

Fact Sheet

Battery Electric Buses: Benefits Outweigh Costs

October 2018



Electric buses lining up in China (Credit: [Dianba](#))

Transit agencies around the United States and several other countries are purchasing battery-powered electric buses (BEBs) at increasing rates and these trends are expected to accelerate in the coming years. BEBs are powered by battery packs that run an electric motor to turn the wheels, the same as battery-powered electric cars. The batteries are recharged by plug-in chargers using electricity from the transmission grid. Since they do not use gasoline or diesel, BEBs do not produce tailpipe pollution. Thus, BEBs offer a better option than other bus technologies for reducing our greenhouse gas emissions, as well as other harmful pollutants in urban areas.¹

As recently as December 2017, most U.S. transit agencies were still skeptical about transitioning to BEBs due to cost and performance issues.² However, that consensus is shifting rapidly. In 2015, a typical 40-foot diesel bus cost about \$445,000 while a BEB of similar length went for \$770,000.³ Since then, the price difference between the two has decreased somewhat, but remains significant. The lower operating costs of BEBs, however, make them more economical in the long run than internal combustion engine buses. It is about 2.5 times cheaper to power vehicles with electricity rather than diesel, and electricity prices are generally much more stable than gasoline or diesel prices.⁴ The U.S. National Renewable Energy Laboratory has found that the fuel economy of BEBs is five times higher than that of diesel buses operated on equivalent routes.⁵ In addition, maintenance costs for electric motors is much lower because they have far fewer moving parts than conventional motors and are far more efficient.⁶

The current battery technology of choice for electric buses is lithium-ion, the price of which has dropped 80 percent since 2010, and is projected to drop another 50 percent by 2020 or 2025. A lithium-ion battery provides enough energy to operate a bus for about 150 miles (in most conditions) before needing to be recharged. For hilly cities or

cities where air conditioning must be used a lot, that range is significantly reduced.⁷ Charging can be done in a few different ways: slowly overnight (which causes the least wear to the battery and other components), by using an overhead charging system, or by using a system that is embedded under the pavement. The latter two methods are much quicker than the first method, but tend to degrade the bus components more quickly.

It is estimated that there are currently about 386,000 electric buses deployed around the world, with 99 percent of them in China, and less than 0.1 percent (only 350 buses) in the United States.⁸ However, a recent report by Bloomberg New Energy Finance estimated that by 2025, half of the world's municipal bus fleet will be electric, and by 2030, 84 percent of new municipal buses sold will be electric.⁹ By 2040, 80 percent of the world's city bus fleet will be electric, along with 33 percent of the world's cars. City buses (vs. inter-city or charter buses) are especially well-suited to electric power because they are regularly returned to a central depot where they can be recharged, and they don't operate over long ranges. Battery-charged vehicles typically have a driving range of 70-100 miles, and some can go up to 265 miles before needing to be recharged (diesel buses have an average range of 690 miles).^{10,11} Municipal buses also don't carry too heavy a load (humans) compared to freight vehicles.

U.S. Transit Agencies Purchasing Battery-Powered Electric Buses

Many major cities and counties around the world are pledging to shift their entire fleets to BEBs by specific dates in the future. In the United States, these include Los Angeles County (by 2030), Seattle (King County, by 2040),¹² San Francisco (by 2035), and New York (by 2040).¹³ To date, however, most city transit agencies have purchased BEBs in small numbers, to test them for reliability and compare them to traditional buses. The American Public Transportation Association (APTA, representing all of the major public transit agencies in the country) has stated that the economics of BEBs are shifting, although the price point for individual buses remains a barrier to overtaking diesel or other fuel systems.¹⁴ Below is a list of cities/transit agencies that have reportedly purchased BEBs to date or are planning BEB purchases.

