

Project Startup: Evaluating the Performance of Electric Buses

The National Renewable Energy Laboratory (NREL) is evaluating the in-service performance of fast-charge battery electric buses compared to compressed natural gas (CNG) buses operated by Foothill Transit in West Covina, California. Launched in 2015 in collaboration with the California Air Resources Board, this study aims to improve understanding of the overall use and effectiveness of fast-charge electric buses and associated charging infrastructure in transit operation.

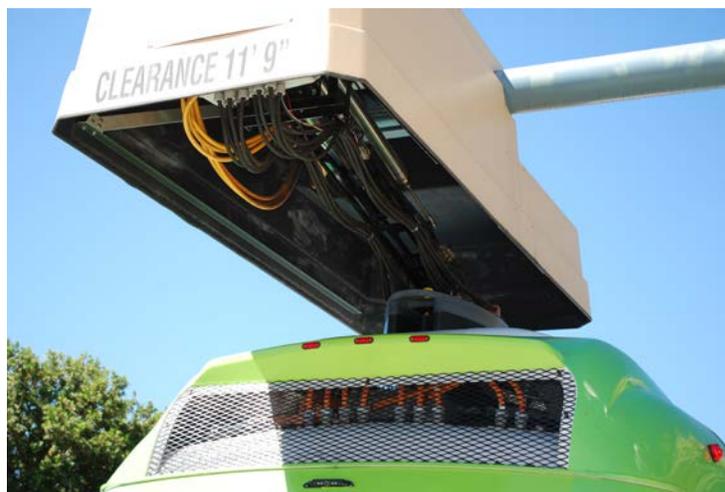
In-Service Testing and Analysis

The on-road portion of the evaluation involves collecting and analyzing vehicle performance data from the electric and CNG buses. NREL is using the data to evaluate vehicle and component performance—with a focus on energy efficiency, battery and electric motor power profiles, reliability, and maintenance costs—and to conduct detailed drive cycle analysis. Based on the field data, NREL will develop a validated vehicle model using the Future Automotive Systems Technology Simulator, or FASTSim, to help the transit agency identify other routes in its service area that are suitable for electrification. NREL will also analyze the infrastructure requirements and grid-side impacts of the high-power charging stations.

Initial results indicate that the electric buses offer significant fuel savings—nearly four times greater—compared to the CNG buses. The average efficiency of the electric buses equates to approximately 17.5 miles per diesel gallon equivalent (DGE) while the average fuel economy of the CNG buses equates to about 4.5 miles per DGE.

Chassis Dynamometer Testing

In addition to the on-road portion of the evaluation, NREL will conduct chassis dynamometer testing of the vehicles to determine the fuel economy and emissions impact of the electric bus technology in a controlled setting. Initial data collected from the buses using global positioning system data loggers will be used to choose standard and custom dynamometer drive cycles that best represent Foothill Transit's operation.



In 2014, Foothill Transit fully electrified one route in its service area—Route 291—and is now investigating the feasibility of electrifying other routes as well. The transit agency's electric buses can fully charge in less than 10 minutes via two 500kW fast chargers located mid-way along the route. The buses are programmed for easy docking—wireless communications govern the speed and stop location of the buses, and the overhead charger connects without input from the driver. *Photos by Leslie Eudy, NREL 36043 and 36044*

Technology Basics

The electric buses under study—35-foot Proterra EcoRide BE35 transit buses—feature 368-V lithium-titanate battery packs offering 88kWh of energy.

Each zero-emission electric bus reduces local greenhouse gas emissions by 146,000 pounds per year.

About Foothill Transit

Foothill Transit provides bus service throughout Southern California's San Gabriel and Pomona Valleys, including express bus routes to Pasadena and downtown Los Angeles. The transit agency operates 36 local and express routes across its 327-square-mile service area, and accommodates approximately 14 million riders a year.

Foothill Transit, which began its path to cleaner buses in 2002 when it added CNG buses to its fleet, retired its last diesel bus in 2013. Today, its 100% alternative fuel bus fleet includes 315 CNG buses and 15 electric buses. Foothill Transit tapped into grant

funding from the American Recovery and Reinvestment Act as well as the Federal Transit Administration's Transit Investments for Greenhouse Gas and Energy Reduction Program to support its electric bus acquisitions.



Manufactured by Proterra, the 35-foot long EcoRide buses are made of lightweight composite materials and are powered with state-of-the-art lithium-titanate battery technology. *Illustration courtesy of Proterra, NREL 500127*

Advanced Vehicle Testing

This project is part of a series of evaluations performed by NREL's Fleet Test and Evaluation Team for the U.S. Department of Energy's Advanced Vehicle Testing Activity (AVTA). AVTA bridges the gap between research and development and the commercial availability of advanced vehicle technologies that reduce petroleum use and improve air quality. AVTA projects provide comprehensive, unbiased assessments of advanced vehicles and comparable conventional vehicles operating in commercial fleet service. Data are collected and analyzed for operation, maintenance, performance, cost, and emissions characteristics. Evaluation results enable fleet owners and operators to make informed vehicle-purchasing decisions.

NREL's Sustainable Transportation RD&D

As the only national laboratory solely dedicated to renewable energy and energy efficiency, NREL spearheads the research, development, and deployment (RD&D) needed to put sustainable transportation solutions on the road. The laboratory's innovative and integrated approach helps government, industry, and other partners develop and deploy the components and systems needed for market-ready, high-performance, low-emission, fuel-efficient passenger and freight vehicles, as well as alternative fuels and related infrastructure. For more information about NREL's sustainable transportation RD&D capabilities and successes, visit www.nrel.gov/transportation.

To learn more about NREL's fleet test and evaluation activities, visit www.nrel.gov/transportation/fleettest.html. To track the progress of the Foothill Transit electric bus evaluation project, visit www.nrel.gov/transportation/fleettest_electric_foothill.html.

National Renewable Energy Laboratory
15013 Denver West Parkway, Golden, CO 80401
303-275-3000 • www.nrel.gov

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

FS-5400-66142 • April 2016

NREL prints on paper that contains recycled content.