NREL
NATIONAL RENEWABLE ENERGY LABORATORY

ARRA Fuel Cell Deployment and Operation

FC Seminar

COM34-4

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Contents

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

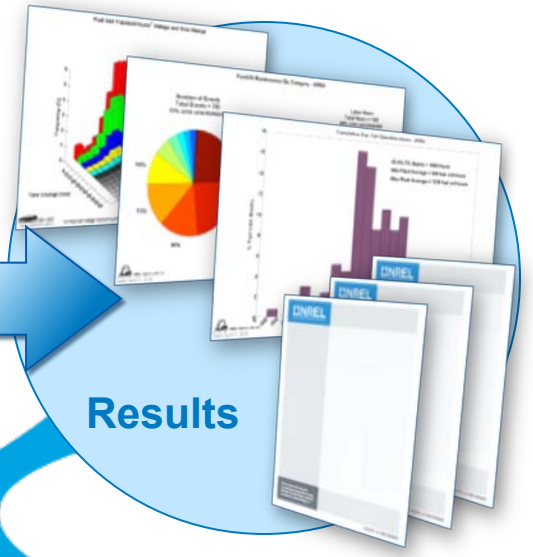
HSDC Data Flow

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

Internal analysis completed quarterly

HSDC

NREL's Hydrogen Secure Data Center



DDPs

CDPs

Detailed Data Products (DDPs)
- Individual data analyses
- Identify individual contribution to CDPs
- Only shared with partner who supplied data every 6 months[1]

Composite Data Products (CDPs)
- Aggregated data across multiple systems, sites, and teams
- Publish analysis results without revealing proprietary data every 6 months[2]

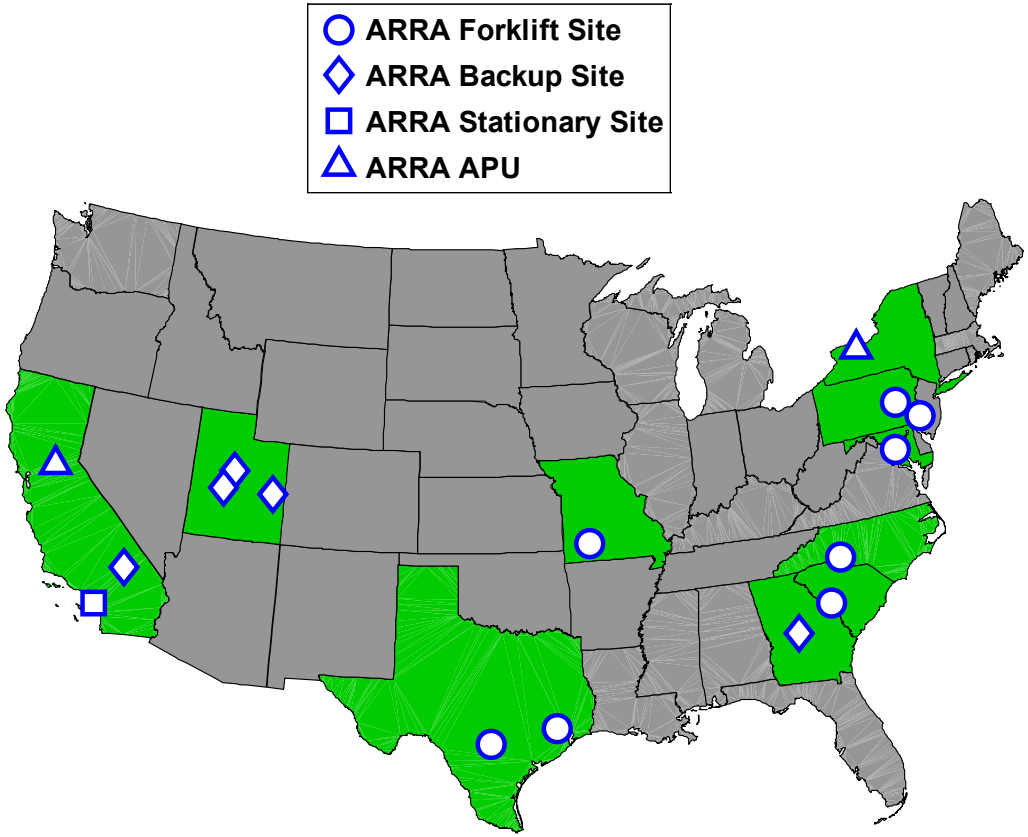
1) Data exchange may happen more frequently based on data, analysis, & collaboration

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

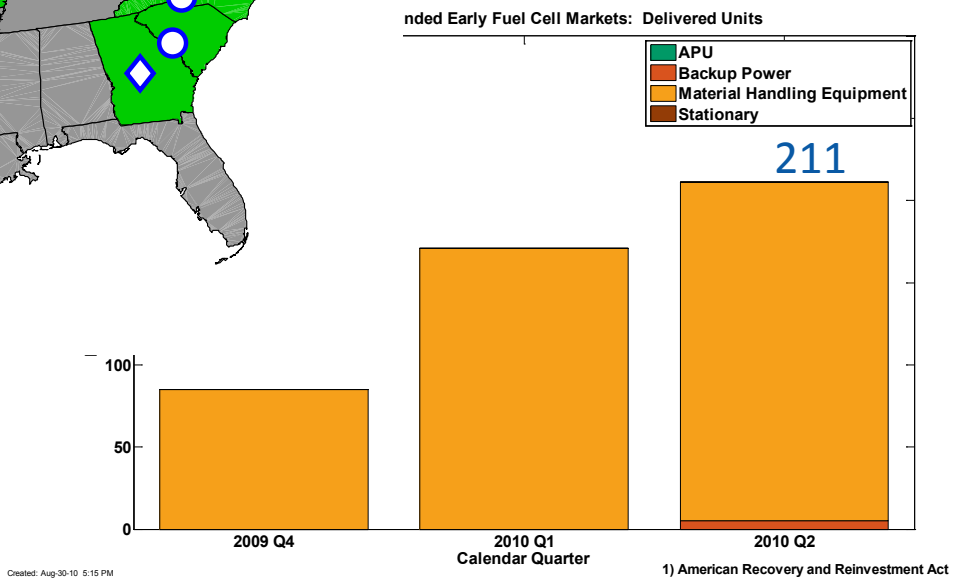
NREL Data Analysis Objectives – ARRA Demonstrations

