X.2 Ground Support Equipment Demonstration

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Project Start Date: January 2013
Project End Date: December 2017

Overall Objectives

- To create a hydrogen fuel cell-based solution for cargo tow tractors (airport vehicle) that is cost-competitive and more energy-efficient as compared to incumbent internal combustion engine-powered alternatives (Table 1).
- To enable airport end users to accomplish daily tasks with a hydrogen fuel cell solution while reducing consumption of gasoline and diesel fuels, reducing U.S. demand for petroleum.
- To demonstrate lower carbon emissions with fuel cells.
- To demonstrate a value proposition that shows decreased energy expenditures when compared to diesel-powered airport vehicles.

Fiscal Year (FY) 2016 Objectives

- Complete first year of demonstration.
- Summarize learning from first year.
- Incorporate improvements to design and service.
- Begin second year of demonstration.
- Greater integration into service operations.

Technical Barriers

- Market Transformation Barrier B, High hydrogen fuel infrastructure capital costs for Polymer Electrolyte Membrane (PEM) fuel cell applications [1]
- Market Transformation Barrier F, Inadequate user experience for many hydrogen and fuel cell applications [1]
- Adapt GenDrive architecture to tractor voltage/power requirements
- Weatherproof for outdoor application

Technical Targets

- Power: Capable of 5,000 lb drawbar capacity
- Availability: >80%
- Run Time: >1 shift
- Reliability Mean Time Between Failures (MTBF): >100 h
- Speed Rating: 10 mph
- Outdoor Operation: no non-recoverable issues
- Hydrogen Fills: 350 bar

FY 2016 Accomplishments

- Completed first year of demonstration.
- Decision to move away from third party stack (16 stack failures averaging 61 h life) and build a new design

TABLE 1. Program Objectives

DOE Project Objectives	Plug Power-FedEx Project Expectations
Reduce petroleum consumption	Each tractor uses ~2 gal/hr. Total tractor run time of 15 tractors over 2 years will be upwards of 175,200 gallons of diesel fuel reduced.
Reduce emissions at airports	AT 9.8 kg CO2 per gal of diesel, there will be upwards of 1717 metric tonnes of CO2 eliminated at airports.
Operate 10 hrs/day & 5,000+ hours	Tractor operation occurs during two shifts: day (10 AM-2 PM) and night (10 PM-2 AM). The total clock day is 10AM-2PM (16 hours). Actual tractor activity is 8 hours per day. Total run time of 15 tractors over 2 years will be upwards of 87,600 fleet hours.
Drawbar capacity 3,000 to 6,000 lbs.	The tractor will be able to tow 4 FedEx containers each weighing 40,000 lbs. The corresponding drawbar capacity of the fuel cell-powered tractor is 5,000 lbs.
Accelerated development of FC-powered GSE	Fleet of 15 80V fuel cell systems in real world application gaining significant field experience while allowing a premier tractor end user to evaluate for larger deployments.

GSE – Ground support equipment; FC – Fuel cell

with Plug Power stacks for the second year of the demonstration.

  - Note: stack issues included hard failures requiring refurbishment, inability to start, and excessive purging.
- Incorporated design improvements into the new design to optimize serviceability.
- Summarized learning from Year 1:
  - The tractor handles application of load.
  - Operating outdoors 24/7 is not a problem.
  - The weatherproofing strategy works well—no water ingress.
  - Air filtration protects the system from airport hydrocarbon emissions.
  - The tractor can operate the worst route for a full shift without needing to refuel.
  - A handful of components had a drastic effect on reliability.
- First year evaluation:
  - Power: Capable of 5,000 lb drawbar capacity YES
  - Availability: >80% NO (Initially 70% but dropped due to accelerating stack failures)
  - Run Time: >1 shift YES
  - Reliability MTBF: >100 h NO (98 h)
  - Speed Rating: 10 mph YES
  - Outdoor Operation: no non-recoverable issues YES
  - Hydrogen Fills: 350 bar YES
- Redesigned system with Plug Power stacks (Figure 1).
- Redesigned system completed and tested.

INTRODUCTION

This project deploys 15 fuel cell-powered units for two years at FedEx's busiest airport. The project is planned for two phases. The first is a one-year development phase where Plug Power develops, builds and tests the 80 VDC (20 kW) fuel cell system for the baggage tow tractor (BTT) application. The second is a two-year demonstration where a fleet of BTTs are integrated into Charlatte CT5E electric tow tractors and deployed at the FedEx locations under real world conditions. The fuel cell fleet is fueled by a GenFuel hydrogen compression, storage, and dispensing solution.

APPROACH

Plug Power designs an 80 VDC fuel cell system as a drop-in-place replacement of an electric Charlatte tractor (Figure 2).

