



Analysis Results for ARRA Fuel Cell Deployments



**Fuel Cell and Hydrogen
Energy Association
Conference**

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Contents

NREL Data Analysis Objectives

Overview of ARRA Fuel Cell Project

Deployment, Performance, and Cross-Application CDPs

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



ARRA Early Market Fuel Cell Project – Evaluating deployments in many applications, sites, and regions

COMPANY	APPLICATION
Delphi Automotive	Auxiliary Power
FedEx Freight East	Specialty Vehicle
GENCO	Specialty Vehicle
Jadoo Power	Backup Power
MTI MicroFuel Cells	Portable
Nuvera Fuel Cells	Specialty Vehicle
Plug Power, Inc. (1)	CHP
Plug Power, Inc. (2)	Backup Power
Univ. of N. Florida	Portable
ReliOn Inc.	Backup Power
Sprint Comm.	Backup Power
Sysco of Houston	Specialty Vehicle

**Deploy up to
1,000 FC Units**

Material Handling, Backup Power, Combined Heat & Power, Auxiliary Power, and Portable Power

Accelerate the commercialization of fuel cells, manufacturing, installation, maintenance, and support service through 12 awards

Material Handling: 206 units deployed, 149,046 hours accumulated, 13,300 fills, and 6,200 kg*

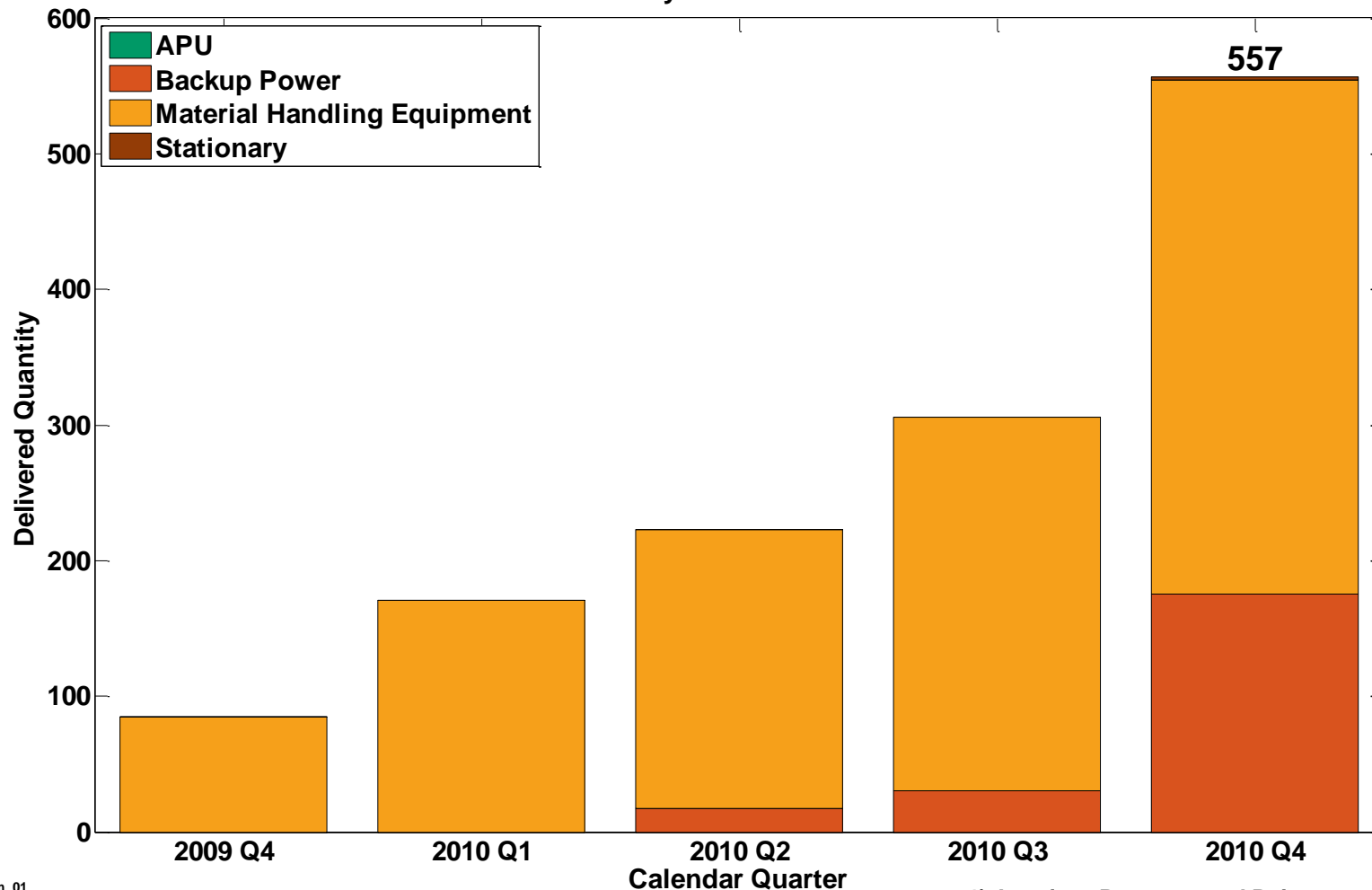
Backup Power units in early stages of deployment and operation

