Making the case for bus electrification

GEOTAB®

Table of contents

Introduction

Across North America, transit and school bus fleets are electrifying, pushed on by the availability of a wide range of public finance programs, tightening regulations and growing investment from manufacturers.

A report from the clean transportation advocacy group CALSTART shows that there is now a transit agency in almost every state that owns at least one electric bus (eBus), or is engaged in the process of procuring one.[1]

Governments across North America will be set to benefit from this transition, with lower fuel and maintenance costs reducing operating budgets and zero emissions fleets reducing the volume of harmful pollutants emitted in metro areas and around school children.

Bloomberg New Energy Finance predicts that by 2040, the global eBus fleet will represent 67% of the entire market.[2] Meanwhile, market analysis by Mordor Intelligence LLP predicts that the eBus market in North America will register a 26.76% Compound Annual Growth Rate (CAGR) between 2020 and 2025, with buyers citing concerns about availability of fossil fuels and environmental pollution as their primary drivers.[3]

A higher cost of ownership has traditionally been the greatest hurdle to widespread EV adoption, but as battery costs continue to fall through the beginning of this decade, upfront costs will fall dramatically to bring the total cost of ownership (TCO) of eBuses in line with their diesel counterparts.

Current deployment and benefits of electrification

Transit buses

Electric transit buses are now fully available at the commercial level. As of September 2019, CALSTART registered 2,184 battery electric buses on the road or on order,[4] with the majority of these being transit buses. Analysis by Prescient Intelligence estimates the total U.S. market opportunity for electric buses to be $1.5 billion by 2024.[5]

Transit buses are the second most intensively utilized vehicles by major vehicle category, surpassed only by Class 8 trucks. Although electric buses currently have higher upfront costs than their diesel alternatives, their high utilization rates enable the lower fuel and maintenance costs to drive down the TCO over their service life and provide cost parity with diesel buses in many scenarios. The U.S. Public Interest Research Group (PIRG) calculated annual operating costs to be less than a half of those for a diesel bus, making the TCO of an electric transit bus $81,000 cheaper over their average 12 years of operation.[6]

The negative environmental and human health impacts of diesel transit buses, exasperated by their high mileage has helped to accelerate public investment in transit bus electrification. PIRG calculates that replacing all of the country's diesel-powered transit buses with electric buses could eliminate more than 2 million tons of greenhouse gas (GHG) emissions each year.[7]

Reducing the emissions of carbon monoxide (CO), nitrogen oxides (NOx), and particulate matter (PM) associated with diesel engines will also deliver significant societal benefits, including avoided healthcare expenses as a result of cleaner air. The benefits of eliminating tailpipe emissions are compounded for transit buses, which tend to be more active in areas of high population density.

Operationally, transit bus duty cycles also lend themselves favorably to electrification. Buses generally have regular routes and can predominantly return to a depot to charge overnight, or rely on strategically placed charging on route. Alternatively, some transit bus fleets reconfigure routes around the capabilities of the BEV buses, rather than trying to get eBuses that can operate on exactly the same duty cycle as an ICE bus. This combination of factors explains why the electric transit bus market has grown the fastest of all the medium- to heavy-duty vehicle sectors.

School buses

Electric school buses are still at the early stages of commercialization, with only 1% of the total U.S. school bus fleet of 480,000 running on electrified drive trains as of the end of 2019.[8]

As most school buses are only used for the morning and afternoon school run and are unutilized during school holidays, their average VMT is much lower than for transit buses. This makes the TCO less favorable, taking longer to pay off the higher upfront cost of an eBus.