City or County (Transit Agency)	BEBs Bought	Delivery Date (Manufacturer)
Anchorage, AK (MOAPTD)	1	January 2018 (Proterra)
Boulder, CO	1	Summer 2018 (unknown)
Chicago, IL (CTA)	20	2019-2020 (Proterra)
Columbus, OH (COTA)	10	2019 or 2020 (Proterra)
Dallas, TX (DART)	7	July 2018 (Proterra)
Hoboken, NJ (Columbia University shuttle system)	6	2018 (New Flyer)
Indianapolis, IN (IndyGo)	21	2018 (unknown)
Los Angeles, CA (L.A. Airports Authority)	20	April 2018 (Byd)
Los Angeles, CA (LADOT)	95	2015 - 2017 (Byd)
Louisville, KY (River City Transit Authority)	15	2017 (Proterra)
Madison, WI (Metro Transit)	3	2019 (unknown)
New York, NY (NYC Transit Authority)	10	Unknown (5 from Proterra, 5 from New Flyer)
Northern Los Angeles County, CA (Antelope Valley Transit Authority)	112	2018 (35 from New Flyer, unknown numbers from Proterra and Byd)
Philadelphia (Southeastern PA Transportation Authority)	25	2019 (Proterra)
Rhode Island Public Transit Authority (RIPTA)	3	2018 (Proterra)
San Francisco, CA (SF Metropolitan Transit Authority)	9	Fall 2018 (various manufacturers)
San Gabriel and Pomona Valleys, CA (Foothill Transit)	15	2017 (Proterra)
Seattle, WA (King County Metro Transit)	20	2018, 2019 (Proterra, Byd, and New Flyer)
St Louis, MO	2	Late 2020 (Gillig)
Stockton, CA (SJRTD)	17	2017 (Proterra)
Washington, DC (WMATA)	14	April 2018 (Proterra)

Battery-Powered Electric Bus Manufacturers in North America

There are many companies worldwide that are engaged in the manufacture of electric buses (not including component parts) or electric-diesel hybrids. Eight of those companies are U.S.-based: five in California, the others in South Carolina, Missouri, and North Carolina.¹⁵

In North America, the main manufacturers of electric buses are: **Byd** (a Chinese company that built a manufacturing facility in Lancaster, CA, 70 miles north of Los Angeles, just prior to winning a contract with the Los Angeles County Metropolitan Transportation Authority); **Proterra** (a Silicon Valley startup with manufacturing facilities in California and South Carolina); and **New Flyer Industries, Inc.** (a Canadian bus manufacturer based in Winnipeg).

Over the past year, several performance problems have been identified with BEBs produced by Byd that were purchased by local transit agencies in California, Colorado, and New Mexico. The buses reportedly depleted their battery charge far before their advertised range, stalled or had problems starting, and had difficulty climbing hills.¹⁶ After the problems were uncovered, the local transit agencies have been seeking recourse with Byd. Meanwhile, rival BEB manufacturers Proterra and New Flyer subsequently demonstrated their vehicles' competency on steep grades and other performance challenges in testing scenarios.¹⁷

Health and Environmental Benefits of Battery-Electric Powered Buses

The health hazards of diesel buses (the technology currently used for the vast majority of buses) are well known among health professionals. Moreover, buses tend to be used in urban settings where there are concentrations of people and air quality is already degraded by other pollutants. Diesel, which is a known carcinogen, can also cause respiratory diseases such as asthma. Those who use public transit most often, including children, the elderly, and those without access to a car, are at particular risk.¹⁸

A particularly compelling case can be made for transitioning school buses from diesel to electric. Because children are exposed daily to the exhaust fumes from their buses, studies have shown that children who ride the bus to school are more likely to develop respiratory diseases and worsening levels of conditions like asthma. Studies have shown that exposure to diesel soot and ground-level ozone created by diesel exhaust is linked to higher rates of cancer and mortality.¹⁹ Children are especially vulnerable to the negative health effects caused by air pollution, as their respiratory systems are still in development and they inhale more air per pound of body weight than adults.²⁰ Electric buses also produce much less noise than combustion engine buses. The beneficial health effects of BEBs over diesel are provided to drivers/operators as well as passengers.

