



Innovation for Our Energy Future

ARRA Fuel Cell Deployment and Operation



FC Seminar

COM34-4

J. Kurtz, K. Wipke, S. Sprik, T. Ramsden

10/20/2010

PR-5600-49764

Contents

Overview of ARRA Fuel Cell Project

NREL Data Analysis Objectives

Deployment CDPs

Backup Power CDPs

Material Handling Technical CDPs

Summary

American Recovery and Reinvestment Act (ARRA) Fuel Cell Early Market Project

Project Objective

Deploy ~1,000 fuel cells to **accelerate the commercialization** and deployment of fuel cells and fuel cell manufacturing, installation, maintenance, and support services



12 awards with >\$40 million
ARRA & ~\$53 million cost share

COMPANY	AWARD	APPLICATION
Delphi Automotive	\$2.4 M	Auxiliary Power
FedEx Freight East	\$1.3 M	Specialty Vehicle
GENCO	\$6.1 M	Specialty Vehicle
Jadoo Power	\$2.2 M	Backup Power
MTI MicroFuel Cells	\$3.0 M	Portable
Nuvera Fuel Cells	\$1.1 M	Specialty Vehicle
Plug Power, Inc. (1)	\$3.4 M	CHP
Plug Power, Inc. (2)	\$2.7 M	Backup Power
Univ. of N. Florida	\$2.5 M	Portable
ReliOn Inc.	\$8.5 M	Backup Power
Sprint Comm.	\$7.3 M	Backup Power
Sysco of Houston	\$1.2 M	Specialty Vehicle

HSDC Data Flow

Bundled data (operation & maintenance/safety) delivered to NREL quarterly

Internal analysis completed quarterly



DDPs

Results

CDPs

Detailed Data Products (DDPs)

- Individual data analyses
- Identify individual contribution to CDPs
- Only shared with partner who supplied data every 6 months¹

Composite Data Products (CDPs)

- Aggregated data across multiple systems, sites, and teams
- Publish analysis results without revealing proprietary data every 6 months²

1) Data exchange may happen more frequently based on data, analysis, & collaboration

2) Results published via NREL Tech Val website, conferences, and reports

NREL Data Analysis Objectives – ARRA Demonstrations

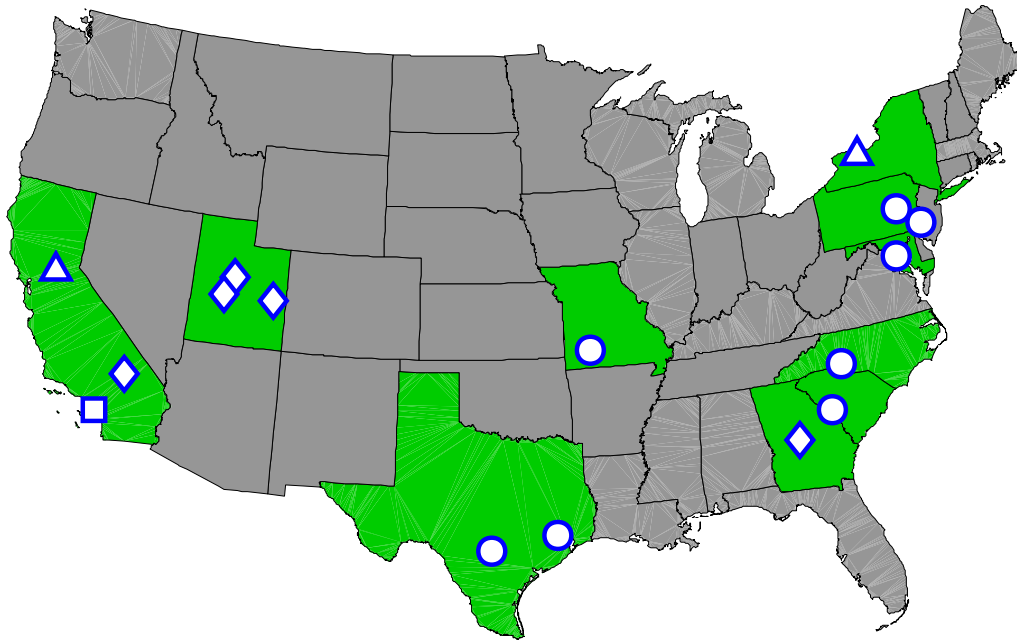
- Independent technology **assessment**; focused on fuel cell system and hydrogen infrastructure: performance, operation, and safety.
- Leverage** data processing and analysis capabilities developed from the fuel cell vehicle Learning Demonstration project and DoD Forklift Demo.
- Establish a **baseline** of real-world fuel cell operation and maintenance data and identify technical/market barriers.
- Support market growth** through analyses relevant to the **value proposition** and reporting on **technology status** to fuel cell and hydrogen communities and **stakeholders**

HSDC
NREL's Hydrogen Secure Data Center



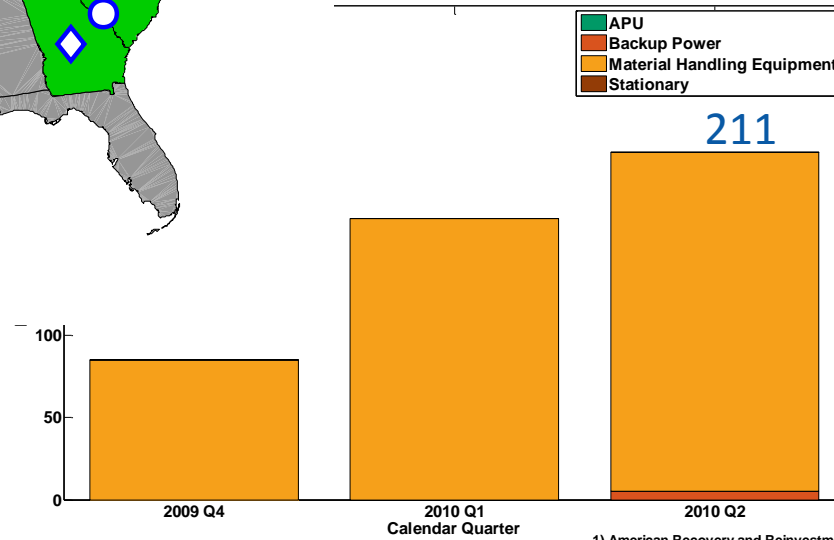
Delivered Fuel Cell Units & Deployment Sites

- ARRA Forklift Site
- ◇ ARRA Backup Site
- ARRA Stationary Site
- △ ARRA APU



Some site locations TBD

Delivered Early Fuel Cell Markets: Delivered Units



Created: Aug-30-10 5:15 PM

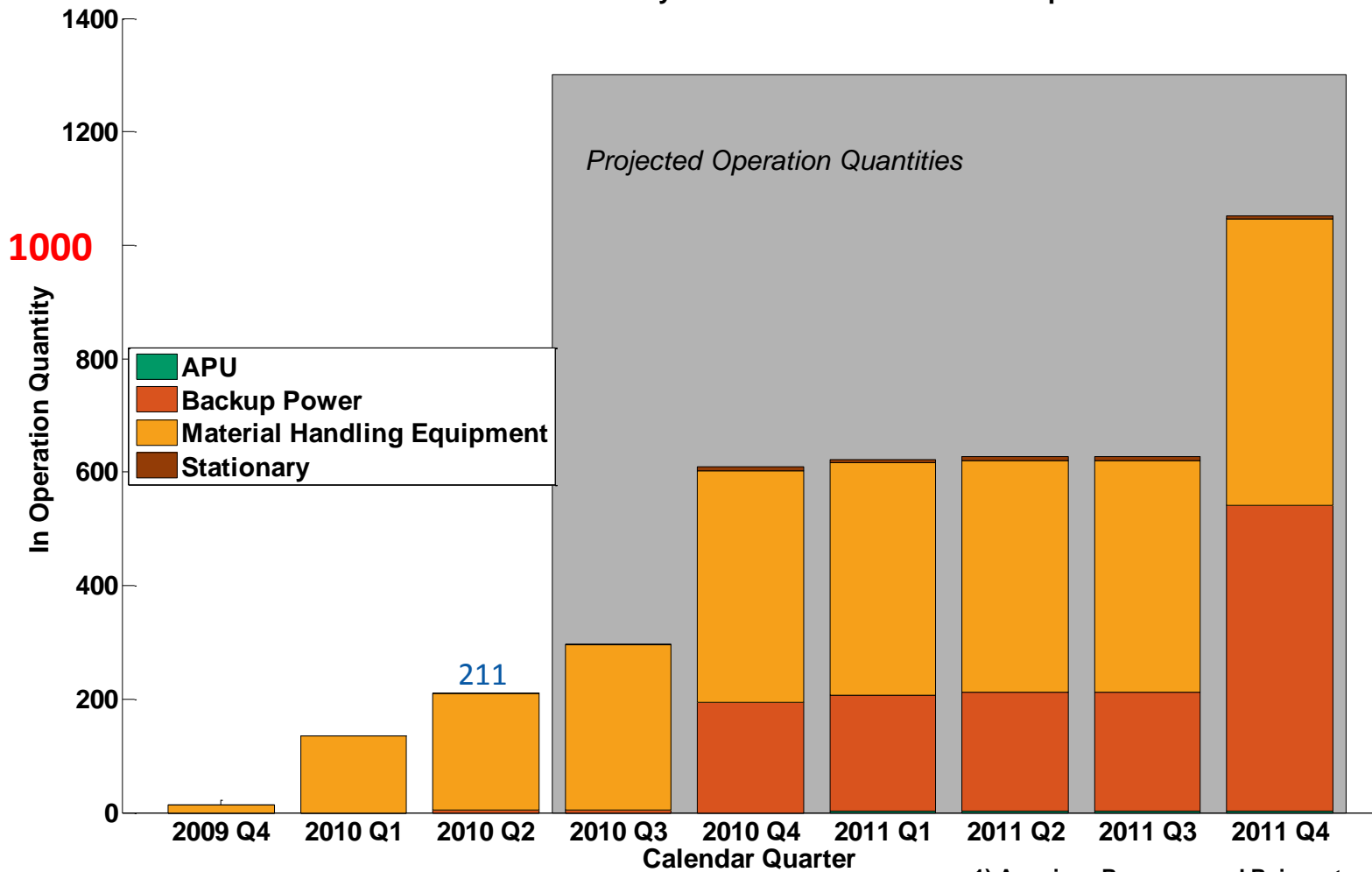
1) American Recovery and Reinvestment Act