Hydrogen is supplied to the tractors via GenFuel hydrogen infrastructure, which provides onsite hydrogen at 350 bar dispensed directly to the fuel cell in the tractor (Figure 3).

- Definition of Requirements – complete
- Alpha Prototype – complete
- BTT Beta Builds – complete
- BTT Testing and Certification – complete
- Site Preparation – complete

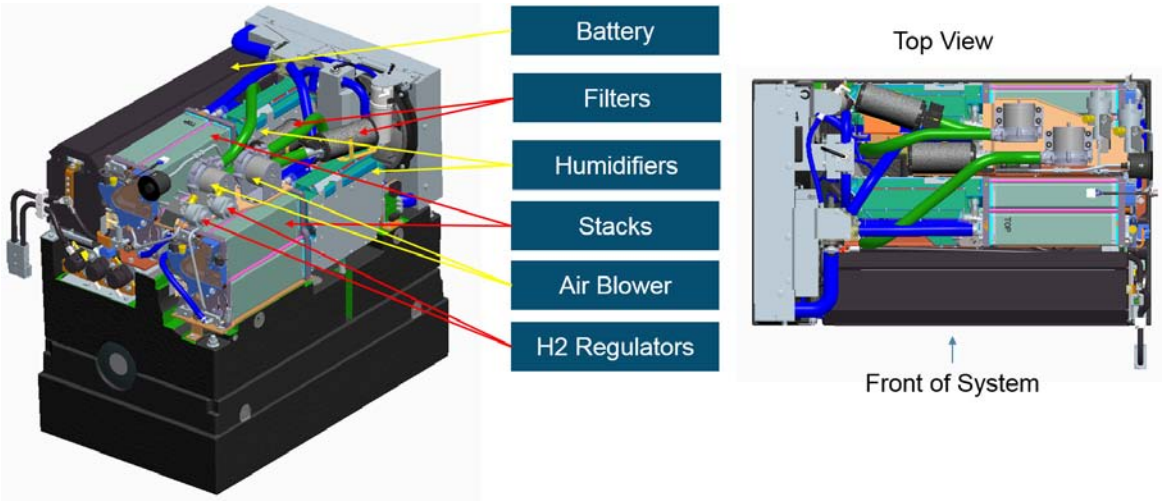
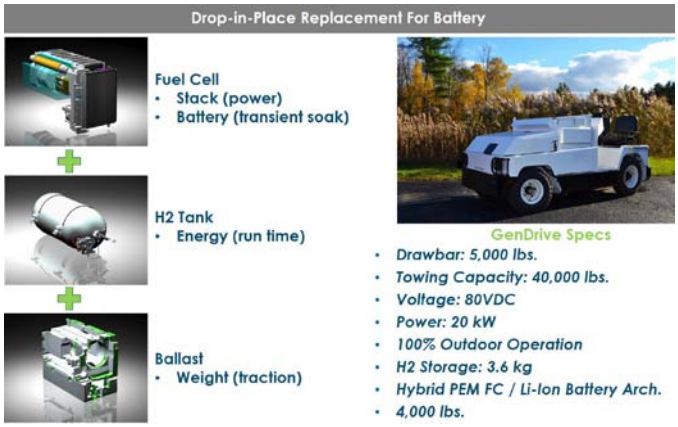


FIGURE 1. System redesign with Plug Power stacks



PEM-FC – Polymer electrolyte membrane fuel cell

FIGURE 2. Fuel cell system as drop-in-place replacement of battery

- Commissioning – complete
- First Year of Demonstration – complete
- Assessment after Year 1 – complete
- Second Year of Demonstration – Third quarter 2016 to Fourth quarter 2017
- Assessment after Year 2 –Fourth quarter 2017

RESULTS

The program delivered a tractor that meets the application requirements in terms of towing the required weight in an outdoor airport application, even in the face of elevated hydrocarbon emissions. Stack lifetime has not been sufficient. The program has recovered with a system redesign using Plug Power stacks. The demonstration continues with design and service improvements in order to validate the changes made as a result of the learning in the first year.

FIGURE 3. Liquid hydrogen station on airport ramp

CONCLUSION AND FUTURE DIRECTION

The first year showed that fuel cells are technically viable for ground support equipment operations. The fuel cell stack is critical to demonstrate lifetime and economic viability. Future direction is to deploy the redesigned fuel cell solution in the tractor fleet. Focus of the second year of demonstration is on system lifetime and economic evaluation.

FY 2016 PUBLICATIONS/PRESENTATIONS

1. J. Petrecky, "MT011 Ground Support Equipment Demonstration," presented at the DOE Hydrogen and Fuel Cells Program Annual Merit Review, Washington, D.C., June 9, 2016.

REFERENCES

1. Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan, Section 3.9 Market Transformation, http://energy.gov/eere/fuelcells/downloads/fuel-cell-technologies-office-multi-year-research-development-and-22.