Fuel Cell-Powered Lift Truck
FedEx Freight Fleet Deployment

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Project ID: H2RA009

Project Overview

- **Timeline**
  - Start: October 1, 2009
  - Finish: September 30, 2013
  - 58% complete (Feb 29, 2012)
- **Budget**
  - Total project funding
    - DOE: $1,290,646
    - FedEx: $1,526,836
- **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 techs 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	50%

Technical Accomplishments and Progress – Fuel Cells

- Plug Power built and delivered 35 GenDrive class-1 power units which were 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 were added in December 2010, for a total of 40 units. No DOE funding was used for these five units.

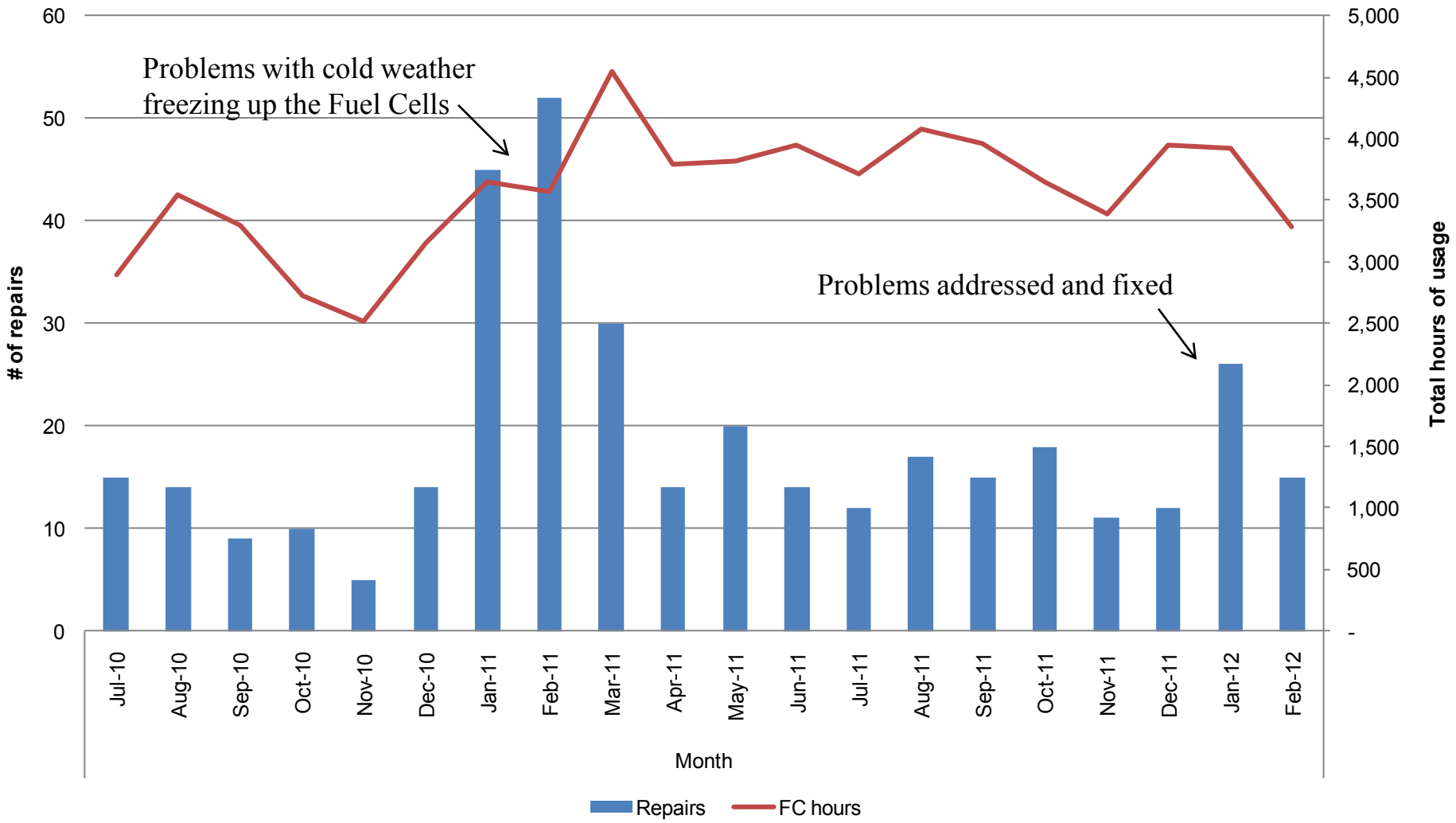
Technical Accomplishments and Progress – Hydrogen

