



Fuel Cell-Powered Lift Truck FedEx Freight Fleet Deployment

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May 13, 2011

Project ID: H2RA009

Project Overview

■ Timeline

- Start: August 1, 2009
- Finish: July 31, 2013
- 35% complete (Feb 28, 2011)

■ Budget

- Total project funding
 - DOE: \$1,290,464
 - FedEx: \$1,549,540

■ Barriers

- High number of repairs on fuel cells
- Operating fuel cells in cold weather
- Fueling fuel cells in cold weather

■ Partners

- Plug Power – GenDrive system and service provider
- Air Products – Hydrogen supplier

Relevance

- Safe and reliable operations of hydrogen material handling equipment (MHE)
- Convert an entire MHE fleet at FedEx Springfield, MO facility with fuel cell powered forklifts (class-1)
- Demonstrate economic benefits of conversion
- Provide cost effective and reliable hydrogen
- Spur further forklift fleet conversions
- Establish proving ground for hydrogen MHE

Plan and Approach

- Install hydrogen fueling equipment
- Retrofit 35 electric forklifts to operate using fuel cells
 - Train forklift operators to fuel hydrogen fuel cells
 - Train maintenance technicians to perform simple repairs and preventive maintenance (PM) on fuel cells
- Fuel cell forklift operation and evaluation
 - Fuel economy
 - Reliability
 - Cost
 - Operator acceptance
- Annual assessments

Milestones

Milestones	Progress	% Complete
Fueling Station Installation	Air Products' completed construction and installation of the fueling equipment. FedEx finished system integration.	100%
Hydrogen Safety Plan	Worked with Air Products and Plug Power to complete the hydrogen safety plan	100%
► Go/No Go	Fueling station tested and operational in June 2010	100%
GenDrive Power Unit Build	Plug Power completed build of 35 class-1 units in December 2009 and 5 more in December 2010	100%
Start-up and Training	Start-up and training completed in June 2010	100%
Forklift Operation and Evaluation	Operation and evaluation started July 2010	21%

Technical Accomplishments and Progress – Fuel Cells

- Plug Power built and delivered 35 GenDrive class-1 power. Installed in forklifts in June 2010
 - Voltage 36 Vdc
 - Power output 10-12 kW
 - Hydrogen storage 2.2 kg
 - Storage pressure 350 bar
- Five additional class-1 power units added in December 2010, for a total of 40 units. No DOE funding was used with these five units



Technical Accomplishments and Progress – Hydrogen

- Air Products installed all fueling and storage equipment
 - 2 indoor dispensers
 - 6,000 USG liquid hydrogen horizontal tank
 - Refuel time 3-6 minutes
 - 1-2 fuelings per day per forklift
 - Purchased more than 13,449 KGs of H₂
 - 6000+ fuelings
- Provided hydrogen fueling station training, including operation, hydrogen safety and emergency response in a “train the trainer” arrangement
- Investigated problems with air-actuated valves during cold-weather operation
 - Found that air supplied to valves had too much moisture in it.