The U.S. Public Interest Research Group (US PIRG) and other public interest groups are advocating for federal policies that help local jurisdictions replace their school buses with BEBs for health benefits, long-term cost savings, and reducing greenhouse gas emissions. Some of their recommended actions at the federal and state levels include:

- Creating an incentive program and grants for transit agencies, school districts and bus contractors to help finance the up-front cost of BEBs and their charging infrastructure;
- Facilitating the installation of charging infrastructure through programs that help cover the costs;
- Encouraging electric utilities to design their rates to support BEBs;
- Designing financing programs for BEB purchases that leverage other sources of funding, such as the Volkswagen settlement money (estimated at \$2 billion);²¹
- Providing technical assistance and conducting research to facilitate the transition to BEBs.

Some members of Congress are considering introducing legislation that promotes some of these policies.

Federal, State, and Private Funding for Battery-Electric Powered Buses

Federal grants are being made to rehabilitate and purchase buses to support the transition of the nation's transit fleet to the lowest polluting and most energy efficient transit vehicles. It remains to be seen, however, whether the federal government will release all the funds earmarked for local transit agencies this year.²² On April 5, 2018, the Federal Transit Administration (FTA, an agency of the U.S. Department of Transportation) announced that it had awarded \$264 million in grants (from a combination of FY2017 and 2018 funds) to 139 projects under its Buses and Bus Facilities Infrastructure Investment Program.²³ On April 23, FTA announced that it had made another \$84.45 million available of FY2018 funds to states and direct recipients for the purchase or lease of low- or no-emissions vehicles and related equipment and facilities (under FTA's "Low-No" Vehicle Program, which is part of the Bus and Bus Facilities infrastructure Investment Program).²⁴ Low- or no-emissions vehicles include electric vehicles as well as vehicles powered by hydrogen fuel cells and hybrids of internal combustion engine and electric powered vehicles. FTA accepted applications until June 18 for these funds and is currently reviewing them for grant awards. On June 21, FTA announced that it was making another \$366.3 million (FY2018 funds) available for competitive grants for transit bus projects.²⁵ Grant applications were accepted until August 1, but FTA has not stated when the awards will be made. School buses are not eligible to receive funds under FTA's "Low-No" program.

At the state level, the California Air Resources Board has approved \$208 million to incentivize school and transit districts to purchase low- and zero emissions bus and truck fleets.²⁶ The California Energy Commission also has allocated \$75 million for BEB purchases.²⁷ In recent weeks, numerous other states have proposed using some of their Volkswagen settlement money to purchase BEBs and charging infrastructure.²⁸

Private sector funding is also beginning to materialize in support of BEB deployment. In July 2018, Byd (with financial backing from Warren Buffett) formed a joint venture with investment company Generate Capital, to lease its BEBs to cities, schools and corporations in the United States.²⁹ Generate Capital is investing \$200 million in the program.

A closely related development that is attracting private sector attention is the increasing deployment of electric trucks, which use basically the same technologies and systems as BEBs. FedEx, DHL, and UPS have been purchasing electric trucks as well as the electric power recharging infrastructure they require. That infrastructure could potentially be used by BEBs if these two groups could work out sharing agreements.³⁰

Next Steps

In the wake of the Trump Administration's abdication of any federal role in fighting climate change, cities and states have ramped up their efforts. One of the areas where this trend can be seen is in the increasing interest in Battery-Powered Electric Buses. As the electricity generation sector transitions to renewable energy sources, cities and transit agencies are eager to become bigger customers by using their power to charge BEB fleets. While the United States cannot hope to catch up to China's level of BEB deployment for the foreseeable future, significant progress can be made on reducing the greenhouse gas emissions associated with the transportation sector by investing in Battery-Powered Electric Buses.

This fact sheet is available electronically (with hyperlinks and endnotes) at www.eesi.org/papers.

Author: Richard Nunno

Editor: Carol Werner

The Environmental and Energy Study Institute (EESI) is a non-profit organization founded in 1984 by a bipartisan Congressional caucus dedicated to finding innovative environmental and energy solutions. EESI works to protect the climate and ensure a healthy, secure, resilient, and sustainable future for America through policymaker education, coalition building, and policy development in the areas of energy efficiency, renewable energy, agriculture, forestry, transportation, buildings, and urban planning.