*Through June 2010

New Data this Spring

ARRA Delivered Fuel Cell Units

DOE ARRA¹ Funded Early Fuel Cell Markets: Delivered Units



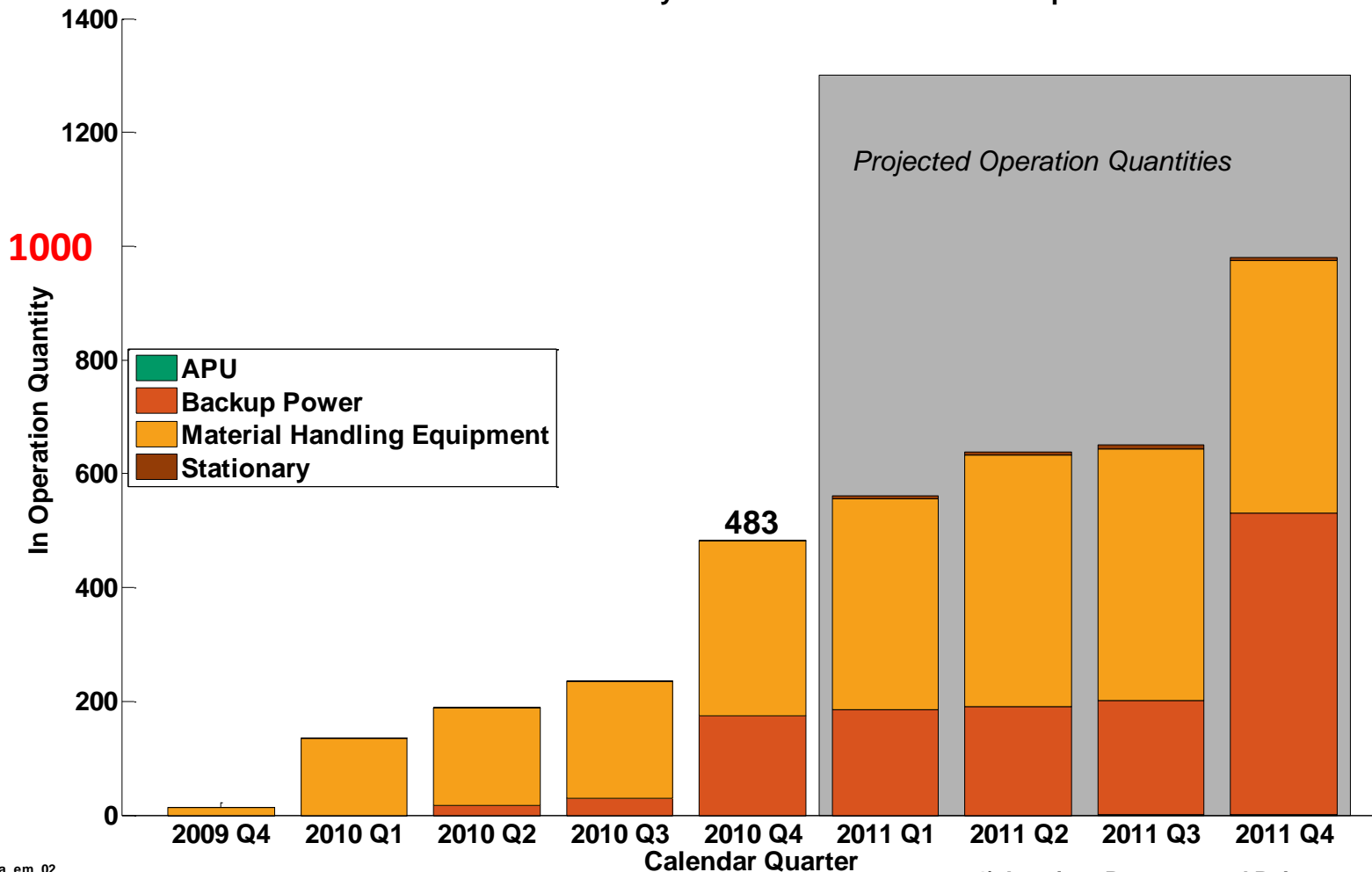
NREL cdparra_em_01
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1) American Recovery and Reinvestment Act

ARRA Fuel Cell Units in Operation

Current and Projected Quantities

DOE ARRA¹ Funded Early Fuel Cell Markets: Units in Operation



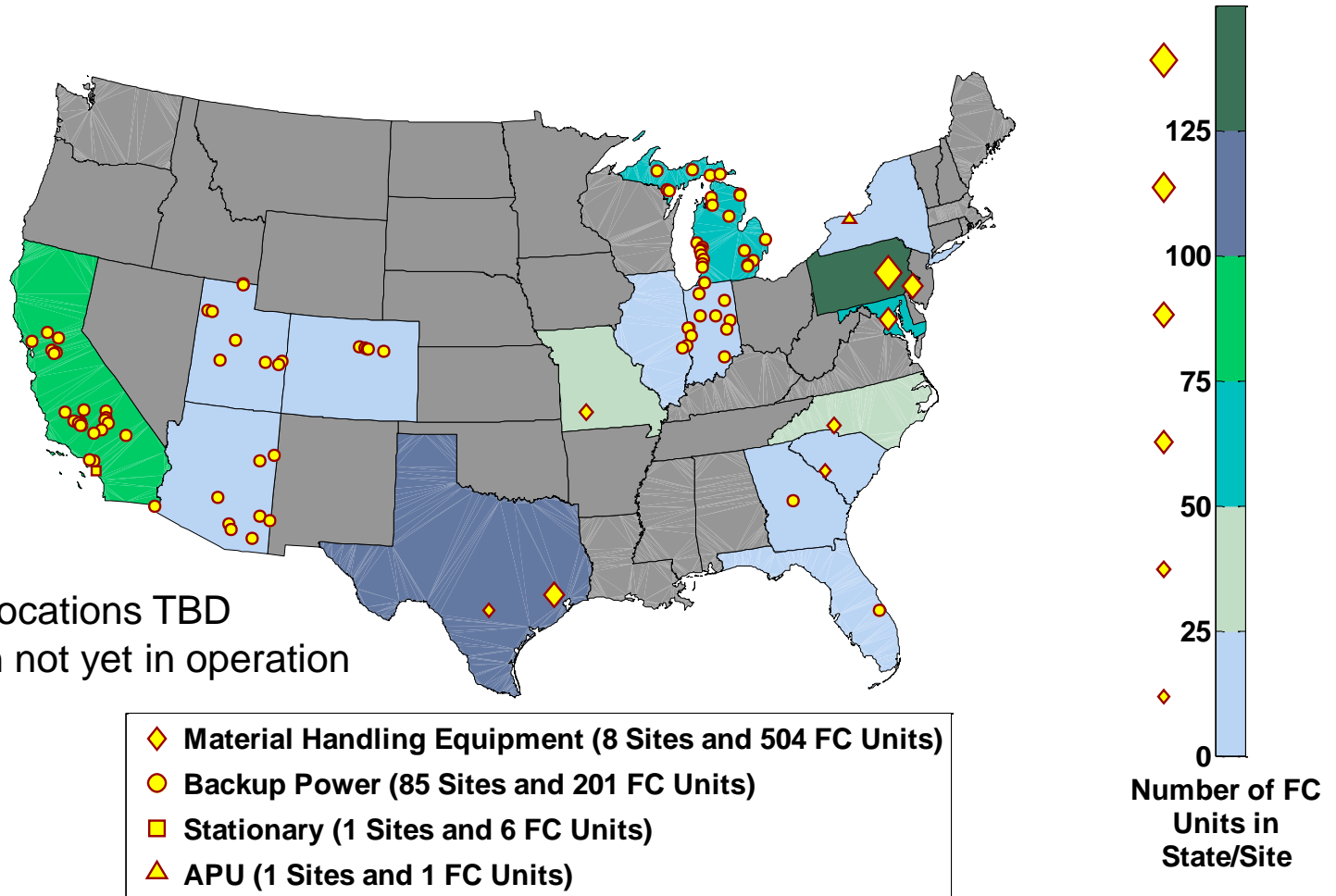
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1) American Recovery and Reinvestment Act