- 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**

Delivered Fuel Cell Units & Deployment Sites



Some site locations TBD



STACK

BACKUP POWER

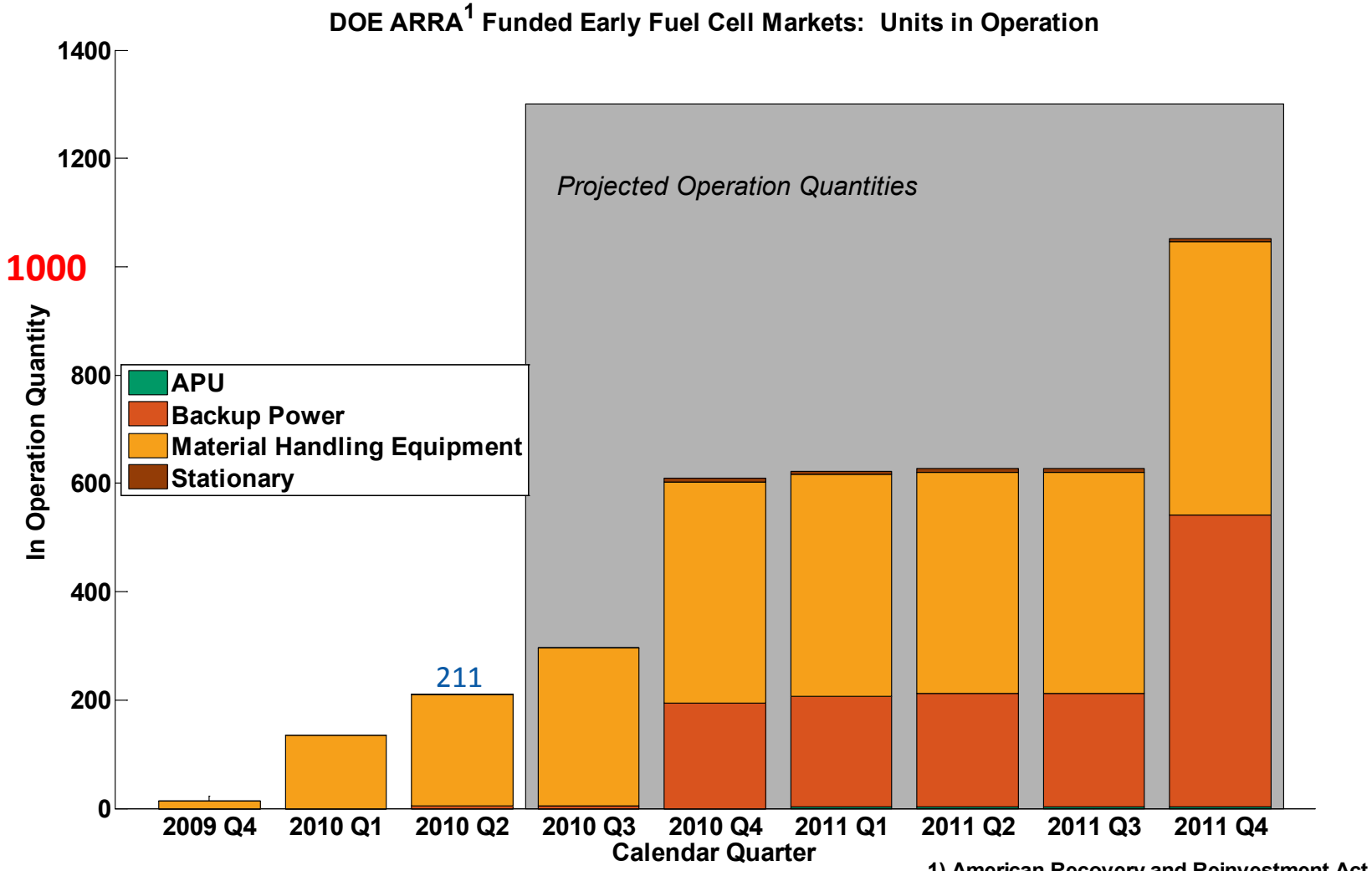
FORKLIFTS

CARS

BUSES

PRIME POWER

Fuel Cell Units in Operation
Current and Projected Quantities



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1) American Recovery and Reinvestment Act

FC Backup Power

Deployment & Operation Data

High level summary of operation

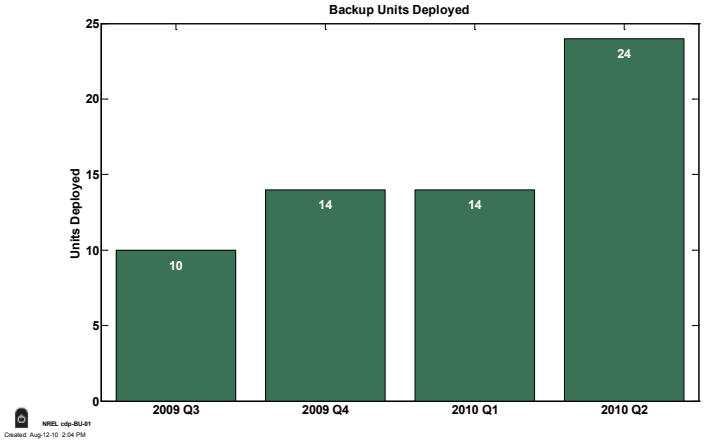
First cycle of CDPs (IA A & ARRA Sites)

Trends still developing

Many additional analyses planned for future CDP cycles

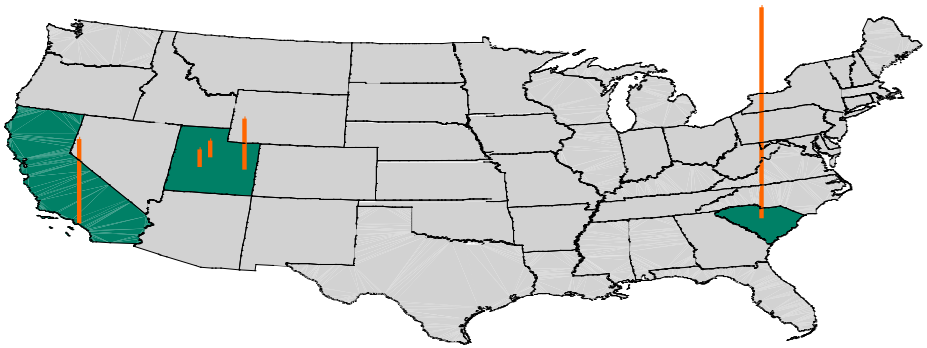
Backup Power Sites

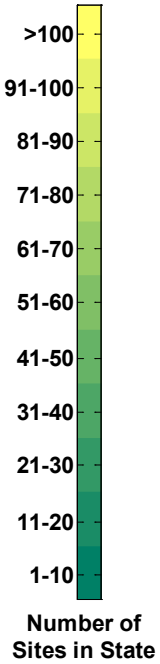
Units Deployed	24
Sites	5
Total Capacity	90 kW



