X.5 FedEx Express Hydrogen Fuel Cell Extended-Range Battery Electric Vehicles

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Contract Number: DE-EE0006522

Subcontractors:
- Workhorse Technologies Inc, Loveland, OH
- Plug Power Inc, Latham, NY

Project Start Date: October 15, 2015
Project End Date: October 10, 2019

Overall Objectives

- To convert an existing electric parcel delivery unit (PUD) into a zero emission extended range electric vehicle by utilizing hydrogen fuel cell technology.
- Understand, demonstrate, and deploy hydrogen fuel cell technologies in a real-world environment.

Fiscal Year (FY) 2017 Objectives

- Test and verify the performance of the fuel cell.
- Optimize, test and complete the integration between the fuel cell and the electric vehicle (EV).
- Determined the optimal hydrogen storage quantity and location.
- Complete the body manufacturing and installation.
- Optimize the power generation and charge strategy.

Technical Barriers

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

(B) High hydrogen fuel infrastructure capital costs for Polymer Electrolyte Membrane (PEM) fuel cell applications

(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

(J) Insufficient numbers of trained and experienced servicing personnel

(L) Lack of qualified technicians for maintenance

(M) Lack of certified service providing organizations for installation and maintenance

Technical Targets

- The target is to achieve a driving range of 150 miles.
- Operate a safe, reliable, and cost effective asset with zero tail pipe emissions.

FY 2017 Accomplishments

- Fuel cell fabrication
- Fuel cell validation and testing
- Computer aided design models finalized
- EV and fuel cell (FC) integration
- Bracketry design and production
- Power generation and charge strategy optimization
- Hydrogen tanks storage and location
- Body modification for hydrogen tank compartmentation
- Body design, manufacture and installation
- Dilution and vent testing
- Optimized thermal management
- Controller area network messaging and instrument cluster integration
- Final placement location site preparation
- Durability test preparation

INTRODUCTION

The ability to reduce fuel consumption and emissions while delivering packages is an immense challenge, particularly with the available technology. This is further

complicated by the diversity of the different duty cycles utilized by the PUDs at FedEx. This has created enormous opportunities for an extended range, zero emission electric PUD.

As a part of this project, we will be converting 20 existing electric vehicles into hydrogen fuel cell powered extended range electric vehicles (eREV), in two different phases and budget periods (BPs).

Successful utilization of fuel cell technologies in real world environments will help foster a better understanding while providing the opportunity to identify and utilize additional duty cycles, eventually reducing costs by achieving economies of scale, while providing clean, safe, secure and affordable energy.

APPROACH

The first step was to find industry partners that had the experience, capabilities and the knowledge to collaborate with us in embarking on this project. As a result, we are collaborating with Workhorse, the EV manufacturer; Plug Power, the fuel cell manufacturer; and Morgan Olson, who is the body manufacturer for the eREV.

The project is divided into two separate phases/budget periods (BP1 and BP2). The first period concentrates on the conversion of just one asset. This will enable the project team to test, analyze and measure the performance. BP2 will only be launched if the first phase is considered successful and the team will utilize the lessons learned and implement those in the second phase.

We have made significant progress in BP1 and are close to launching the first eREV PUD. The identification of the ideal route and location for the first PUD was completed. The optimized charge strategy and power generation for the fuel cell was implemented. The fabrication, validation and testing of the fuel cells has successfully been completed. The various integration activities between the EV and FC is completed. The ideal hydrogen tank size, packaging and compartment locations are finalized and being utilized. The body for the PUD was installed on the electric chassis. The safety and venting testing has been initiated. Next, the eREV will be taken through a series of durability tests, before it is placed in active service.

The second phase is launched if the first phase is considered successful and will convert an additional 19 EVs into FC extended range electric PUDs.

RESULTS

This is an ongoing project but the desired results have been achieved. Our analysis of the drive cycle and overall FC performance enabled us to implement the best performance, power generation and charge strategy (Figures 1 and 2).