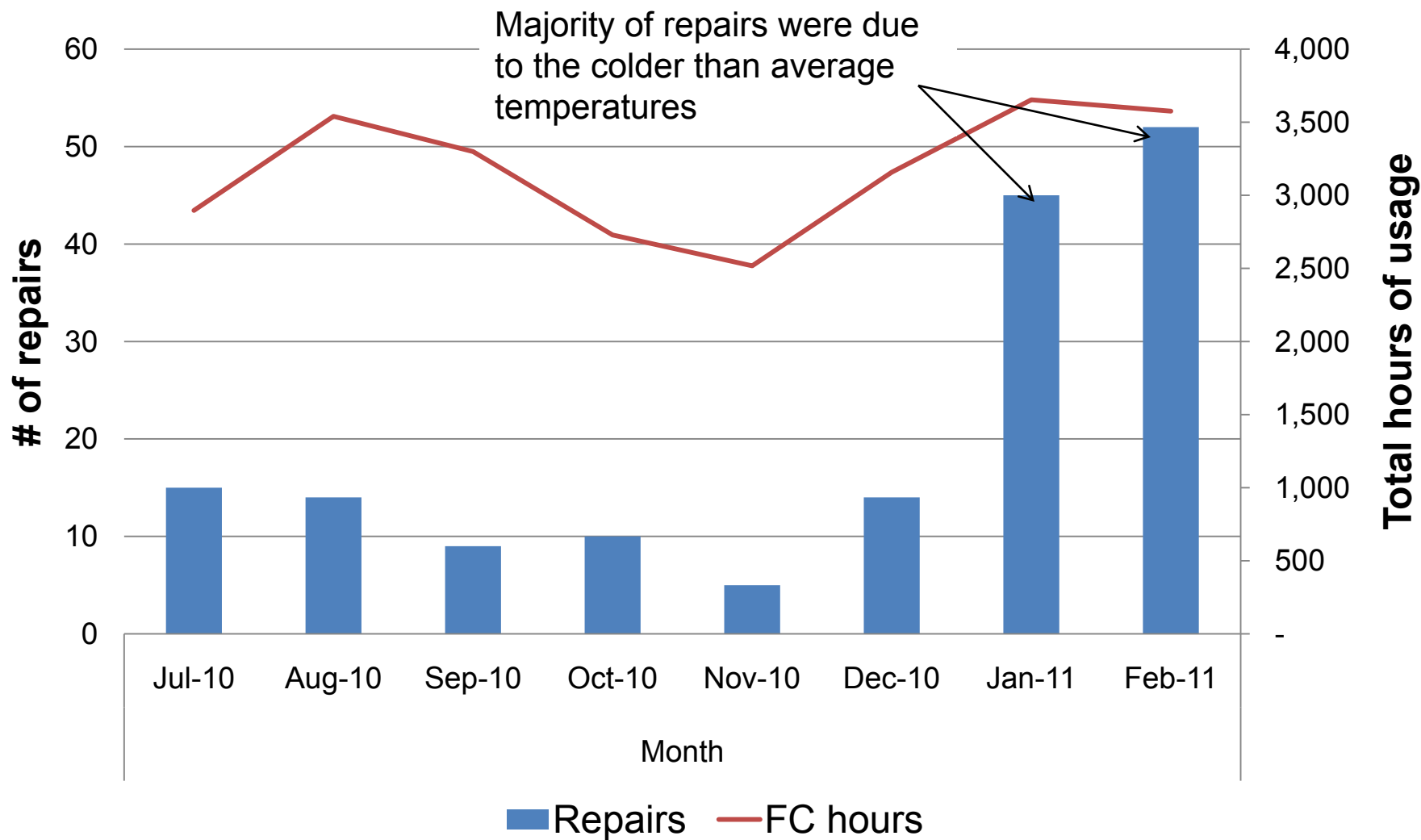


Technical Accomplishments and Progress – Fuel Cells

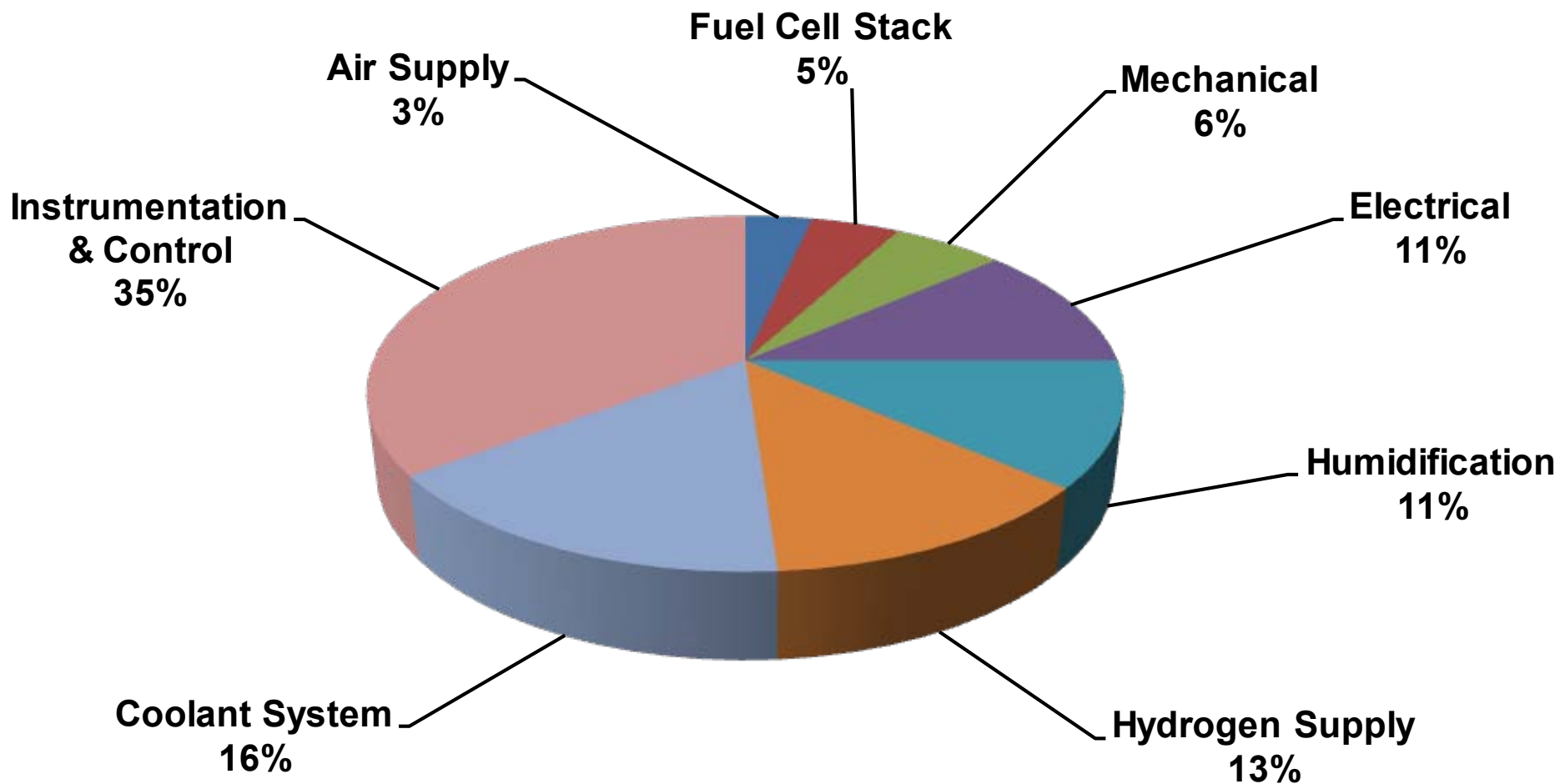
- Provided power unit training, including operation, planned maintenance, service, hydrogen safety and emergency response in a “train the trainer” arrangement
- Started evaluation of operational and maintenance support for the GenDrive power units compared to conventional propane forklifts
- Modified forklifts to prevent drive-offs that damaged the hydrogen hose
 - Installed fuel shield on forklift to cover fuel intake while seat is down
- Over 28,000 hours of usage on all fuel cells



