NREL
NATIONAL RENEWABLE ENERGY LABORATORY

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December 2010

National Renewable Energy Laboratory's Technology Validation Activities

J. Kurtz, K. Wipke, L. Eudy, S. Sprik, T. Ramsden, C. Ainscough, G. Saur

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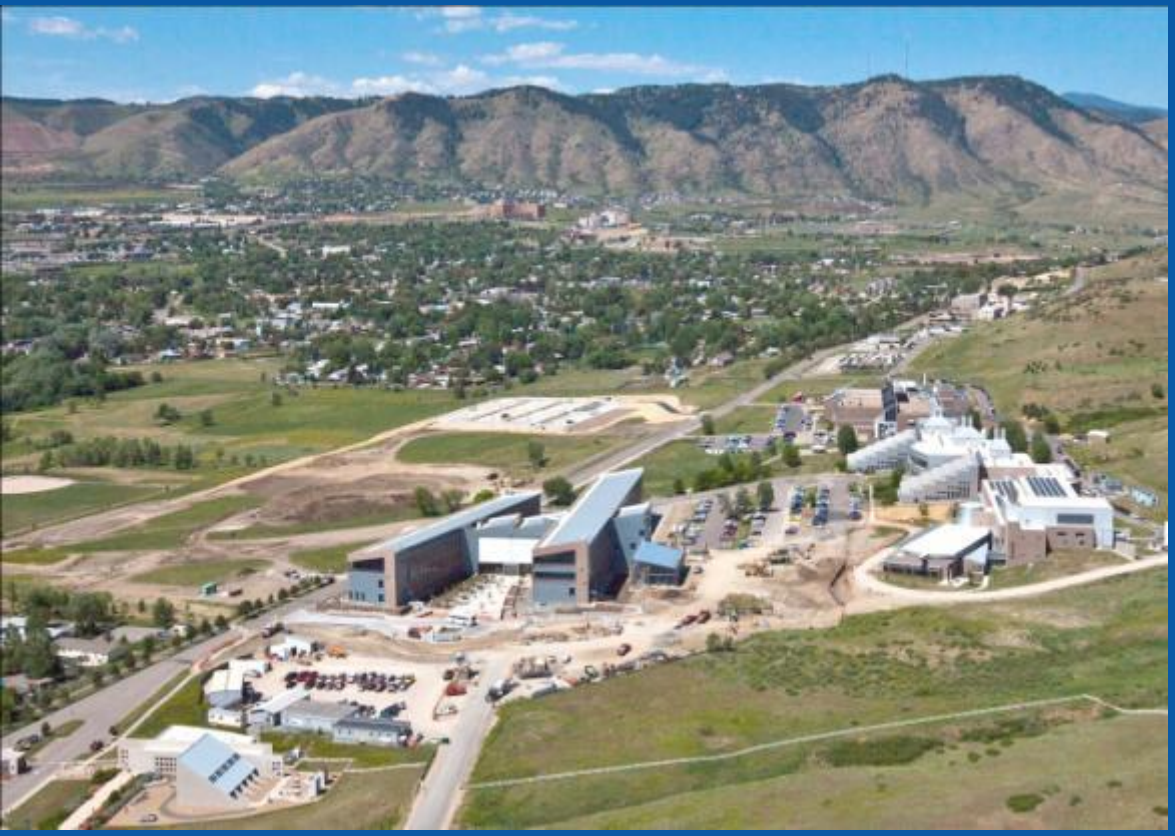
National Renewable Energy Laboratory's Technology Validation Activities



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December 10th 2010

FCHEA Winter Meeting

Contents

NREL Tech Val – Who We Are, What We Do

Within NREL's **Hydrogen Technologies and Systems Center** the **Technology Validation** group works on third party assessment and validation of operation targets and system performance under realistic operating conditions.

HSDC

NREL's Hydrogen Secure Data Center

- ✓ ***Real World Operation Data***
  from the Field and State of the Art Lab
- ✓ ***Collection***
- ✓ ***Analysis***
- ✓ ***Collaboration***
- ✓ ***Reporting***

NREL Tech Val – Capabilities

NREL's Team

Sam Sprik, Chris Ainscough, Jennifer Kurtz, Keith Wipke, Leslie Eudy, Todd Ramsden, & Genevieve Saur *(not pictured)*

