MT017: Medium Duty Parcel Delivery Truck

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June 2016

Connect the world responsibly and resourcefully

Program Overview

Hydrogen Fuel Cell Extended-Range Battery Electric Vehicles Demonstration

- $3.0 million from Department of Energy
- Integration of fuel cells into 20 battery electric pickup and delivery vehicles, PUDs
  - BP1 – 1 truck
    - Design
    - Integrate & test fuel cell systems
      - Safety
      - Communication
      - Performance
      - Reliability
    - Validate in revenue service
  - BP2 – 19 trucks
    - Integrate hydrogen fuel cell systems
    - Operate in revenue service in Memphis, TN and several locations in CA

Project Main Objectives

DOE Project Objectives	Project Impact
Demonstrate / deploy hydrogen and fuel cell technologies in real-world environments.	20 parcel delivery trucks will operate one shift 260 days annually for approximately 10 hours per day.
Ancillary Objectives	**Project Impact**
Operate 5,000+ hours	Over approx. 1.92 years, this amounts to approximately 5,000 hours per truck. Total fleet activity is 100,000 hours annually. (Numbers represent minimum.)
Reduce petroleum consumption	Each diesel truck uses 2,600 gallons per year. The program will reduce diesel consumption by 100,000 gallons over ~1.92 years.
Reduce emissions	A net of 270 metric tons of CO2 will be prevented.

Potential Expansion	
Similar Assets & Duty Cycles (count)	7000
Annual Utilization Range (miles)	20k - 50k
Approx Annual Fuel Displaced (gal)	14M
Annual CO2 Avoided (Metric Tons)	69,500

Program Overview

Timeline

- Grant awarded – October 2015
- Kickoff meeting – May 2016
- Project end – October 2019
- Project completion - < 5%

Budget

- DOE – $3.0M
- Partners – $3.367M

Barriers

- Unknown ability to meet safety, performance & reliability needs
- Variable energy requirements
  - Route differences
  - Parasitic losses (HVAC, ancillary systems, effects of temperature)
- EV & FC control systems integration
- Fuel availability

Partners

- U.S. Department of Energy
- FedEx Express – Prime rec
- Plug Power – Fuel cell manufacturer
- Workhorse Group – Truck manufacturer

Relevance: DOE Strategy

DOE Goals

- **Office of Energy Efficiency and Renewable Energy**
  - **Fuel Cell Technology Office**
    - **Provide clean, safe, secure, affordable and relivable energy**
    - **Diverse domestic resources, provides energy security, reduces petroleum use, lower GHG emissions and criteria pollutants**

Relevance: FedEx Express Strategy

- Connect the world responsibly and resourcefully
  - Business case
    - Reduce fuel use
    - Sustainability
    - Energy independence
    - Lower Total Cost of Ownership
  - Desire for long-range zero emission PUD
  - Continued need for zero emissions alternative to traditional battery EV
    - Weight reduction
    - Cost reduction
    - Refueling time reduction
  - Evaluation of Hydrogen Fuel Cells as an On-Board Traction Battery Charger

Relevance: FedEx Express Fleet Size 71,309

The 2nd Largest Fleet in North America

WORLD WIDE VEHICLE COUNT

Walk-In	29,610
GSE (powered)	15,007
Panel Van	11,440
Straight	3,572
Tractor	3,259
Other	8,421