- 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 20,800 kg of H_2
- Provided hydrogen fueling station training, including operation, hydrogen safety and emergency response in a “train the trainer” arrangement - 2010
- Solved problems with cold-weather operation of air-operated fueling station valves by reducing moisture in air supply - 2011

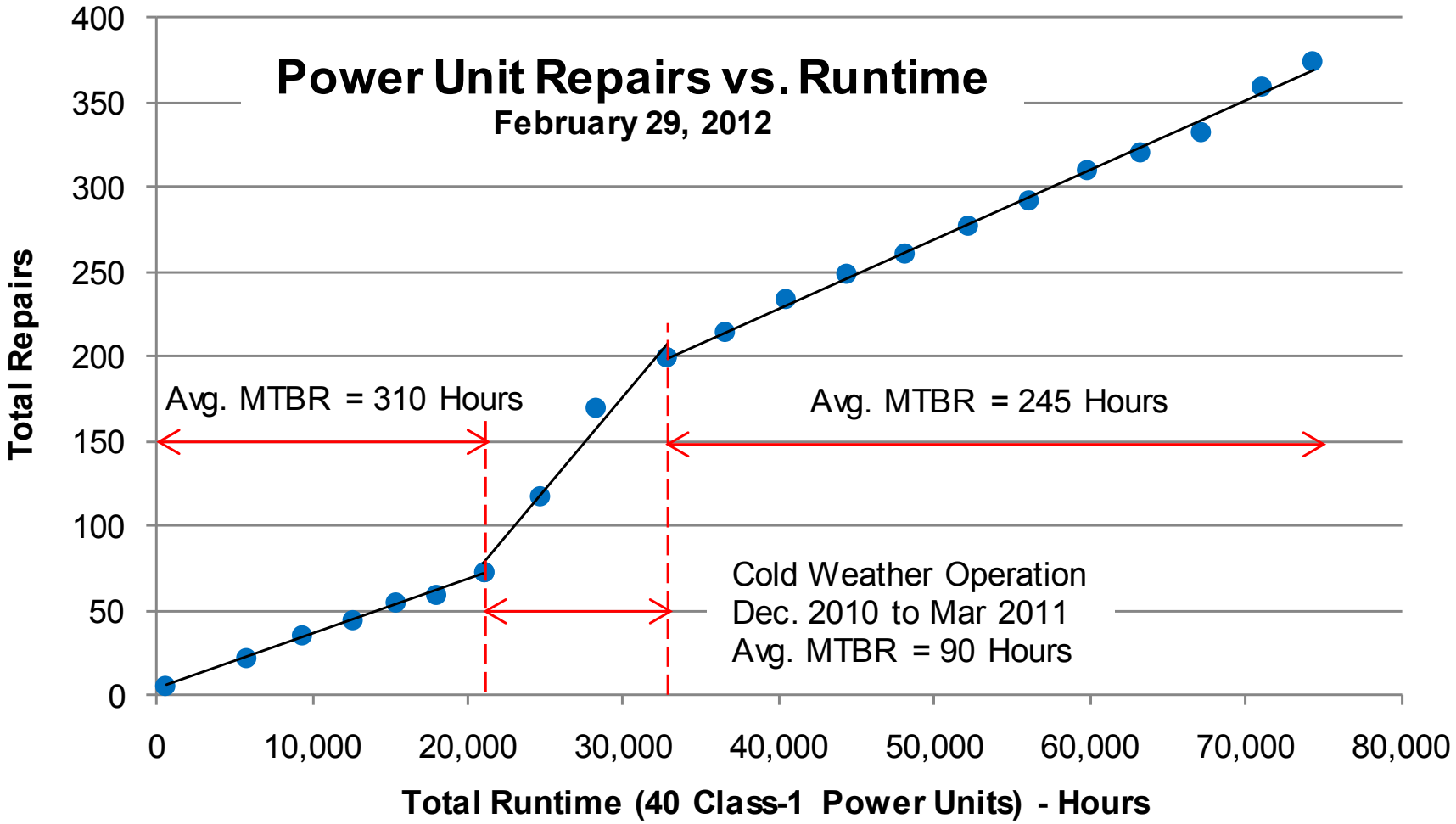
Technical Accomplishments and Progress – Fuel Cells