Fleet Analysis Toolkit

Real World Data Analysis

Facility

HSDC

NREL's Hydrogen Secure Data Center

Reporting

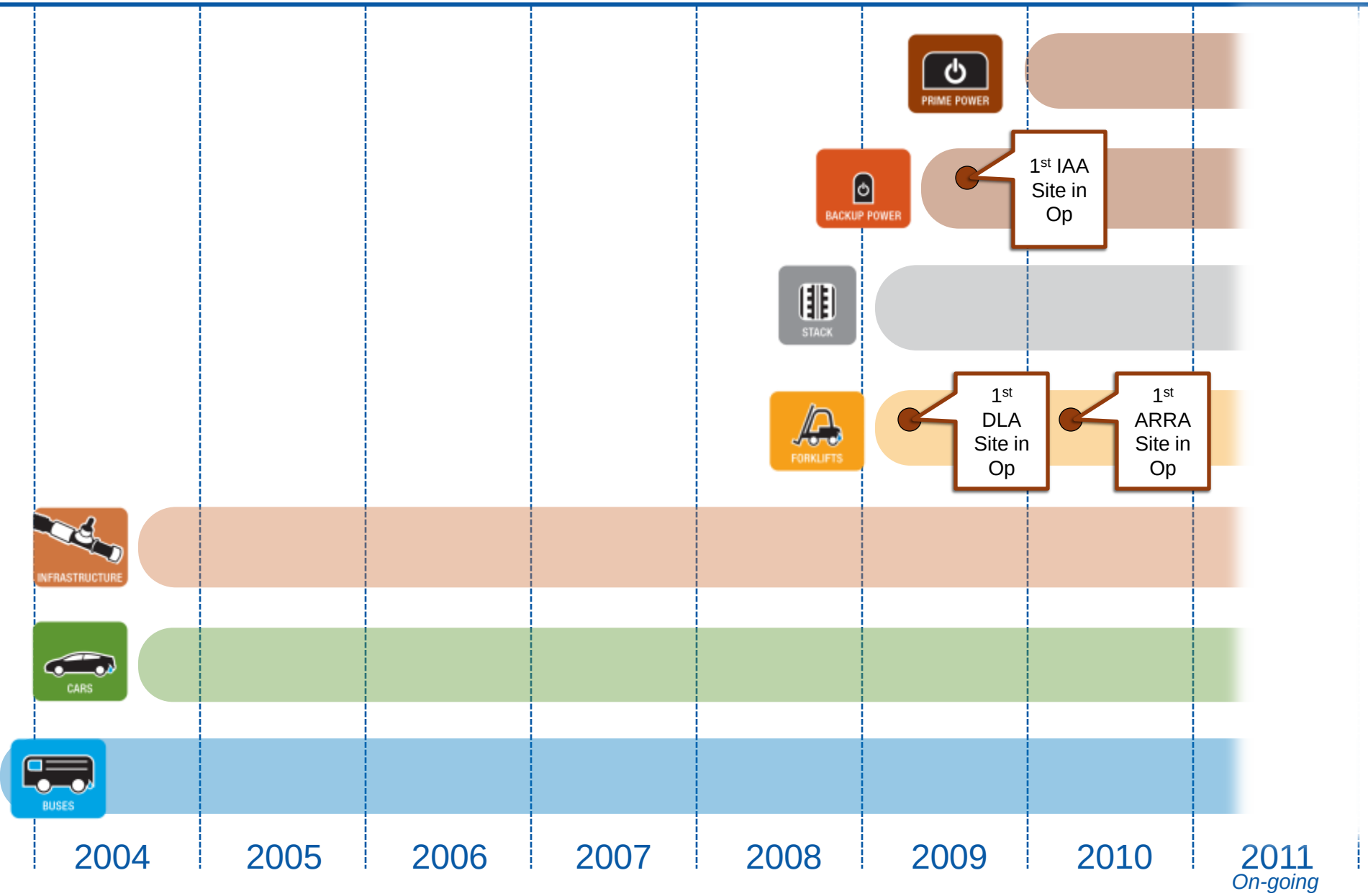
Results

DDPs

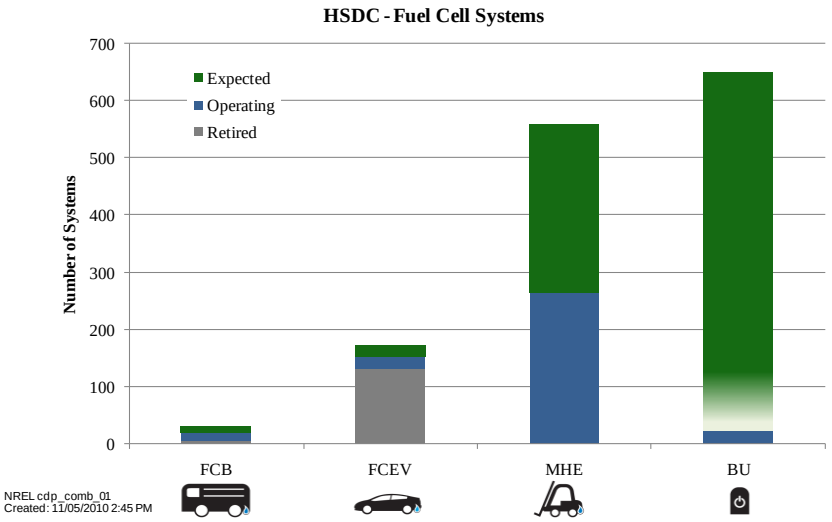
Partner Collaboration

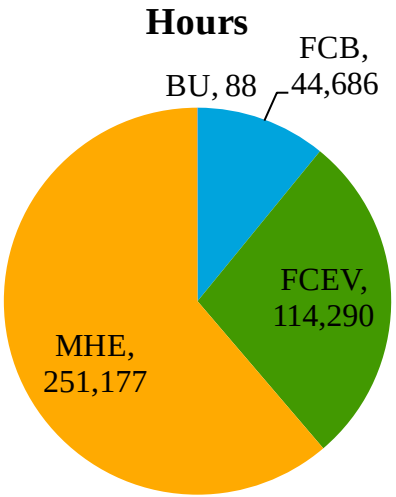
CDPs

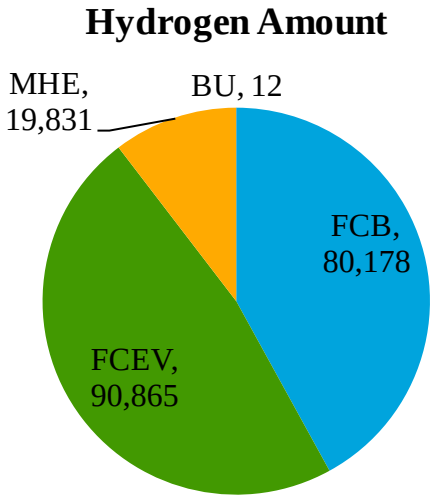
NREL Tech Val Projects – Timeline Highlights

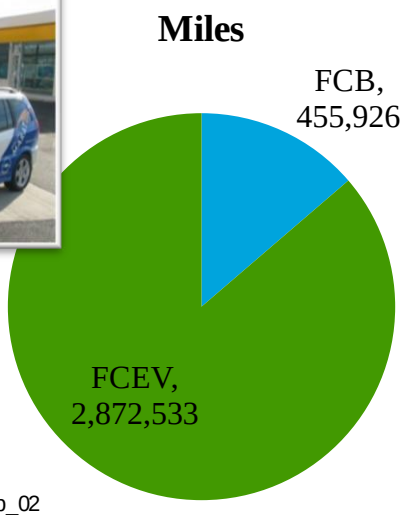


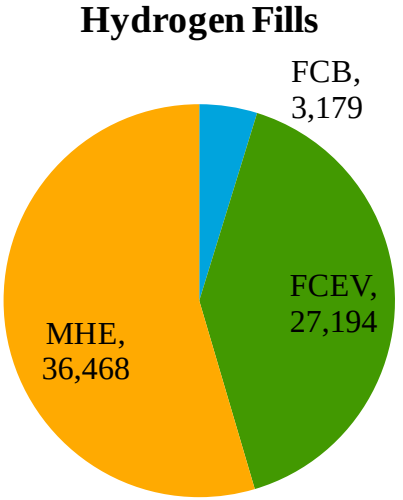
Demonstrations are essential for validating the performance of technologies in integrated systems, under real-world conditions.











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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

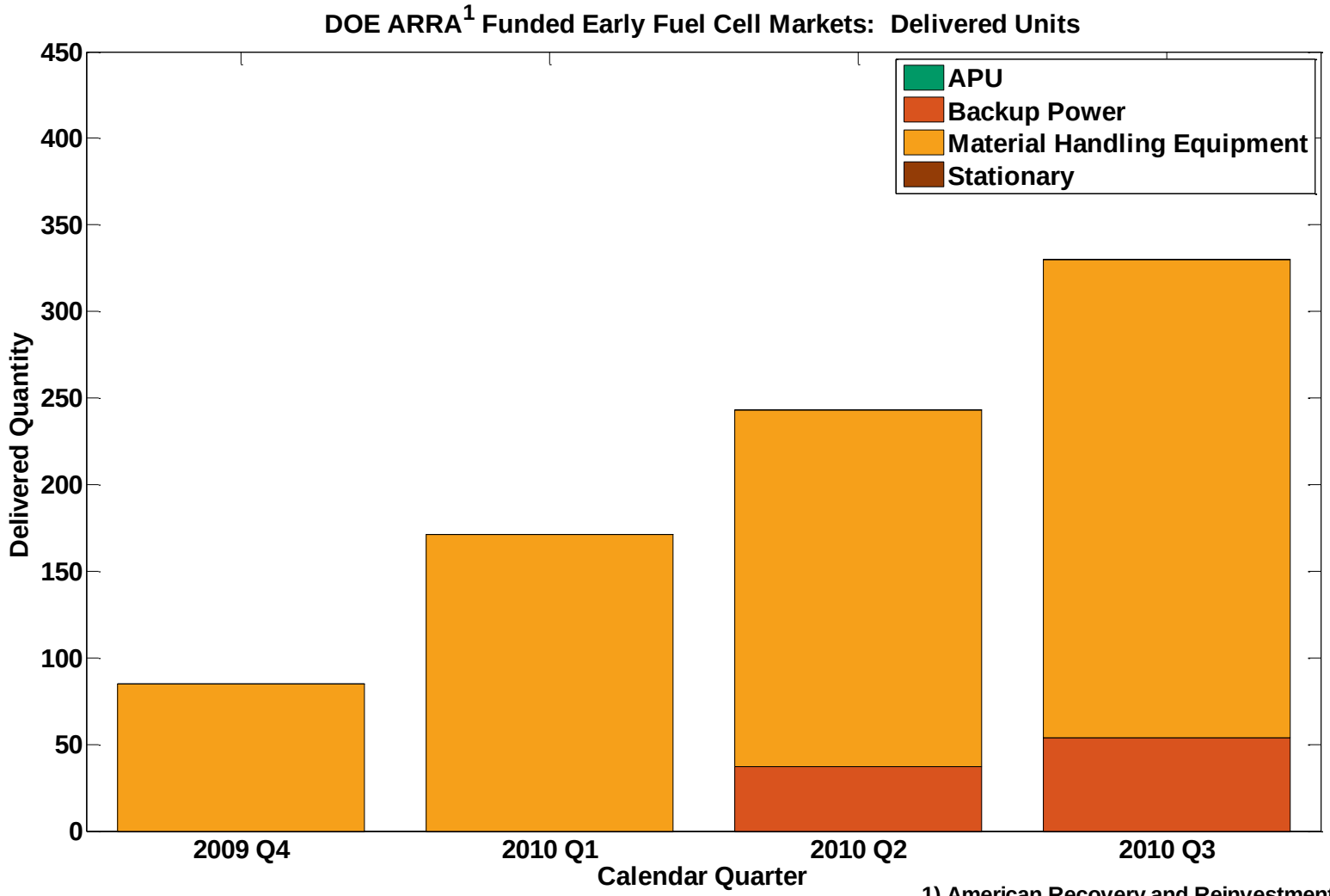
Accelerate the commercialization of fuel cells, manufacturing, installation, maintenance, and support service through 12 awards