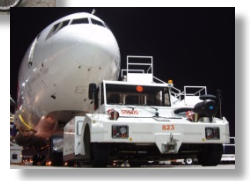












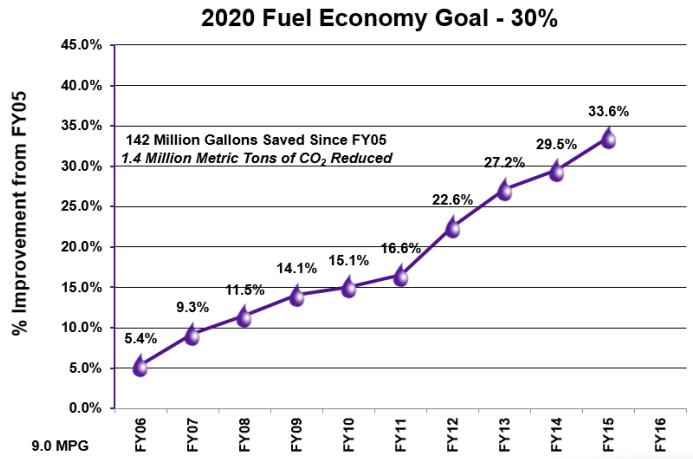
ALTERNATIVE VEHICLE COUNT

GSE	3,300
HEV	424
EV	190
CNG	57
LPG	32

** Fleet count October 2015*

Relevance: FedEx Goals

Vehicle Fuel Economy



FedEx Express®

Relevance: Committed to Improving

REDUCE
Optimize routing and driving habits to reduce mileage and fuel use

REVOLUTIONIZE
Identify and invest in future technologies such as alternative fuel, hybrid-electric and electric vehicles

REPLACE
Upgrade vehicles to more efficient ones wherever possible

FedEx Express®

FY15 Efficiency Gains and Cost Savings

Environmental objective	FedEx initiative	FY15 cost savings	FY15 emissions avoided
Reduce aircraft emission intensity 30% from a 2005 baseline by 2020	Aircraft fleet modernization, FedEx® Fuel Sense operational improvements	$296 million	1.15 million metric tons of CO_2e avoided
Increase FedEx Express vehicle fuel efficiency 30% from a 2005 baseline by 2020	Fuel-efficient driving, vehicle technology improvements and alternative fuel usage	$65 million	215,000 metric tons of CO_2e avoided

FedEx Express®

Relevance: Mileage Management

Right Vehicle
Right Route
Mileage Bands – Miles Per Year

RANGE – SPEED – TIME

Right Technology | Right Duty Cycle

PAYLOAD – STOPS – VOLUME

HYBRID
15,000 – 30,000

COMPOSITE BODY REACH
10,000 – 40,000

EXISTING W700
UP TO 20,000

SPRINTER TYPE
10,000 – 50,000

PANEL VAN
> 40,000

EV
UP TO 16,000

eREV
> 16,000

Miles Per Year	5,000	10,000	15,000	20,000	25,000	30,000	35,000	40,000	45,000	50,000	55,000	60,000

Approach/Milestones

Task Title (Milestone Description)	Task or Milestone Completion Date			
	Original Planned	Revised Planned	Actual Completed	Current % Complete (0-100)
Budget Period 1 Demonstration				
Task 1: Program Management (3+ years)				
Completed Quarterly and Final Reports	Quarterly and 10/1/19	Quarterly and 10/1/19		12.5
Task 2: Optimization Analysis and Safety Planning (4 weeks)				
Optimization Analysis Completed/Safety Plan Draft Submitted to PNNL Hydrogen Safety Panel	11/1/2015	6/30/2016		10
Task 3: First Fuel Cell Unit Build (8 weeks)				
Fuel Cell System Pass Factory Aceptance Test	2/1/2016	8/31/2016		
Task 4: First Unit Integration (8 weeks)				
Integrated Truck Performs per Stated Specifications	4/1/2016	10/31/2016		
Task 5: First Unit Validation (4-8 weeks)				
Evaluation Document of First Unit Performance	6/1/2016	1/31/2016		
Budget Period 1 Go/No-Go Decision Point				
Task 1 (continued): Program Management (3+ years)				
Completed Quarterly and Final Reports				
Task 6: Remaining Fleet Builds (8 weeks)				
FC Systems Pass Factory Acceptance Testing				
Task 7: Remaining Fleet Integration (8 weeks)				
Integrated Trucks pass FAT				
Task 8: Full Deployment (4 weeks)				
Trucks Deployed and Operating in PUD Application				
Task 9: Continued Deployment (152 weeks)				
Deployment Exceeds 5000 hours in PUD application				

