VII.A.3 Fuel Cell Hybrid Electric Delivery Van Project

Jason Hanlin
Center for Transportation and the Environment
730 Peachtree Street, Suite 760
Atlanta, GA 30308-1209
Phone: (404) 808-6489
Email: Jason@cte.tv

DOE Manager: James Alkire
Phone: (720) 356-1426
Email: James.Alkire@ee.doe.gov

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Subcontractors:
- Hydrogenics USA, San Diego, CA
- United Parcel Service (UPS), Sandy Springs, GA
- Unique Electric Solutions, Stony Brook, NY
- University of Texas at Austin - Center for Electromechanics, Austin, TX
- Valence Technology, Austin, TX

Project Start Date: July 15, 2014
Project End Date: November 30, 2020

Overall Objectives

- Increase the zero-emission driving range and commercial viability of medium-duty electric drive trucks.
- Phase 1 – develop a fuel cell hybrid electric delivery van and validate its design and construction through in-service operation.
- Phase 2 – build the Phase 1 delivery van at pre-commercial volume (up to 16 vehicles) and perform at least 5,000 operation hours of in-service demonstration.
- Develop an economic/market opportunity assessment for medium-duty fuel cell hybrid electric trucks.

Fiscal Year (FY) 2017 Objectives

- Conduct hazard analysis and update system safety plan.
- Complete vehicle design, component procurement, and build.
- Coordinate fueling availability at West Sacramento, California demonstration site.
- Train end-user fleet operations and maintenance personnel.
- Begin demonstrating the prototype van in regular parcel service delivery. Collect and evaluate operating data during the demonstration period.

Technical Barriers

This project addresses the following technical barriers from the following sections of the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan.

Technology Validation

(A) Lack of Fuel Cell Electric Vehicle and Fuel Cell Bus Performance and Durability Data

Market Transformation

(D) Market uncertainty around the need for hydrogen infrastructure versus timeframe and volume of commercial fuel cell applications

(F) Inadequate user experience for many hydrogen and fuel cell applications

Technical Targets

This project directly addresses Market Transformation Section 3.9.4 Sub-Program Targets. It provides a pathway for the introduction of fuel cell technologies into the medium-duty vehicle market. The project has a technology validation phase and a follow-on deployment of a pre-commercial volume of the vehicles in parcel delivery service. The project is built upon the initial structure that DOE prescribed in the funding opportunity announcement and is augmented by the active participation and guidance of a major commercial fleet operator, UPS. UPS operates 46,000 medium-duty vehicles worldwide. Furthermore, the vehicles will be deployed in California to take advantage of that state's focused growth of fueling infrastructure and desire to deploy zero-emission vehicles. The Center for Transportation and the Environment has coordinated with station providers early in the project in order to identify and overcome fueling station barriers for this emerging application of fuel cell technologies, such as the limitation of J2601 fueling protocol described below. This project further leverages the resources and support of the State of California. The project team has also focused on upfront design to ensure that (1) selection of the fuel cell size will take advantage of volume growth from other applications and markets, and (2) the design will meet the needs of our commercial fleet operator by matching the performance of incumbent technologies, while meeting the range requirements for over 97% of delivery van duty cycles.

FY 2017 Accomplishments

- Completed a hazard analysis with support from DOE's Hydrogen Safety Panel.
- Finalized vehicle design. Procured long lead-time components and integrated primary components of the fuel cell hybrid electric powertrain into the vehicle.
- Displayed the vehicle chassis with primary fuel cell and electric powertrain components installed at the 2017 ACT Expo in Long Beach, California.
- Reviewed project fueling requirements with Linde, the hydrogen fueling station operator in West Sacramento, California. Discussed fueling tests and fuel purchase strategies in preparation for the demonstration.
- Outlined training plans, demonstration support plans, and an operator's manual.

INTRODUCTION

Parcel delivery van fleets are currently dominated by diesel and compressed natural gas-powered Class 3–6 trucks. In recent years, some parcel delivery services have integrated battery-electric trucks into their fleet; however, these battery-electric vehicles have been unable to match the performance of existing delivery vans and their limited range significantly impacts deployment strategy. The intent of this project is to develop a hydrogen fuel cell hybrid electric van that provides fleet operators with a zero-emission vehicle capable of meeting route range requirements while matching the performance characteristics of its existing fleet vehicles. According to Fleet DNA Project Data compiled by the National Renewable Energy Laboratory, a vehicle with a 125-mile range will meet 97% of Class 3–6 daily delivery driving distances [1]. Meeting this 125-mile range threshold will increase the attractiveness of zero-emission trucks to fleet operators and increase their commercial viability.

APPROACH

This project aims to develop and demonstrate a hydrogen fuel cell hybrid electric van with a 125-mile operational range and validate the vehicle through in-service deployment in a California UPS fleet. This project has two phases:

- Develop a fuel cell hybrid electric delivery van and validate its design and construction through in-service operation.
- Build the Phase 1 delivery van at pre-commercial volume (up to 15 additional vehicles) and perform at least 5,000 operation hours of in-service demonstration.

During Phase 1, real-world delivery van route data is collected to define the expected duty cycle requirements. All potential fuel cell hybrid electric van powertrain configurations are then modeled and simulated on the duty cycles to assess vehicle performance and aid final design. Trade studies (including cost and projected costs at high volumes) are accomplished and vehicle components are then downselected and the physical layout is completed. The first delivery van can then be built and validated through in-service operation. If the delivery van meets Phase 1 performance requirements, the project team will build and deploy up to 15 additional vans in Phase 2. All of the vans will be demonstrated in California. Vehicle performance data during the demonstration periods will be collected and provided to the National Renewable Energy Laboratory's National Fuel Cell Technology Evaluation Center for analysis.