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

ARRA Delivered Fuel Cell Units



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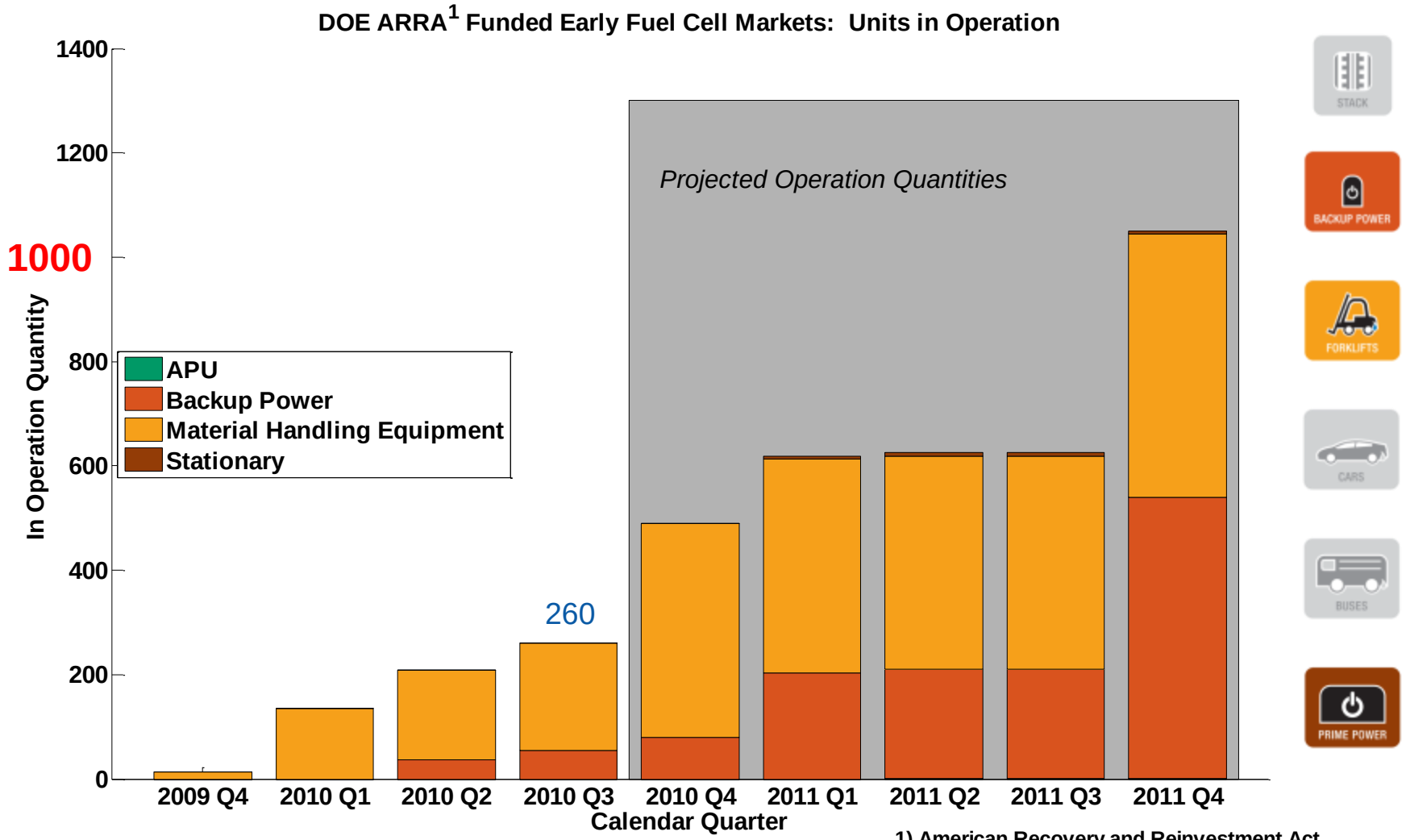
1) American Recovery and Reinvestment Act

ARRA Fuel Cell Units in Operation
Current and Projected Quantities



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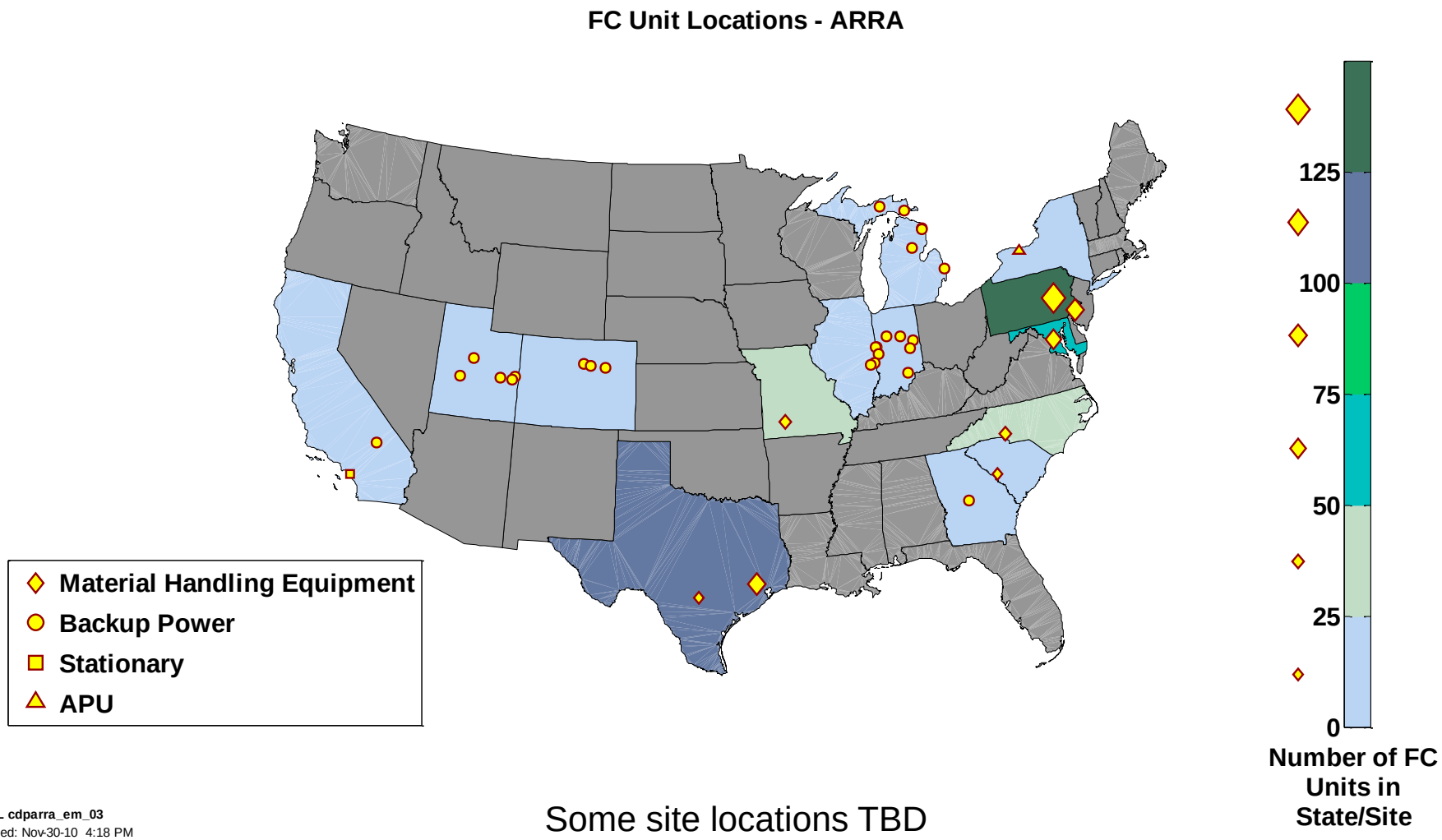
1) American Recovery and Reinvestment Act