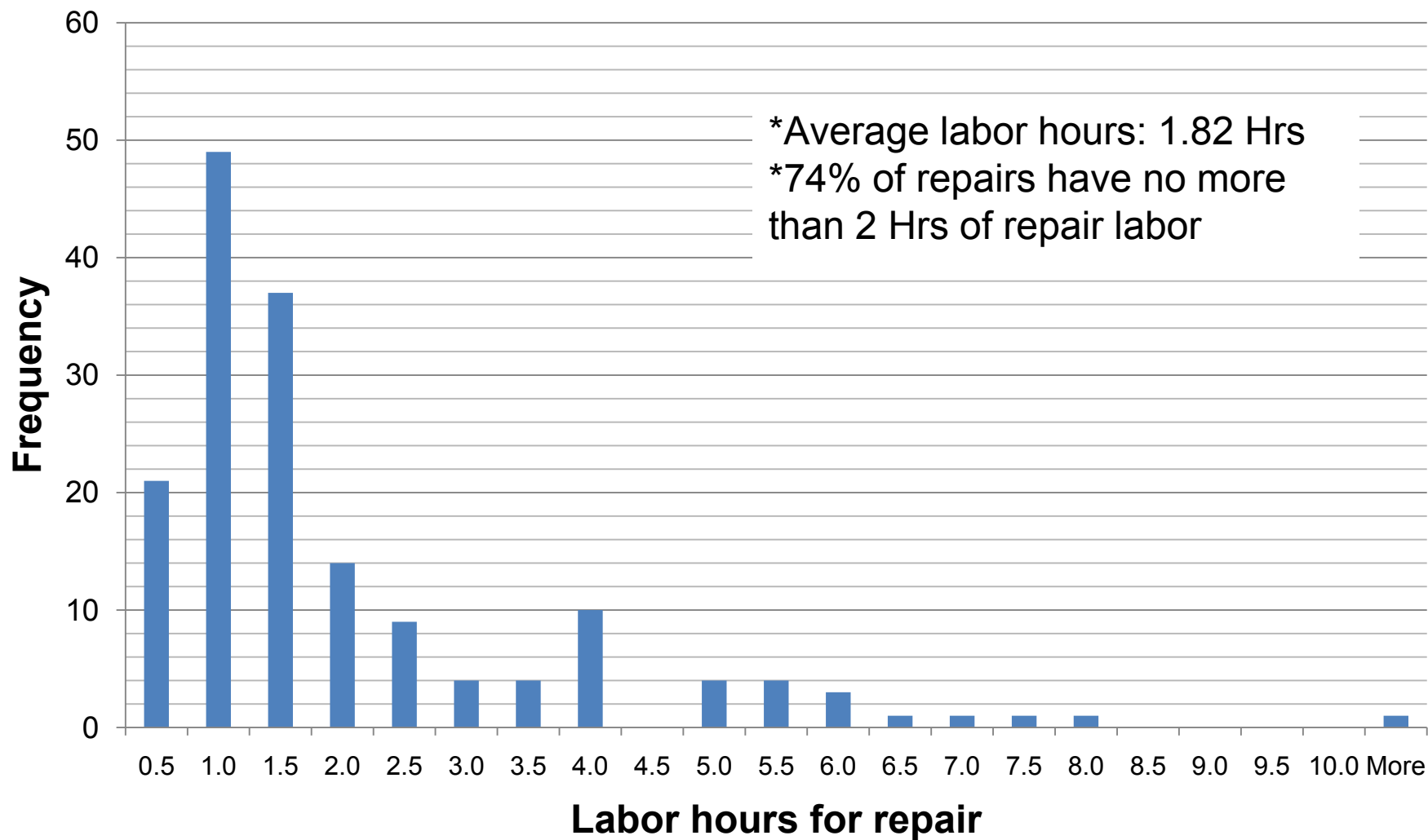
Total Fuel Cell Usage Hours and Repairs by Month