Fuel Cell Units in Operation

Current and Projected Quantities

DOE ARRA¹ Funded Early Fuel Cell Markets: Units in Operation



FC Backup Power

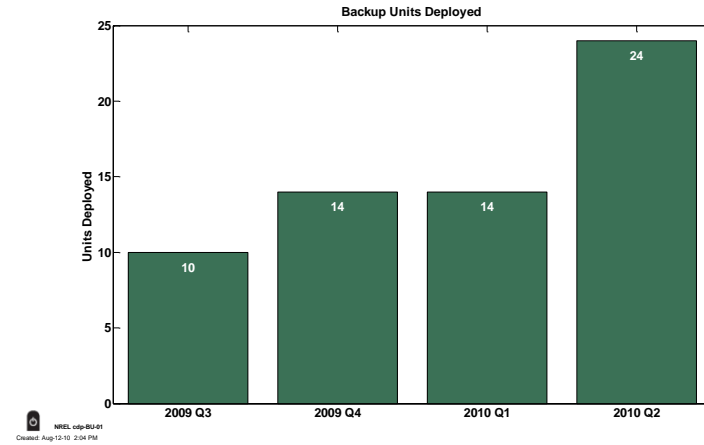
Deployment & Operation Data



High level summary of operation
First cycle of CDPs (IAA & ARRA Sites)
Trends still developing
Many additional analyses planned for future
CDP cycles

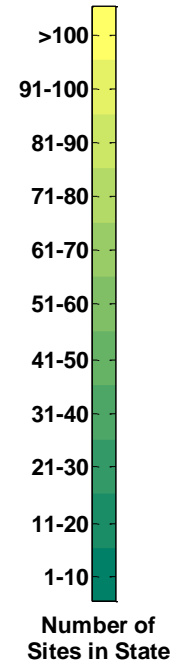
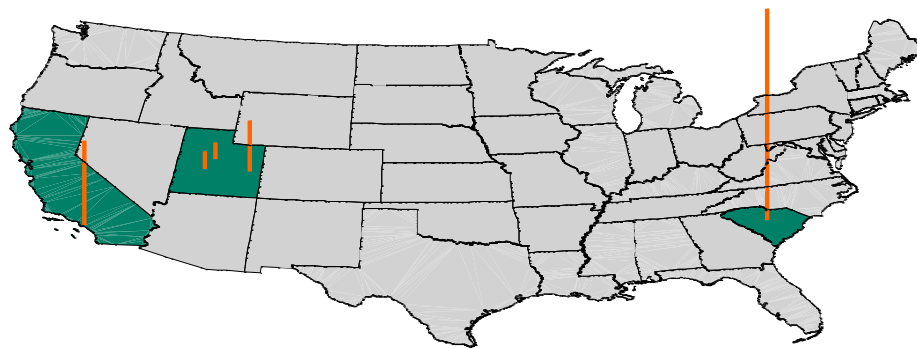
Backup Power Sites

Units Deployed	24
Sites	5
Total Capacity	90 kW



Backup Power Deployments

State	kW Capacity	Sites
California	20	1
South Carolina	50	1
Utah	20	3



| Site Capacity (line height proportional to installed site kW capacity)

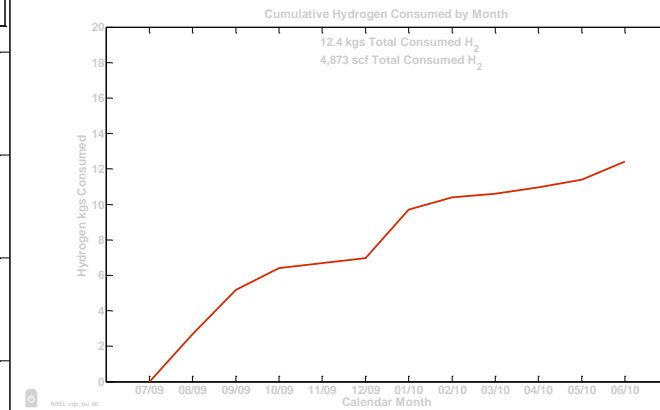
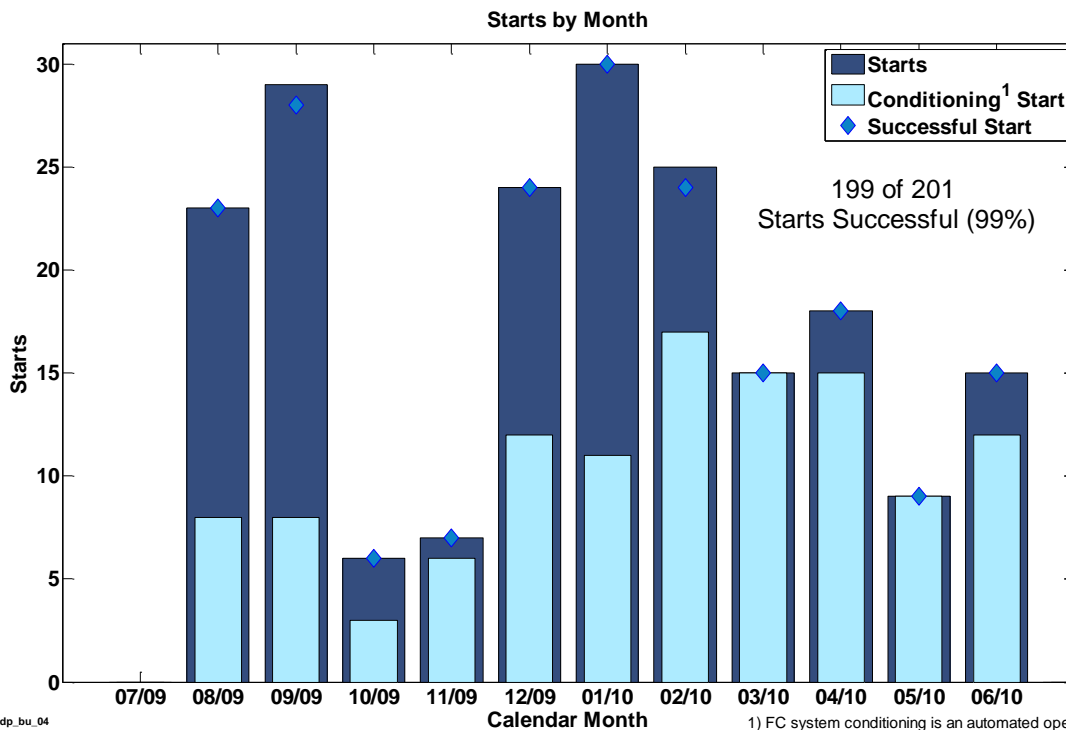
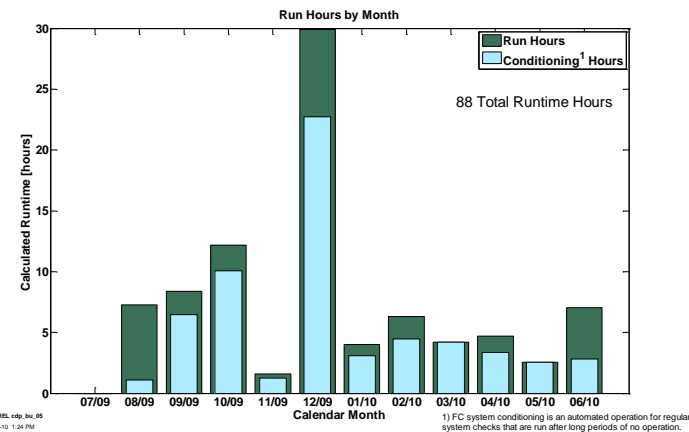


NREL cdp_bu_03

Created: Sep-28-10 5:58 PM

Backup Power Starts and Run Time

Total Starts (Thru June 2010)	201
Total Successful Starts	199 (99%)
Total Run Time	88 hours
Total Hydrogen	12.4 kg