ARRA Early Fuel Cell Market Deployment Sites



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Some site locations TBD
Some site location not yet in operation

FC Backup Power

Deployment & Operation Data

High level summary of operation

First cycle of CDPs (IA A & ARRA Sites)

Trends still developing

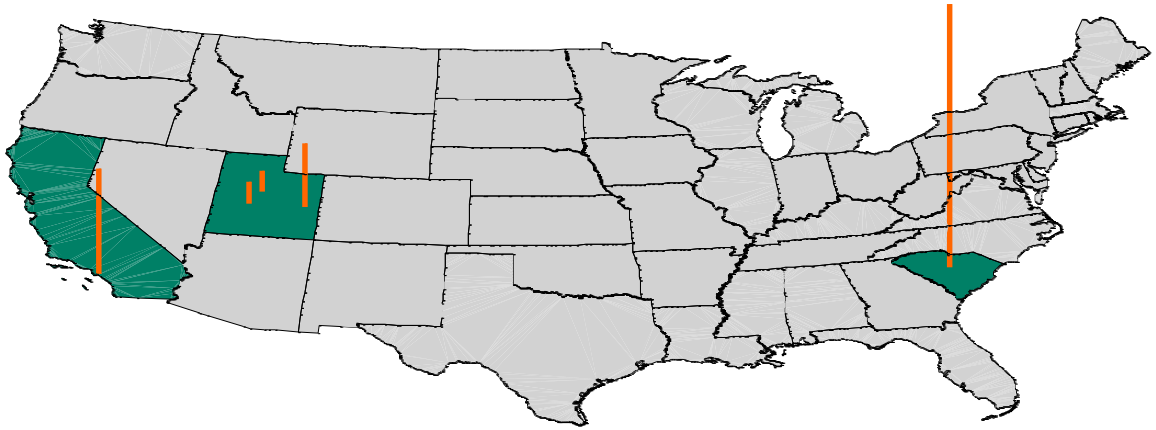
Many additional analyses planned for future CDP cycles

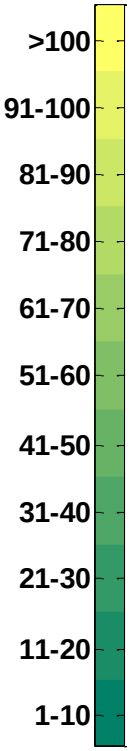
Backup Power Sites

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





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Site Capacity (line height proporational to installed site kW capacity)

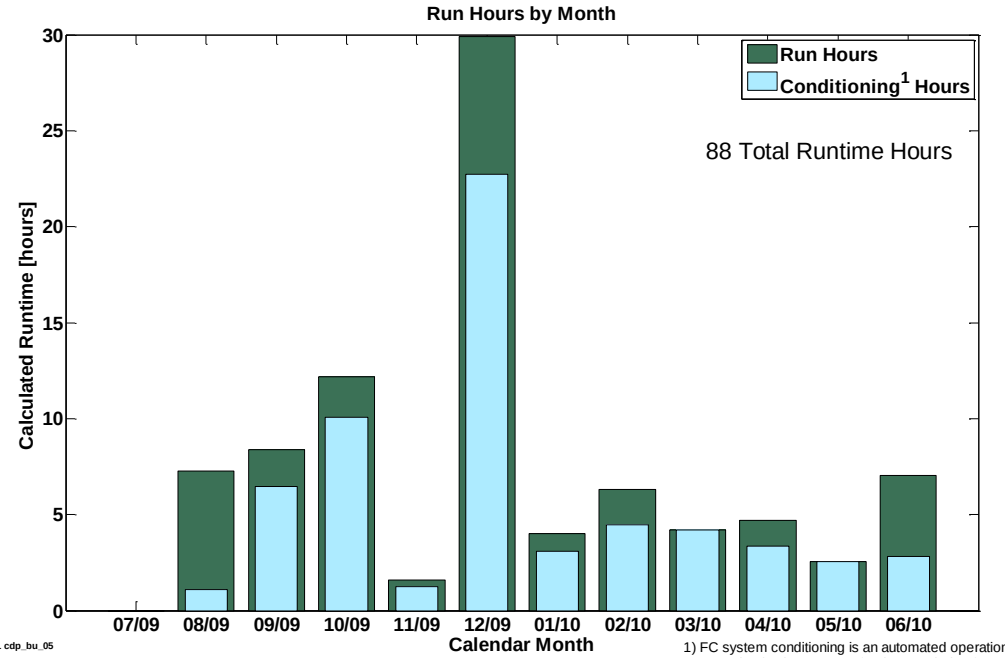
Backup Power Sites – Many deployments in the next year

BACKUP POWER

Total Starts *(Thru June 2010)*	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

High level summary of operation

First cycle of CDPs

Trends still developing

Many additional analyses planned for future CDP cycles

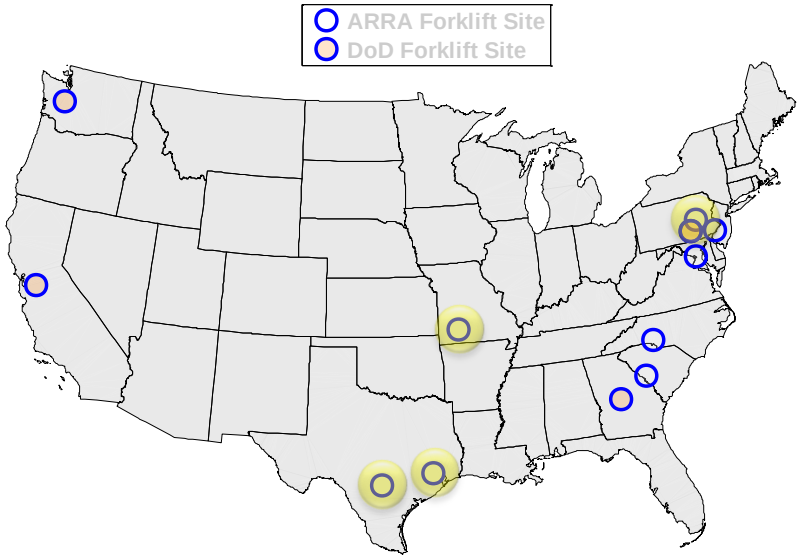
FCMHE – End User facilities, accumulating high hours and fills safely and already showing productivity gains