However, the potential environmental and public health impact of electrification of these buses is considerable. Poor air quality has been linked to asthma, cancer and heart disease, and studies show that children are especially vulnerable to exhaust pollutants.[9]

Electrifying the entire U.S. school bus fleet would significantly reduce roadside emissions for school children and cut emissions of greenhouse gases by 5.3 million tons per year, the equivalent of removing almost a million cars from the road.[10]

While the upfront cost of an electric school bus is roughly twice that of a diesel bus, PIRG calculated that if an electric school bus was to sell its electricity back to the grid during down times, it would make up for its higher purchase cost within 13 years of service, and would save over $31,000 over the average 16 years that a school bus operates for.[11] This is based on a pilot program funded by the Clinton Global Initiative that showed annual savings of nearly $2,000 a year in fuel and $4,400 a year in reduced maintenance costs.[12] Access to government funding would make these numbers even more favorable for operators.

Public funding and private financing options for electric buses

Transit buses

Electric transit buses receive the majority of public investment in the medium- to heavy-duty sector. At the national level, transit fleet operators can find financial support in the VW Settlement and the FTA's Low or No Emission (Low-No) Program. There is also a range of other public programs available at the state level to reduce the cost of purchasing electric buses.

California has awarded the most public funds of all states, predominantly through its California Low Carbon Fuel Standard (LCFS) Program. Up to October 2019, the state awarded a total of $421 million for electric bus and truck acquisitions, $386 million more than Virginia in second place.

The majority of these programs provide funds to reduce the higher upfront costs of eBuses, but some also include grants to assist with the costs of building the charging infrastructure.

In June 2020, cumulative public funding surpassed $2 billion, with the awarding of $130 million for electric transit buses through the Low-No Bus Program.[13]

In Canada, CUTRIC and seven other partners are contributing USD $4.2 million to support the National Academic Committee on Zero-Emission Buses (NAC-ZEB), together with additional federal funding of USD $551,000.[14]

Private financing mechanisms like Proterra and Mitsui's battery leasing program could also make upfront electric bus costs roughly equivalent to those for a diesel bus. The program allows customers to purchase the vehicle while leasing the battery from Proterra.[15]

School buses

Although school buses have historically received very little public money to assist with electrification, public funding has recently started to accelerate. Only $22 million had been awarded by the end of 2018, but this rose to more than $138 million by the end of October 2019.[16]

In 2020, the EPA's School Bus Rebate Program awarded over $11.5 million to public and private fleet owners across 43 states for the replacement of 580 old diesel school buses with buses certified to their cleanest emission standards.[17] Rebates were received through EPA's Diesel Emissions Reduction Act (DERA) funding.

The President's Build Back Better plan proposes making all American-made buses zero-emission by 2030, starting by converting all school buses to zero-emission within five years.[18] The greatest hurdle that the new government will face to bring this plan to fruition is the massive jump in manufacturing capacity needed for electric bus OEMs to reach these numbers so fast. Interact Analysis projects that based on current capabilities and orders, there will be 560,000 school buses built in the next 10 years, less than 27,000 of which will be electrified.[19]

Vehicle to Grid (V2G) charging offers a potential additional revenue stream for electric school bus operators, allowing greater asset utilization during vehicle downtimes. Operators could sell power back to the electric grid at peak-demand times of the day, and during the holidays when school buses are otherwise sitting idle. Many states and utility providers are considering this mechanism and Dominion Energy is running a trial in Virginia to explore the battery storage capabilities of the buses and to study how they can enhance the reliability of their electric grid.[20]

Latest OEM electric bus models

Transit buses

OEM investment in electric transit buses has grown significantly in recent years, with the market originating in China and now firmly established in North America. The new breed of all-electric models is capable of achieving significant real-world mileage on a single charge, making them suitable for most metro and city transit duty cycles.

Many manufacturers produce a range of lengths and battery capacity combinations. The table below shows the combination that accommodates the greatest battery capacity and delivers the best mileage range.

OEM	Model	Length	Max Battery Capacity	Max Range
BYD	Electric Transit Bus	40-foot	352kWh	177 miles[21]
Gillig and Cummins	GILLIG Battery Electric Bus	40-foot	444kWh	150 miles[22]
GreenPower	EV350	40- foot	320kWh	185miles[23]
New Flyer	Xcelsior CHARGE	40-foot	466kWh	225 miles[24]
Nova Bus	LFSe+	40- foot	594kWh	292 miles[25]
Proterra	ZX5	40-foot	660kWh	329 miles[26]
Solaris	Urbino 15 LE electric	40- foot	470kWh	186 miles[27]

School buses

At present, there are six main manufacturers of electric school buses, all of which manufacture their buses in North America. Some OEMs produce a range of bus specifications, but the table below summarizes the combination that offers the greatest mileage range.