The project team benefits from having members with extensive hydrogen fuel cell experience, including the University of Texas and Hydrogenics, and one of the largest medium-duty truck fleet operations in the world, UPS. UPS has deployment experience with delivery vans powered by various fuels, including gasoline, diesel, compressed natural gas, and battery-electric. This experience gives them a unique perspective on the commercial viability of alternative fueled vehicles and their project contributions are invaluable. Project funding is provided by the DOE, the California Energy Commission, and the South Coast Air Quality Management District. UPS is providing cost share during the demonstration periods by supplying operation, maintenance, and fueling costs.

RESULTS

Vehicle design was finalized, including component layout and packaging details. The fuel cell module and balance of plant are positioned in the engine compartment area, where the internal combustion engine is located in traditional trucks. This is a retrofit project, and the project team overcame significant design challenges related to the limited space inside the existing engine compartment area. The fuel cell system is mounted to a removable skid to simplify future maintenance for the end-user. Hydrogen tank cylinders are mounted to the outside face of the chassis frame rails and the mounting hardware was designed to mimic the tank mounting strategy that UPS currently uses for their compressed natural gas fleet vehicles. The vehicle's high-voltage battery system is positioned between the frame rails in four individual enclosures. An illustration of the vehicle chassis that shows the physical layout and component packaging is shown in Figure 1. Notice that no components are positioned behind the rear axle or in the cargo area above the chassis frame.

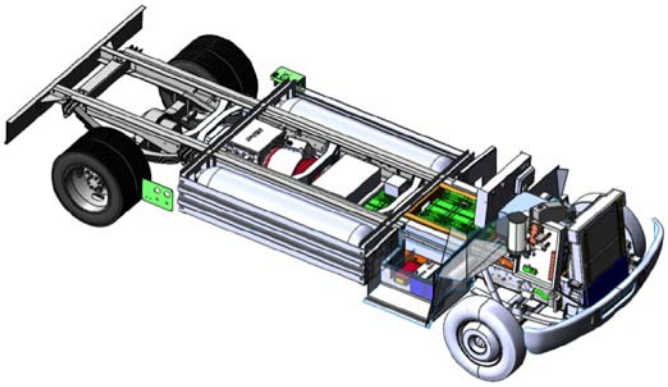

FIGURE 1. Illustration of the vehicle chassis with energy storage and fuel cell hybrid electric powertrain components

Project stakeholders, including members of DOE's Hydrogen Safety Panel, conducted a hazard analysis of the vehicle based on traditional failure mode and effect analysis practices. The analysis focused on the systems that are unique to fuel cell hybrid configuration, such as hydrogen system, high voltage system, and the electric drive train. Strategies for design and operations to mitigate high-risk hazards during daily delivery, hydrogen fueling, and maintenance were identified and incorporated into the vehicle design.

Long-lead time components were procured and vehicle build activities began. Primary components of the fuel cell hybrid electric powertrain were integrated and the vehicle chassis was displayed at the 2017 ACT Expo in Long Beach, California. Figures 2 and 3 show the vehicle chassis and project team members at the Expo.

CONCLUSIONS AND UPCOMING ACTIVITIES

The Fuel Cell Hybrid Electric Delivery Van project is utilizing team member experience with hydrogen fuel cell technologies, alternate fuel vehicle fleet familiarity, and stakeholder feedback to develop commercially viable zero-emission medium-duty trucks. The team has developed:

- Vehicle and component specifications to promote commercial acceptance.
- Component selection to ensure performance on real-world delivery duty cycles.
- Solid models of major components within vehicle body.
- Strategy to ease UPS fleet acceptance and fueling procedures.

Upcoming activities includes:

FIGURE 2. The vehicle chassis on the ACT Expo display floor, with primary powertrain components installed

FIGURE 3. Project team members around the vehicle chassis on the ACT Expo display floor, May 2017

- Finish building, commission, and deliver prototype van.
- Validating prototype van through a 6-month demonstration in parcel delivery service.
- Building final van design at pre-commercial volume (minimum six additional vehicles).
- Training end-user fleet operations and maintenance personnel.
- Coordinating fueling availability at other deployment sites and continue coordinating the development of medium-duty hydrogen fueling protocol.
- Deploying and supporting vans in UPS California fleets.

- Collecting and evaluating operating data during deployment in parcel delivery service.
- Developing an economic/market opportunity assessment for the vehicles.
- Continuing to pursue additional funding from outside sources to build and demonstrate more Phase 2 vehicles.

FY 2017 PUBLICATIONS/PRESENTATIONS

1. J. Hanlin, "Fuel Cell Hybrid Electric Delivery Van Project," presented at the DOE Annual Merit Review, Washington, D.C., June 2017.

2. M. Lewis, et al. "Design and Modeling for Hydrogen Fuel Cell Conversion of Parcel Delivery Trucks." Paper presented at the 2017 IEEE Transportation Electrification Conference and Expo (iTEC), June 2017.

REFERENCES

1. Walkowicz, K.; Kelly, K.; Duran, A.; Burton, E. (2014). *Fleet DNA Project Data*. National Renewable Energy Laboratory. http://www.nrel.gov/fleetdna