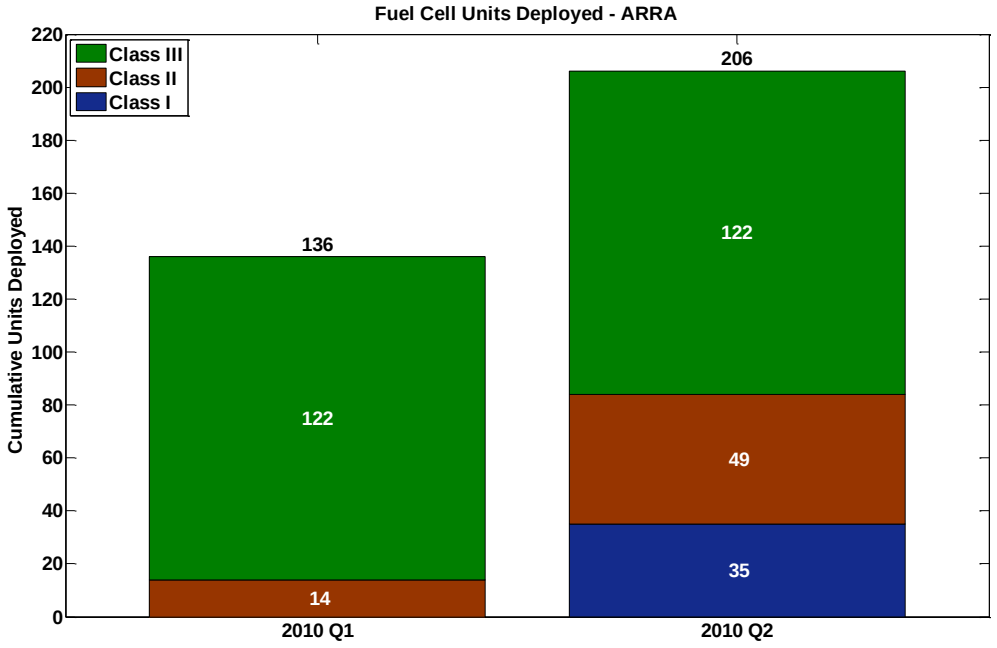
6 (ARRA & DLA)	Sites*
266	Units in Operation
251,177	Hours Accumulated
19,831	kg Hydrogen Dispensed
36,468	Hydrogen Fills
0.5 – 0.6 kg/fill	Average Fill Amount
1.9 – 3.4 min/fill	Average Fill Time

*Through June 2010

ARRA FCMHE Units & Sites

Sites			4	
Operational MHE Units/Site	14	35	59	98
Operating Shifts/Site	2 9 hrs	3 8 hrs	2 8-10 hrs	2 9 hrs
Facility Square Footage (1,000)	1,000	75	90	580
FC Units/MHE Unit	1.0	1.0	1.0	1.0





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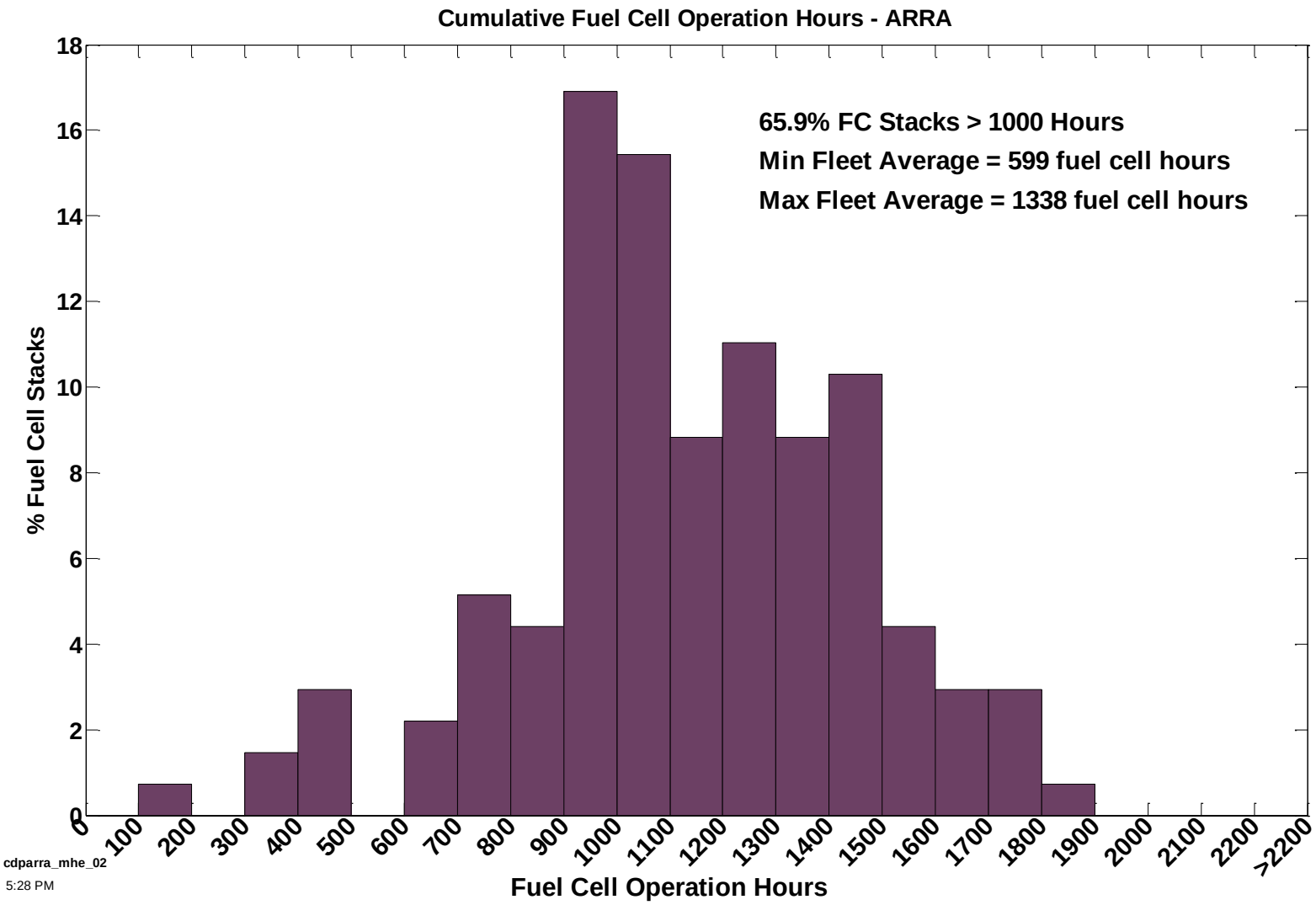
FC Operation Summary – ARRA Sites