OEM	Model	Type	Max Battery Capacity	Max Range
Blue Bird	Vision Electric	C	155kWh	120 miles[28]
Collins Bus Corporation and Motiv-Power Systems	Type A Electric School Bus	A	127kWh	105 miles[29]
Daimler's Thomas Built Buses and Proterra	Saf-T-Liner C2 Jouley series	C	220kWh	135 miles[30]
GreenPower	Synapse 72 fully electric	D	200kWh	140 miles[31]
Lion Electric	LionC	C	220kWh	155 miles[32]
Trans Tech and Motiv Power Systems	SST-e	A	106kWh	85 miles[33]

Studies testing the real-world performance of electric buses

Several pilot programs have shown electric buses to perform reliably, often with lower operating costs compared to their diesel counterparts. Despite this, some of the early adopters encountered hurdles that can serve as considerations for future programs to overcome.[34]

Ability to handle adverse road and weather conditions

With an average low of 18 F in the winter, a pilot program in Chicago, Illinois tested the performance of electric transit buses in extreme cold weather. The transit authority has run two electric buses across six indicative routes since October 2014 and found that the eBuses suffered no significant adverse performance in the extreme cold. The buses were equipped with diesel-fired heaters to maintain optimal cabin temperature without draining the batteries.

A study in King County, Washington tested the reliability of electric transit buses in hilly, rainy conditions. The vehicles' speed and responsiveness was good, they found little disparity between predicted and actual performance, and the electric buses proved to be more energy efficient than their diesel buses.

The Massachusetts Department of Energy Resources tested electric school buses in three school districts across the state. Their findings were that the vehicles encountered no difficulties with range, and cold weather didn't affect their performance.

Real-world battery performance

A study in Seneca, California found that their electric transit buses exceeded expectations regarding charging time, range and battery life.

In King County, the transit authority encountered some problems with battery life and range, and found the per-mile fuel costs to be greater than for their diesel counterparts. This was predominantly due to utility fees for high power usage (demand charges), which vary depending on location and utility provider.

A pilot program in Albuquerque, New Mexico in 2018 encountered issues with subpar battery life, inadequate range and sensitivity to extreme heat. The city cancelled the contract and returned the buses. However, this trial was conducted with eBus models that were not yet approved by FTA, the range assumptions weren't based on route elevations and climate, and insufficient assessments were conducted to match charging needs with the routes. In 2020, the city was awarded funding for five new electric buses, armed with data and expertise gained from their previous experience.[35]

Operational cost savings

The Chicago transit authority found that their two buses saved them more than $54,000 in fuel and maintenance costs annually, compared to new diesel buses purchased in 2014.

An electric school bus study in Twin Rivers, California found that their eBuses delivered a 75-80% saving in fuel costs compared to their diesel buses, exceeding the district’s expectations. Savings from fuel and maintenance costs equated to approximately $15,000 per year.

Health and environmental benefits

The electric school bus pilot in Massachusetts found that their eBuses emitted significantly fewer harmful emissions than diesel school buses.

The King County transit authority included the environmental and health benefits of buses in its evaluation of their costs and benefits. The total societal cost over the service life of a 40-foot electric bus using renewable energy was estimated to be only $19,000, significantly less than the estimated $121,000 cost for a 40-foot diesel-hybrid bus.

Thanks to the findings and successes of these and other pilot programs, many major cities are now implementing plans to electrify their transit bus fleets. Los Angeles and Seattle plan to run 100% electric municipal fleets by 2030, and New York plans to convert its buses to electric by 2040.36

TTC becomes the largest electric bus fleet operator in North America

In September 2020, Toronto Transit Commission (TTC) became the largest electric bus fleet operator in North America, with 60 vehicles.37 It now runs eBus models from BYD Canada Co. Ltd., Proterra Inc. and New Flyer Industries Inc. and plans to run a completely electrified fleet by 2040.