Backup Power Deployments

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





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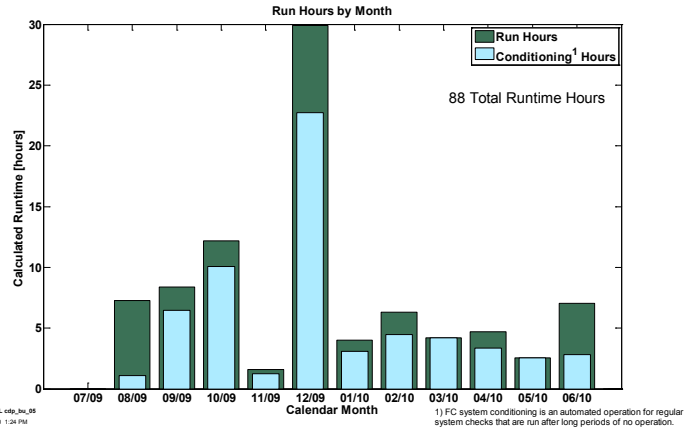
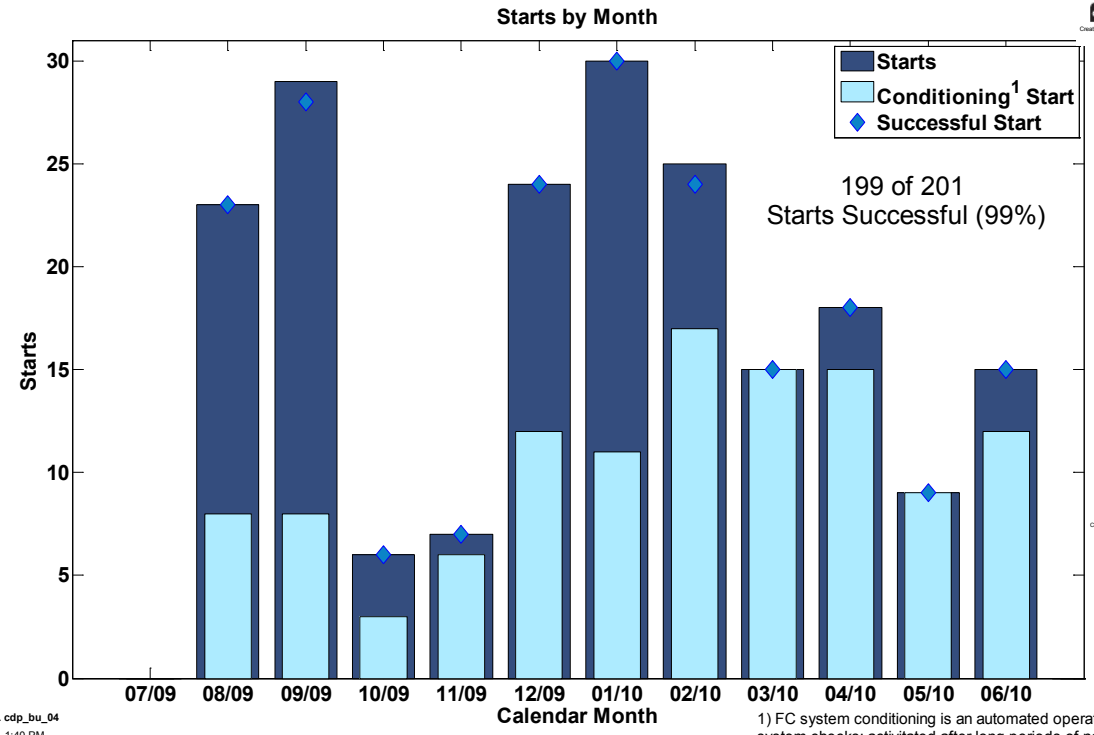
Site Capacity (line height proporational to installed site kW capacity)

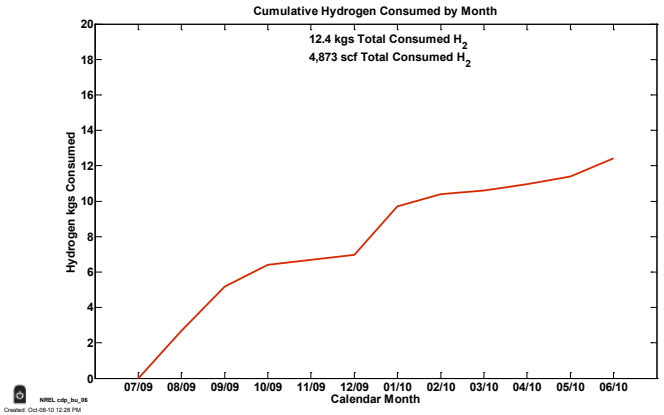
Backup Power Starts and Run Time

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





1) FC system conditioning is an automated operation for regular system checks; activitated after long periods of no operation.