149,046 Total Hours Accumulated **66% FC Stacks > 1000 hours**



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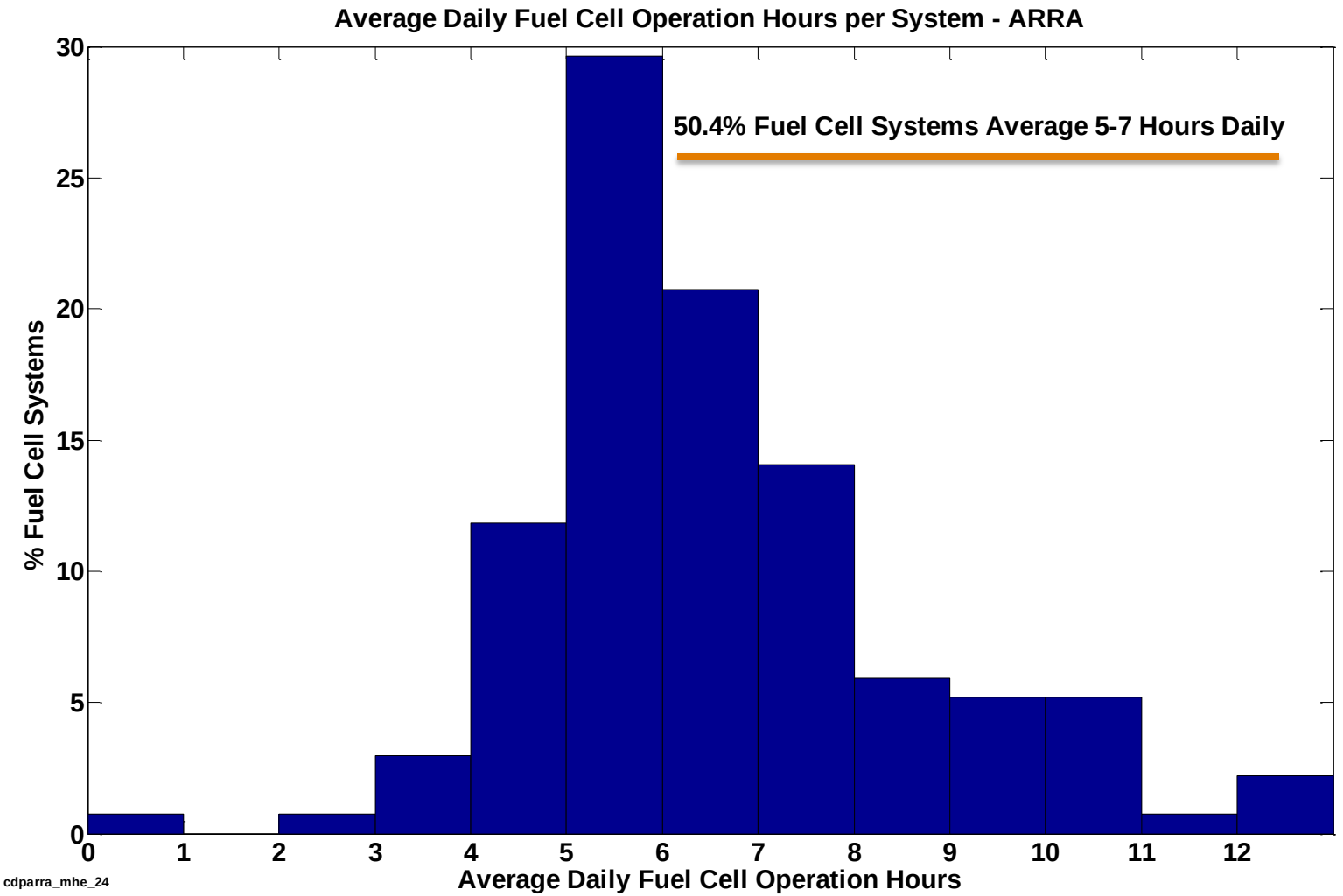
FC Daily Operation – ARRA Site



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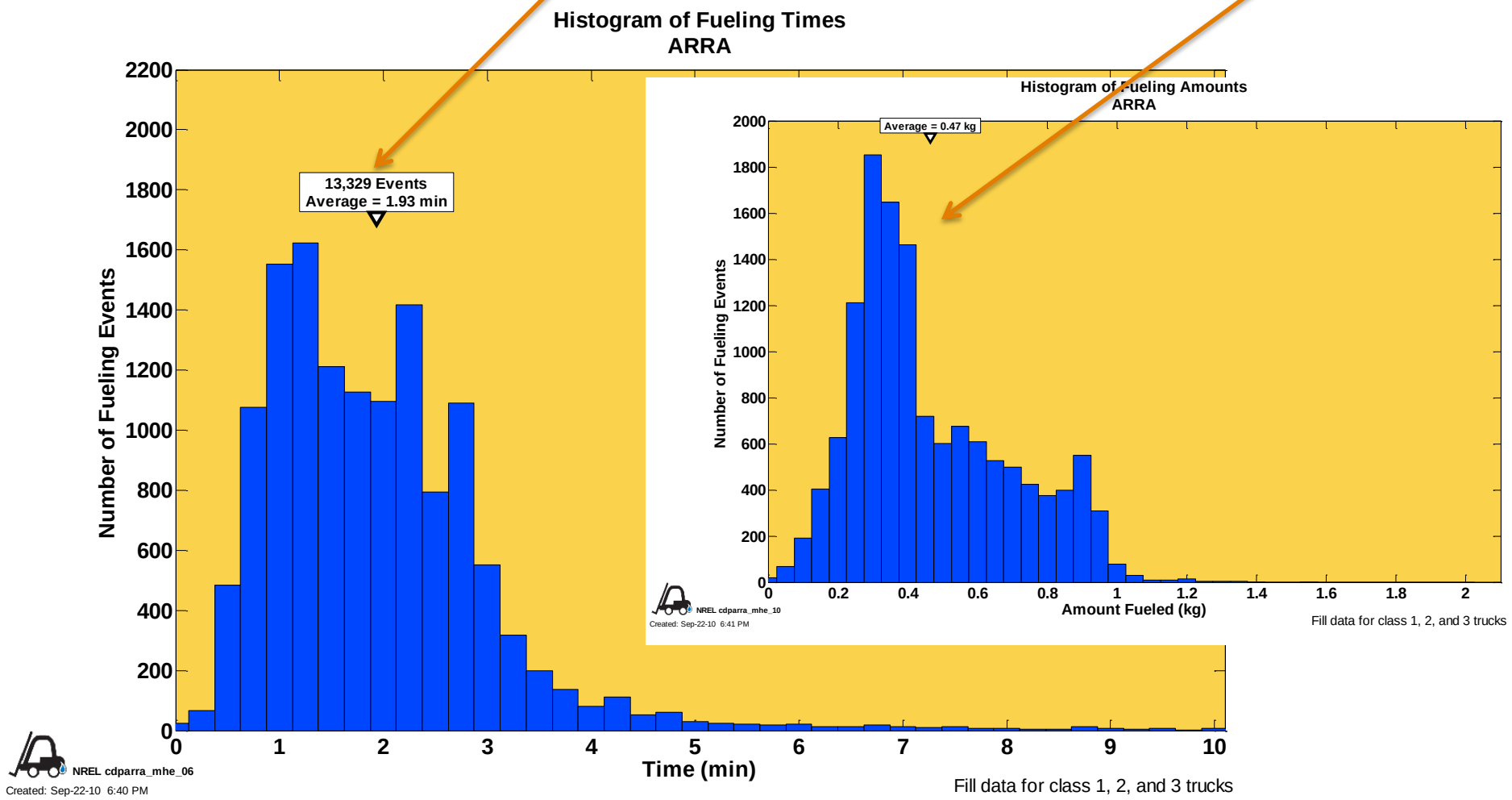
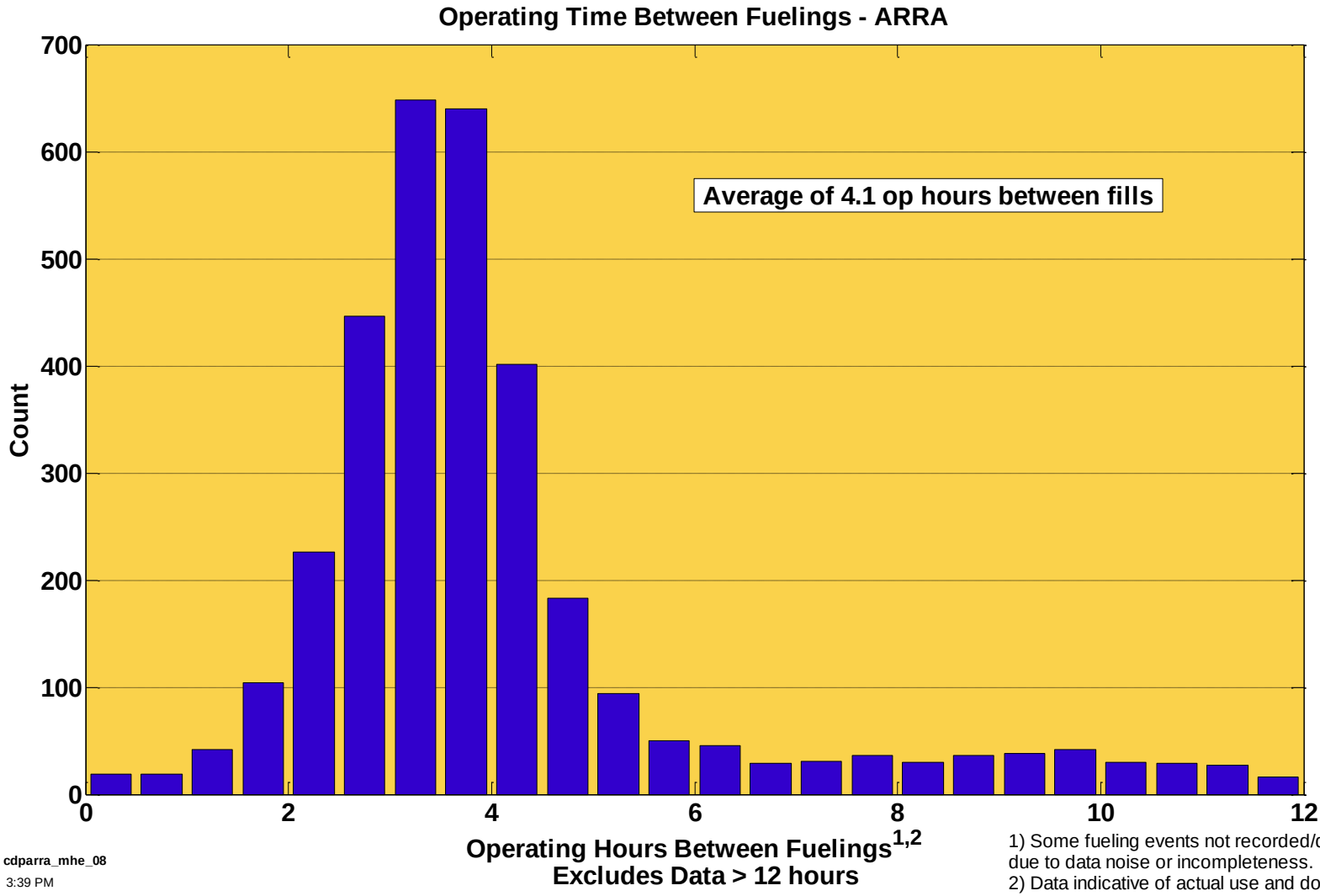
Indoor Hydrogen Fill Events