ARRA Early Fuel Cell Market Deployment Sites

16 States

FC Unit Locations - ARRA



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FC Backup Power

Deployment & Operation Data

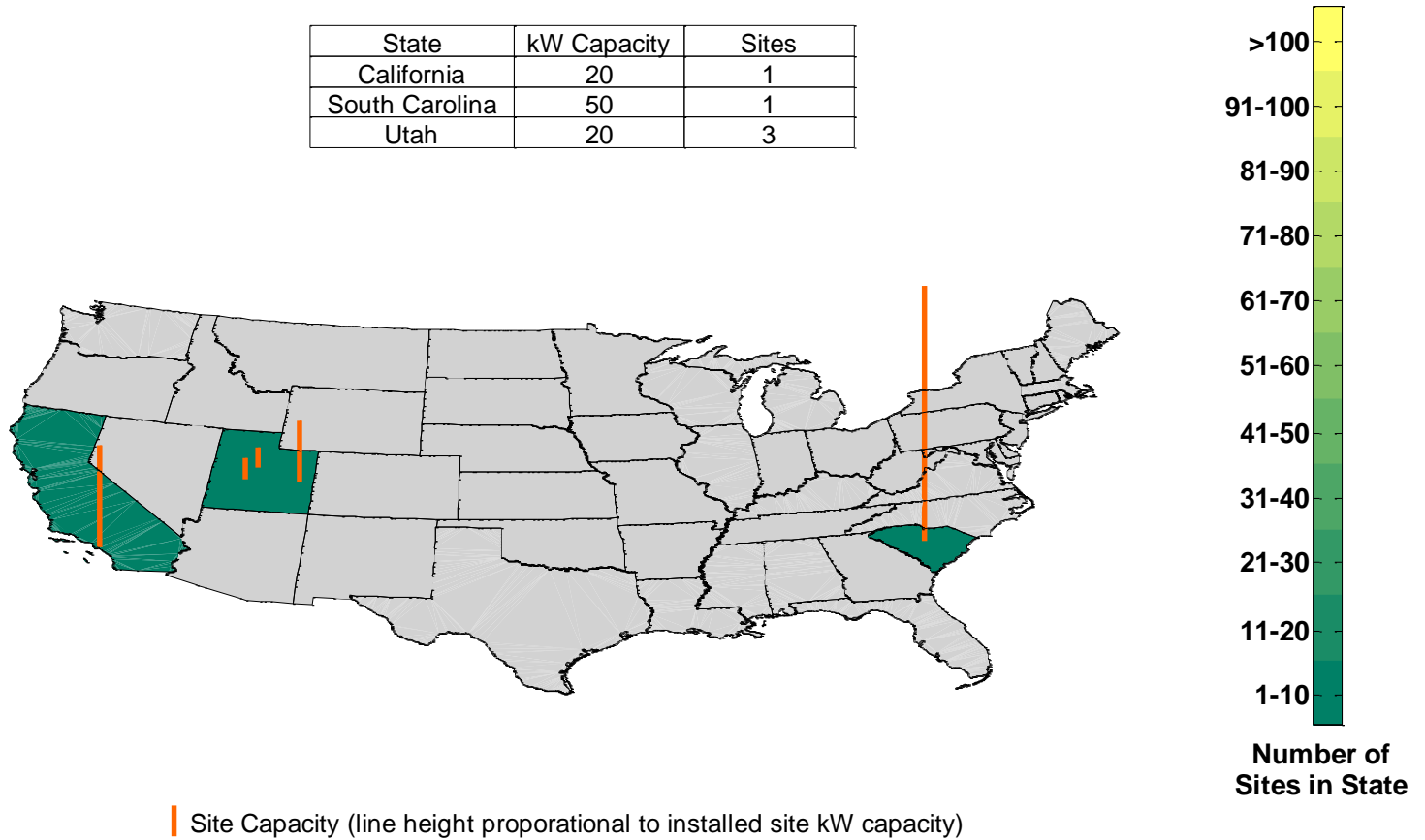


Backup Power Sites

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



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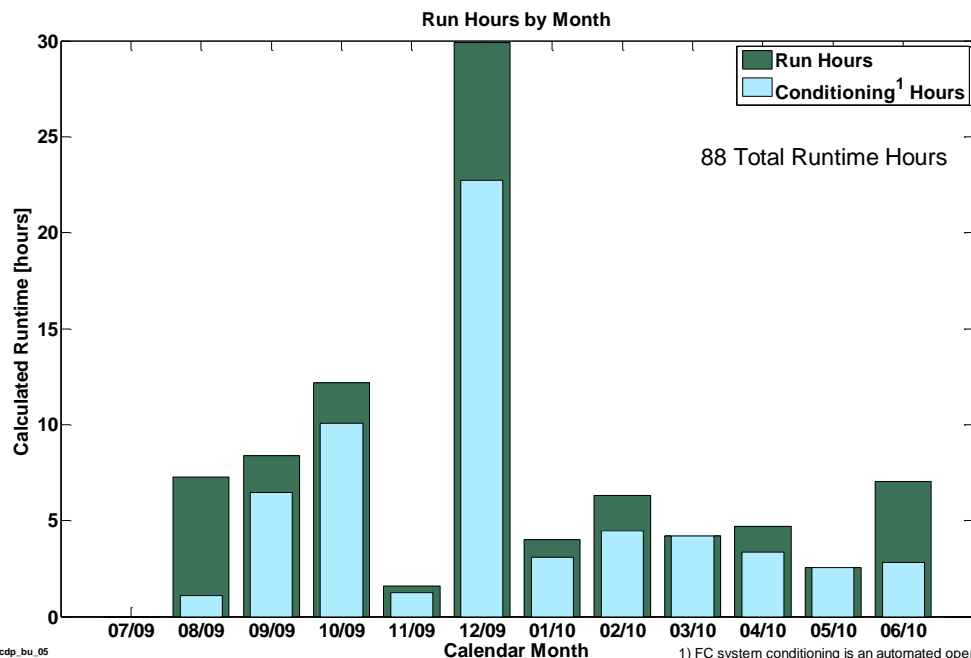
Backup Power Sites – Many deployments in the next year