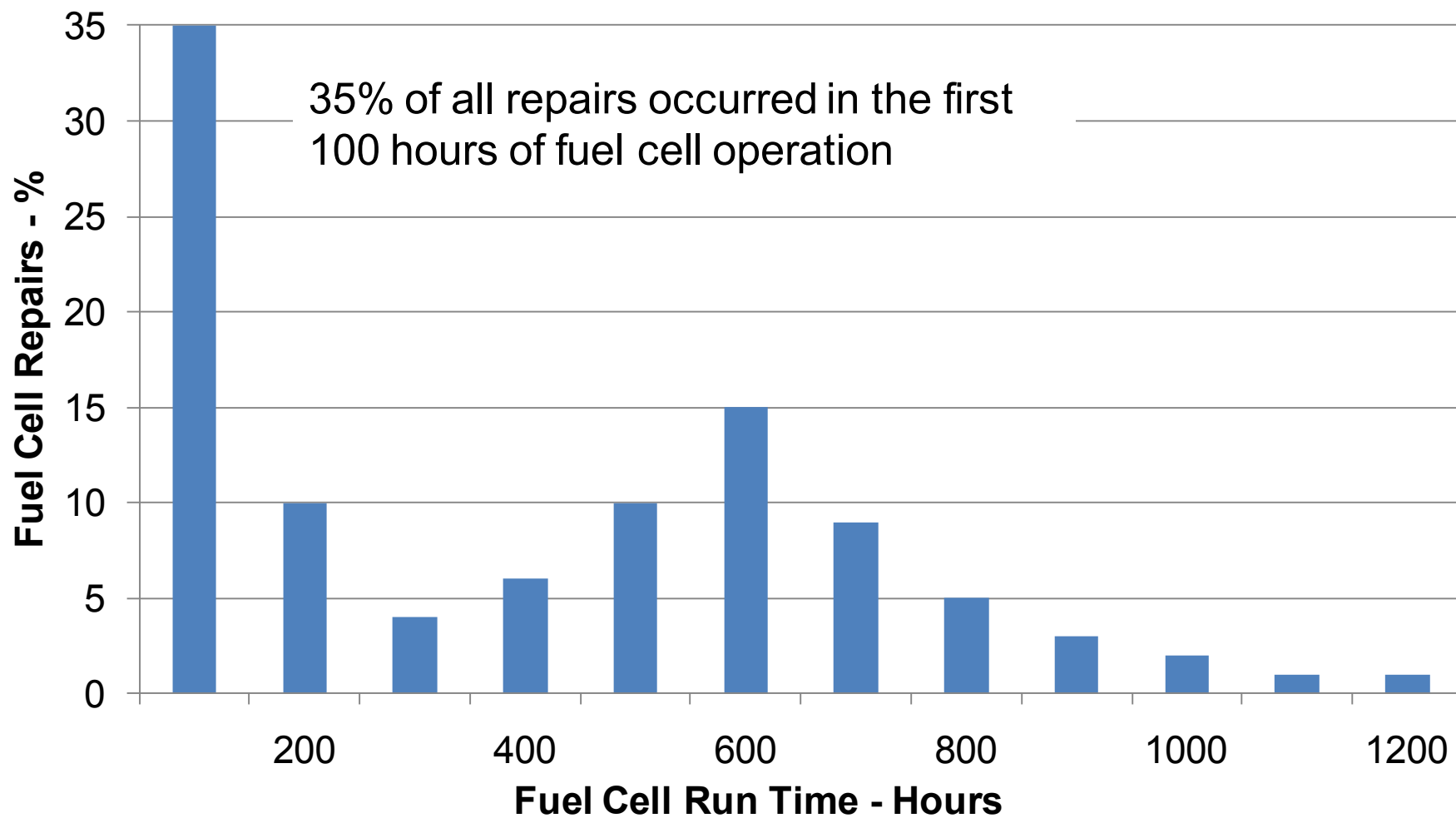
Types of Fuel Cell Repairs



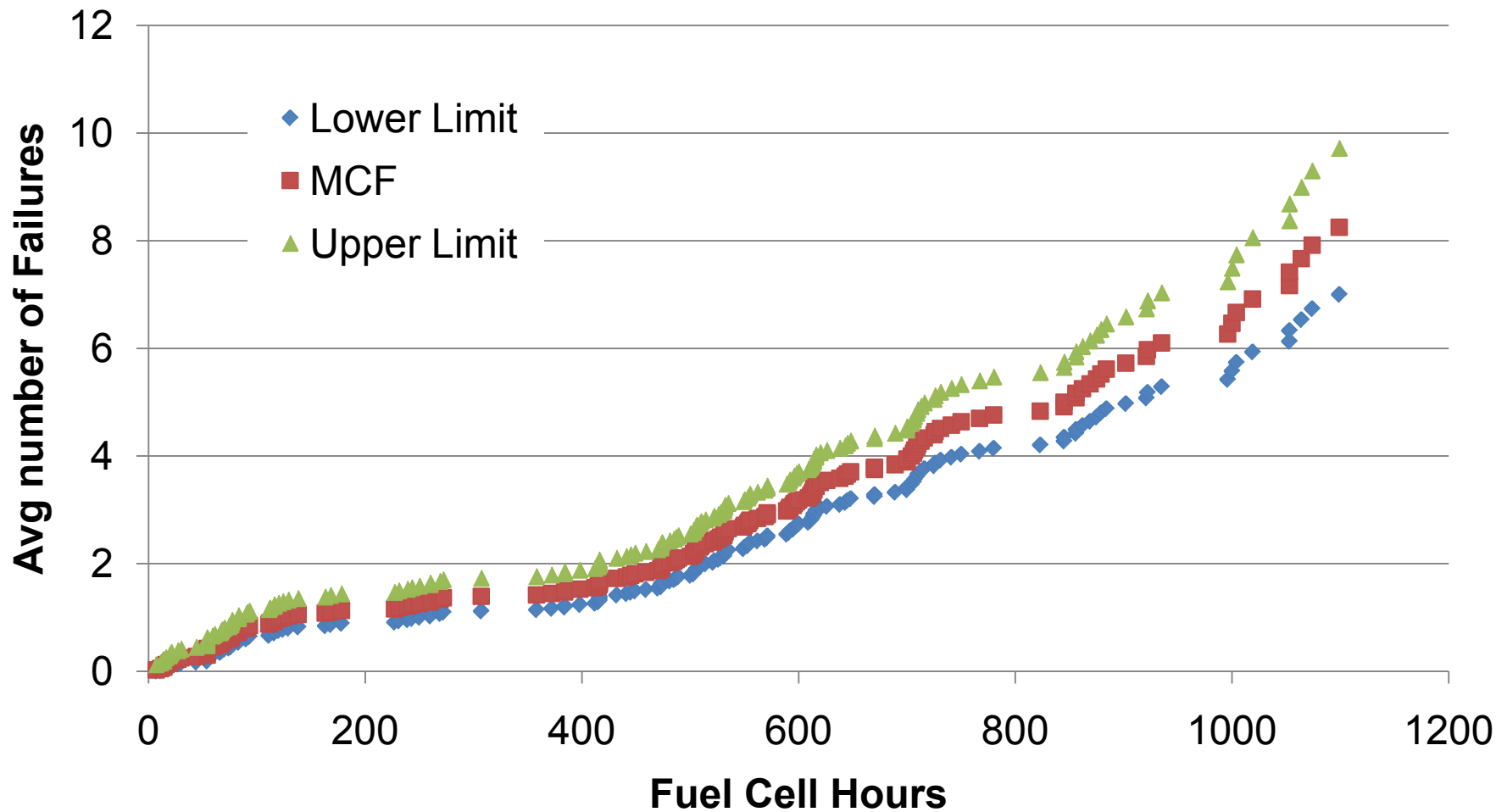
Labor Hours for Fuel Cell Repairs



Fuel Cell Repair Frequency vs. Run Time



Mean Cumulative Number of Fuel Cell Failures



Forklift Repair Comparison 1

- Compared Springfield (SGF) fuel cell forklifts to our South Dallas (SDA) location that has propane forklifts
- Both locations have 40 Toyota forklifts with an average year model of 2004
- Used repair data from July 2010 – February 2011
- Included fuel cell repairs in the comparison
- Average usage hours per repair:
 - SDA propane forklifts : 70.5 hours
 - SGF fuel cell forklifts : 115.2 hours
- Even with the high number of fuel cell repairs, the fuel cell forklifts at SGF have 63% more hours per repair than the propane forklifts

Forklift Repair Comparison 2

- Compared Springfield (SGF) fuel cell forklifts to all FedEx Freight forklifts
- Both have an average year model of 2004
- Used repair data from July 2010 – February 2011
- Included fuel cell repairs in the comparison
- Average usage hours per repair:
 - All FedEx forklifts: 88.3 hours
 - SGF fuel cell forklifts : 115.2 hours
- The fuel cell forklifts still have 30% more hours per repair than the propane forklifts

Collaborations

■ Partners

- Plug Power (Industry) – GenDrive fuel cell and service provider
- Air Products (Industry) – Hydrogen supplier

■ Technology Transfer

- Collaboration with Plug Power for the commissioning and technical help serving the GenDrive fuel cells
- Collaboration with Air Products for the installation and servicing of the hydrogen fueling system

Proposed Future Work

- Continue providing operational and maintenance support for the GenDrive power units and the hydrogen handling and dispensing equipment and evaluate their performance over the duration of the project, including:
 - Collecting data from the power units and evaluate performance, operability and safety
 - Collecting data from the liquid and gaseous hydrogen fueling equipment and evaluate performance, operability and safety
- Resolve cold-weather operation problems with air-actuated valves in the hydrogen fueling equipment
- Work with Plug Power to resolve cold weather issues on fuel cells

Summary

- Relevance:** Develop safe hydrogen MHE operations to spur future conversions and demonstrate economic benefits
- Approach:** Install Air Products hydrogen fueling station, build 35 Plug Power GenDrive power units, and commission and evaluate for a successful operation
- Technical Accomplishments:** Plug Power built and delivered 40 GenDrive units. Air Products installed the hydrogen fueling system. FedEx personnel were trained in the operation and maintenance of the fueling system and power units. Started evaluation of fuel cell repair data.
- Technology Transfer/Collaborations:** Plug Power and Air Products
- Future Work:** Ongoing operation and evaluation of GenDrive power units and Air Products hydrogen fueling system