ENDNOTES

-
- ¹ While compressed natural gas (CNG) engines emit fewer greenhouse gases and other air pollutants than those of diesel engines (except methane emissions, which are higher), the environmental benefits of CNG cannot compare with the zero emissions offered by fully electric vehicles. Hydrogen fuel cell electric engines emit zero tailpipe emissions, but the infrastructure for refueling these vehicles is different from that of BEBs, and there are far fewer of these buses deployed in the United States and globally, making a comparison with BEB deployment difficult.
- ² U.S. Transit Agencies Cautious on Electric Buses Despite Bold Forecasts, www.reuters.com/article/us-transportation-buses-electric-analysis/u-s-transit-agencies-cautious-on-electric-buses-despite-bold-forecasts-idUSKBN1E60GS. December 12, 2017.
- ³ The Very Good Math of Electric Buses, RouteFifty, www.routeifty.com/smart-cities/2018/06/electric-buses-energy-economics/148876/. June 11, 2018.
- ⁴ Saving on Fuel and Vehicle Costs, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, www.energy.gov/eere/electricvehicles/saving-fuel-and-vehicle-costs. Updated May 19, 2018.
- ⁵ County Connection Battery Electric Bus Demonstration – Preliminary Project Results, Federal Transit Administration, U.S. Department of Transportation, www.nrel.gov/docs/fy18osti/71910.pdf. July 2018.
- ⁶ Here's What's Really Involved in an Electric Car Drivetrain, AutoWeek, autoweek.com/article/technology/electric-motors-less-parts-more-complex. September 20, 2017.
- ⁷ Charging Ahead with Electric Buses, National Bus Trader, busmag.com/wp-content/uploads/2018/05/Electric-April.pdf. April 2018.
- ⁸ Buffett-Backed BYD Forms Venture to Lease Electric Buses, Bloomberg News, www.bloomberg.com/news/articles/2018-07-10/buffett-backed-byd-forms-venture-to-lease-electric-buses-in-u-s. July 10, 2018.
- ⁹ City Buses Are about to Swiftly Electrify, Greenbiz, www.greenbiz.com/article/city-buses-are-about-swiftly-electrify; E-Buses to Surge Even Faster Than EVs as Conventional Vehicles Fade, about.bnef.com/blog/e-buses-surge-even-faster-evs-conventional-vehicles-fade/. May 21, 2018.
- ¹⁰ How Do Battery Electric Cars Work, Union of Concerned Scientists, www.ucsusa.org/clean-vehicles/electric-vehicles/how-do-battery-electric-cars-work. Updated March 12, 2018.
- ¹¹ Which Alternative Fuel Technology is Best for Transit Buses?, Carnegie Mellon University Scott Institute for Energy Innovation, www.cmu.edu/energy/education-outreach/public-outreach/17-104%20Policy%20Brief%20Buses_WEB.pdf. October 19, 2018.
- ¹² King County Rolls on with its Electric Bus Fleet Plans, Seattleweekly, www.seattleweekly.com/news/king-county-rolls-on-with-its-electric-bus-fleet-plans/. July 20, 2018.
- ¹³ New York City Aims for All-Electric Bus Fleet by 2040, Inside Climate News, insideclimatenews.org/news/26042018/nyc-air-pollution-electric-bus-public-transportation-mta-clean-technology. April 26, 2018.
- ¹⁴ Public Transit Leading in Transition to Clean Energy, Policy Development and Research, American Public Transportation Association, www.apta.com/resources/reportsandpublications/Documents/APTA-Transit-Leading-Clean-Technology.pdf. July 2, 2018.
- ¹⁵ List of Electric Bus Makers and Models, Wikipedia, en.wikipedia.org/wiki/List_of_electric_bus_makers_and_models. Last edited July 9, 2018.
- ¹⁶ Stalls, Stops and Breakdowns: Problems Plague Push for Electric Buses, Los Angeles Times, www.latimes.com/local/lanow/la-me-electric-buses-20180520-story.html. May 20, 2018.
- ¹⁷ Byd's Electric Bus Woes Threaten to Tarnish the Broader Industry, Greentechmedia, www.greentechmedia.com/articles/read/byds-electric-bus-woes-threaten-to-tarnish-the-broader-industry. May 25, 2018.
- ¹⁸ Electric Buses: Clean Transportation for Healthier Neighborhoods and Cleaner Air, USPIRG, uspirg.org/reports/usp/electric-buses-clean-transportation-healthier-neighborhoods-and-cleaner-air. May 3, 2018.
- ¹⁹ Quian Di et al., "Air Pollution and Mortality in the Medicare Population," The New England Journal of Medicine, 376:2513-2522, DOI: 10.1056/NEJMoa1702747. June 29, 2017.