FC Material Handling Equipment

Deployment & Operation Data



High level summary of operation

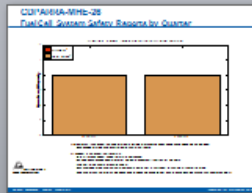
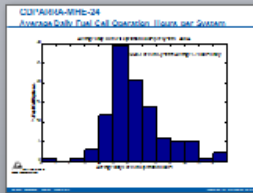
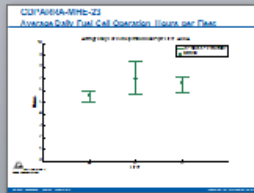
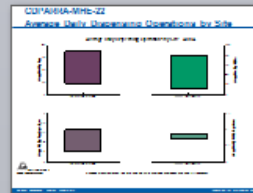
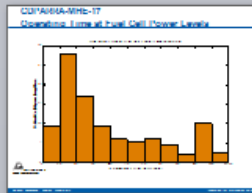
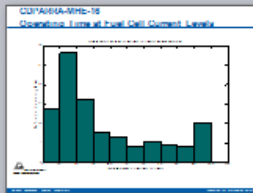
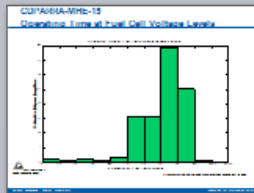
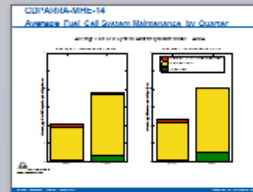
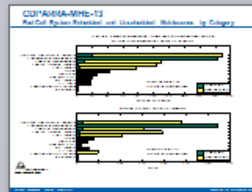
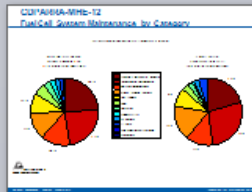
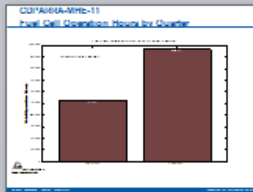
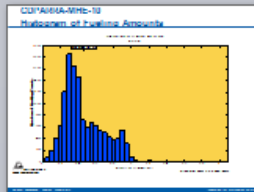
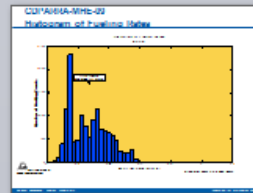
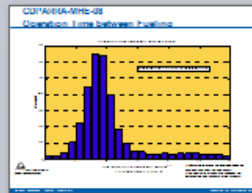
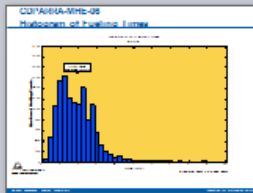
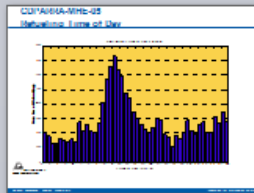
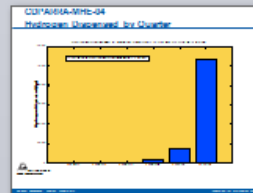
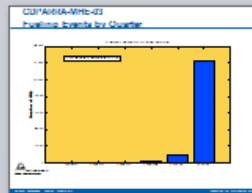
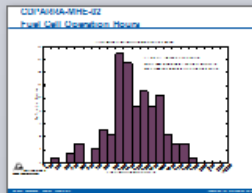
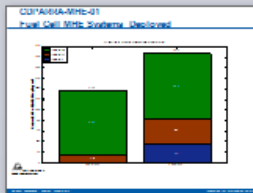
First cycle of CDPs

Trends still developing

Many additional analyses planned for future

CDP cycles

FCMHE Fall 2010 CDPs



Analysis Topics

Units Deployed,
Operation Hours,
Refueling,
Maintenance, Safety,
FC Performance, Site
Usage

ARRA FCHMHE CDPs

22

ARRA & DLA Infrastructure CDPs

4

Data Files Analyzed

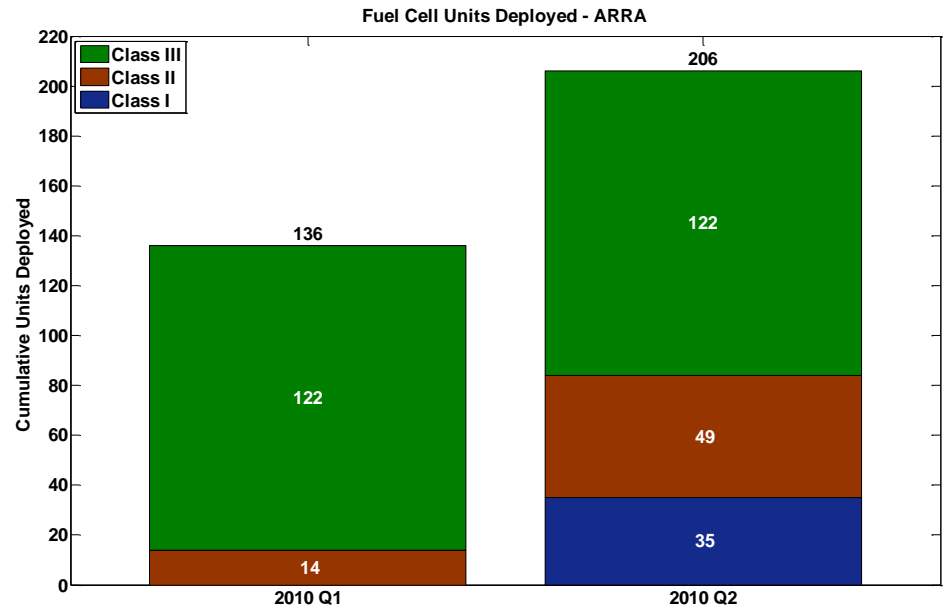
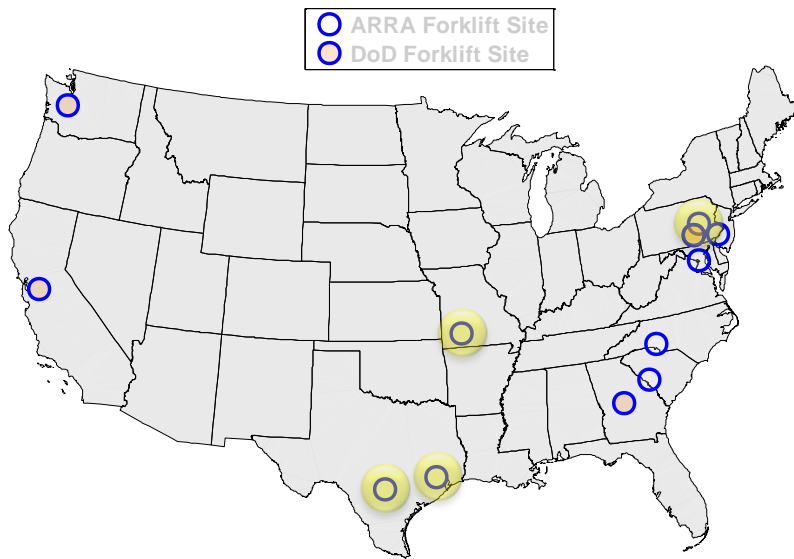
23,307 (1.7GB)

MHE FC Units & Sites

Sites

4

Operational MHE Units/Site	14	35	59	98
Operating Shifts/Site	2	3	2	2
	9 hrs	8 hrs	8-10 hrs	9 hrs
Facility Square Footage (1,000)	1,000	75	90	580
FC Units/MHE Unit	1.0	1.0	1.0	1.0