FC Material Handling Equipment

Deployment & Operation Data

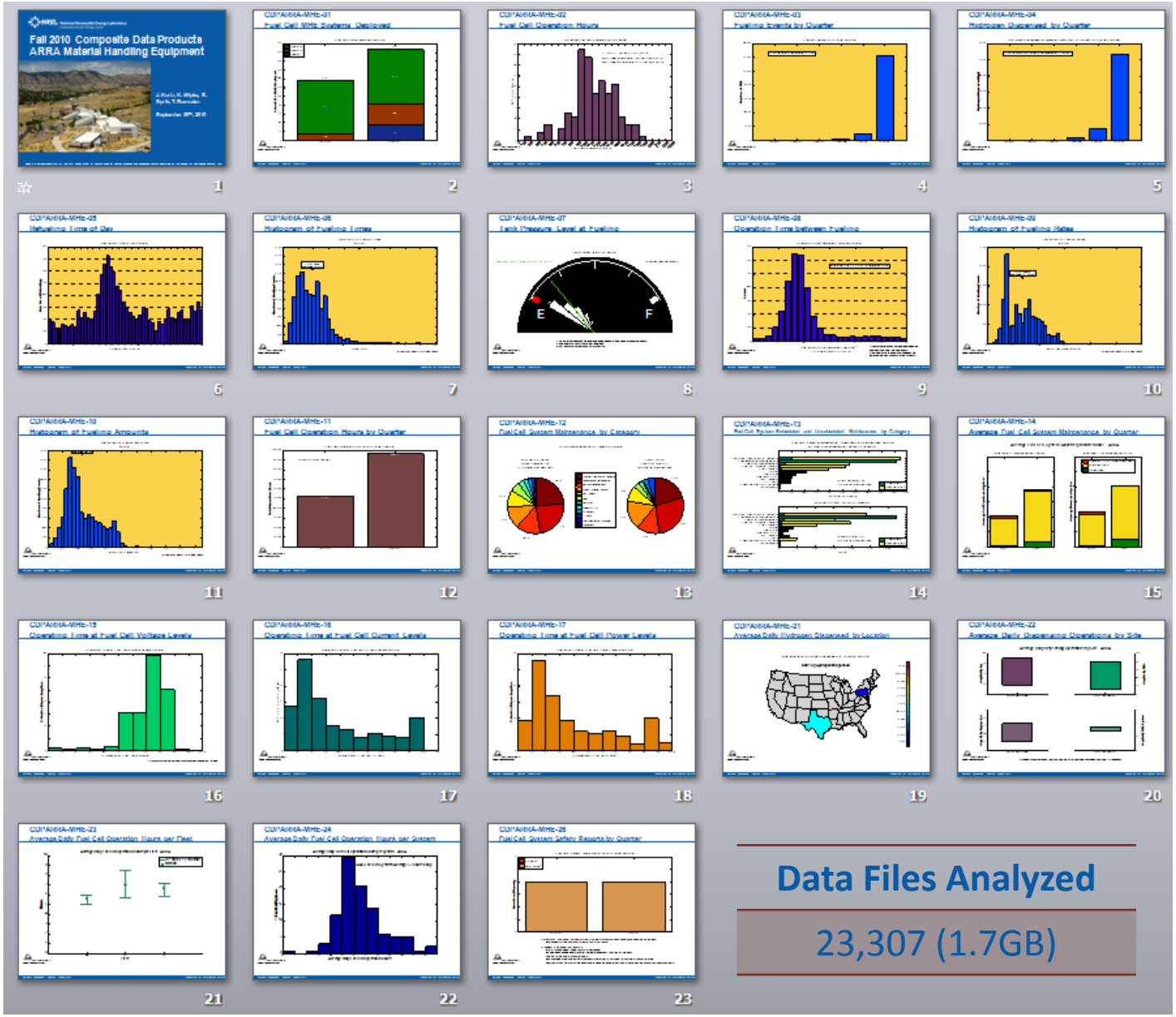
High level summary of operation

First cycle of CDPs

Trends still developing

Many additional analyses planned for future CDP cycles

FCMHE Fall 2010 CDPs



Analysis Topics

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

ARRA FCHMHE CDPs

22

ARRA & DLA Infrastructure CDPs

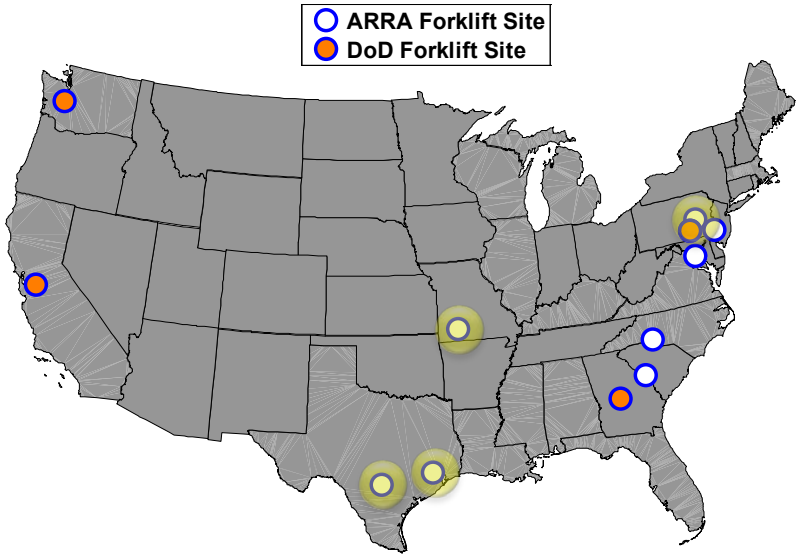
4

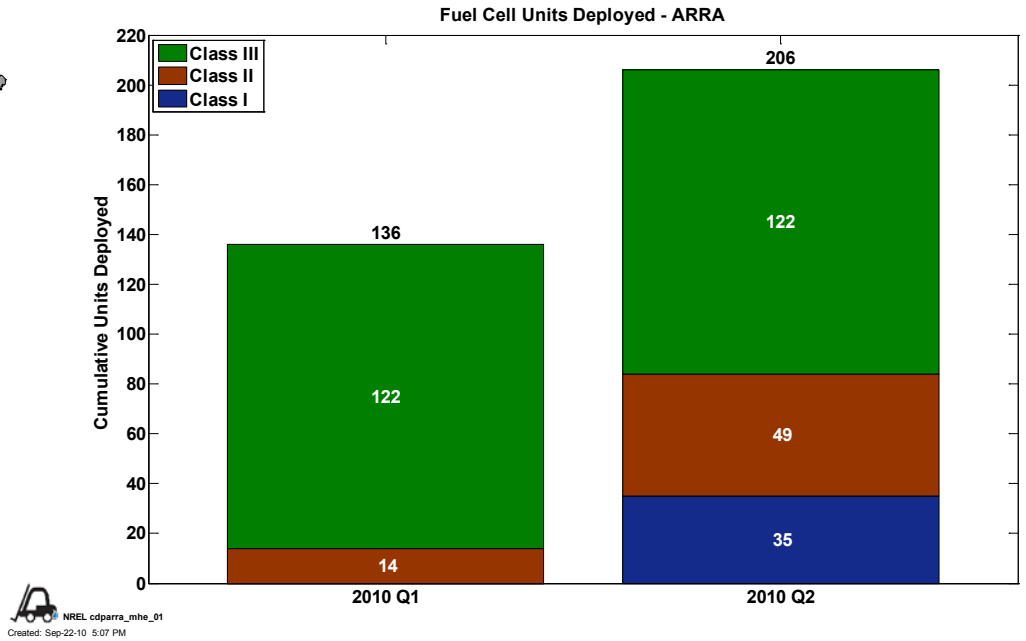
Data Files Analyzed

23,307 (1.7GB)

MHE FC Units & Sites

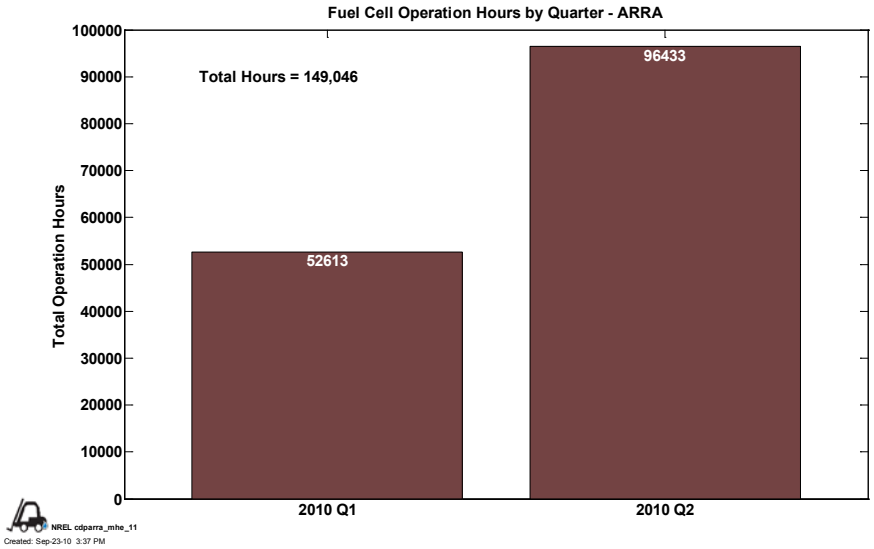
Sites			4	
Operational MHE Units/Site	14	35	59	98
Operating Shifts/Site	2 9 hrs	3 8 hrs	2 8-10 hrs	2 9 hrs
Facility Square Footage (1,000)	1,000	75	90	580
FC Units/MHE Unit	1.0	1.0	1.0	1.0