-
- ²⁰ Protect Yourself from Wildfire Smoke, Centers for Disease Control and Prevention website, www.cdc.gov/features/wildfires/index.html, Accessed January 12, 2018.
- ²¹ Volkswagen Group of America has agreed to spend \$14.7 billion to settle allegations of cheating vehicle emissions standards. Of that amount, \$2 billion will be spent on national zero emission vehicle investments, and \$2.7 billion will be used for an Environmental Mitigation Trust, which states and Territories may use to invest in transportation projects that reduce NOx emissions. See www.naseo.org/volkswagen-settlement.
- ²² FTA has been withholding money that was appropriated for various public transit projects in local jurisdictions around the country, ostensibly for ideological reasons. See thehill.com/opinion/energy-environment/407738-administration-thwarting-congress-by-withholding-transit-funds.
- ²³ U.S. Department of Transportation Announces \$264 Million in Grants to Modernize and Improve America's Bus Infrastructure Nationwide, Federal Transit Administration, U.S. Department of Transportation, www.transit.dot.gov/about/news/us-department-transportation-announces-264-million-grants-modernize-and-improve-america. April 5, 2018.
- ²⁴ Low or No Emission Program 2018 Notice of Funding, Federal Transit Administration, U.S. Department of Transportation, www.transit.dot.gov/funding/applying/notices-funding/low-or-no-emission-program-low-no-program-2018-notice-funding. April 23, 2018.
- ²⁵ U.S. Department of Transportation Announces \$366.3 Million Funding Opportunity to Improve Transit Bus Infrastructure, Federal Transit Administration, U.S. Department of Transportation, www.transit.dot.gov/about/news/us-department-transportation-announces-3663-million-funding-opportunity-improve-transit. June 21, 2018.
- ²⁶ Lower Costs, Incentives, Drive Electric Bus Adoption, Cleantechnica, cleantechnica.com/2018/09/05/lower-costs-incentives-drive-electric-bus-adoption. September 5, 2018.
- ²⁷ California Energy Commission Works to Replace State's Oldest, Most Polluting School Buses, California Energy Commission, calenergycommission.blogspot.com/2018/07/california-energy-commission-works-to.html. July 24, 2018.
- ²⁸ Washington and 16 Other States Pledge to Use \$1.4 billion in VW Settlement Money to Cut Vehicle Emissions, Seattle Times, www.seattletimes.com/seattle-news/politics/washington-and-16-other-states-pledge-to-use-1-4b-in-vw-settlement-money-to-cut-vehicle-emissions. September 14, 2018.
- ²⁹ Buffett-Backed Byd Forms Venture to Lease Electric Buses, Bloomberg News, www.bloomberg.com/news/articles/2018-07-10/buffett-backed-byd-forms-venture-to-lease-electric-buses-in-u-s. July 10, 2018.
- ³⁰ Your UPS Deliveries May Soon Arrive in Electric Trucks, FastCompany, www.fastcompany.com/90229460/your-ups-deliveries-may-soon-arrive-in-electric-trucks. September 11, 2018.