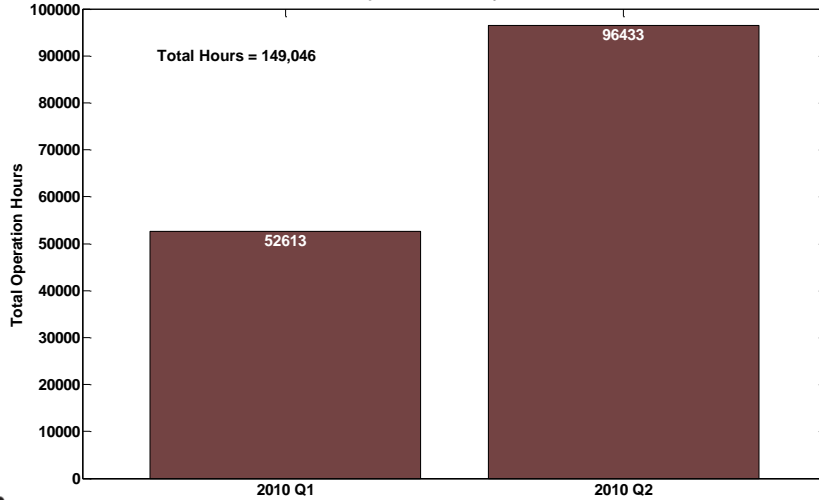
FC Operation Summary

149,046

Total Hours Accumulated

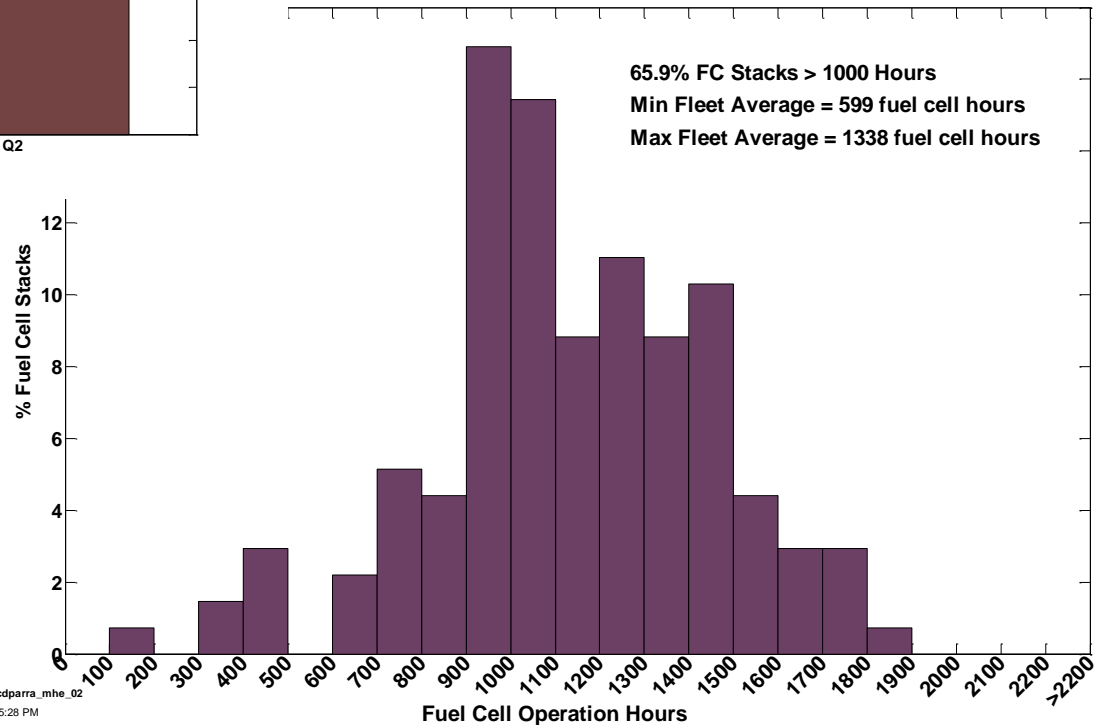
66% FC Stacks > 1000 hours

Fuel Cell Operation Hours by Quarter - ARRA



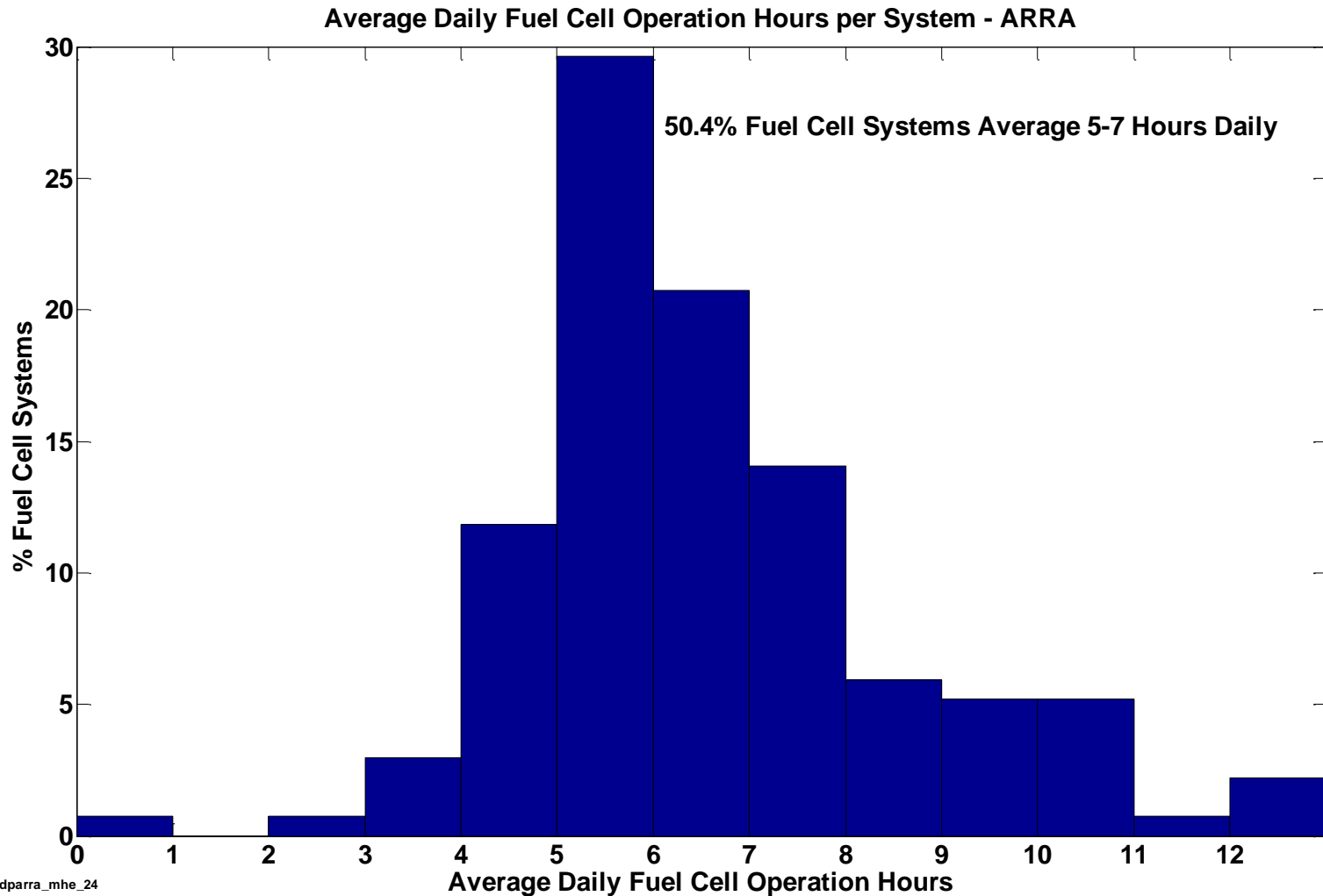
 NREL cdparra_mhe_11
Created: Sep-23-10 3:37 PM

