Fuel Cell Hybrid Electric Delivery Van

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Contract Number: DE-EE0006523/0004

Subcontractors:
- Hydrogenics USA, San Diego, CA
- United Parcel Service, Sandy Springs, GA
- Unique Electric Solutions, Stony Brook, NY
- The University of Texas at Austin—Center for Electromechanics, Austin, TX
- Lithium Werks, 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 15 additional 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) 2018 Objectives

- Complete major component and final system integration into the base electric vehicle.
- Test and validate the vehicle according to DOE contractual specifications.
- Complete pre-deployment training and education at the demonstration site in West Sacramento.
- Begin demonstration of vehicle by deploying it into United Parcel Service (UPS) fleet service.

Technical Barriers

This project addresses the following technical barriers from the sections of the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan listed below.[1]

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

Contribution to Achievement of DOE Market Transformation Milestones

This project directly addresses Market Transformation subprogram 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. Further, 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

[1] https://www.energy.gov/eere/fuelcells/downloads/fuel-cell-technologies-office-multi-year-research-development-and-22

(CTE) has coordinated with station providers early in the project 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 selection the fuel cell size will take advantage of volume growth from other applications and markets, and that the design will meet the needs of our commercial fleet operator by matching the performance of incumbent technologies, while meeting the range requirements for more than 97% of delivery van duty cycles.

FY 2018 Accomplishments

- Completed the vehicle build. All systems were integrated and the first iteration of the vehicle control software was implemented.
- Conducted stationary testing of the fuel cell power system.
- Began driving tests to validate vehicle performance parameters prior to delivery to fleet operator.
- Began detailed vehicle demonstration preparation tasks, such as coordinating hydrogen fueling tests, drafting a fueling agreement between UPS and the fuel provider, and developing a training matrix for all necessary deployment training.
- Received a preliminary funding award from California Air Resources Board (CARB) for all remaining funds required to deploy the 15 additional vehicles in Phase 2.

INTRODUCTION

Parcel delivery van fleets currently are 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 fleets; 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 existing fleet vehicles. According to Fleet DNA project data compiled by the National Renewable Energy Laboratory (NREL), 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:

1. Develop a fuel cell hybrid electric delivery van and validate its design and construction through in-service operation.
2. 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 then are 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 then are down-selected and the physical layout is completed. The first delivery van then can be built and validated through in-service operation. If the delivery van meets Phase 1 performance requirements, then 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 NREL'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 at Austin—Center for Electromechanics (UT-CEM), 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 DOE, the California Energy Commission, and the South Coast Air Quality Management District. UPS is providing cost-sharing during the demonstration periods by supplying operation, maintenance, and fueling costs.

RESULTS

During FY 2018, the project team completed the vehicle design, received the last remaining long lead-time components, completed component integration and vehicle build, began vehicle acceptance testing, and made preparations for Phase 1 vehicle deployment. The project team also submitted and was preliminarily awarded all remaining funds required to deploy the 15 additional vehicles in Phase 2 under the CARB Zero- and Near Zero-Emission Freight and Facilities (ZANZEFF) program.

The battery pack was assembled, balanced, tested, and integrated with the power electronics hardware and motor required for the base electric drive van assembly and commissioning. The switched reluctance traction motor was tested, and a new motor cradle was designed, fabricated, and installed to dampen the motor

vibration and noise identified during testing. The fuel cell power system components were validated and integrated. Figure 1 shows the project team monitoring the fuel cell power system during stationary testing.

Figure 1. Hydrogenics, Unique Electric Solutions, and UT-CEM monitoring the fuel cell power system during bench tests

Some issues arose during component and acceptance testing, but the project team worked cooperatively to resolve them in a timely manner, and design improvements were implemented to prevent the issues from recurring. As a result of project risk analysis, the team keeps spare equipment on hand in case a DC-to-DC converter or fuel cell pump blower fails during the Phase 1 demonstration period. Figure 2 shows the vehicle undergoing preliminary driving tests, and vehicle acceptance testing will continue into FY 2019.

Figure 2. Unique Electric Solutions and UT-CEM conducting drive test of vehicle

The project team is preparing for the upcoming Phase 1 demonstration period that includes fueling tests, training, and data-collection procedures. Fueling agreements have been drafted, and there is a plan in place for an initial fueling test when the vehicle arrives in West Sacramento. All upcoming training activity has been documented in a responsibility matrix and assigned to project team members. A data-collection procedure is in place and is overseen by NREL.

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:

- Finished building the Phase 1 vehicle
- Completed stationary subsystem and vehicle-level testing
- Begun driving tests to validate contract parameters
- Developed a strategy to ease UPS fleet acceptance and fueling procedures.

Future work includes:

- Complete vehicle acceptance testing
- Deliver vehicle to West Sacramento, where UPS will operate the vehicle
- Train UPS operations and maintenance personnel and local first responders
- Operate the vehicle for 6 months in parcel delivery service
- Update the vehicle design based on lessons learned from 6-month demonstration
- Execute a contract with CARB for the remaining funds required to build and demonstrate 15 additional Phase 2 vehicles
- Build 15 additional fuel cell hybrid electric delivery vans
- Coordinate hydrogen fueling availability at other deployment sites
- Deploy and support additional vans as they are deployed in UPS California fleets
- Collect and evaluate operating data during deployment
- Develop an economic/market opportunity assessment for the vehicles.

FY 2018 PUBLICATIONS/PRESENTATIONS

1. Maria Gallucci. “UPS to Deploy Fuel Cell/Battery Hybrids as Zero-Emission Delivery Trucks.” *IEEE Spectrum: Technology, Engineering, and Science News.* August 24, 2018. https://spectrum.ieee.org/green-tech/fuel-cells/ups-to-deploy-fuel-cellbattery-hybrids-as-zeroemission-delivery-trucks (accessed November 19, 2018).
2. J. Hanlin. Fuel Cell Hybrid Electric Delivery Van Project (2018).

REFERENCES

1. K. Walkowicz, K. Kelly, A. Duran, and E. Burton. *Fleet DNA Project Data*. National Renewable Energy Laboratory (2014). http://www.nrel.gov/fleetdna (accessed February 25, 2019).