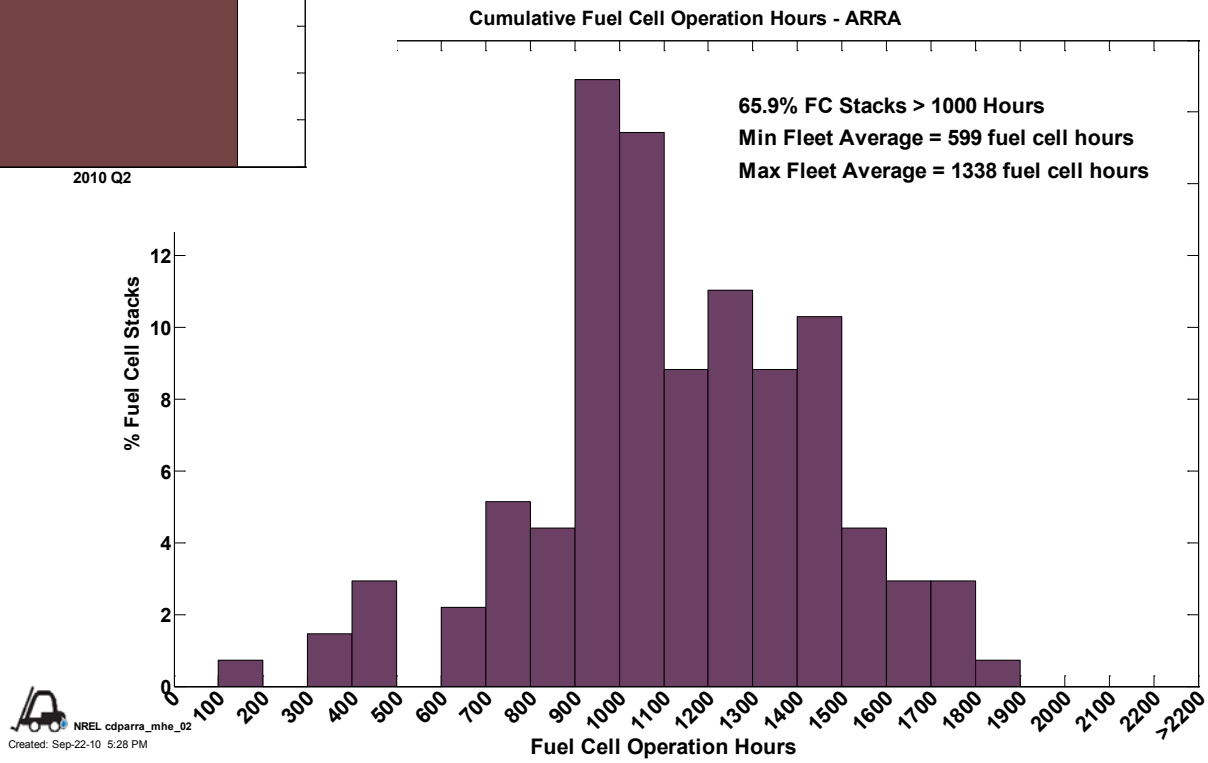




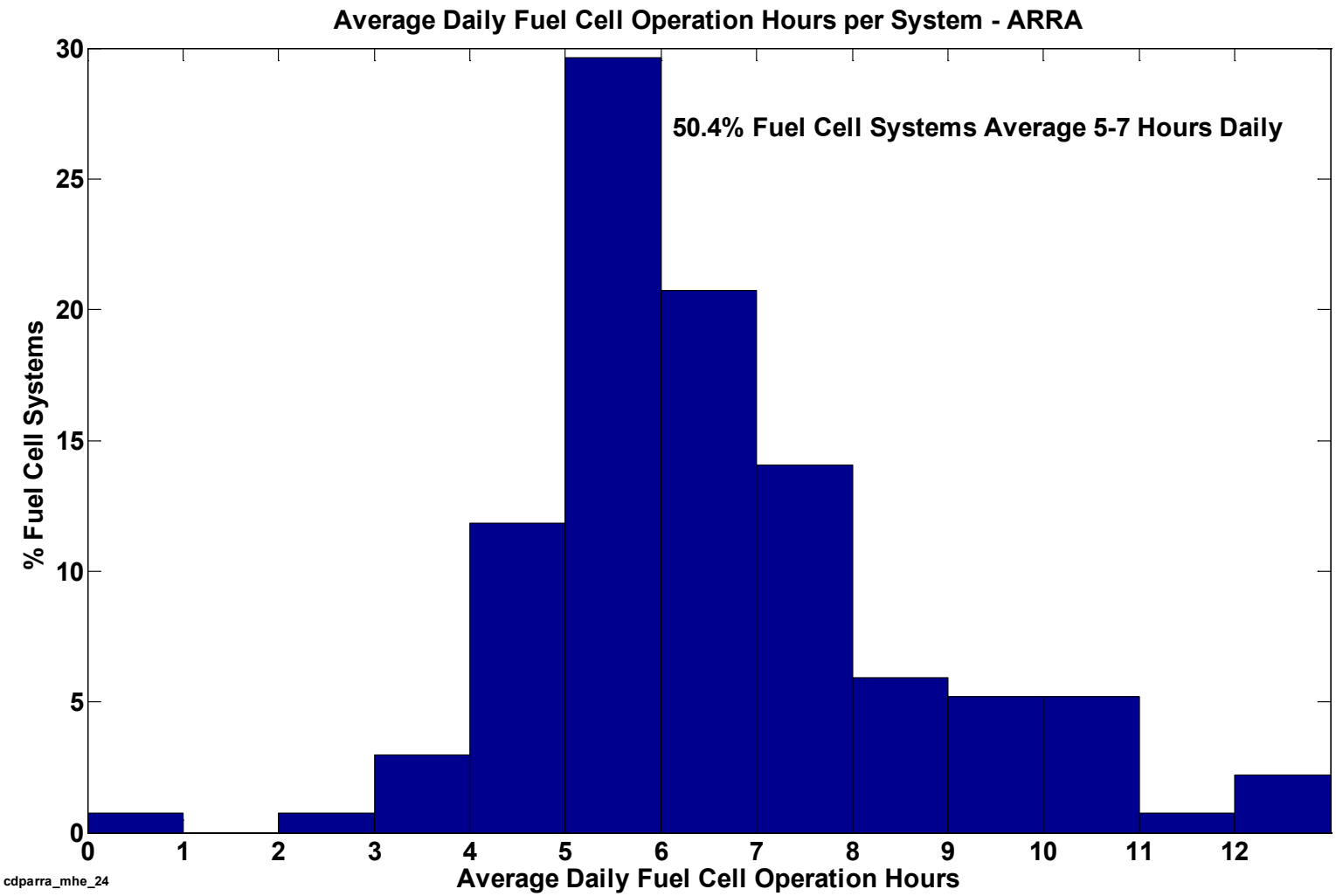
FC Operation Summary

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





FC Daily Operation



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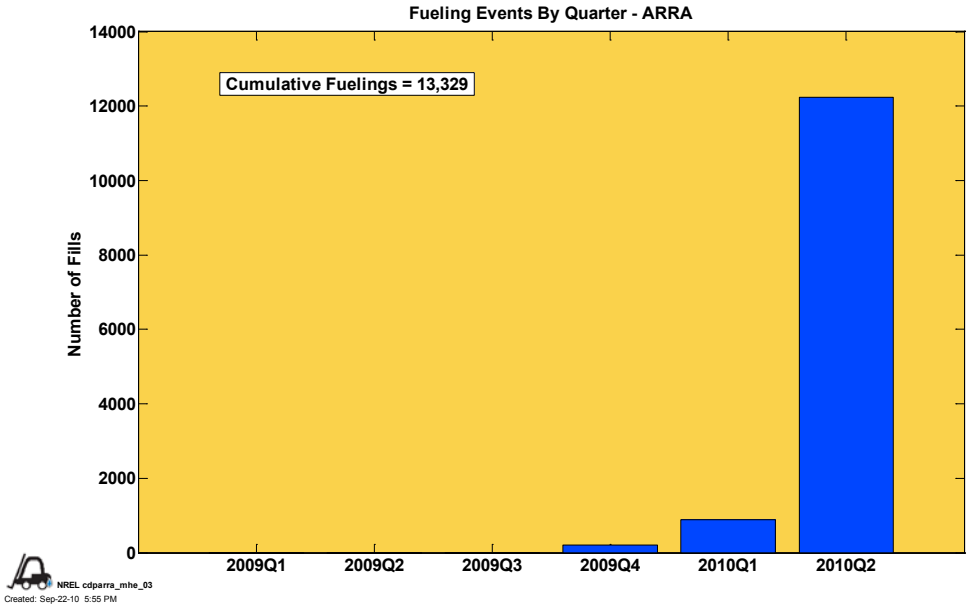
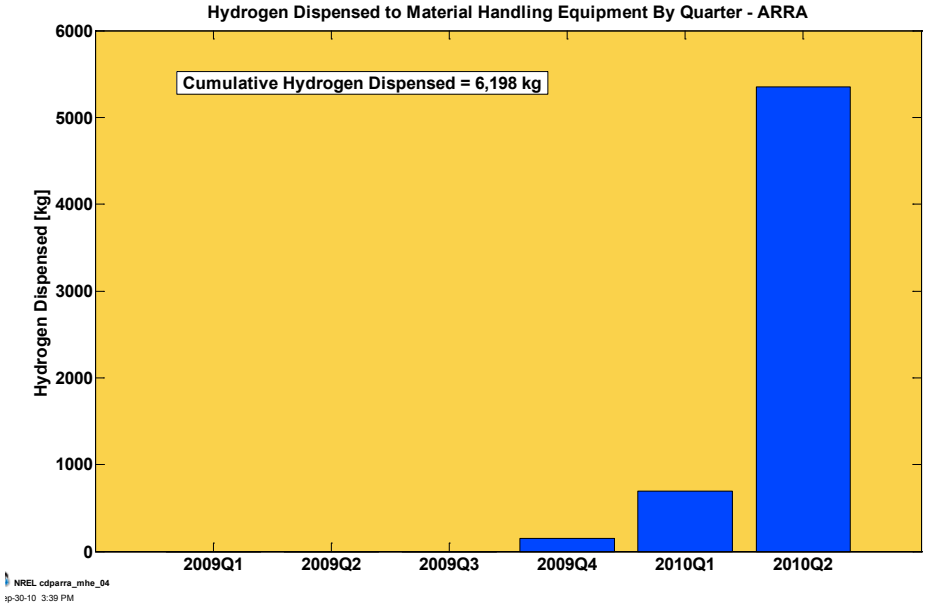
Hydrogen Fill Event Summary