Cumulative Fuel Cell Operation Hours - ARRA



 NREL cdparra_mhe_02
Created: Sep-22-10 5:28 PM

FC Daily Operation



NREL cdparra_mhe_24

Created: Sep-09-10 5:51 PM

Hydrogen Fill Event Summary

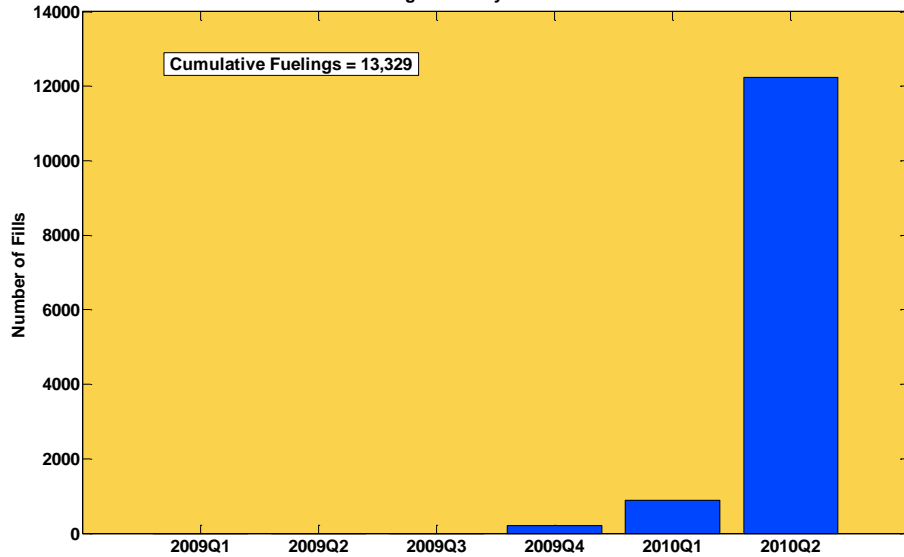
Total Hydrogen Dispensed

6,198 kg

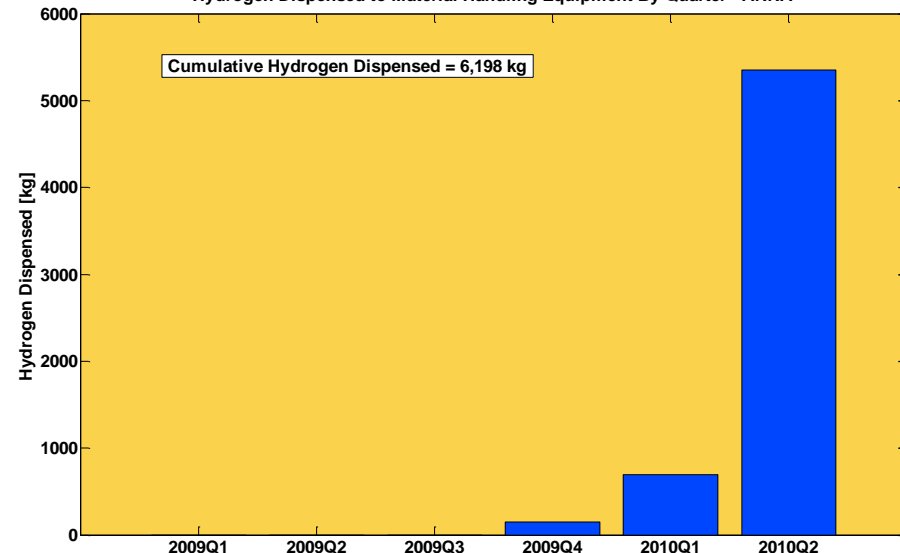
Total Hydrogen Fill Events

13,329 fills

Fueling Events By Quarter - ARRA



Hydrogen Dispensed to Material Handling Equipment By Quarter - ARRA



Hydrogen Fill Event Rates and Amounts

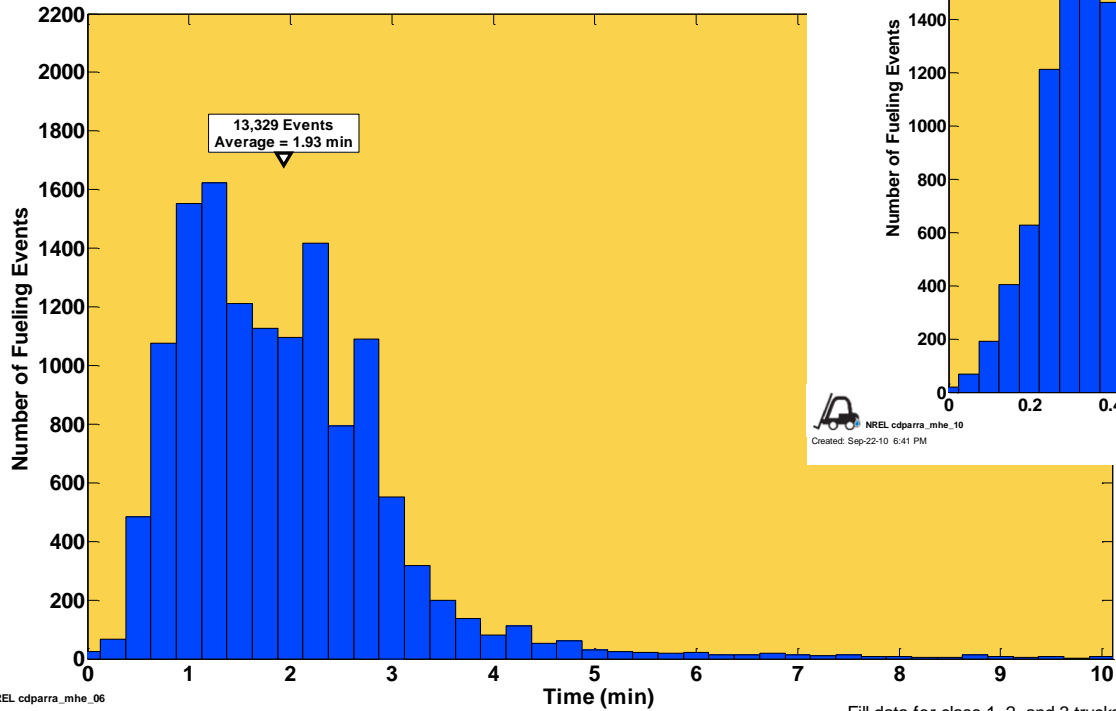
Average Fill Time

1.9 minutes

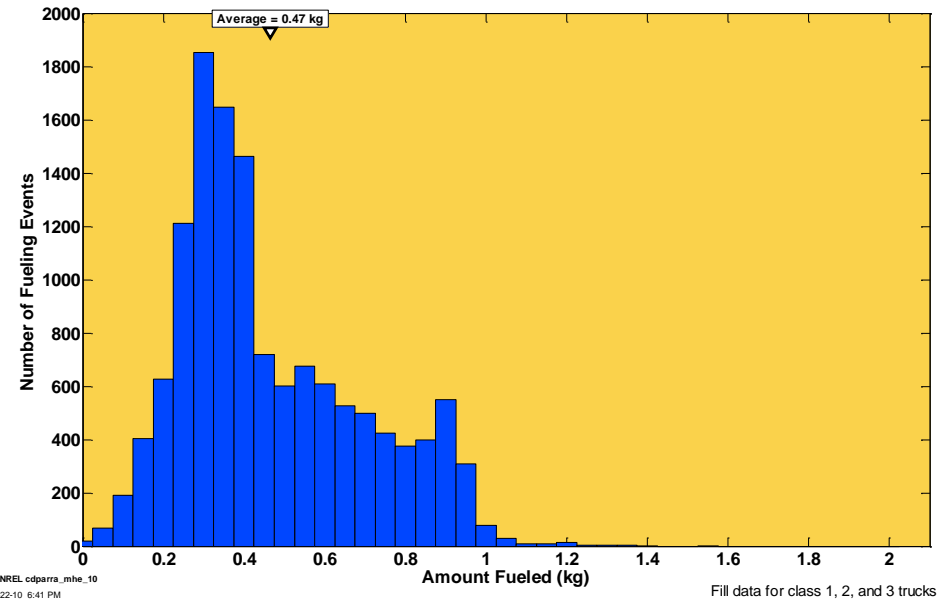
Average Fill Amount

0.47 kg

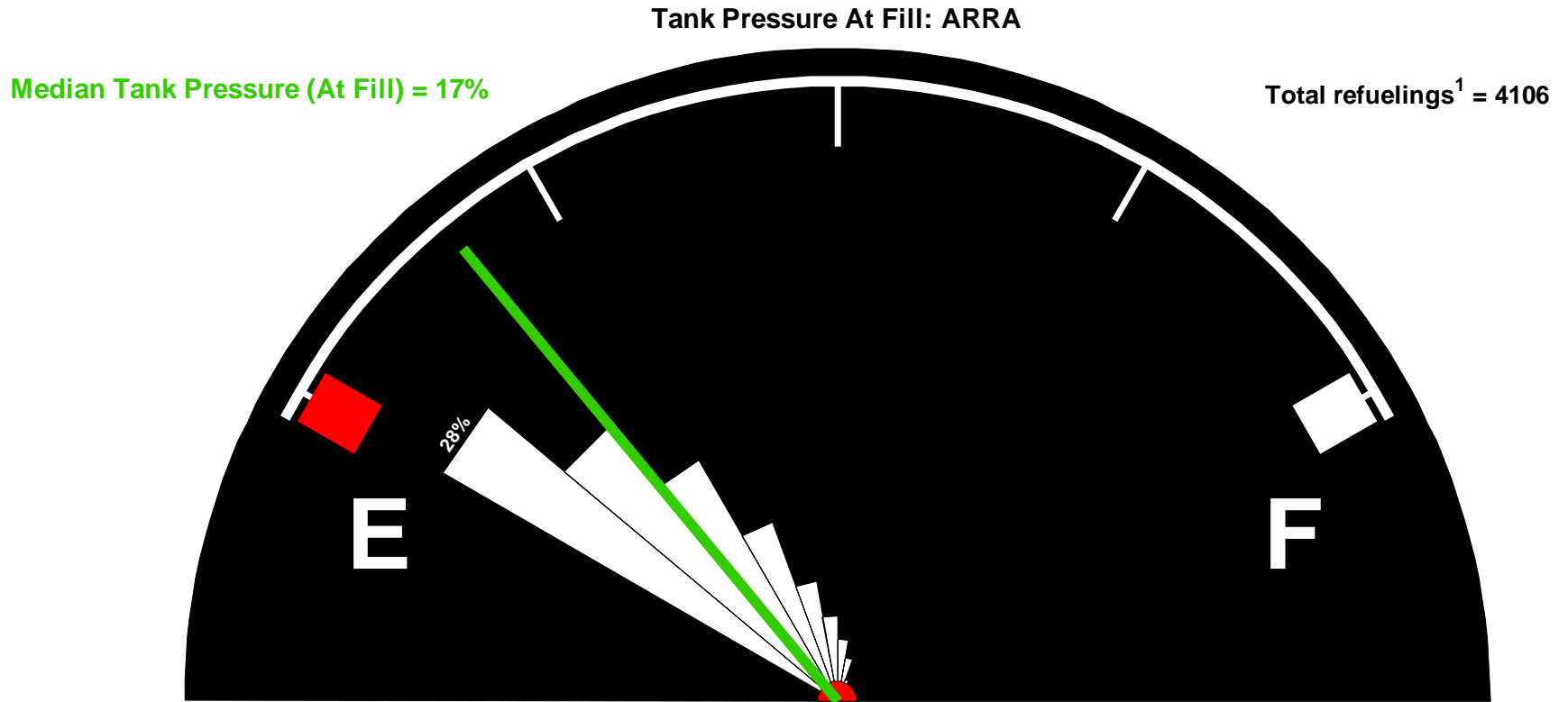
Histogram of Fueling Times
ARRA



Histogram of Fueling Amounts
ARRA

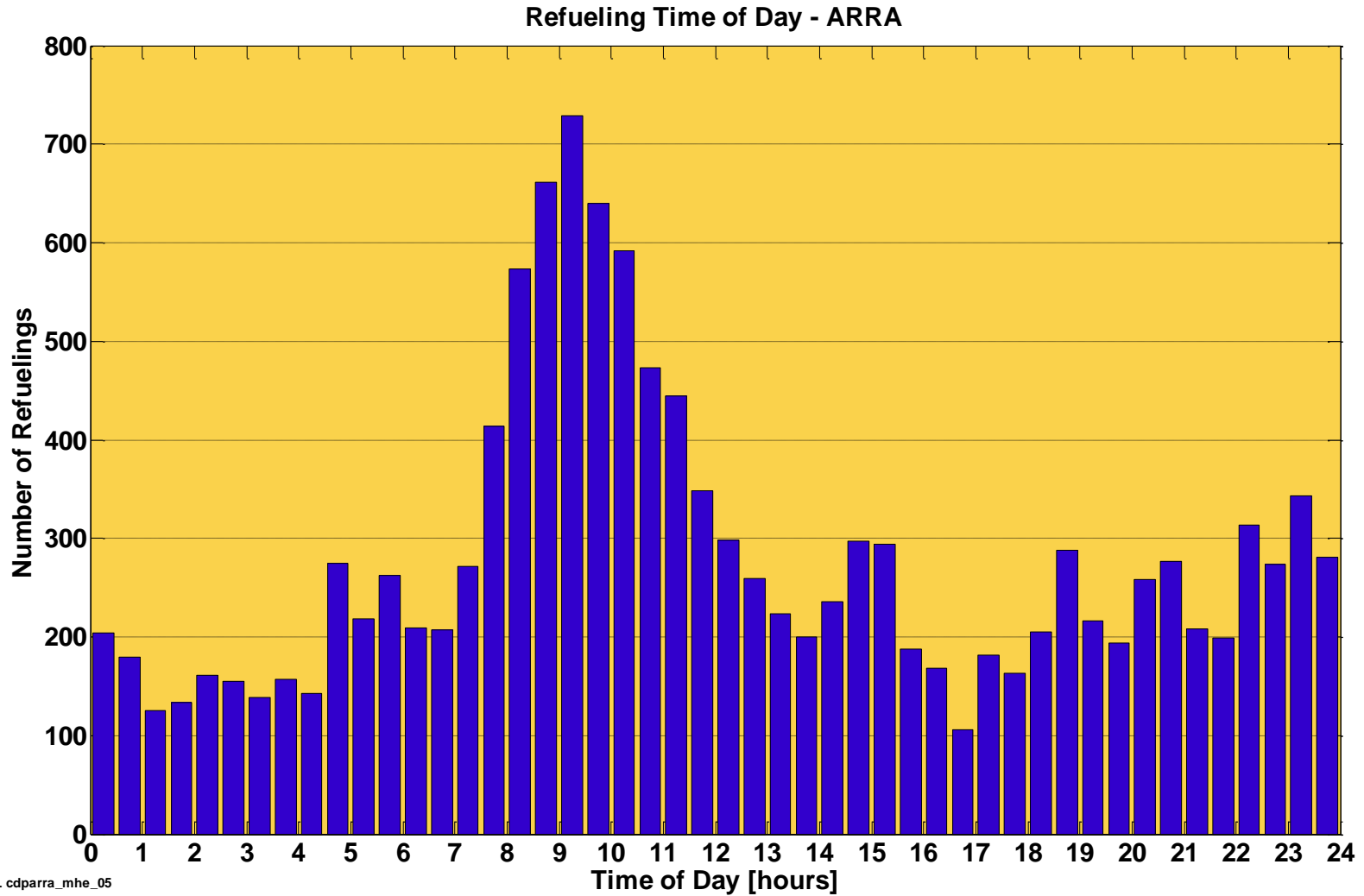


Tank Pressure Level at Fueling



1. Some refueling events not recorded/detected due to data noise or incompleteness.
2. The outer arc is set at 40% total refuelings.
3. Full Pressure is either 3600 psi or 5000 psi.

