emissions in populated urban centers. Bloomberg expects that EV will comprise 24% of municipal bus sales in the US by 2026.

To be successful in this market, it is important to work with a partner who understands the unique requirements of the transit bus sector and who can scale operations as demand increases. This paper examines the drivers for electrification and the factors critical to success.

FEASIBILITY

All over the country, municipalities and regional transit authorities are demonstrating the feasibility of operating battery electric buses (BEB). Because transit buses typically operate over relatively short distances, with frequent engine idling to accommodate both passengers’ on-and off-boarding and urban traffic jams, they are especially well-suited to electrification. In fact, a report from the State of California noted that the “energy efficiency ratio is about 3.5 at highway speeds

and 5 to 7 times the efficiency of conventional diesel vehicles when operated at lower speed duty cycles where idling and coasting losses from conventional engines are highest.”

As transit authorities evaluate the potential for electrification, they focus especially on the driving range and reliability of vehicles, both of which factors are highly dependent on battery choice.

Packing more energy into batteries without adding significant weight will enable buses to travel longer routes before having to recharge. Bus manufacturers must balance performance, weight, and cost to win in this segment of the EV market. American Battery Solutions carefully considered the tradeoffs before choosing the technology underlying our battery design. We opted for batteries with high specific density (i.e., the relationship of energy to battery weight) to provide needed performance and our design offers scalability without adding unduly to vehicle weight.

Transit buses are an essential part of the local economy. They move people to and from work, medical appointments, shopping destinations, and recreational activities. When service breaks down, transit authority executives are called to task. The battery that propels the bus must work as expected, all day every day. American Battery Solutions batteries combine years of development and validation testing that is specific to the transit bus market with manufacturing expertise and certifications built upon traditional automotive quality standards. This combination provides the transit bus with Reliability and Safety.



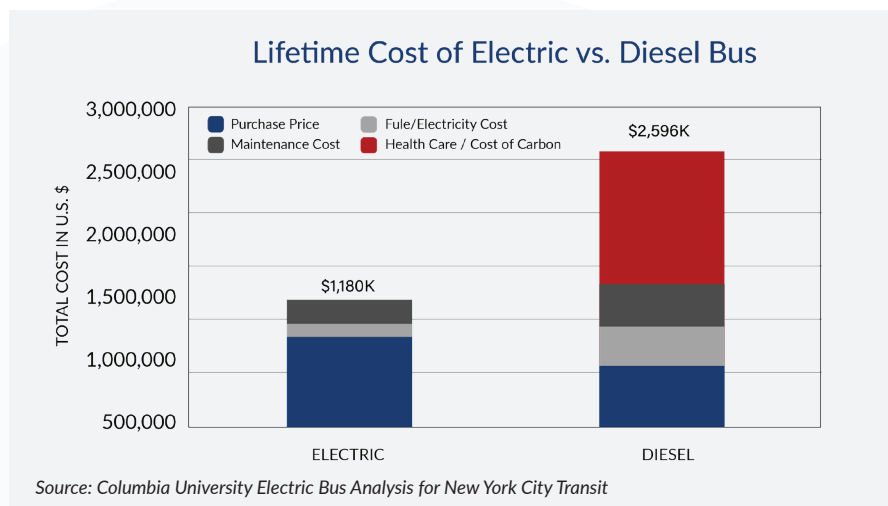
GROWING DEMAND

Political Pressure

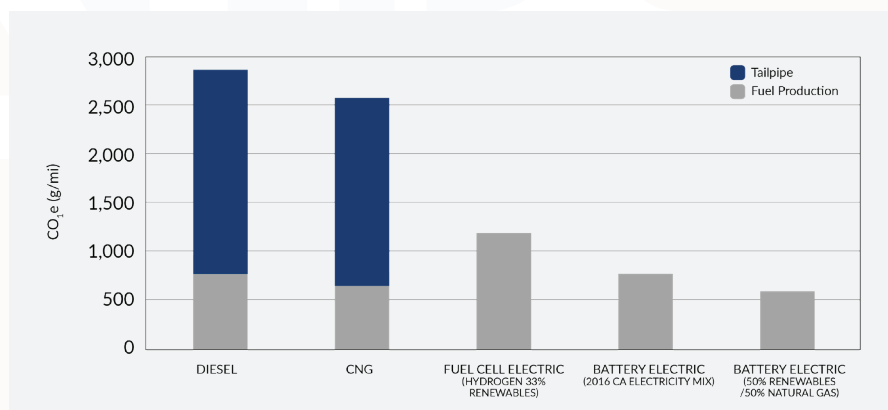
Municipal and regional transit authorities are under increasing pressure to help solve a range of problems from moving the growing urban population to addressing equity and climate change. And they must do this while containing costs.