- Provided power unit training, including operation, planned maintenance, service, hydrogen safety and emergency response in a “train the trainer” arrangement - 2010
- Evaluated operational and maintenance support for the GenDrive power units compared to conventional propane forklifts
- Installed fuel shield on forklifts that covers fuel intake while seat is down to prevent drive-offs and damage to the hydrogen hose - 2010
- Added heaters to power units to reduce cold-weather operating problems- 2011
- Accumulated over 74,300 hours of usage on all 40 fuel cells

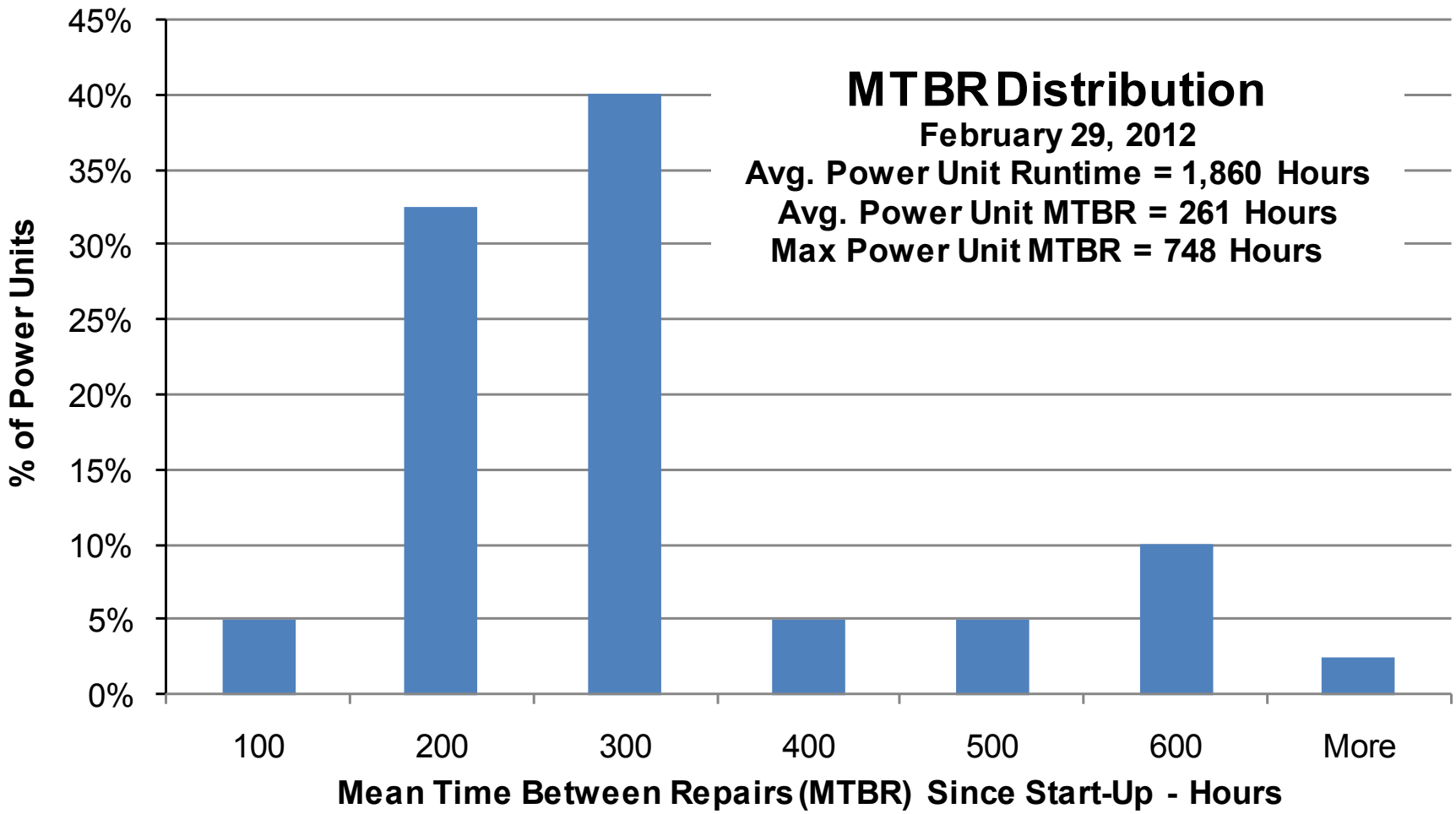