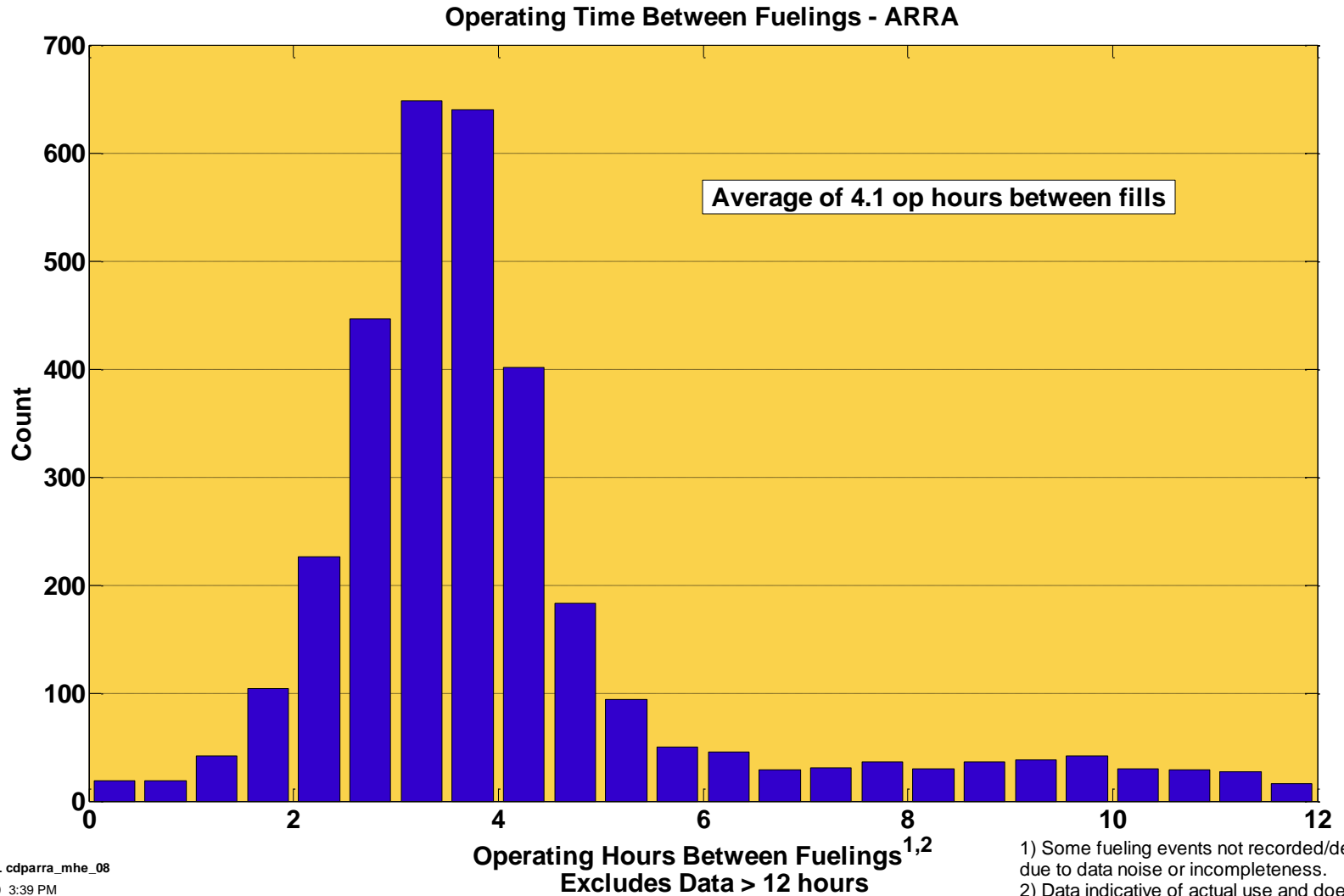
Refueling Time of Day



NREL cdparra_mhe_05

Created: Sep-22-10 6:12 PM

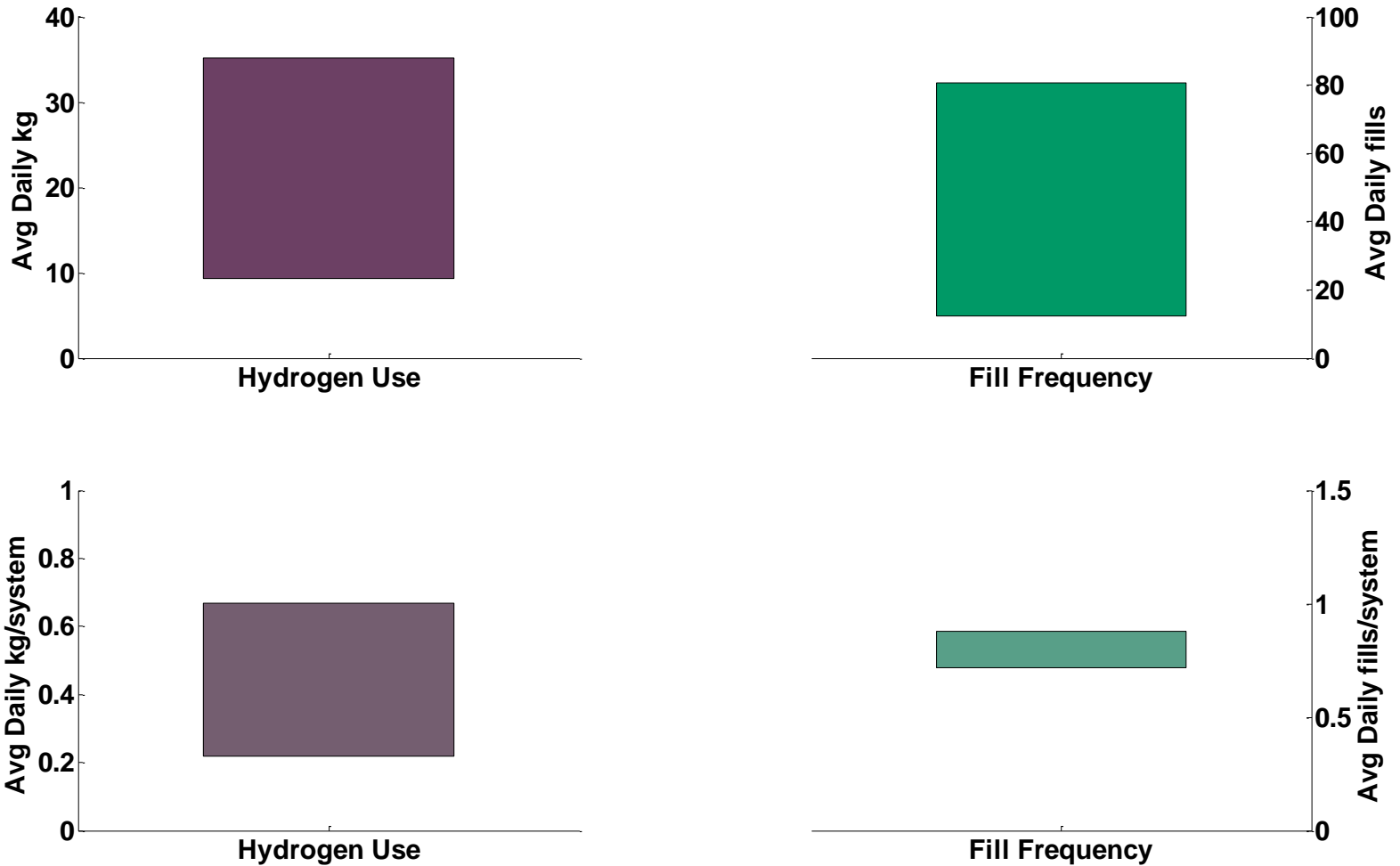
Operation Time between Fueling



1) Some fueling events not recorded/detected due to data noise or incompleteness.
2) Data indicative of actual use and does not represent the max capability of the systems.

Average Daily Site H2 Dispensing

Average Daily Dispensing Operations by Site - ARRA

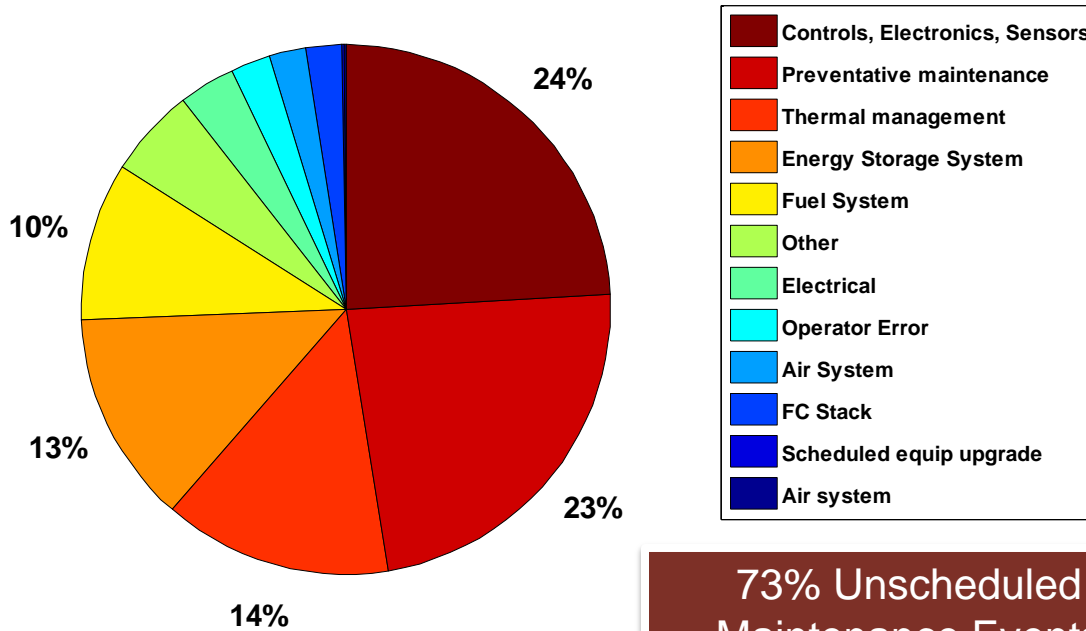


Shaded areas represent the min and max site average hydrogen use and fill frequency