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

Key Performance Metrics

Reliability
Low Emissions
Low Noise
Ease of Use
Remote Monitoring



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¹) FC system conditioning is an automated operation for regular system checks that are run after long periods of no operation.

FC Material Handling Equipment

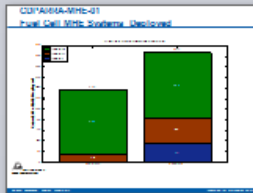
Deployment & Operation Data



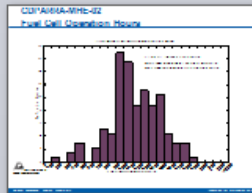
FCMHE Fall 2010 CDPs



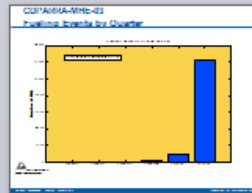
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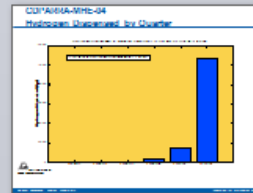
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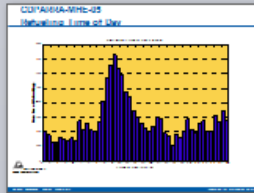
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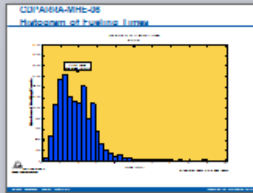
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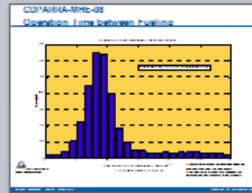
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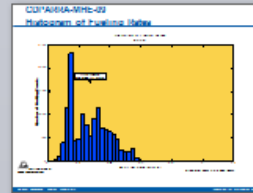
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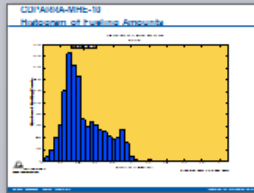
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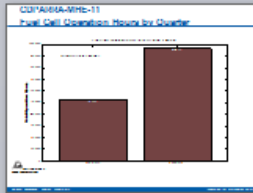
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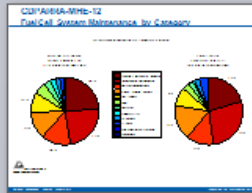
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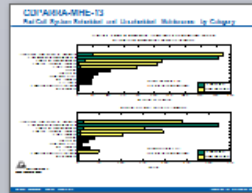
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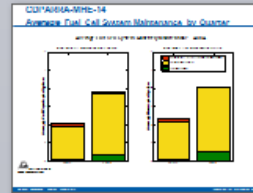
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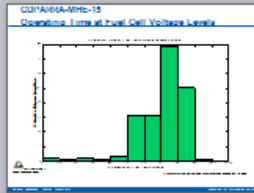
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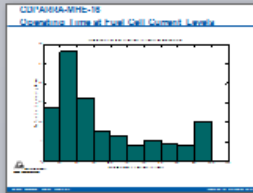
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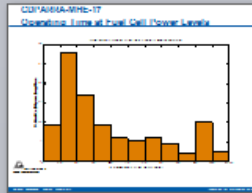
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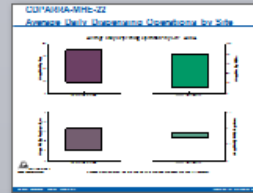
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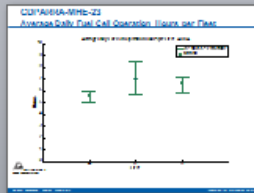
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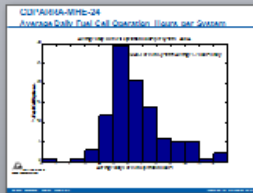
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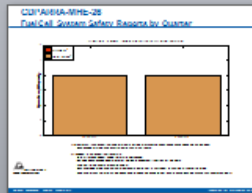
20



21



22



23

Data Files Analyzed
23,307 (1.7GB)

Analysis Topics

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

ARRA FCMHE CDPs

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ARRA & DLA Infrastructure CDPs

