

Project Startup: Evaluating the Performance of Hydraulic Hybrid Refuse Vehicles

The Fleet Test and Evaluation Team at the National Renewable Energy Laboratory (NREL) is evaluating the in-service performance of 10 next-generation (model year 2015) hydraulic hybrid refuse vehicles (HHVs), 8 previous-generation (model year 2013) HHVs, and 8 comparable conventional diesel vehicles operated by Miami-Dade County's Public Works and Waste Management Department in southern Florida.

In-Service Testing and Analysis

Launched in March 2015, the on-road portion of this 12-month evaluation focuses on collecting and analyzing vehicle performance data—fuel economy, maintenance costs, and drive cycles—from the HHVs and the conventional diesel vehicles. The fuel economy of heavy-duty vehicles, such as refuse trucks, is largely dependent on the load carried and the drive cycles on which they operate. In the right applications, HHVs offer a potential fuel-cost advantage over their conventional counterparts. This advantage is contingent, however, on driving behavior and drive cycles with high kinetic intensity (such as with stop-and-go traffic) that take advantage of regenerative braking.

NREL's evaluation will assess the performance of this technology in commercial operation and help Miami-Dade County determine the ideal routes for maximizing the fuel-saving potential of its HHVs. Based on the field data, NREL will develop a validated vehicle model using the Future Automotive Systems Technology Simulator, also known as FASTSim, to study the impacts of route selection and other vehicle parameters. NREL is also analyzing fueling and maintenance data to support total-cost-of-ownership estimations and forecasts. The study aims to improve understanding of the overall usage and effectiveness of HHVs in refuse operation compared to similar conventional vehicles and to provide unbiased technical information to interested stakeholders. NREL will add relevant data to the Fleet DNA clearinghouse of commercial fleet vehicle operating data at nrel.gov/fleetdna.

Chassis Dynamometer Testing

In addition to the on-road portion of the evaluation, one HHV and one conventional vehicle will undergo chassis dynamometer testing to analyze the performance of the HHV technology in a controlled setting. Initial data collected from the refuse trucks using



With 530 hybrid vehicles ranging from light-duty sedans to refuse trucks and transit buses, Miami-Dade County boasts the third largest municipal hybrid fleet in the nation. As part of the county's overall strategy to reduce emissions and fuel use, it recently added 29 new hydraulic hybrid refuse vehicles to its fleet, bringing its total to 64. *Photo courtesy of Parker Hannifin, NREL 32783*

global positioning system data loggers will be used to choose standard dynamometer drive cycles and create custom cycles that best represent Miami-Dade's residential operation. NREL will use the Drive-Cycle Rapid Investigation, Visualization, and Evaluation (DRIVE) analysis tool to develop representative chassis dynamometer drive cycles from the field data. Fuel economy and emissions of nitrogen oxides, carbon monoxide, hydrocarbons, and carbon dioxide will be measured for each truck.

Technology Basics

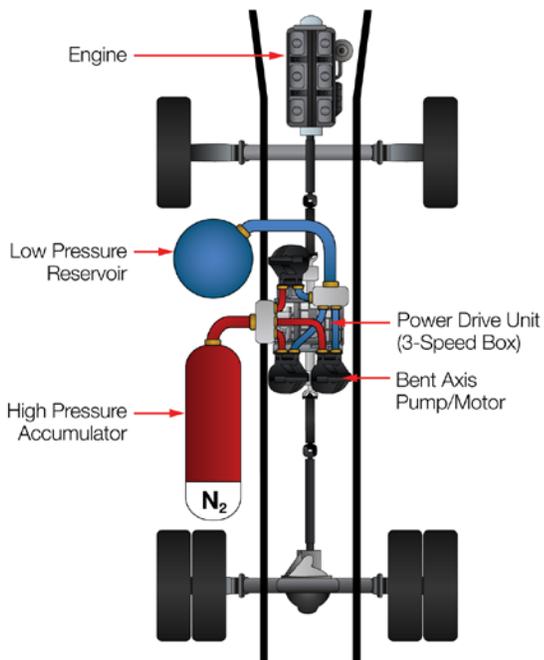
The HHVs under study—Autocar E3 refuse trucks equipped with Parker Hannifin's RunWise Advanced Series Hybrid Drive systems—can recover as much as 70% of the energy typically lost during braking and reuse it to power the vehicle. The system features a two-speed hydrostatic drive combined with a mechanical direct drive, which optimizes vehicle performance at both low and high speeds.

About Miami-Dade County

With a fleet of 190 refuse vehicles, Miami-Dade County's Public Works and Waste Management Department provides waste collection to more than 320,000 households in unincorporated

How RunWise Works

- 1 When the truck is started the engine and primary bent axis pump/motor charge the high pressure accumulators.
- 2 As the driver presses on the throttle the truck's stored energy is used to drive the truck hydraulically. Once that energy is used up, then engine supplies the power.
- 3 Each time the driver presses the brakes, the system captures energy into the high pressure accumulators. Therefore, the more stops the more saved energy!
- 4 When the truck drives over speeds of 45 mph the driveshaft connects directly with the engine to drive the truck in mechanical mode.



Parker Hannifin's RunWise Advanced Series Hybrid Drive replaces the conventional transmission. *Diagram courtesy of Parker Hannifin*

Miami-Dade County is a long-recognized leader in its commitment to reducing greenhouse gas (GHG) emissions. It has an impressive track record of implementing numerous programs and policies that contribute to the regional GHG reduction target of 80 percent below 2008 levels by 2050.

The county is a member of the Southeast Florida Clean Cities

Miami-Dade County and eight municipalities—Aventura, Cutler Bay, Doral, Miami Gardens, Miami Lakes, Palmetto Bay, Pinecrest, and Sunny Isles Beach—in southern Florida. It processes more than 1.2 million tons of waste a year, converting 240,000 tons of material into a biomass fuel. The county's 77-megawatt waste-to-energy facility produces enough energy to run the plant and meet the electrical needs of approximately 45,000 homes.

Coalition, which aims to reduce petroleum use and GHG emissions by maximizing the use of alternative fuels and higher efficiency vehicles in Florida's Miami-Dade, Monroe, Broward, and Palm Beach counties. Visit afd.energy.gov/cleancities/coalition/southeast-florida to learn more about the coalition.

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 nrel.gov/transportation.

To learn more about NREL's fleet test and evaluation activities or to track the progress of the Miami-Dade HHV evaluation project, visit nrel.gov/transportation/fleetest.html.

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