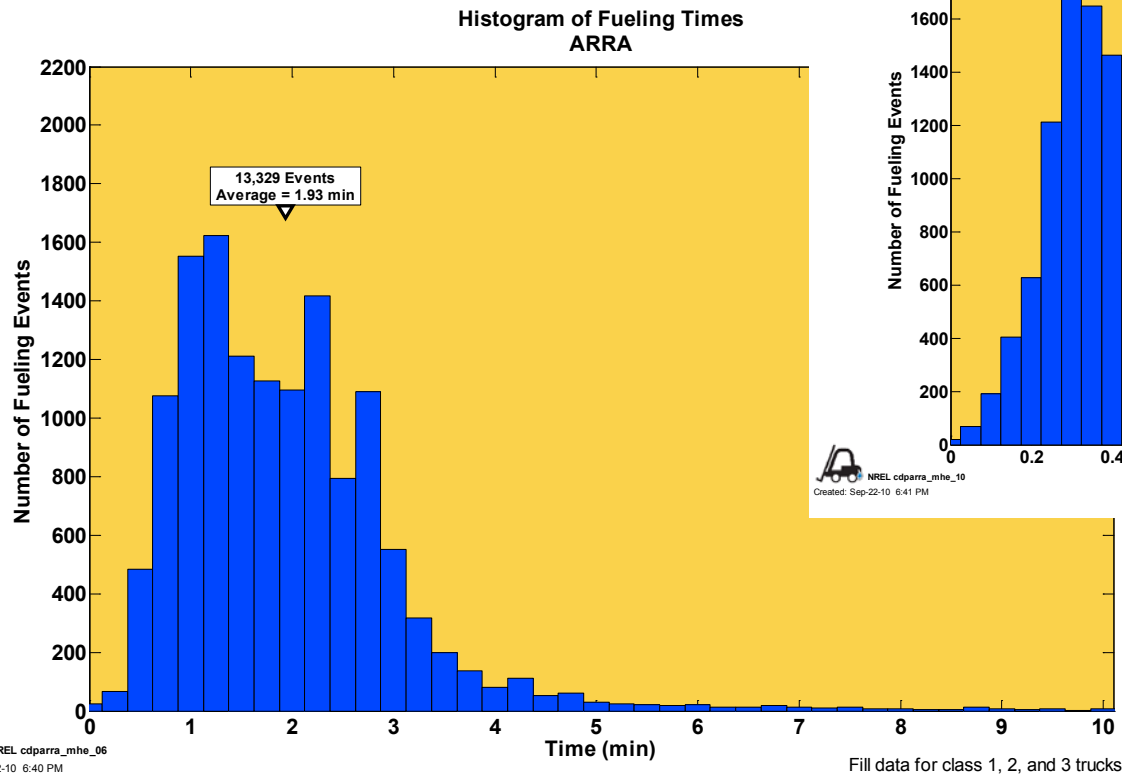
Total Hydrogen Dispensed	**6,198 kg**
Total Hydrogen Fill Events	13,329 fills