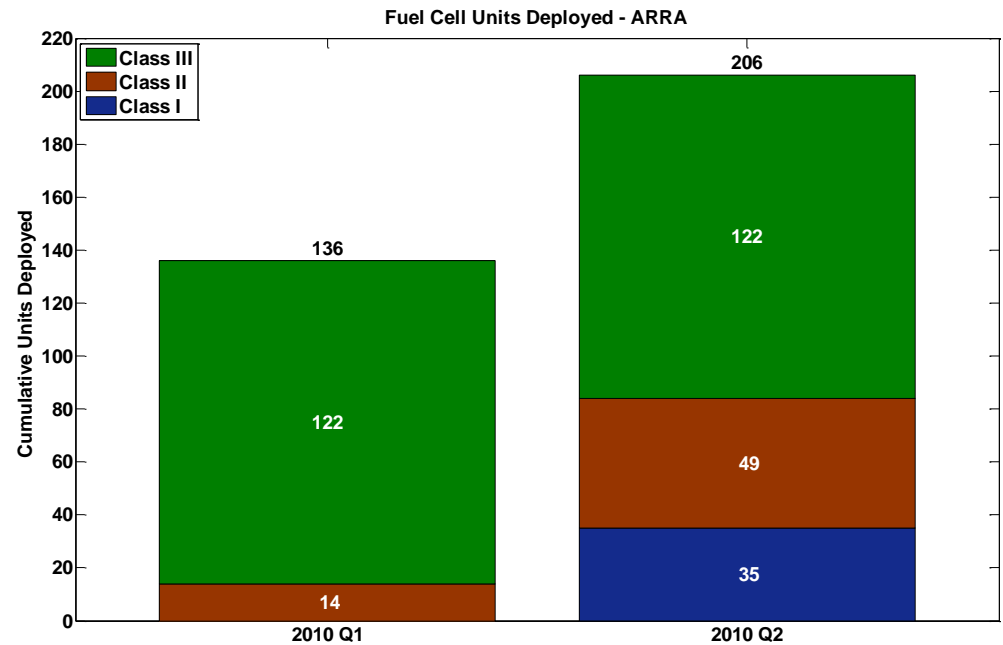
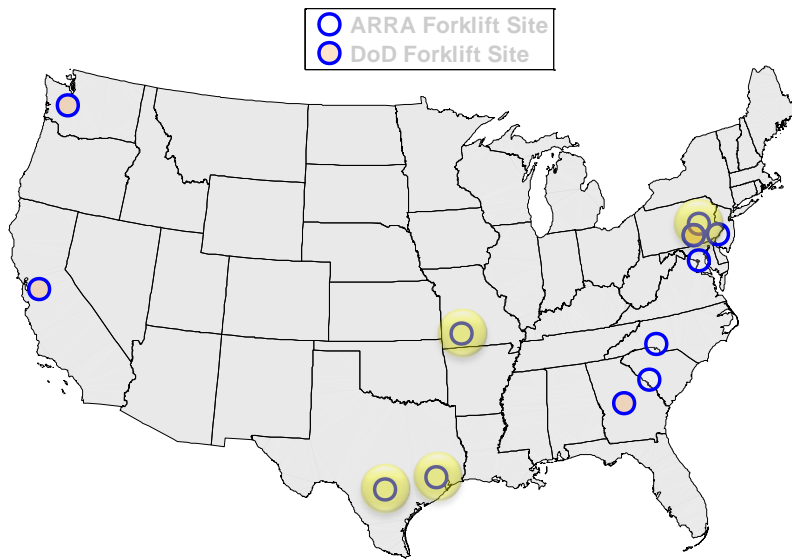
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ARRA FCMHE Units & Sites

