



U.S. Department of Transportation
Federal Transit Administration



Zero-Emission Bus Evaluation Results: King County Metro Battery Electric Buses

Background

The Federal Transit Administration (FTA) is collaborating with the U.S. Department of Energy (DOE) and DOE's National Renewable Energy Laboratory (NREL) to conduct in-service evaluations of advanced technology buses developed under its programs. In 2010, King County Metro transit agency in Seattle, Washington, received funding from a Transit Investments for Greenhouse Gas and Energy Reduction (TIGGER) award to add three zero-emission battery electric buses (BEBs) to its fleet.

Objectives

The purpose of this report is to outline the evaluation plan and analysis protocol and present the results from a one-year evaluation of three battery electric buses (BEBs) at King County Metro in Seattle, Washington.

Findings and Conclusions

KC Metro implemented the agency's first BEB fleet, accumulated more than 100,000 miles on the battery buses in the first 15 months of revenue service, and increased operation of the battery fleet since the end of the data collection period.

This report presents evaluation results for the BEBs in comparison to a selection of baseline buses. The focus of the analysis is on one year of data from April 2016 through March 2017. The four bus fleets included in the evaluation are the battery fleet, hybrid fleet, diesel fleet, and trolley fleet. Among the findings of the evaluation are the following:

- The overall average availability for the battery fleet was 80.6%. For the baseline buses, the overall average availability was 90.5% for the hybrid fleet, 86.4% for the diesel fleet, and 84.9% for the trolley fleet.
- The battery buses had an overall average efficiency of 2.36 kWh per mile, which equates to a fuel economy of 15.9 miles per diesel gallon equivalent (mpdge). The hybrid buses had an average fuel economy of 6.3 mpdge, and the diesel buses had a fuel economy of 5.3 mpdge.
- The battery fleet propulsion-related MBRC was 6,927. Propulsion-related MBRC for the diesel and hybrid baseline fleets were similar to each other—34,665 and 29,037, respectively. The propulsion-related MBRC for the trolley buses was 2,960, which reflects the trolley fleet's low average mileage and early issues with the current collection system.
- During the data period, KC Metro paid an average of \$0.20/kWh for electricity for the battery buses and \$1.60/gal for diesel fuel. The fuel economy advantage of the hybrid fleet over the diesel fleet resulted in a slightly lower per-mile fuel cost for the hybrid fleet (\$0.25/mi) compared to the diesel fleet (\$0.30/mi). The per-mile fuel (electricity) cost for the battery fleet was \$0.57/mi.

Summary of Evaluation Results

Data Item	Battery	Hybrid	Diesel	Trolley
Number of buses	3	10	3	10
Total mileage in data period	83,128	435,552	69,329	180,554
Average mileage per bus	27,709	43,555	23,110	18,055
Average monthly mileage per bus	2,309	3,630	1,926	1,505
Availability (85% is target)	80.6	90.5	86.4	84.9
Fuel economy (kWh/mile)	2.36	—	—	2.57
Fuel economy (miles/dge ^a)	15.9	6.3	5.3	14.7
Average speed, including stops (mph) ^b	14.8	15.2	14.6	9.0
Miles between roadcalls (MBRC) – bus ^c	2,771	7,641	17,332	1,641
MBRC – propulsion system only ^c	6,927	29,037	34,665	2,960
Total maintenance cost (\$/mile) ^d	0.26	0.32	0.46	0.46
Maintenance – propulsion system only (\$/mile)	0.05	0.12	0.13	0.17

^a Diesel gallon equivalent.

^b Based on scheduled revenue service.

^c MBRC data cumulative through March 2017.

^d Work order maintenance cost.

Benefits

As with all new technology development, lessons learned during this project could aid other agencies considering BEB technology. KC Metro reports that it has had a positive experience with Proterra and Proterra has expressed appreciation with KC Metro’s feedback on the bus design and has used that input to make improvements. KC Metro is committed to an environmentally-friendly fleet and plans to purchase 120 BEBs by 2020. In 2017, the agency entered into a contract with Proterra to purchase up to 73 BEBs.

Project Information

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