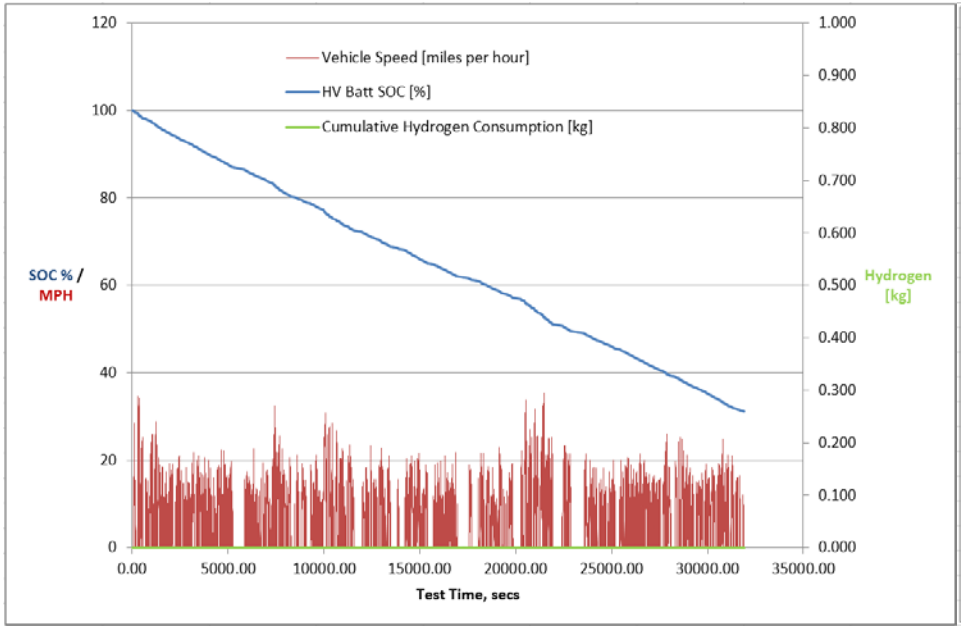
Accomplishments

- Identified replacement EV OEM
  - Already has experience with range extension
- Technical kick-off meeting among program partners at manufacturing facility
- Program kick-off meeting among program partners at Memphis Superhub
- Analysis of worst case drive cycle (150 mile total route length with 60 mile stem length at beginning and end)
- Preliminary mechanical layout of batteries, fuel cell, converter H2 storage
- Planning in process for dyno testing

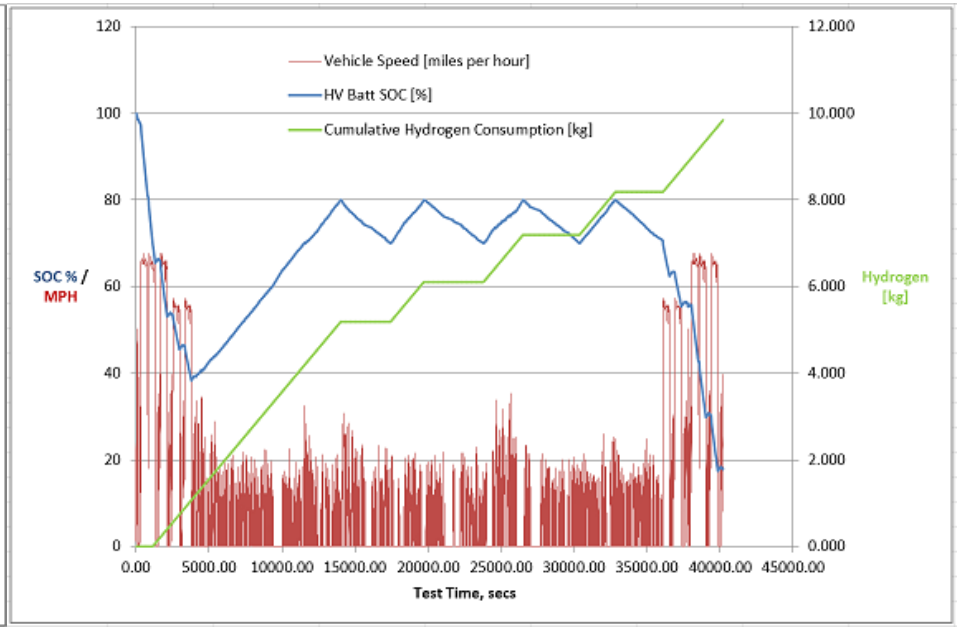
Accomplishments

Usage profile simulation to confirm right sizing
Includes drive cycle, parasitic losses, regenerative braking