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

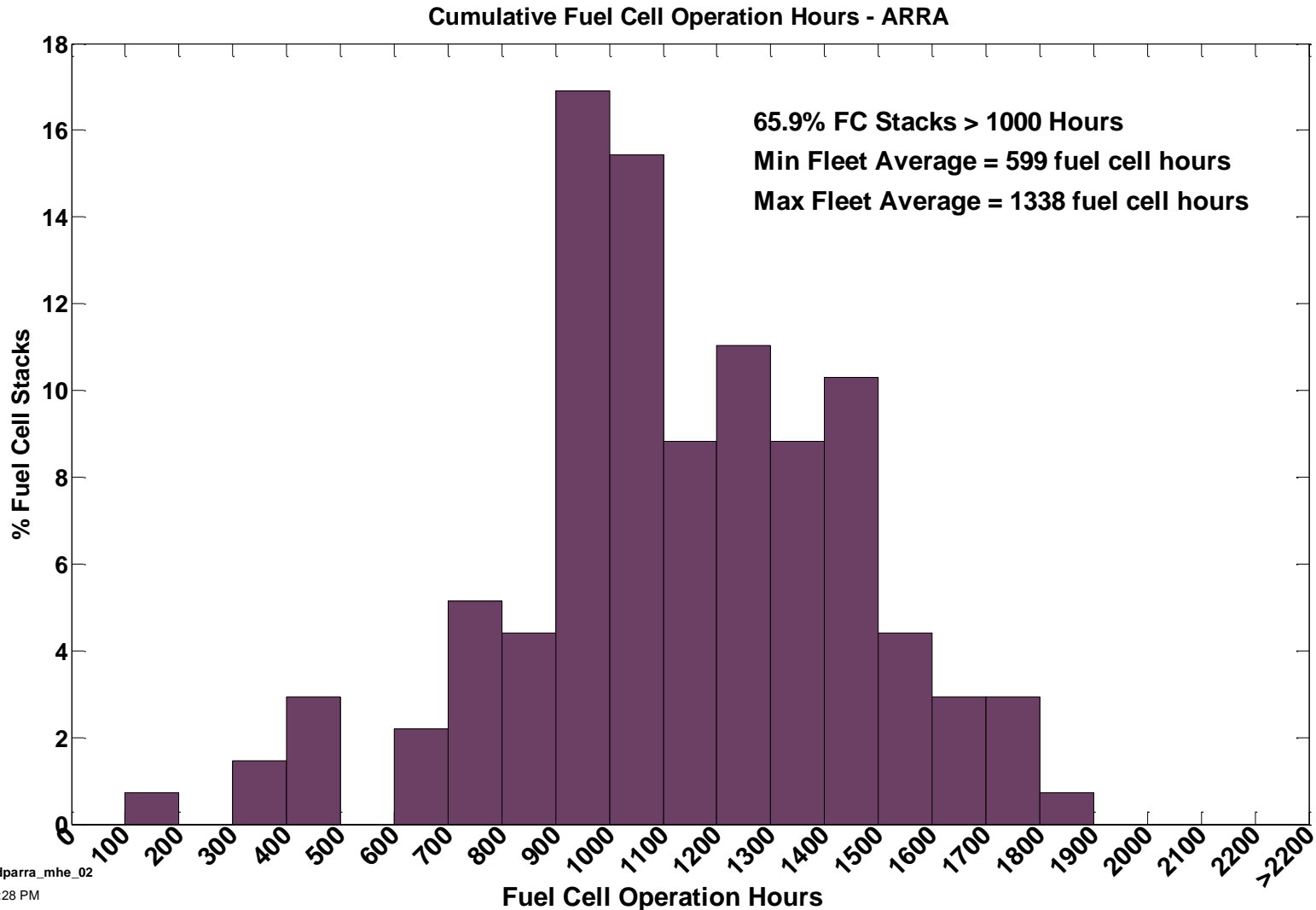


FC Operation Summary – ARRA Sites

149,046

Total Hours Accumulated

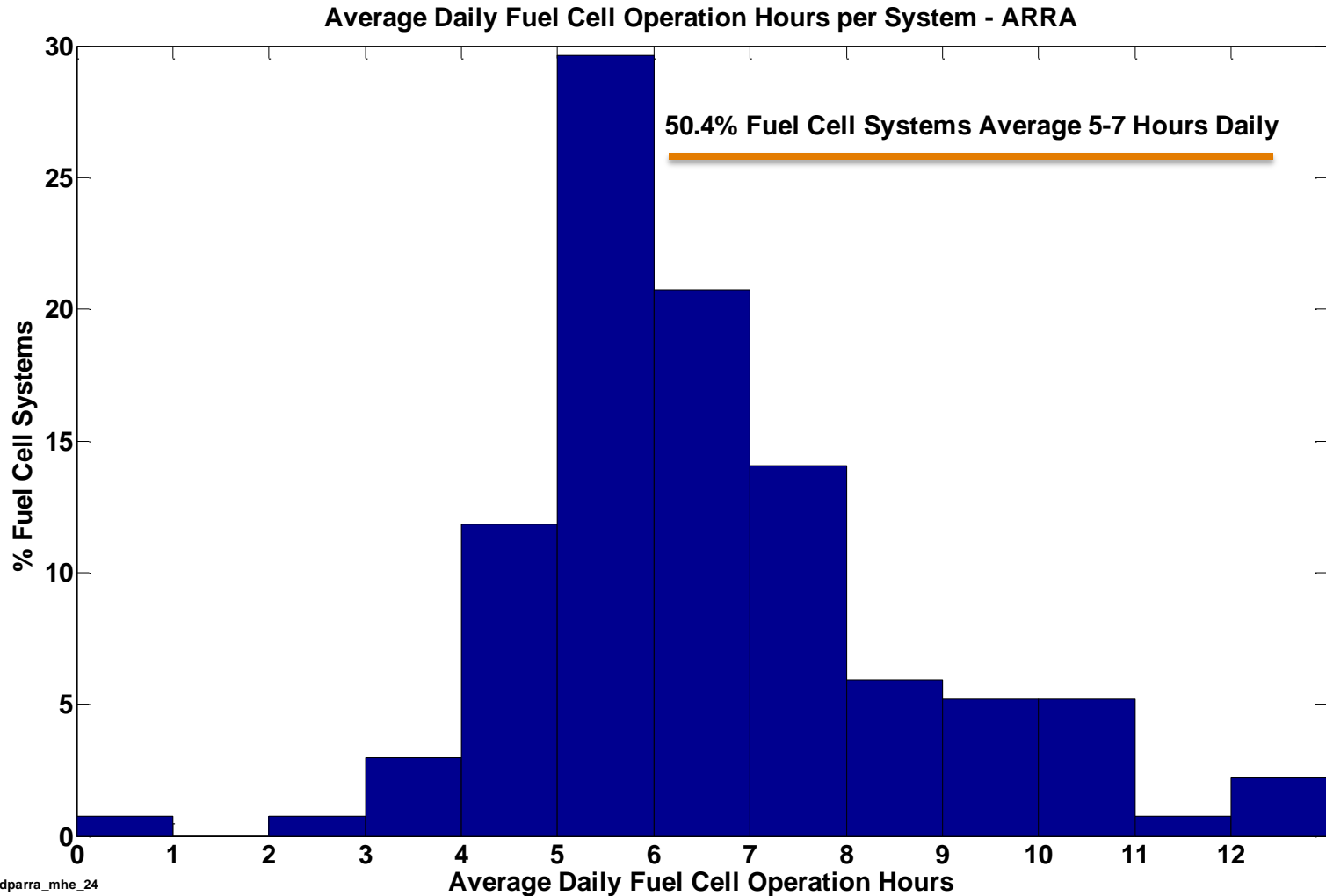
66% FC Stacks > 1000 hours



NREL cdparra_mhe_02

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FC Daily Operation – ARRA Site