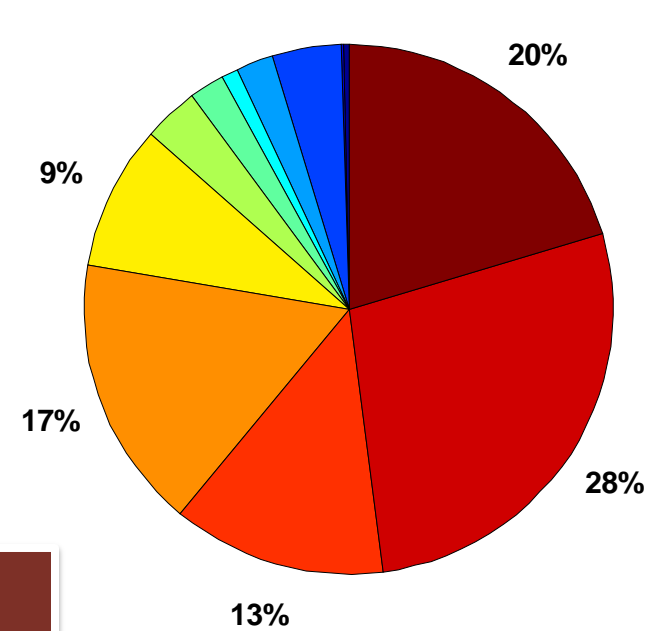
Fuel Cell System Maintenance by Category

Forklift Maintenance By Category - ARRA

Number of Events
Total Events = 789
73% were unscheduled



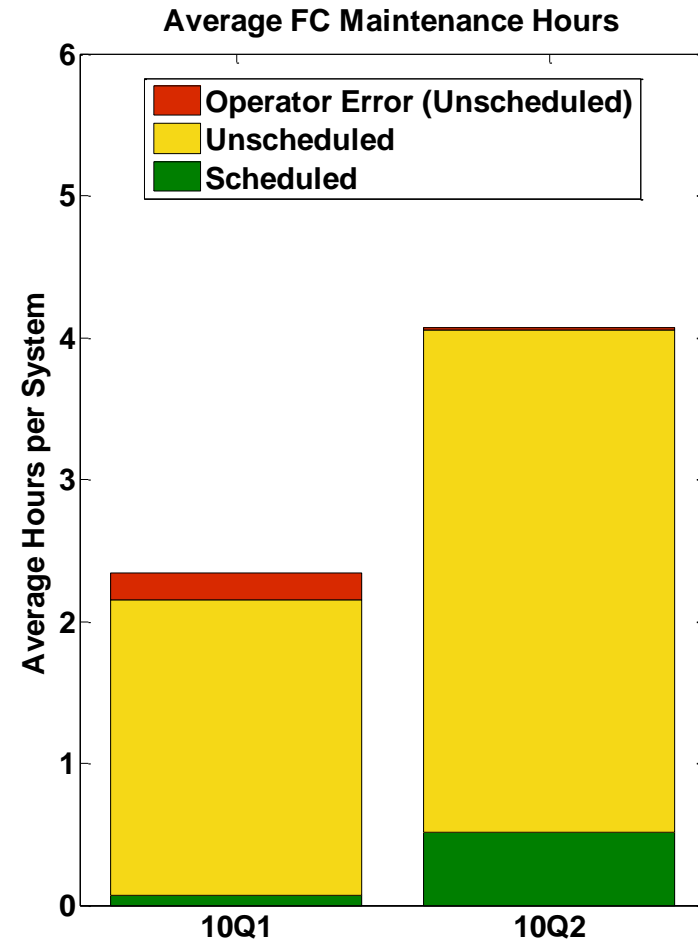
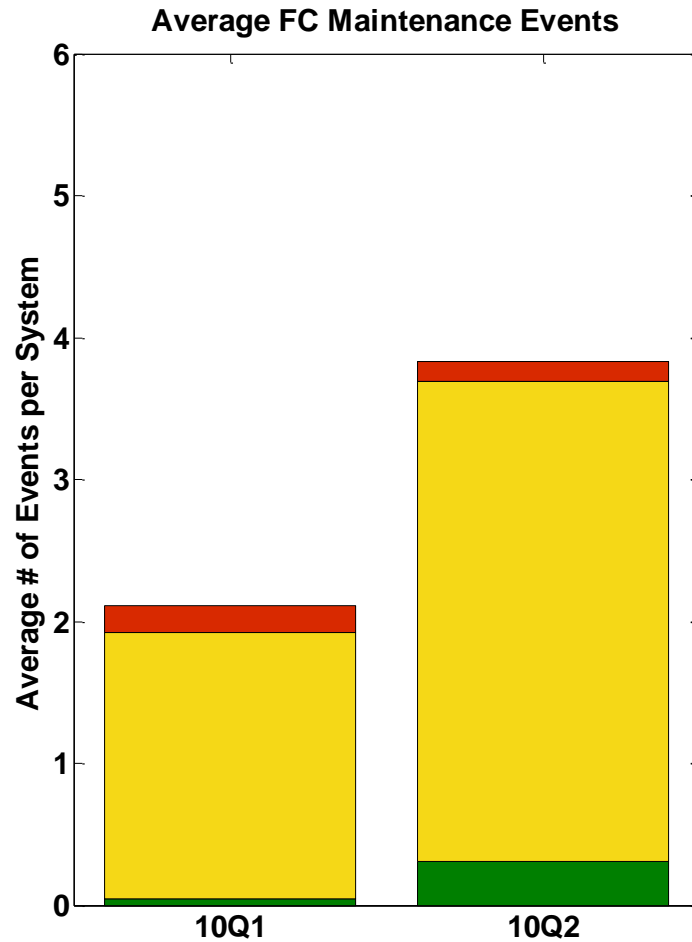
Labor Hours
Total Hours = 1165
69% were unscheduled



73% Unscheduled Maintenance Events
38% Events for Controls, Electronics, Sensors or Thermal Mgmt

Average Fuel Cell System Maintenance by Quarter

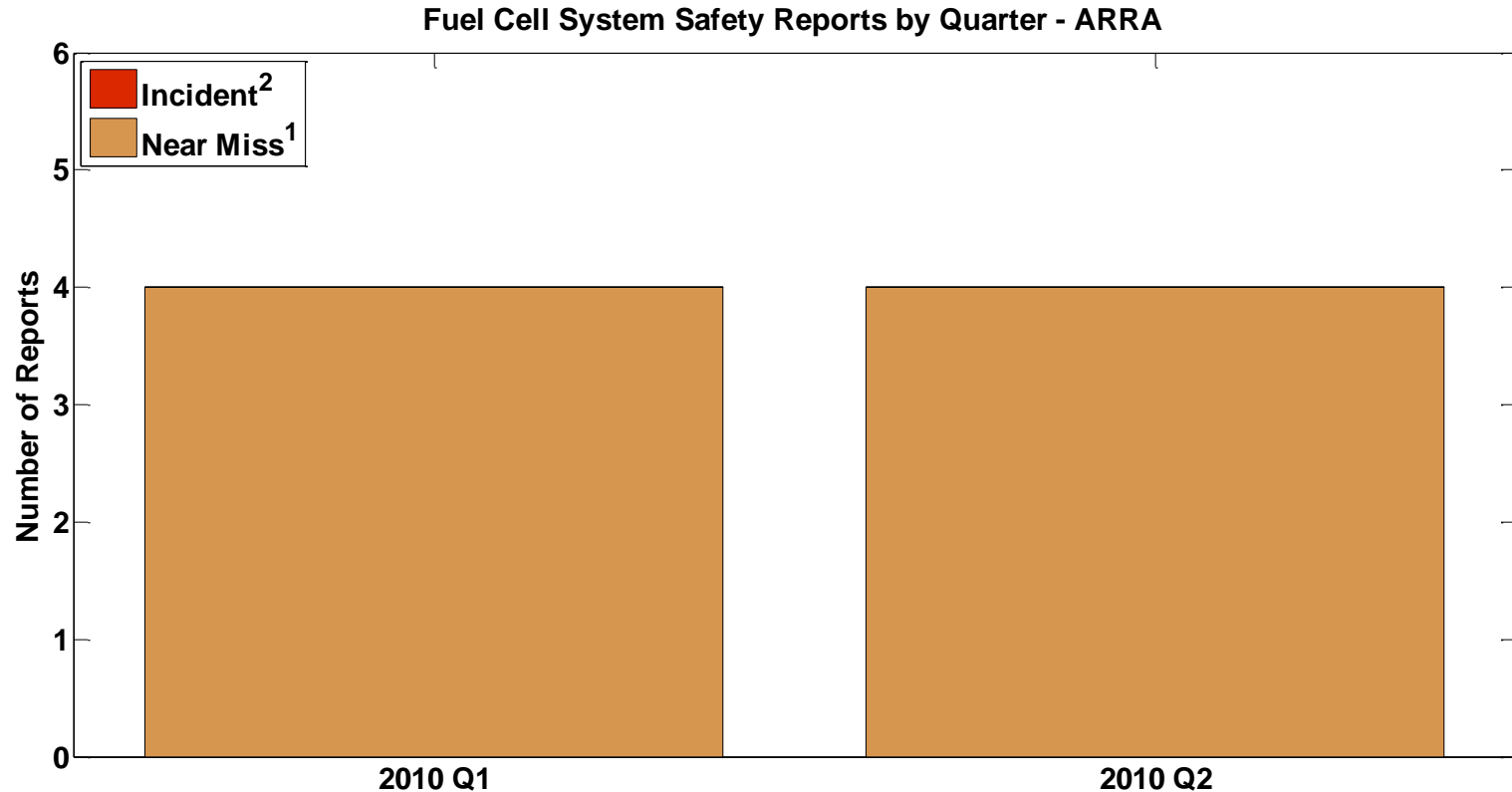
Average Fuel Cell System Quarterly Maintenance - ARRA