H_2 Fills	13,329	H_2 Dispensed	6,198 kg
Average Fill Time	1.9 minutes	Average Fill Time	0.47 kg



Operation Time between Fueling



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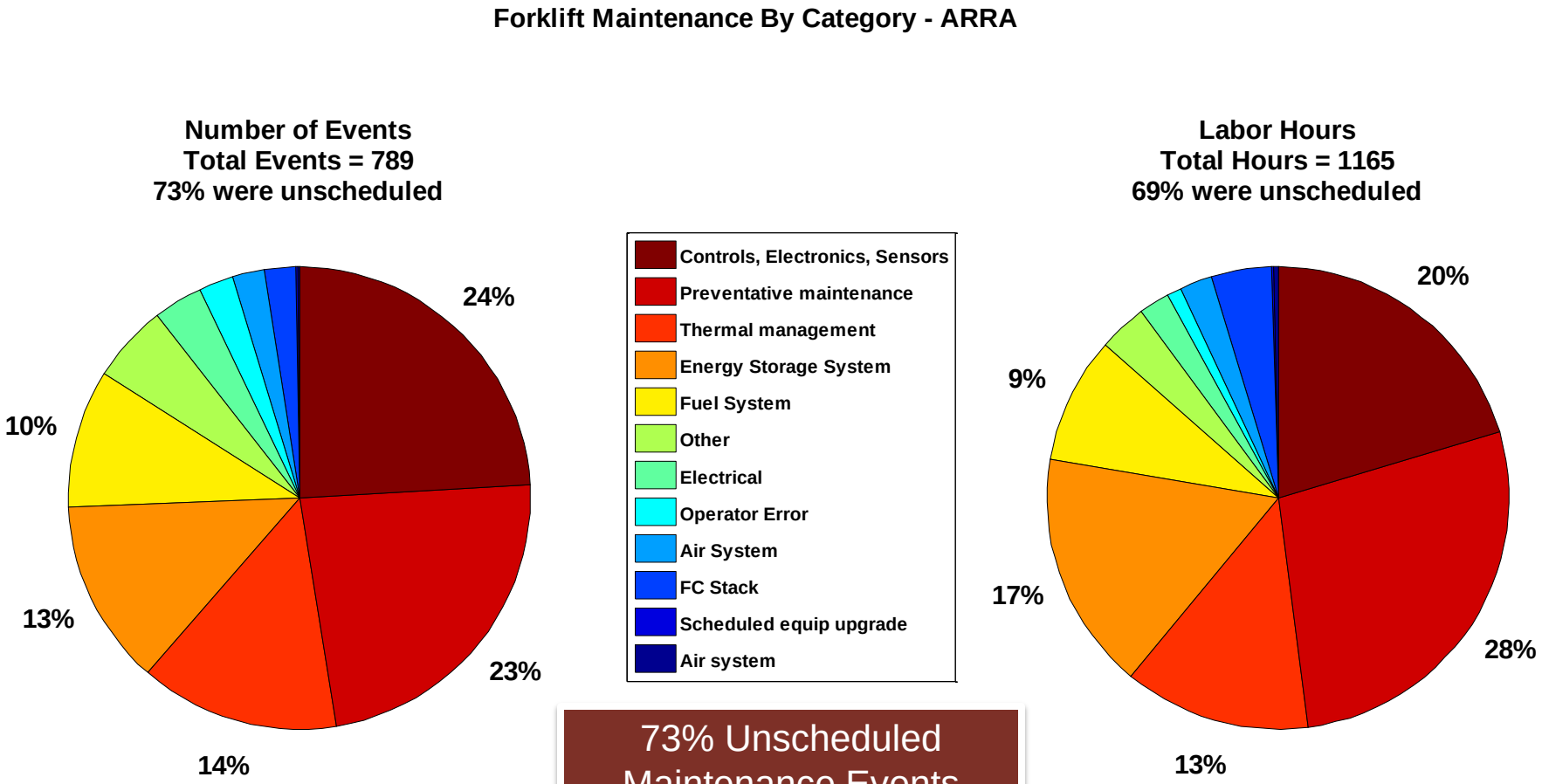
1) Some fueling events not recorded/detected due to data noise or incompleteness.
2) Data indicative of actual use and does not represent the max capability of the systems.