Buses powered by diesel fuel, compressed natural gas (CNG), or even hybrid engines contribute disproportionately to greenhouse gas emissions simply because they operate for so many hours in a day. Those who ride buses or live along bus routes suffer the health consequences of higher particulate matter and CO₂ emissions. Our most vulnerable populations—children, elderly, and those with chronic respiratory/bronchial and cardiac conditions—have been the unintended victims of our past policies on energy.

Columbia University's Electric Bus Analysis for New York City Transit concluded that "The projected annual cost benefit in New York City associated with health benefits of switching from diesel buses to electric buses is approximately \$150k per bus. This translates to roughly \$100 per New York City resident of health care savings per year if the entire fleet is converted to all electric." The following graphic from the report demonstrates that these hidden costs may be a much larger factor than expected.



While an electric bus offers a zero emissions alternative, to be fair, one must consider the emissions involved in the production of energy to charge the battery. An early report from the Union of Concerned Scientists factored in these emissions to develop a fair comparison of transit bus emissions in California and factored in the potential improvement as electric energy companies move to cleaner fuel sources.



Total Cost of Ownership

Organizations that have begun the transition to electric vehicles do incur significant startup costs. EV buses are more expensive, and they necessitate investment in the infrastructure needed to charge the bus.

Current government incentive programs will off-set some of the start-up costs. As technology evolves, charging infrastructure becomes more widespread, infrastructure costs are spread over more miles, and the inevitable competition in the market offers more

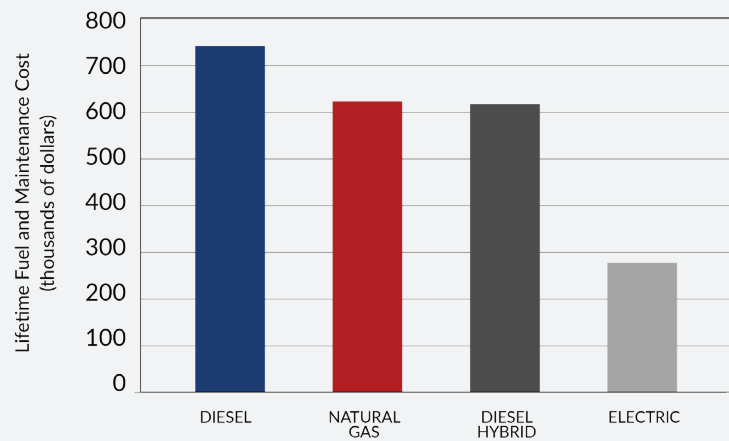
choices, the business case will become even more favorable.

However, even early studies of total costs pointed to significant savings—as much as 40%-50%--in maintenance cost over the life of the vehicle. These savings were attributed to the fact that the EV does not require the routine maintenance (e.g., oil change, filter replacement) of the internal combustion engine. Also, experience points to less wear and tear on tires and brake pads.

Electric Buses Have Lower Operation and Maintenance Cost

With fewer moving parts, electric buses are hundreds of thousands of dollars less expensive to fuel and maintain over their lifetime.

Source: U.S. PIRG



DRIVING SUCCESS

When we combine government incentives, the strong business case, and the growing concern about carbon emissions and public health, it is obvious that the future is EV. As more vendors enter the market, buyers will be faced with more choices. Success will hinge on being able to keep pace with demand while also providing the customers with the product best suited to their application.

Reliable Supply

In an ever-evolving marketplace, battery makers emerge, and battery makers disappear. In order to meet commitments to customers, the bus manufacturer/OEM needs a reliable partner that not only has the deep technical expertise needed today but also has the manufacturing capacity and financial wherewithal to meet the OEM's needs in the future.

The average life of a transit bus in the United States is 12 years, but some may be in service for up to 20 years. Therefore, service and support for a bus battery launched today must be available for 15-20 years, making selection of a battery partner capable of a long run partnership absolutely critical.