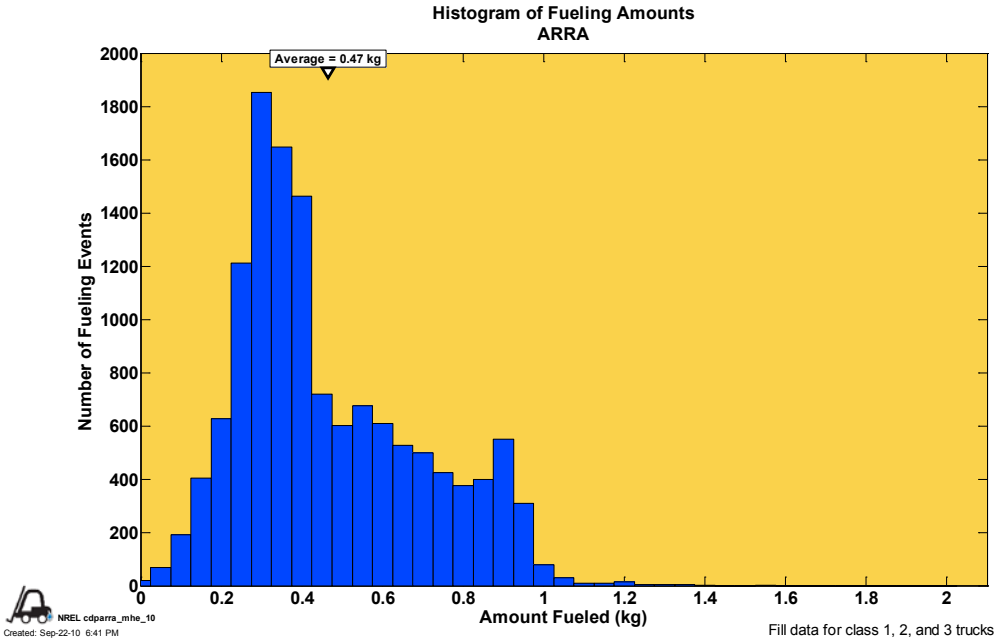


Hydrogen Fill Event Rates and Amounts

Average Fill Time	**1.9 minutes**
Average Fill Amount	0.47 kg

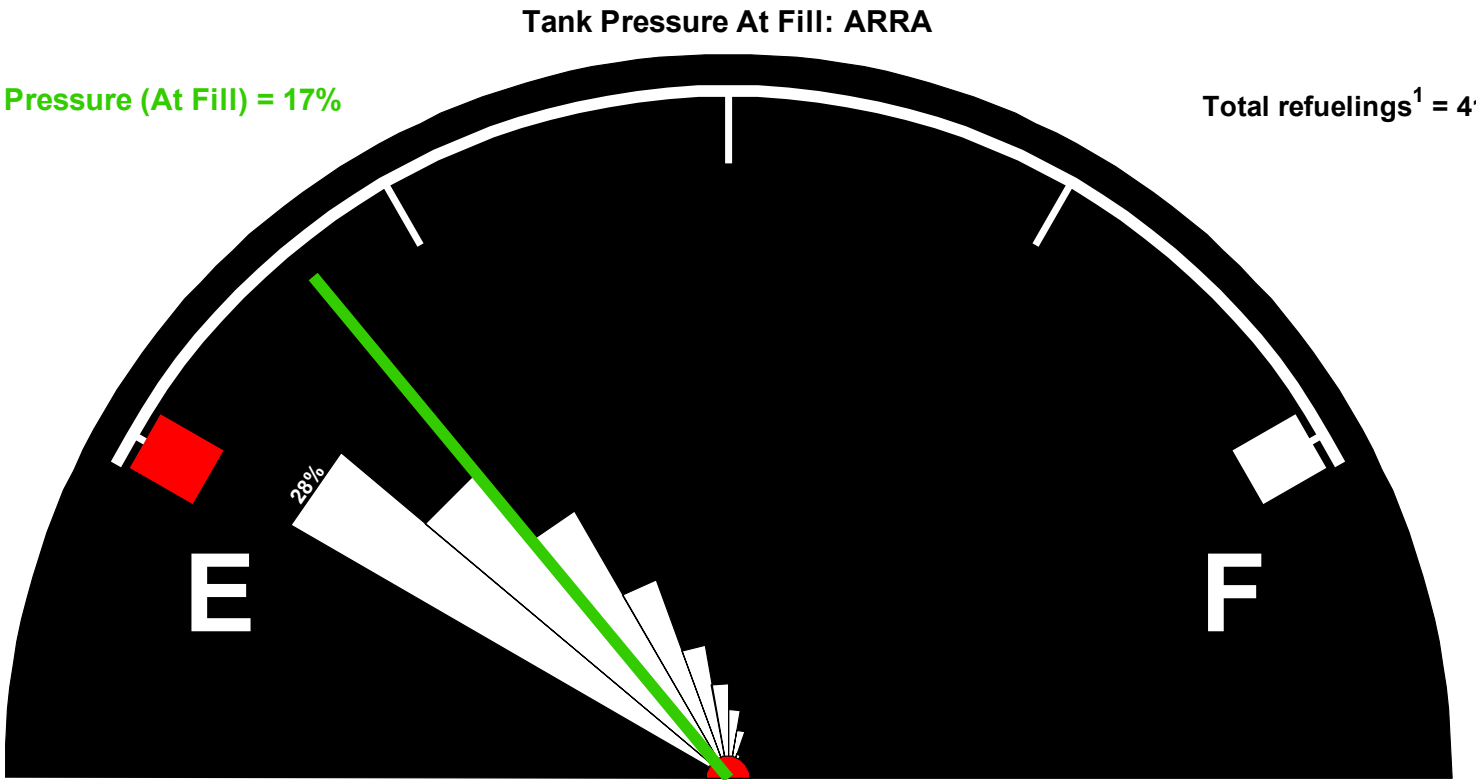


Fill data for class 1, 2, and 3 trucks



Fill data for class 1, 2, and 3 trucks

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.

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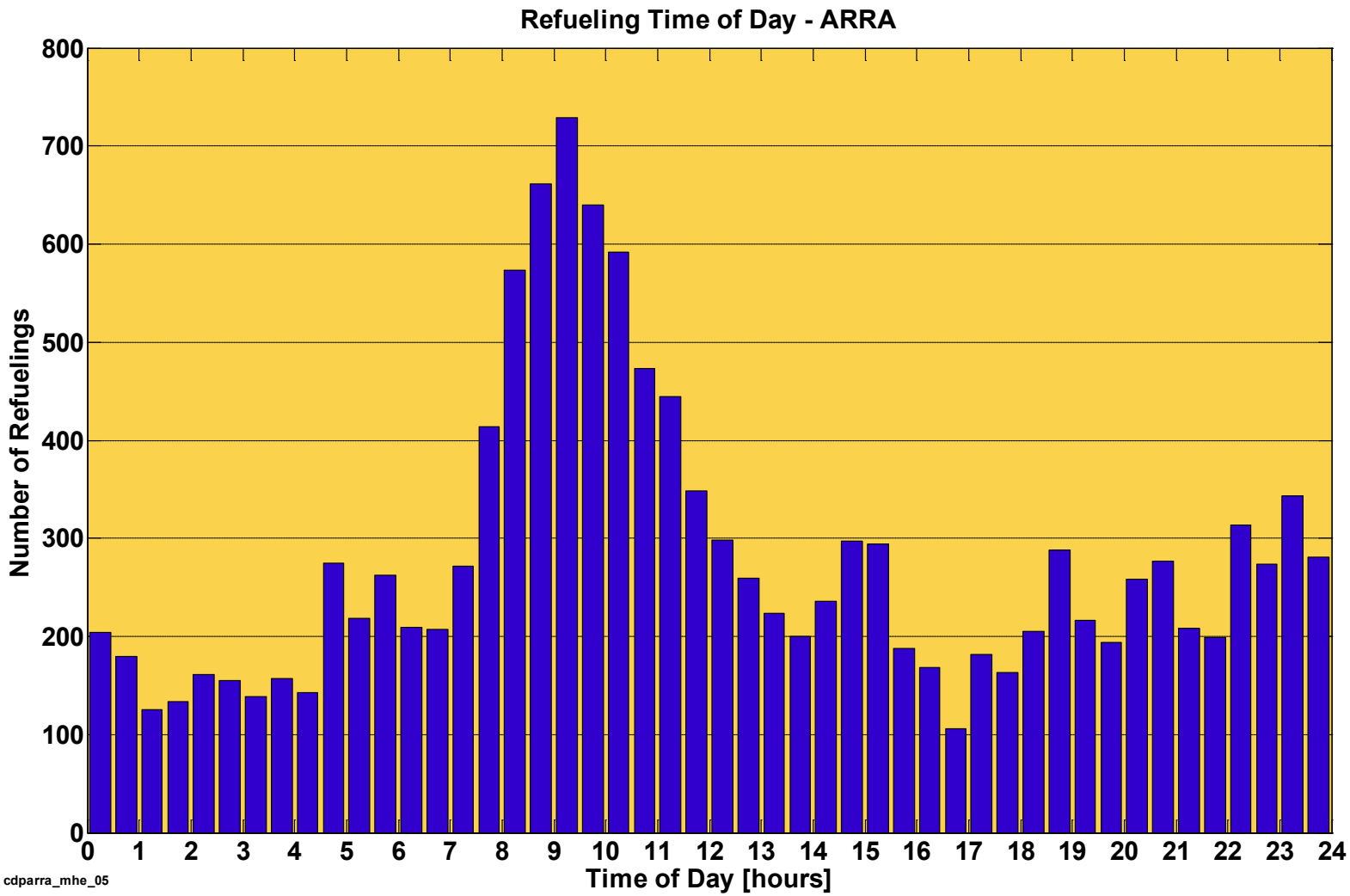
Refueling Time of Day