Baseline Electric Vehicle

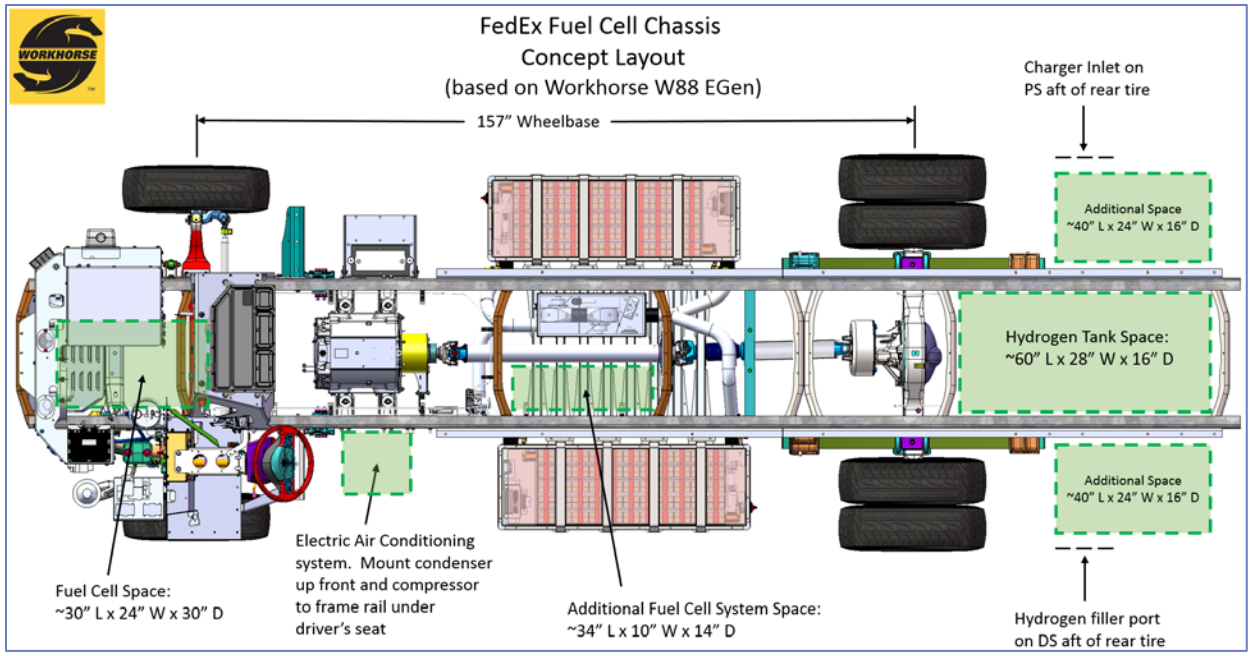


Fuel Cell Extended Range Electric Vehicle



Accomplishments

Preliminary mechanical layout of batteries, fuel cell, converter H2 storage



Accomplishments

- Identified replacement EV OEM
  - New EV subrecipient has experience with range extension
- Technical kick-off meeting among program partners at manufacturing facility to discuss component requirements and placement
- Program kick-off meeting among program partners at Memphis Headquarters
- Analysis of 150 mile drive cycle with up to 60 mile stem length at beginning and end
- Planning in process for dyno testing
  - Variable payloads
  - Temperature effects
  - Parasitic loads

Future Work

Budget Period 1

- Safety Planning
- First Fuel Cell Unit Build
- First Unit Integration
- Verify Optimization Analysis
  - Dyno Testing
  - Durability Testing
- First Unit Validation

Project Phase BP2

Budget Period 2

- Fuel system design
- Safety planning

Optimization modeling

- Battery capacity (kW-hr)
- Fuel Cell Power (kW)
- Hydrogen Tank capacity (kg H_2)

Safety Planning

- Communications and Control Strategies
- Leak detection and fuel isolation or purging

Integration of fuel cell into first truck

- Performance testing
- Shock and vibration testing

Commissioning

- Place into revenue service
- Validation
- Prepare for BP2

Collaborations

U.S. Department of Energy
Project Sponsor

FedEx Express
Prime Recipient

Subrecipients

NREL NATIONAL RENEWABLE ENERGY LABORATORY
Vehicle and Fuel Cell Data Collection

PLUG POWER
Fuel Cell Manufacturer

WORKHORSE
EV chassis and Powertrain Manufacturer

Transportation.gov U.S. Department of Transportation
Vehicle Safety Regulations

Pacific Northwest NATIONAL LABORATORY
Hydrogen Safety Advisors

MORGAN OLSON
Truck Body Manufacturer

Thank You

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FedEx Low Emission
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All Electric

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