Fuel Cell System Maintenance by Category



73% Unscheduled Maintenance Events

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

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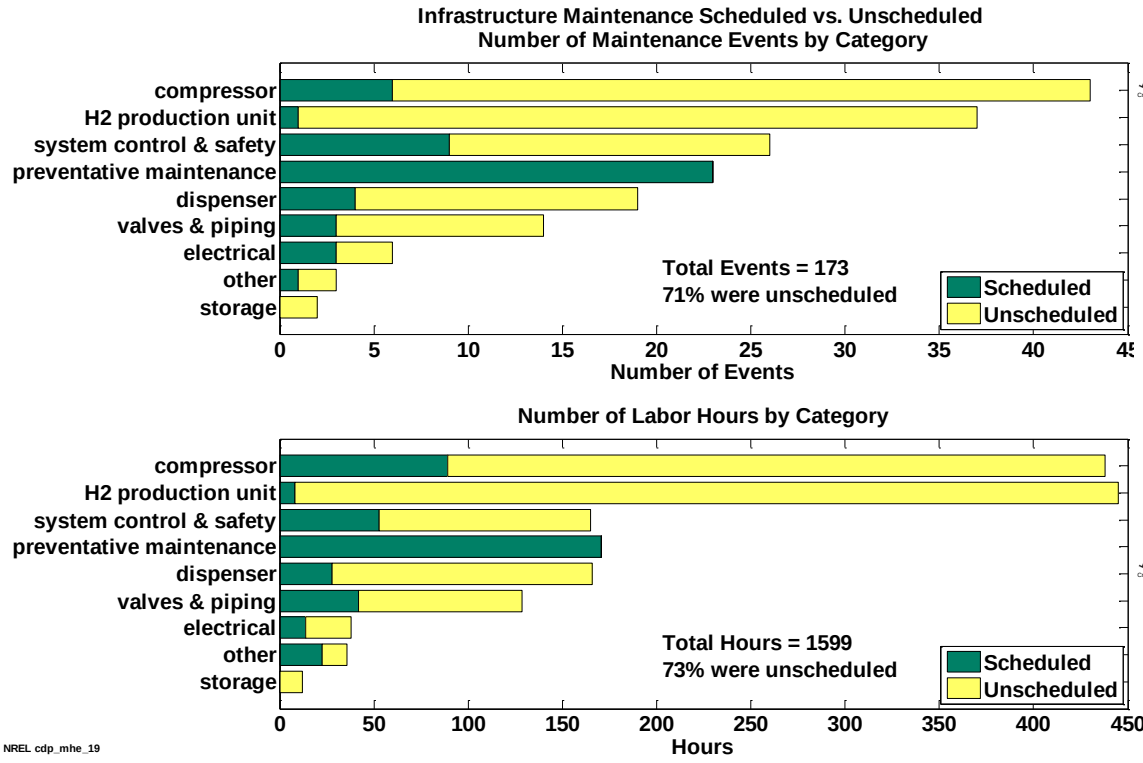
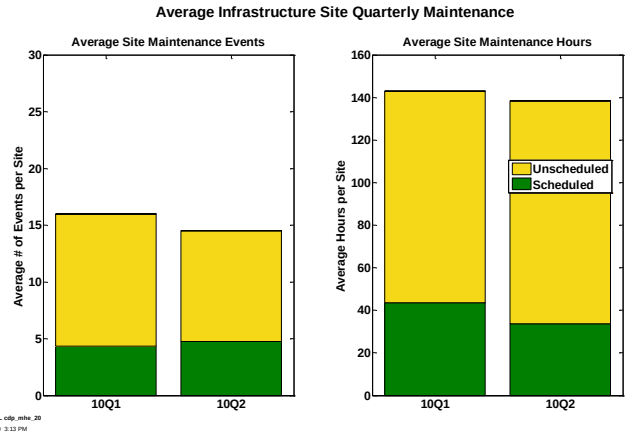
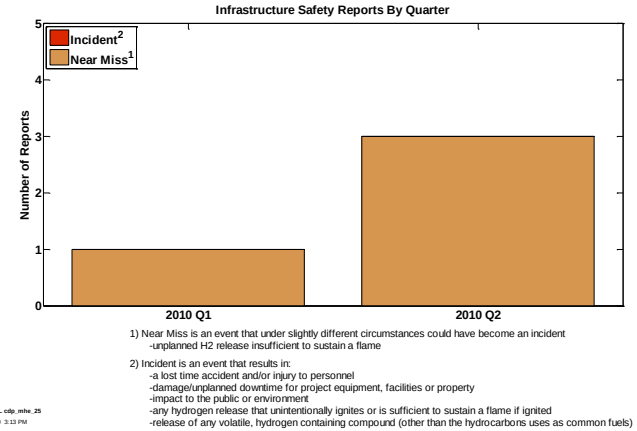
Infrastructure Maintenance

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







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)

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ARRA & DLA Sites Combined

Summary

- NREL's technology validation team provides third party validation of demonstrations, focusing on target validation, real world operation, performance status, and collaboration
- 206 ARRA FCMHE 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 FCBU 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

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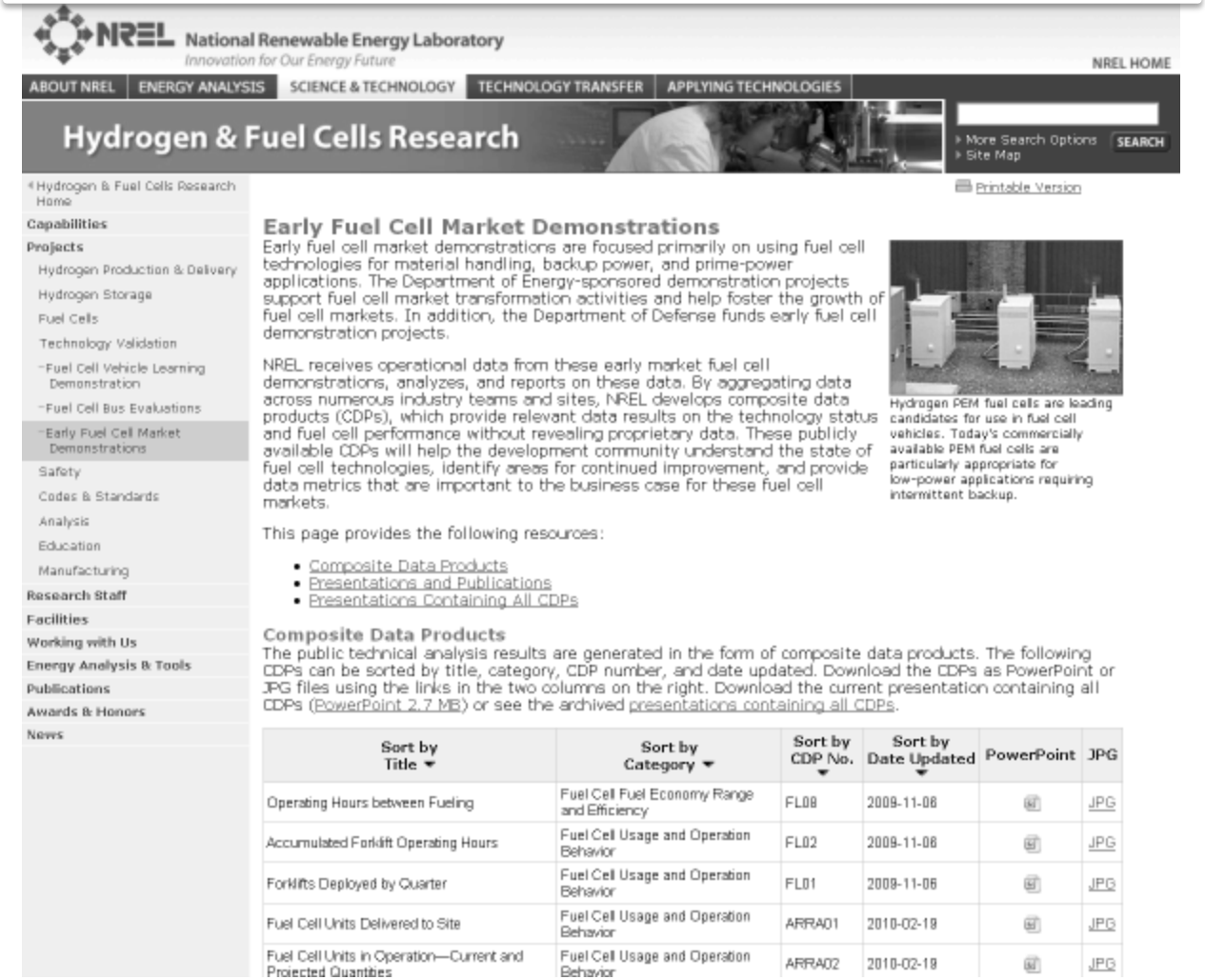
HSDC
NREL's Hydrogen Secure Data Center

FC STACK
FC BACKUP POWER
FC FORKLIFTS
FC CARS
FC BUSES
FC PRIME POWER

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



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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.

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.

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	2009-11-06		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