By purchasing eBuses from three different suppliers, TTC will be able to complete direct performance comparisons, which will help to inform their future procurement decisions.

The federal government and the City of Toronto provided financing for the eBuses, through the Public Transit Infrastructure Fund.

A successful transition relies on detailed planning

Electric bus models are now firmly established in the North American bus market, and their market presence is fast gaining ground. Various pilot programs have proven that electric buses can handle the majority of urban and school duty cycles, enabling major cities to establish plans to transition 100% of their fleets to zero emission buses.

With a new government in the U.S. expecting strong bipartisan support for its plan to make all buses electric by 2040, the future is bright for governments and bus fleet operators wanting to go electric.

To ensure successful deployment of these new vehicles, the number one ingredient is detailed planning. A thorough understanding of current routes, vehicle capabilities and environmental conditions is vital, together with an analysis of the capabilities of the potential electric models and the infrastructure required to support them.

Pilot projects will then enable fleet and sustainability managers to perform real-word comparisons of the few best candidate EV bus models on indicative routes, providing additional data to right size the eBuses to actual operational requirements.

Once these new eBuses have been incorporated into the fleet, it's likely that managers will initially have to operate a fleet consisting of both electric and diesel buses. For maximum ROI, the fleet management platform must therefore work with all drivetrains, collecting performance data such as mpg and mpg-e, together with electric-only data such as battery state of charge.

Managers will also need to rely on providers with the most accurate vehicle data for the greatest range of makes and models, that also have the capability to accommodate the greatest number of eBuses as they come to market.

Geotab currently supports a number of electric Bus models, and has the capability to accommodate the greatest number of new eBuses, supporting fleets today and into tomorrow.

To learn more about EV solutions for fleet management, visit Geotab.com/ev.

About Geotab

Geotab is advancing security, connecting commercial vehicles to the internet and providing web-based analytics to help customers better manage their fleets. Geotab's open platform and Marketplace, offering hundreds of third-party solution options, allows both small and large businesses to automate operations by integrating vehicle data with their other data assets. As an IoT hub, the in-vehicle device provides additional functionality through IOX Add-Ons. Processing billions of data points a day, Geotab leverages data analytics and machine learning to help customers improve productivity, optimize fleets through the reduction of fuel consumption, enhance driver safety, and achieve strong compliance to regulatory changes. Geotab's products are represented and sold worldwide through Authorized Geotab Resellers.

To learn more, please visit www.geotab.com and follow us @GEOTAB and on LinkedIn.

References

1. Fred Silver, John Jackson & Bryan Lee. "Zeroing in on ZEBs." CALSTART. October 17, 2019. https://calstart.org/wp-content/uploads/2019/10/Zeroing_In_on_ZEBs_Final_10182018-10.21.19.pdf

2. "Electric Vehicle Outlook 2020." BloombergNEF. https://about.bnef.com/electric-vehicle-outlook/

3. "North America Electric Bus Market - Growth, Trends, and Forecast (2020 - 2025)." Mordor Intelligence LLP. October 2020. https://www.reportlinker.com/p05986874/North-America-Electric-Bus-Market-Growth-Trends-and-Forecast.html?utm_source=GNW

4. Fred Silver, John Jackson & Bryan Lee. "Zeroing in on ZEBs." CALSTART. October 17, 2019. https://calstart.org/wp-content/uploads/2019/10/Zeroing_In_on_ZEBs_Final_10182018-10.21.19.pdf

5. "Electric Bus Market in U.S. to Boom in Coming Years." Prescient and Strategic Intelligence. October 19, 2020. www.prnewswire.com/news-releases/electric-bus-market-in-us-to-boom-in-coming-years-says-ps-intelligence-301154713.html