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Indoor Hydrogen Fill Events

H₂ Fills

13,329

H₂ Dispensed

6,198 kg

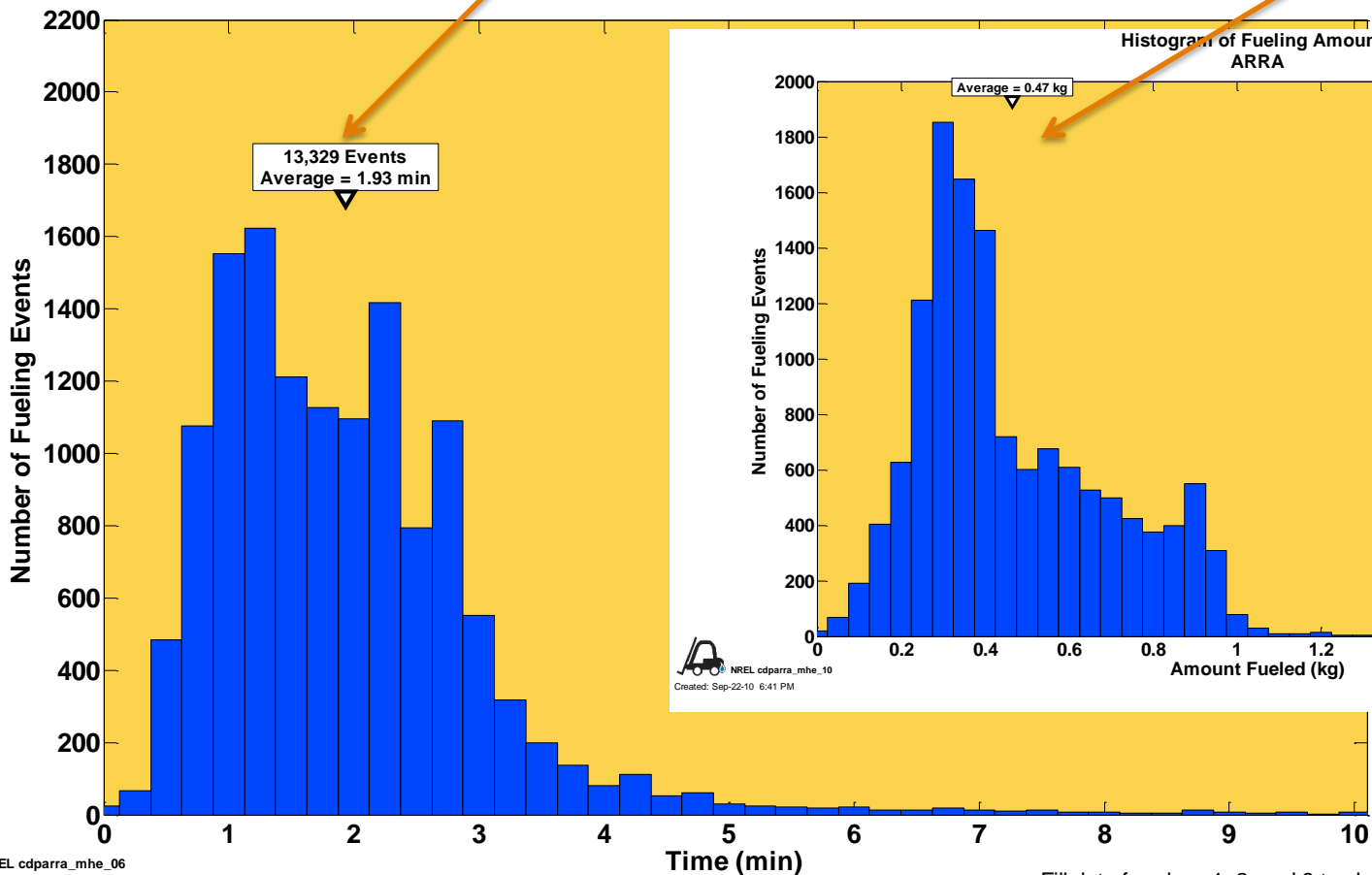
Average Fill Time

1.9 minutes

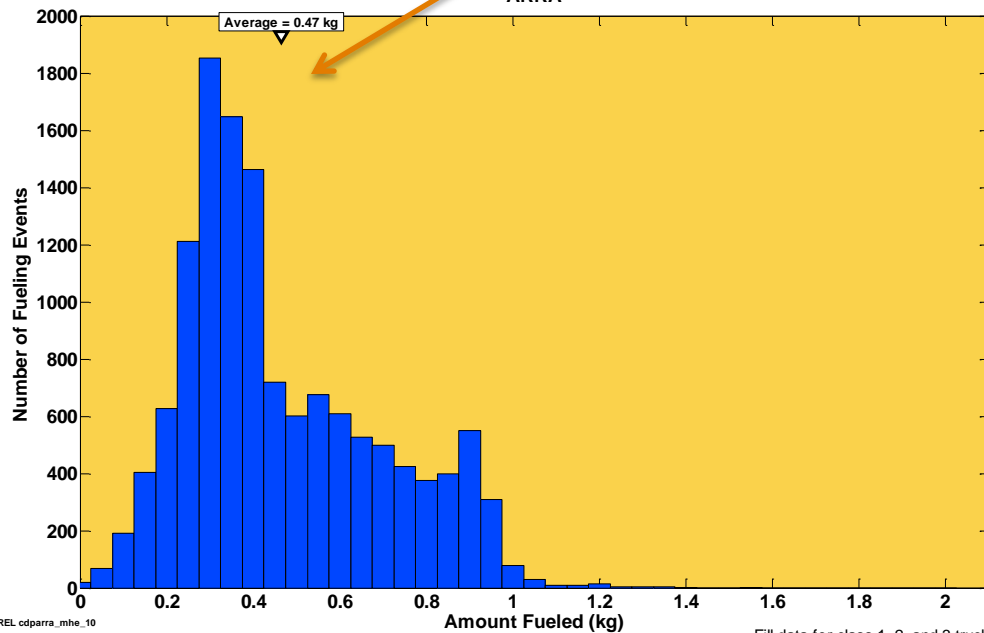
Average Fill Amount

0.47 kg

Histogram of Fueling Times
ARRA



Histogram of Fueling Amounts
ARRA



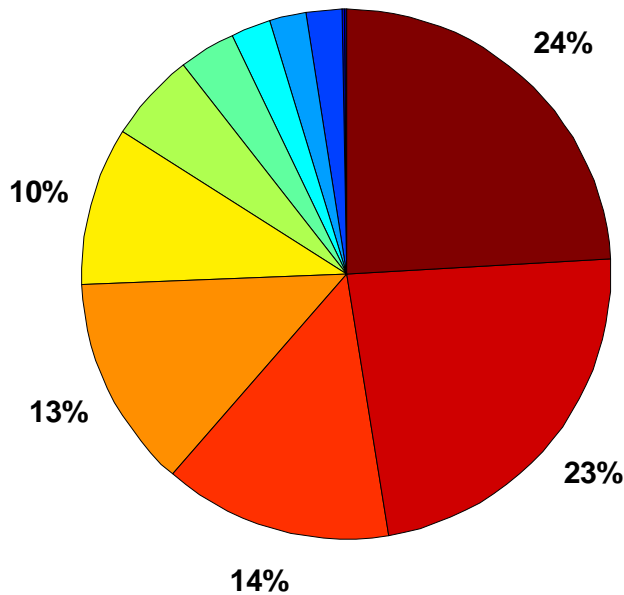
Fill data for class 1, 2, and 3 trucks

Fill data for class 1, 2, and 3 trucks

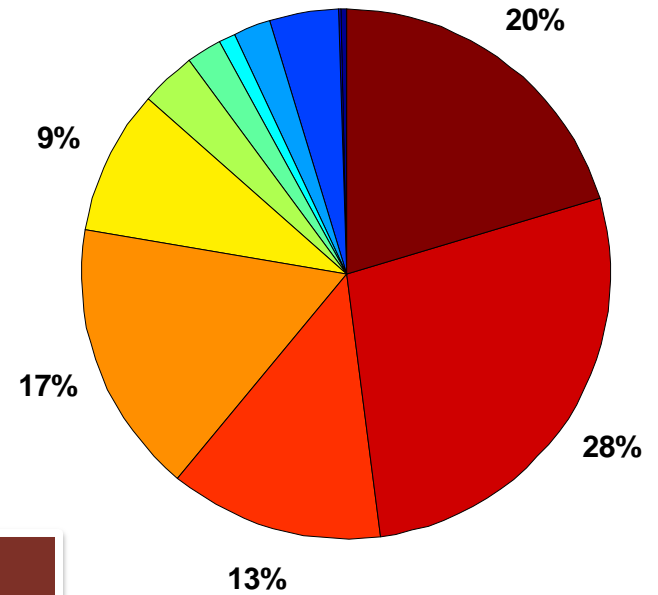
Fuel Cell System Maintenance by Category