Battery Choice

The battery choice is a significant decision as it impacts vehicle weight and range and has implications for charging infrastructure and operations. Because transit buses come in different sizes and operate in different climates and over a variety of routes, the battery you choose must be designed from the ground up to provide the performance and reliability you require. Fortunately, this does not require a different supplier for different routes.

American Battery Solutions offers the ProLiance Intelligent Battery Series™ lithium-ion battery packs designed to provide exceptional energy, reliability, run-time, and cycle-life specifically for the 35', 40' and 60' Transit Bus applications. The batteries can be configured with eight packs connected in parallel or in series so that you can standardize technology across the fleet—simplifying everything from staff training to spare parts. Whether you are powering an airport shuttle bus, a school bus or a transit bus the ProLiance battery can be configured to meet a wide range of needs for a wide range of fleets.

Battery technology is evolving, and manufacturers now have more choices when it comes to materials. American Battery Solutions chose a 2170 cylindrical NMCA/NMC chemistry for its designs to provide the best balance of performance, lifespan, and cost for this market segment. High energy density enables us to optimize range while high quality design and production optimize battery life. Future product offerings will expand the portfolio to include LFP and 46xx cells to continue to improve the energy density and cost and bolster our product offerings for our customers.

But it is not just the cells that are important. The battery pack itself is a system of interrelated sub-systems including the thermal management system,

the control electronics, the mechanical structure, the safety features, and the battery management system. The battery pack must withstand the duty cycle, life and abuse conditions while protecting and optimizing the lithium-ion cells. As we often say “it is the system that makes the cell safe, not the cell that makes the system safe”.

The Battery Management System (BMS) is designed to ensure the vehicle uses the battery in a way that is safe and that does not jeopardize the performance or the expected useful life of the battery. The BMS is engaged at startup, to make sure all contacts are made, and that the vehicle can safely be put into drive. During operation, the BMS monitors the temperature and voltage of individual cells and sends alerts to the vehicle if there are any problems. ABS works with customers to determine how to best set limits for event warnings consistent with operations.

The Thermal Management System (TMS) is responsible for maintaining the lithium-ion cell temperatures no matter the ambient temperature or duty cycle. Temperature management is vital to ensure the longevity and safety of the lithium-ion battery.

And the mechanical structure and enclosure provide protection from the environment and elements while also protecting against harsh abuse and operational conditions.



CONFIGURABILITY

One of the keys to managing a transit bus fleet is knowing your routes. Having a scalable battery solution can help meet the needs of different transit routes within the same fleet using a single pack. For example, for one customer ABS developed a 110kWh 665V custom battery pack based on the ProLiance architecture that can be connected in parallel from as few as two (2) packs all the way up to eight (8) packs. This solution allowed the OEM to offer a range of different bus solutions to their municipal customers, but they only need to manage a single part number within the system.

Characteristic	Unit	Single Pack Specification	4 Packs	5 Packs	6 Packs	7 Packs	8 Packs
Voltage, Nominal	V	665					
Energy, Total	kWh	110	440	550	660	770	880
Capacity	Ah	165	660	835	990	1155	1320

EXPERT SUPPORT

Whether it is an off-the-shelf ProLiance battery pack or a custom designed solution, ABS' architecture allows for a wide range of possible solutions. Backed by a team of battery engineers and experts, we work with our partners to help them solve their battery challenges in the most optimized manner possible.

Leveraging the depth of our engineering expertise, ABS offers concept development, battery system sizing and configuration, and a team of service and warranty experts. This gives our partners the peace of mind that comes from knowing we will be there to help them from the first interaction -through the first installations to the field deployments.



PARTNERING WITH ABS

ABS designs and manufactures modular battery solutions for transportation, industrial and commercial markets primarily in North America and Europe. The team at American Battery Solutions Inc. includes some of the most recognized battery systems experts in the industry, possessing decades of experience in designing, developing, and manufacturing high-volume advanced battery systems. Our experts are now applying this experience to the emerging and rapidly growing transportation segments, concentrating on module production, pack assembly, and customer integration.

ABS operates a 120,000 sq. ft. technical center in Michigan and a dedicated 170,000 square foot purpose-built state of the art battery manufacturing facility in Ohio. It employs more than 165 people in Michigan, Ohio, and Massachusetts.

ABS works closely with our customers to understand their requirements and assist them in accelerating the transition to electric vehicle fleets.



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