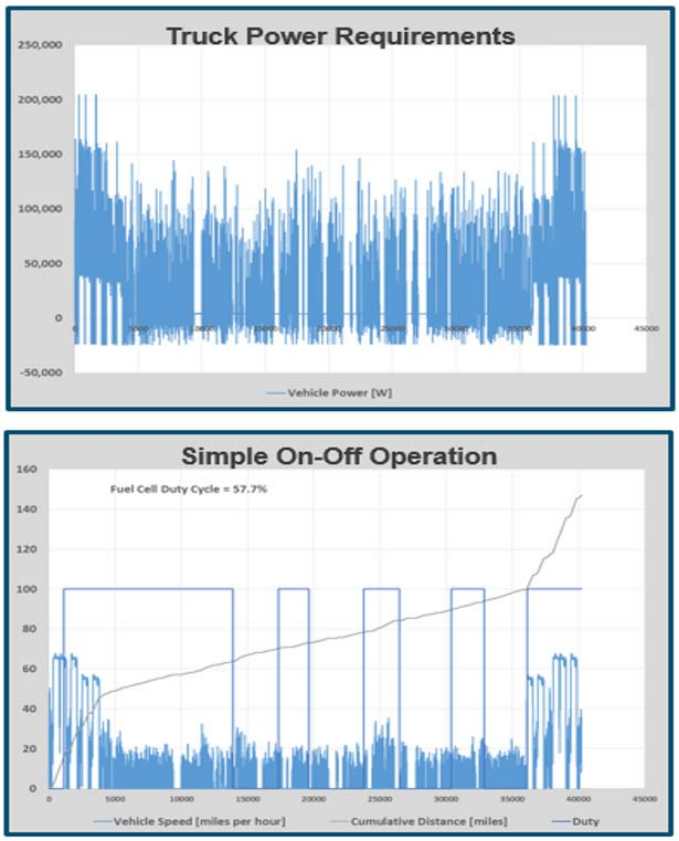

FIGURE 1. Simulated truck requirements

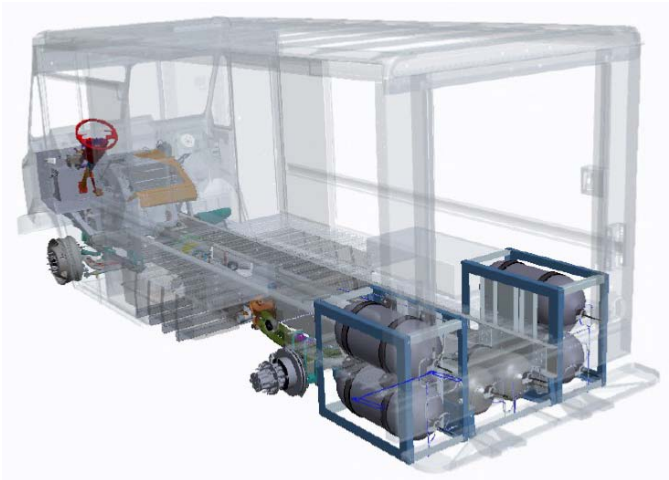

FIGURE 2. Simulated fuel cell duty cycle

The size, capacity and location of the hydrogen tanks in the PUD body were a big challenge and finding the right balance was critical. This was successfully accomplished, providing the eREV the desired range and overall performance (Figure 3).

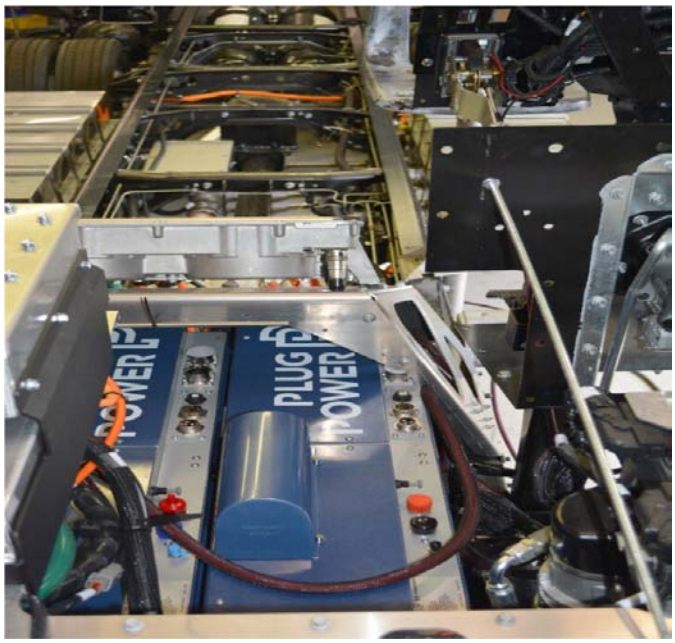

FIGURE 3. Illustration of H_2 tank compartment on the fuel cell eREV

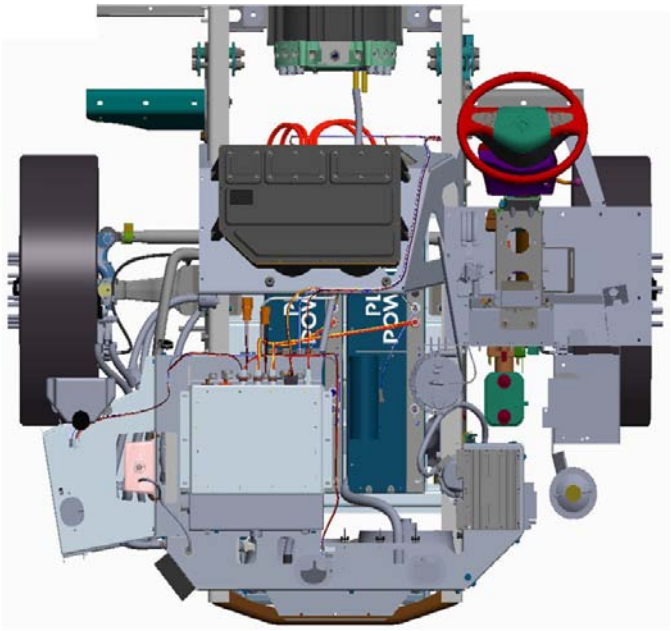

FIGURE 4. Fully integrated FCs in the EV

The integration between the FC and the EV chassis is complete, providing the project team a better understanding (Figure 4).

CONCLUSIONS AND UPCOMING ACTIVITIES

Based on the initial results, the fuel cell eREV PUD is proving to be a viable option, when looking at the overall emission reduction requirements. This will be further clarified as the first unit is put into service and actual data from real life utilization is collected and evaluated.

Since the project is split into two separate budget periods, the future direction is divided accordingly:

BP1

- Fuel system design
- Safety planning
- Design requirements
- Verify optimization analysis
- Communications and control strategies
- Leak detection and fuel isolation
- Integration of fuel cell into first truck
- Durability testing
- Commissioning
- Place into revenue service
- Validation
- Prepare for BP2

FY 2017 PUBLICATIONS/PRESENTATIONS

1. Imran Ahmed, "FedEx Express Hydrogen Fuel Cell Extended Range Battery Electric Vehicles," presented at the DOE Annual Merit Review, Washington, DC, June 5–9, 2017.

REFERENCES

1. Section 3.9 Market Transformation. (n.d.). Retrieved July 10, 2017, from http://energy.gov/eere/fuelcells/downloads/fuel-cell-technologies-office-multi-year-research-development-and-22