Forklift Maintenance By Category - ARRA

Number of Events
Total Events = 789
73% were unscheduled



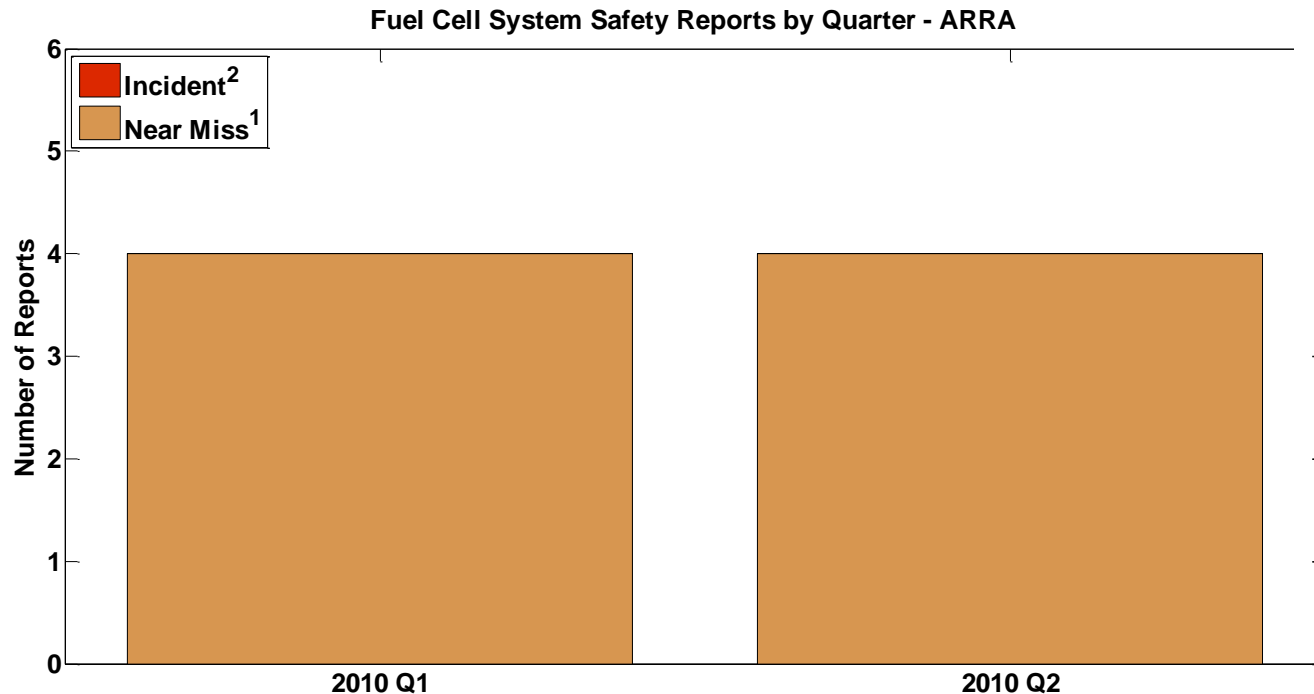
Labor Hours
Total Hours = 1165
69% were unscheduled



**73% Unscheduled
 Maintenance Events**

**38% Events for Controls,
 Electronics, Sensors or
 Thermal Mgmt**

Fuel Cell System Safety Reports by Quarter



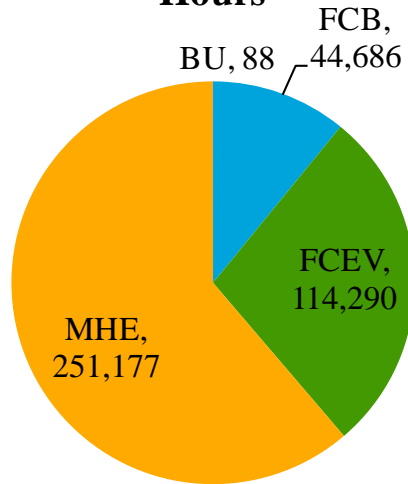
Collaborating with
Codes and
Standards
Activities

- 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
 - release of any volatile, hydrogen containing compound (other than the hydrogen)

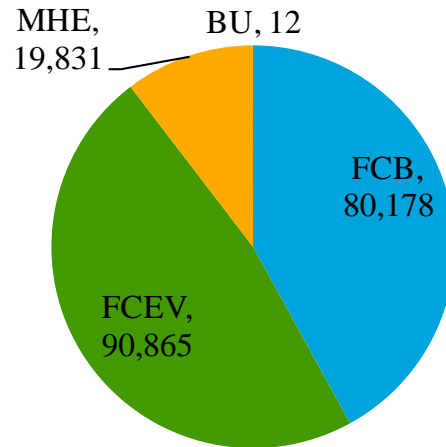
Hydrogen Safety Panel
Review site safety plans
Site Visits
Comprehensive Safety
Evaluation Report

NREL Tech Val Projects – Timeline Highlights

Hours



Hydrogen Amount



>470 FC Systems
>410,000 hours
>190,000 kgs

2004

2005

2006

2007

2008

2009

2010

2011
On-going

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 6-9 months
- Performance based CDPs scheduled for this spring

Contact Information & Website

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

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Innovation for Our Energy Future

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- Fuel Cell Bus Evaluations
- Early Fuel Cell Market Demonstrations

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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.



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.

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	2009-11-06		JPG
Accumulated Forklift Operating Hours	Fuel Cell Usage and Operation Behavior	FL02	2009-11-06		JPG
Forklifts Deployed by Quarter	Fuel Cell Usage and Operation Behavior	FL01	2009-11-06		JPG
Fuel Cell Units Delivered to Site	Fuel Cell Usage and Operation Behavior	ARRA01	2010-02-19		JPG
Fuel Cell Units in Operation—Current and Projected Quantities	Fuel Cell Usage and Operation Behavior	ARRA02	2010-02-19		JPG

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