6. James Horrox, Matthew Casale. "Electric Buses in America Lessons from Cities Pioneering Clean Transportation." U.S. PIRG Education Fund Environment America Research And Policy Center Frontier Group. October 2019. https://uspirg.org/sites/pirg/files/reports/ElectricBusesInAmerica/US_Electric_bus_scrn.pdf

7. James Horrox, Matthew Casale. "Electric Buses in America Lessons from Cities Pioneering Clean Transportation." U.S. PIRG Education Fund Environment America Research And Policy Center Frontier Group. October 2019. https://uspirg.org/sites/pirg/files/reports/ElectricBusesInAmerica/US_Electric_bus_scrn.pdf

8. "Decarbonising The US's Yellow School Bus Fleet: A Policy Worth Pursuing?" InteractAnalysis.com. November 19, 2020. https://www.interactanalysis.com/decarbonising-the-us-yellow-school-bus-fleet-a-policy-worth-pursuing/

9. K.J. Brunst, Y. Leung, P. Ryan, G. Hershey, L. Levin, H. Ji, G. LeMasters and S.Ho. "FOXP3 hypermethylation is associated with diesel exhaust exposure and risk for childhood asthma." Journal of Allergy Clinical Immunology. December 20, 2012. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3563724

10. Alana Miller and Hye-Jin Kim, Frontier Group Jeffrey Robinson and Matthew Casale, U.S. PIRG Education Fund. "Electric Buses - Clean Transportation for Healthier Neighborhoods and Cleaner Air." U.S. PIRG Education Fund Environment America Research And Policy Center Frontier Group. May 2018. https://uspirg.org/sites/pirg/files/reports/Electric%20Buses%20-%20National%20-%20May%202018%20web.pdf

11. James Horrox, Matthew Casale. "Electric Buses in America Lessons from Cities Pioneering Clean Transportation." U.S. PIRG Education Fund Environment America Research And Policy Center Frontier Group. October 2019. https://uspirg.org/sites/pirg/files/reports/ElectricBusesInAmerica/US_Electric_bus_scrn.pdf

12. "ZEV School Buses – They're Here and Possibly Free". Clinton Global Initiative V2G EV School Bus Working Group. April 22, 2016. https://green-technology.org/gcsummit16/images/35-ZEV-School-Buses.pdf

13. "Fiscal Year 2020 Low or No-Emission (Low-No) Bus Program Projects." Federal Transit Administration. August 6, 2020. https://www.transit.dot.gov/funding/grants/fiscal-year-2020-low-or-no-emission-low-no-bus-program-projects

14. "North America Electric Bus Market - Growth, Trends, and Forecast (2020 - 2025)." Mordor Intelligence LLP. October 2020. https://www.reportlinker.com/p05986874/North-America-Electric-Bus-Market-Growth-Trends-and-Forecast.html?utm_source=GNW

15. "Proterra And Mitsui & Co., Ltd. Create $200 Million Credit Facility To Scale Proterra Battery Leasing Program." https://www.proterra.com/press-release/proterra-and-mitsui-co-ltd-create-200-million-credit-facility-to-scale-proterra-battery-leasing-program/

16. Connor Smith. "Public and Electric Utility Support for Electric Buses and Trucks. The State of Public Funding and Utility Programs for Medium- and Heavy-Duty Vehicle Electrification." Atlas Public Policy. December 2019. https://atlaspolicy.com/wp-content/uploads/2020/02/Electric-Buses-and-Trucks-Public-and-Utility-Funding.pdf

17. "EPA Awards $11.5 Million to Clean Up 580 School Buses in 43 States $1.8 Million Designated for New York, New Jersey and Puerto Rico." Epa.gov. April 23, 2020. https://www.epa.gov/newsreleases/epa-awards-115-million-clean-580-school-buses-43-states-18-million-designated-new-york

18. "How the US plans to turn all its iconic school buses electric." Electric and Hybrid Vehicle Technology International. November 27, 2020. https://www.electrichybridvehicletechnology.com/opinion/how-the-us-plans-to-turn-all-its-iconic-school-buses-electric.html

