Project Results: Evaluating FedEx Express Hybrid-Electric Delivery Trucks

The National Renewable Energy Laboratory's (NREL's) Fleet Test and Evaluation Team evaluated the 12-month, in-service performance of three Class 4 gasoline hybrid-electric delivery trucks and three comparable conventional diesel trucks operated by FedEx Express in Southern California. In addition, the tailpipe emissions and fuel economy of one of the gasoline hybrid-electric vehicles (gHEVs) and one diesel truck were tested on a chassis dynamometer. The gHEVs were equipped with a parallel hybrid system manufactured by Azure Dynamics, including a 100-kW alternating current induction motor, regenerative braking, and a 2.45-kWh nickel-metal-hydride battery pack. This fact sheet summarizes the results of the evaluation of the gHEVs.

This technology evaluation was part of a collaborative effort co-funded by the U.S. Department of Energy's (DOE's) Vehicle Technologies Program and the South Coast Air Quality Management District (SCAQMD) via CALSTART. The in-use technology evaluation was conducted by NREL and primarily sponsored by DOE. The chassis dynamometer testing was conducted by NREL and primarily funded by SCAQMD via CALSTART.

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 in the United States. The main objective of AVTA projects is to provide comprehensive, unbiased evaluations of advanced vehicle technologies in commercial use. Data are collected and analyzed for operation, maintenance, performance, costs, and emissions characteristics of advanced-technology fleets and comparable conventional-technology fleets operating at the same site. AVTA evaluations enable fleet owners and operators to make informed vehicle-purchasing decisions.

FedEx Express's gasoline hybrid-electric delivery trucks demonstrated lower tailpipe emissions compared with conventional diesel delivery trucks. Courtesy of Sam Snyder, FedEx Express

In-Service Testing

Three routes served by gHEVs and three served by conventional diesel trucks were selected for the evaluation, which took place from April 2009 to April 2010. The gHEVs were moved to the initial diesel routes after 6 months of evaluation, while the diesel trucks were moved to the initial gHEV routes.

In-service refueling data were collected from driver fuel logs and fuel purchase records and analyzed. Real-time data loggers were used periodically to measure fuel consumption data from some of the vehicles as a way to cross-check the primary data sources. FedEx Express personnel performed all scheduled and unscheduled maintenance. Maintenance data were collected from repair orders and analyzed. The results are summarized below.

Fuel Economy and Cost: The difference in diesel-equivalent fuel economy between the gHEVs and diesel trucks was not statistically significant: 7.5 miles/gallon for the gHEVs and 7.9 miles/gallon for the diesel trucks. The average fuel cost was $0.42/mile for the gHEVs (based on $2.94/gallon gasoline) and $0.37/mile for the diesel trucks (based on $2.90/gallon diesel). This difference also was not statistically significant.

Maintenance Cost: The maintenance cost difference was not statistically significant: $0.21/mile for the gHEVs and $0.22/mile for the diesel trucks. For both vehicle types, about half this cost was due to preventive maintenance and tire replacement. The gHEVs had repairs that were covered under warranty whereas the diesel trucks did not. If warranty repairs were included, the maintenance cost for the gHEVs would have been $0.23/mile.

Total Operating Cost: The higher fuel cost for the gHEVs offset their lower maintenance cost and resulted in a higher total operating cost: $0.63/mile for the gHEVs versus $0.59/mile for the diesel trucks. However, this difference was not statistically significant.

Vehicle Uptime: Vehicle uptime is the ratio of actual days in service to planned days in service. FedEx Express has set a vehicle uptime target of 98%. Vehicle uptime was 95.8% for the gHEVs and 98.4% for the diesel trucks. Only four of the gHEVs' 46 unplanned days out of service were related to hybrid propulsion system issues; thus, the vehicle uptime related to hybrid system performance was 99.6% for the gHEVs.

Chassis Dynamometer Testing

Chassis dynamometer testing was performed on one gHEV and one diesel truck at NREL's Renewable Fuels and Lubricants research laboratory in Denver, Colorado. The gHEV was from the evaluation fleet and was equipped with a three-way catalyst emission-control device. The diesel truck was a model year 2006 diesel truck (with 2004 engine certification) from FedEx Express's Denver fleet and was not equipped with a diesel particulate filter. Tailpipe emissions and fuel consumption were measured over three drive cycles that approximate the likely range of driving patterns for this type of delivery vehicle.

The gHEV emitted lower amounts of criteria tailpipe emissions than the diesel truck across all drive cycles: 75%–89% lower nitrogen oxides, 59%–90% lower carbon monoxide, 90%–100% lower total hydrocarbons, and 100% lower particulate matter. Although there was no statistically significant difference between the diesel-equivalent fuel economies of the gHEV and the diesel truck over any of the three drive cycles, there was an apparent trend toward a fuel-economy advantage for the gHEV with increasing drive-cycle kinetic intensity.[1]

Conclusions

The gHEVs performed well, required minimal unscheduled maintenance, and met the expectations of FedEx Express during this study. There was no statistically significant difference in total operating cost per mile between the gHEVs and the diesel trucks. Chassis dynamometer testing showed that the gHEVs had substantially reduced criteria tailpipe emissions compared with the diesel trucks over three drive cycles. There were no significant differences in diesel-equivalent fuel economy between the gHEVs and the diesel trucks, but the fuel economy trends observed indicate the importance of matching hybrid vehicles to the most appropriate routes/drive cycles in order to reap the maximum benefits of their fuel-saving technologies.

Download the full report for this project at *www.nrel.gov/docs/fy11osti/48896.pdf*. For more information, visit the AVTA (*www.eere.energy.gov/vehiclesandfuels/avta*) and Fleet Test and Evaluation (*www.nrel.gov/vehiclesandfuels/fleettest*) Web sites.

Test Vehicle Specifications

	Gasoline Hybrid Electric	Conventional Diesel
Chassis Manufacturer/Model	Ford E-450 Strip Chassis	Freightliner MT-45
Chassis Model Year	2008	2006
Engine Manufacturer/Model	Ford 5.4L EFI Triton V-8	Cummins 5.9L ISB 200 I-6
Engine Model Year	2008	2006 (EPA 2004 certification)
Engine Ratings Maximum Horsepower Maximum Torque	 255 hp @ 4,500 rpm 350 lb-ft @ 2,500 rpm	 200 hp @ 2,300 rpm 520 lb-ft @ 1,600 rpm
Fuel Capacity	55 gal (gasoline)	45 gal (diesel)
Transmission Manufacturer/Model	Ford 5R110 5-speed automatic	Allison 1000 5-speed automatic
Curb Weight	9,300 lb	9,700 lb
Gross Vehicle Weight Rating	14,050 lb	16,000 lb
Retarder/Regenerative Braking	Regenerative braking	None
Advanced Emission-Control Equipment	Three-way catalyst	None
Cabin Air Conditioning	Yes	Yes

[1] A drive cycle with high kinetic intensity is characterized by many acceleration and deceleration events.

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