Monthly Fuel Cell Usage and Repairs



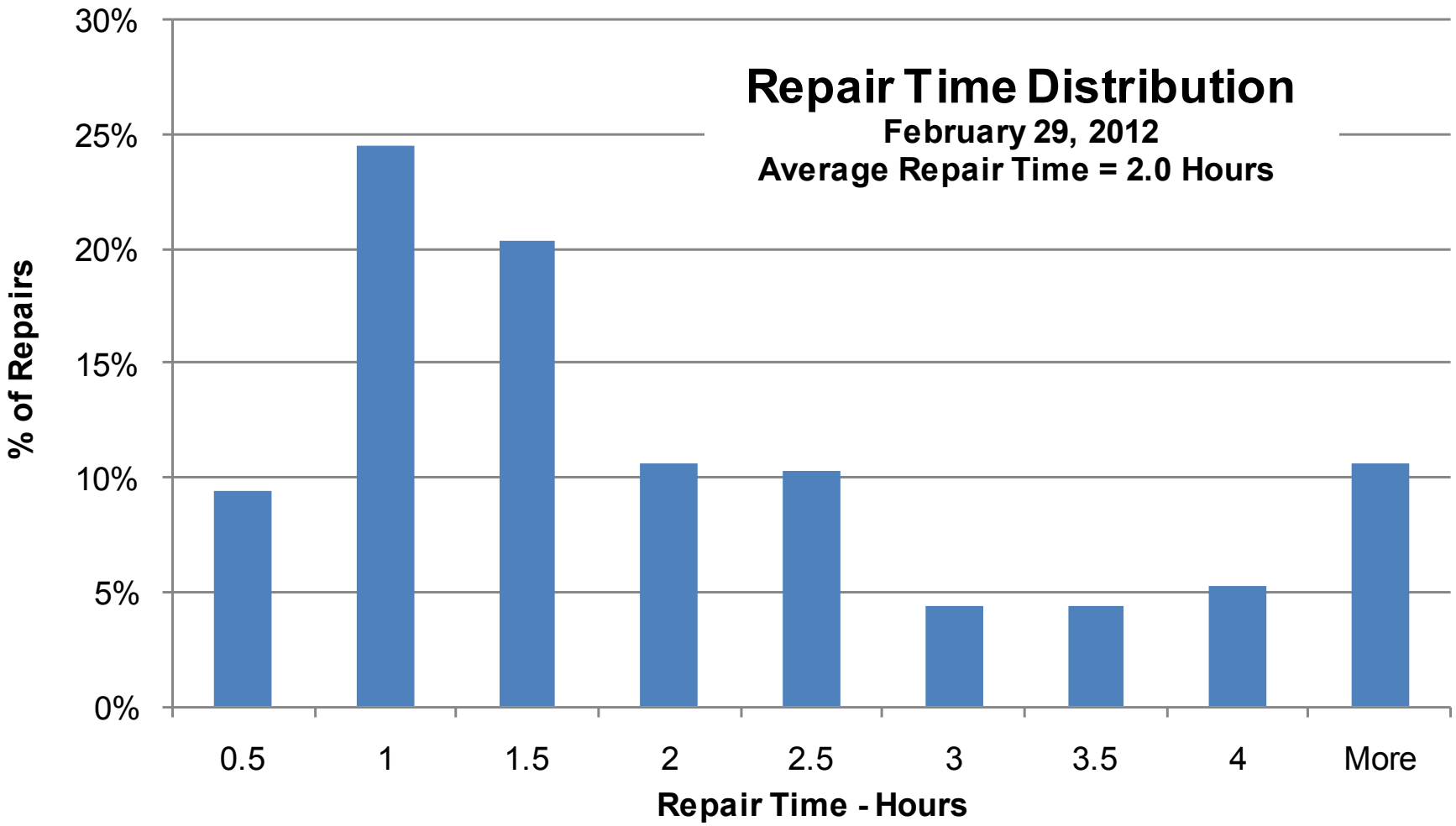
Power Unit Repairs vs. Runtime



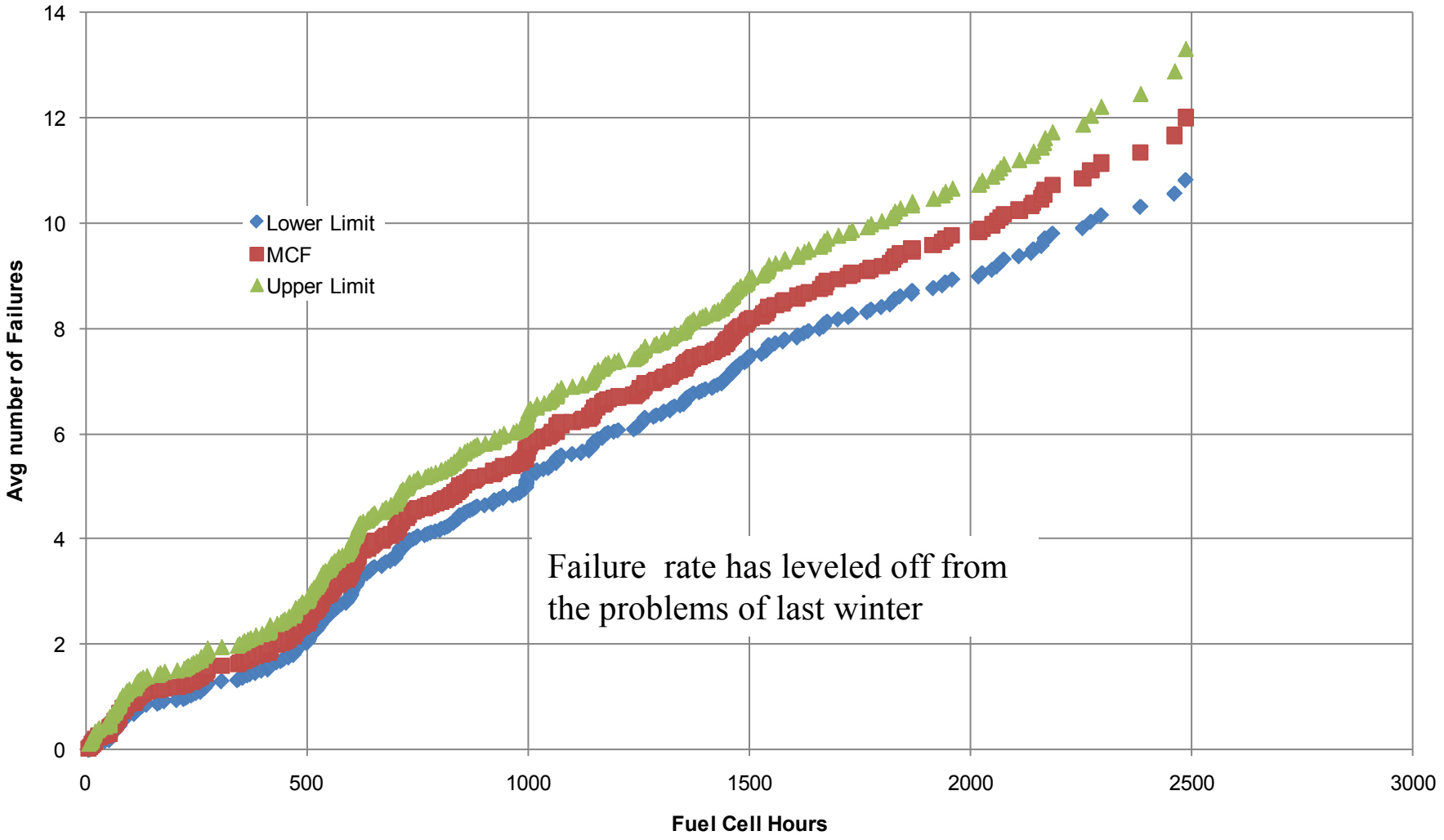
Mean Time Between Repair (MTBR) Distribution



Repair Time Distribution



Mean Cumulative Number of Fuel Cell Failures



Forklift Repair Comparison

- Compared fuel cell forklifts at Springfield MO (SGF) to propane forklifts at Whittier CA (WHT)
  - SGF has 40 forklifts with an average age of 7.5 years
  - WHT has 42 forklifts with an average age of 7.1 years
- Used forklift repair data from July 2010 to February 2012
- Only looked at unscheduled forklift repairs
- Included fuel cell repairs in the comparison
- Average usage hours per forklift repair:
  - SGF fuel cell forklifts : 144 hours
  - WHT propane forklifts : 64 hours
- Fuel cell forklifts had 125% more usage hours per repair

Collaborations

- **Suppliers**
  - 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 evaluating performance, operability and safety
  - Collecting data from the liquid and gaseous hydrogen fueling equipment and evaluating performance, operability and safety

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. Ongoing 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