19. "Decarbonising The US's Yellow School Bus Fleet: A Policy Worth Pursuing?" InteractAnalysis.com. November 19, 2020. https://www.interactanalysis.com/decarbonising-the-us-yellow-school-bus-fleet-a-policy-worth-pursuing/

20. "Electric School Buses." Dominionenergy.com. June 18, 2020. https://www.dominionenergy.com/our-stories/electric-school-buses

21. "40' Electric Transit Bus." BYD.com. https://en.byd.com/bus/40-foot-electric-transit-bus/#specs

22. "A Closer Look at GILLIG, Cummins Battery Electric Bus Partnership." Gillig.com. July 3, 2019. https://www.gillig.com/post/a-closer-look-at-gillig-cummins-battery-electric-bus-partnership

23. "EV350 All Electric Transit Bus." GreenPowerBus.com http://www.greenpowerbus.com/EV350SpecSheet-Jan19-2016.pdf

24. "Xcelsior CHARGE™ Our next-generation battery-electric bus." NewFlyer.com. https://www.newflyer.com/buses/xcelsior-charge/

25. "LFSe+." NovaBus.com https://novabus.com/bus/lfse-plus

26. "Proterra Unveils the Proterra ZX5 Next-Generation Battery-Electric Transit Vehicle." Proterra.com. September 15, 2020. https://www.proterra.com/press-release/proterra-launches-zx5-electric-bus/

27. "Urbino 15 LE electric." SolarisBus.com https://www.solarisbus.com/en/vehicles/zero-emissions/new-u15le-electric

28. "Blue Bird Vision - Electric." Blue-bird.com. https://www.blue-bird.com/images/brochures/SB-VIS-EV-0920.pdf

29. "Type A All-Electric School Buses." Collinsbus.com https://www.collinsbus.com/electric-school-bus

30. "Saf-T-Liner® C2 Jouley™ Electric School Bus. The future is just around the corner." ThomasBuiltBuses.com. https://thomasbuiltbuses.com/school-buses/saf-t-liner-c2-jouley/

31. "Synapse Shuttle Bus Specification." GreenPowerBus.com. February 20, 2018. http://www.greenpowerbus.com/wp-content/uploads/2015/12/Synapse72-Synapse-Shuttle-Bus-Specification-FEB20-2018-908x1024.jpg

32. "Electric School Bus." TheLionElectric.com. https://thelionelectric.com/en/products/electric

33. “Motiv Power Systems to power 13 electric school buses in California pilot.” GreenCarCongress.com. May 11, 2017. https://www.greencarcongress.com/2017/05/20170511-motivps.html#:~:text=The%20powertrain%20includes%20a%20remote,of%2068%20to%2085%20miles

34. James Horrox, Matthew Casale. “Electric Buses in America Lessons from Cities Pioneering Clean Transportation.” U.S. PIRG Education Fund Environment America Research And Policy Center Frontier Group. October 2019. https://uspirg.org/sites/pirg/files/reports/ElectricBusesInAmerica/US_Electric_bus_scrn.pdf

35. “City of Albuquerque awarded funding for electric buses and 24 electric vehicle charging stations.” MassTransitMag.com. April 23, 2020. https://www.masstransitmag.com/bus/vehicles/hybrid-hydrogen-electric-vehicles/press-release/21135350/city-of-albuquerque-city-of-albuquerque-awarded-funding-for-electric-buses-and-24-electric-vehicle-charging-stations

36. Here are the cities that are electrifying transportation.” GreenBiz.com. November 21, 2020. https://www.greenbiz.com/article/here-are-cities-are-leading-electrifying-transportation

37. “TTC becomes largest battery electric bus fleet in North America with rollout of third e-bus model.”ElectricAutonomy.com. September 10, 2020. https://electricautonomy.ca/2020/09/10/ttc-battery-electric-bus-fleet/

GEOTAB®

geotab.com