NREL cdparra_mhe_14

Created: Sep-30-10 3:27 PM

Fuel Cell System Safety Reports by Quarter

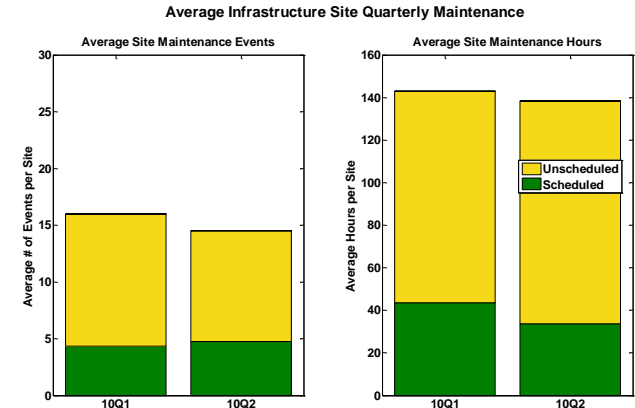


- 1) Near Miss is an event that under slightly different circumstances could have become an incident
 - unplanned H₂ release insufficient to sustain a flame
- 2) Incident is an event that results in:
 - a lost time accident and/or injury to personnel
 - damage/unplanned downtime for project equipment, facilities or property
 - impact to the public or environment
 - any hydrogen release that unintentionally ignites or is sufficient to sustain a flame if ignited
 - release of any volatile, hydrogen containing compound (other than the hydrocarbons uses as common fuels)

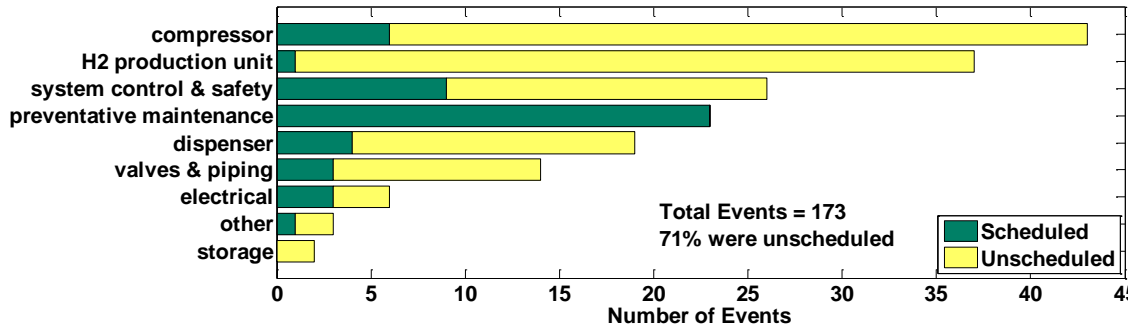


Infrastructure Maintenance

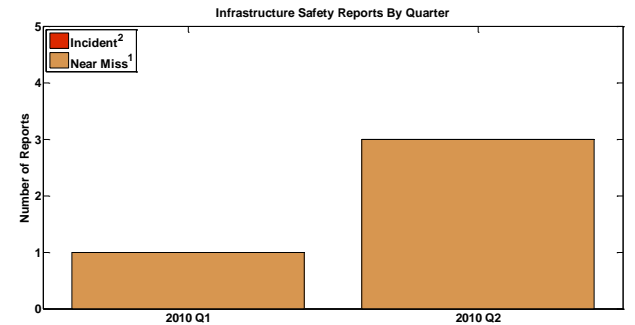
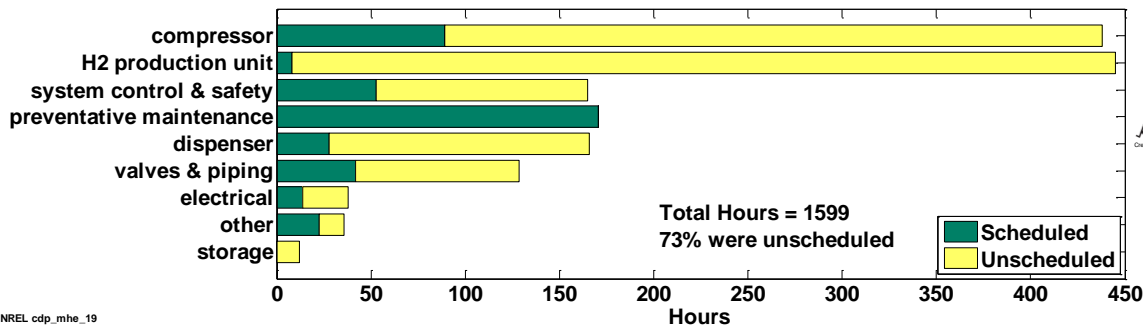
Total Hydrogen Dispensed	19,831 kg
Total Hydrogen Fill Events	36,468 fills
Total FC Hours	251,177 hours
Maintenance Events	173 (71% Unscheduled)
Safety Incidents	0



**Infrastructure Maintenance Scheduled vs. Unscheduled
Number of Maintenance Events by Category**



Number of Labor Hours by Category



- Near Miss is an event that under slightly different circumstances could have become an incident
-unplanned H2 release insufficient to sustain a flame
- Incident is an event that results in:
 - a lost time accident and/or injury to personnel
 - damage/unplanned downtime for project equipment, facilities or property
 - impact to the public or environment
 - any hydrogen release that unintentionally ignites or is sufficient to sustain a flame if ignited
 - release of any volatile, hydrogen containing compound (other than the hydrocarbons uses as common fuels)

ARRA & DLA Sites Combined

Innovation for Our Energy Future

Summary

- 206 MHE Units in operation at 4 sites with more than 13,300 fills, 6,200 kgs dispensed, and 149,000 hours accumulated without a safety incident.
- 24 BU Units (90 kW installed capacity) in operation at 5 sites with 199 of 201 Starts successful and 88 total hours run time.
- Operation trends unclear because we are in early stage of deployment and analysis
- Many more sites coming on-line in the next 6-12 months
- Many more planned analyses like fuel cell durability, system reliability, and application value proposition

Contact Information & Website

http://www.nrel.gov/hydrogen/proj_fc_market_demo.html

Jennifer Kurtz
jennifer.kurtz@nrel.gov
 303-275-4061





NREL National Renewable Energy Laboratory
Innovation for Our Energy Future

NREL HOME

ABOUT NREL
ENERGY ANALYSIS
SCIENCE & TECHNOLOGY
TECHNOLOGY TRANSFER
APPLYING TECHNOLOGIES

Hydrogen & Fuel Cells Research

More Search Options

Site Map

[Printable Version](#)

Hydrogen & Fuel Cells Research Home

Capabilities

Projects

- Hydrogen Production & Delivery
- Hydrogen Storage
- Fuel Cells
- Technology Validation
- Fuel Cell Vehicle Learning Demonstration
- Fuel Cell Bus Evaluations
- Early Fuel Cell Market Demonstrations**
- Safety
- Codes & Standards
- Analysis
- Education
- Manufacturing

Research Staff

Facilities

Working with Us

Energy Analysis & Tools

Publications

Awards & Honors

News

Early Fuel Cell Market Demonstrations

Early fuel cell market demonstrations are focused primarily on using fuel cell technologies for material handling, backup power, and prime-power applications. The Department of Energy-sponsored demonstration projects support fuel cell market transformation activities and help foster the growth of fuel cell markets. In addition, the Department of Defense funds early fuel cell demonstration projects.

NREL receives operational data from these early market fuel cell demonstrations, analyzes, and reports on these data. By aggregating data across numerous industry teams and sites, NREL develops composite data products (CDPs), which provide relevant data results on the technology status and fuel cell performance without revealing proprietary data. These publicly available CDPs will help the development community understand the state of fuel cell technologies, identify areas for continued improvement, and provide data metrics that are important to the business case for these fuel cell markets.

This page provides the following resources:

- [Composite Data Products](#)
- [Presentations and Publications](#)
- [Presentations Containing All CDPs](#)

Composite Data Products

The public technical analysis results are generated in the form of composite data products. The following CDPs can be sorted by title, category, CDP number, and date updated. Download the CDPs as PowerPoint or JPG files using the links in the two columns on the right. Download the current presentation containing all CDPs ([PowerPoint 2.7 MB](#)) or see the [archived presentations containing all CDPs](#).

Sort by Title ▼	Sort by Category ▼	Sort by CDP No. ▼	Sort by Date Updated ▼	PowerPoint	JPG
Operating Hours between Fueling	Fuel Cell Fuel Economy Range and Efficiency	FL08	2009-11-08		JPG
Accumulated Forklift Operating Hours	Fuel Cell Usage and Operation Behavior	FL02	2009-11-08		JPG
Forklifts Deployed by Quarter	Fuel Cell Usage and Operation Behavior	FL01	2009-11-08		JPG
Fuel Cell Units Delivered to Site	Fuel Cell Usage and Operation Behavior	ARRA01	2010-02-18		JPG
Fuel Cell Units in Operation—Current and Projected Quantities	Fuel Cell Usage and Operation Behavior	ARRA02	2010-02-18		JPG



Hydrogen PEM fuel cells are leading candidates for use in fuel cell vehicles. Today's commercially available PEM fuel cells are particularly appropriate for low-power applications requiring intermittent backup.