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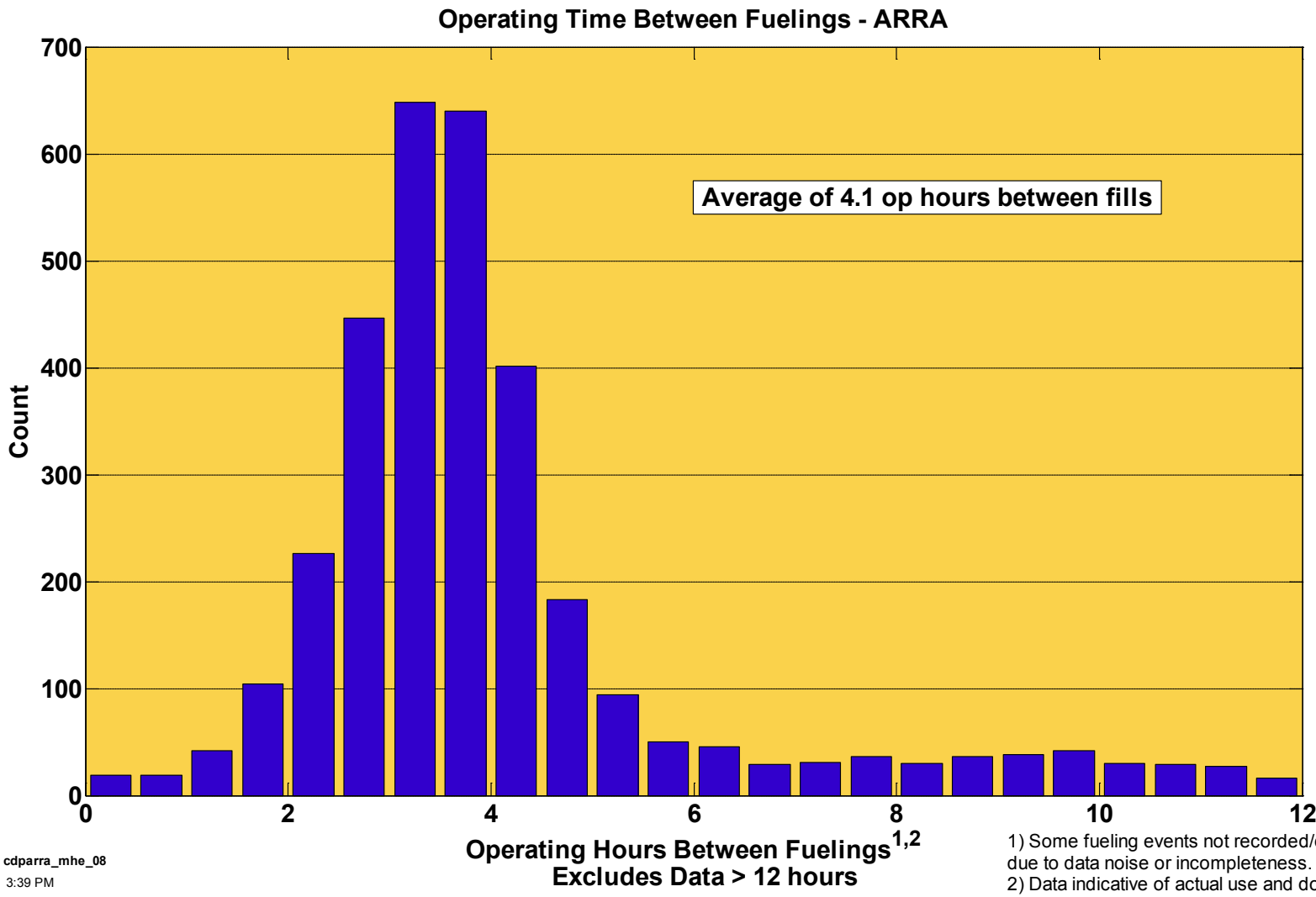
Operation Time between Fueling



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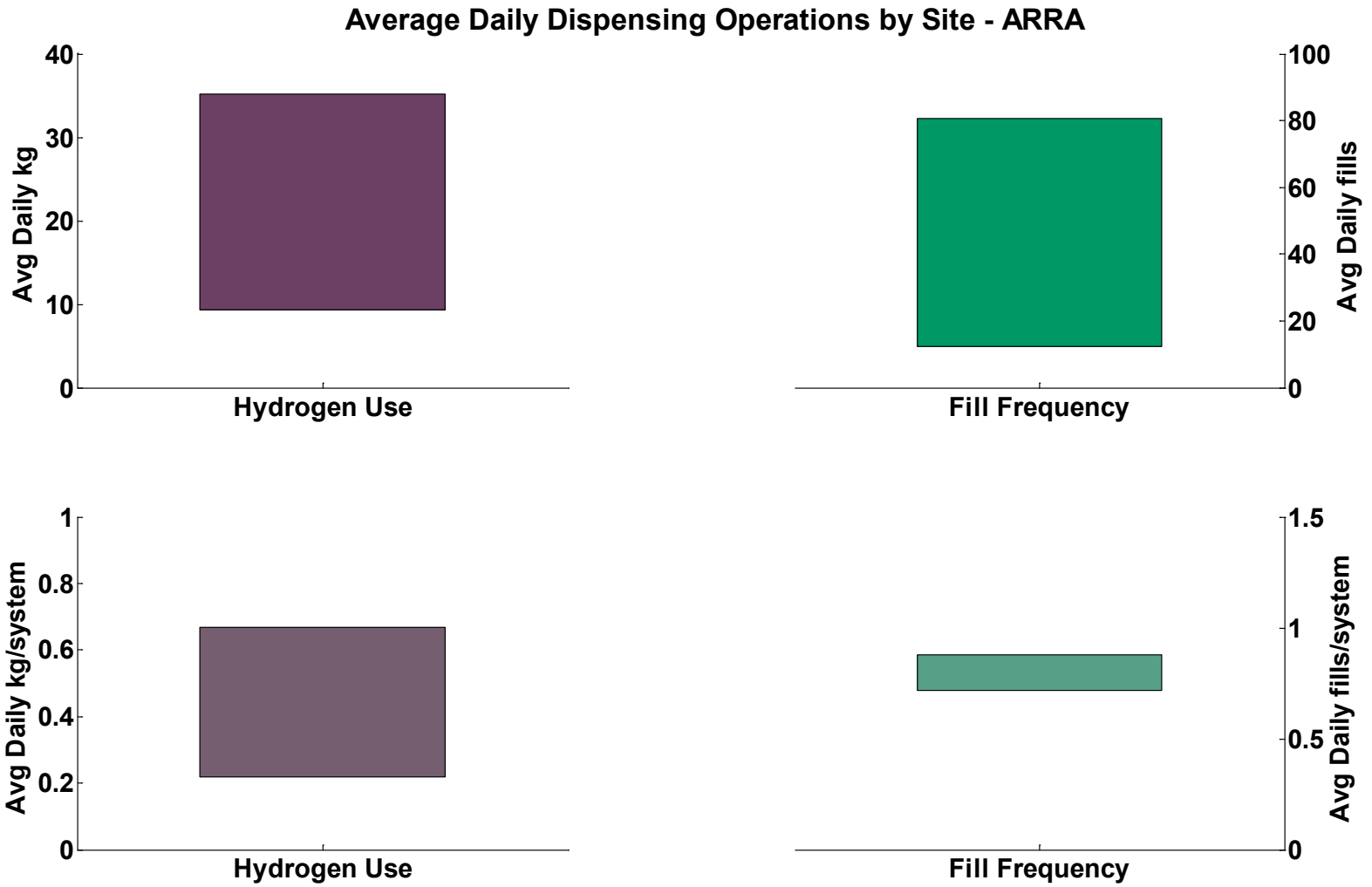
1) Some fueling events not recorded/detected due to data noise or incompleteness.
2) Data indicative of actual use and does not represent the max capability of the systems.

Average Daily Site H2 Dispensing



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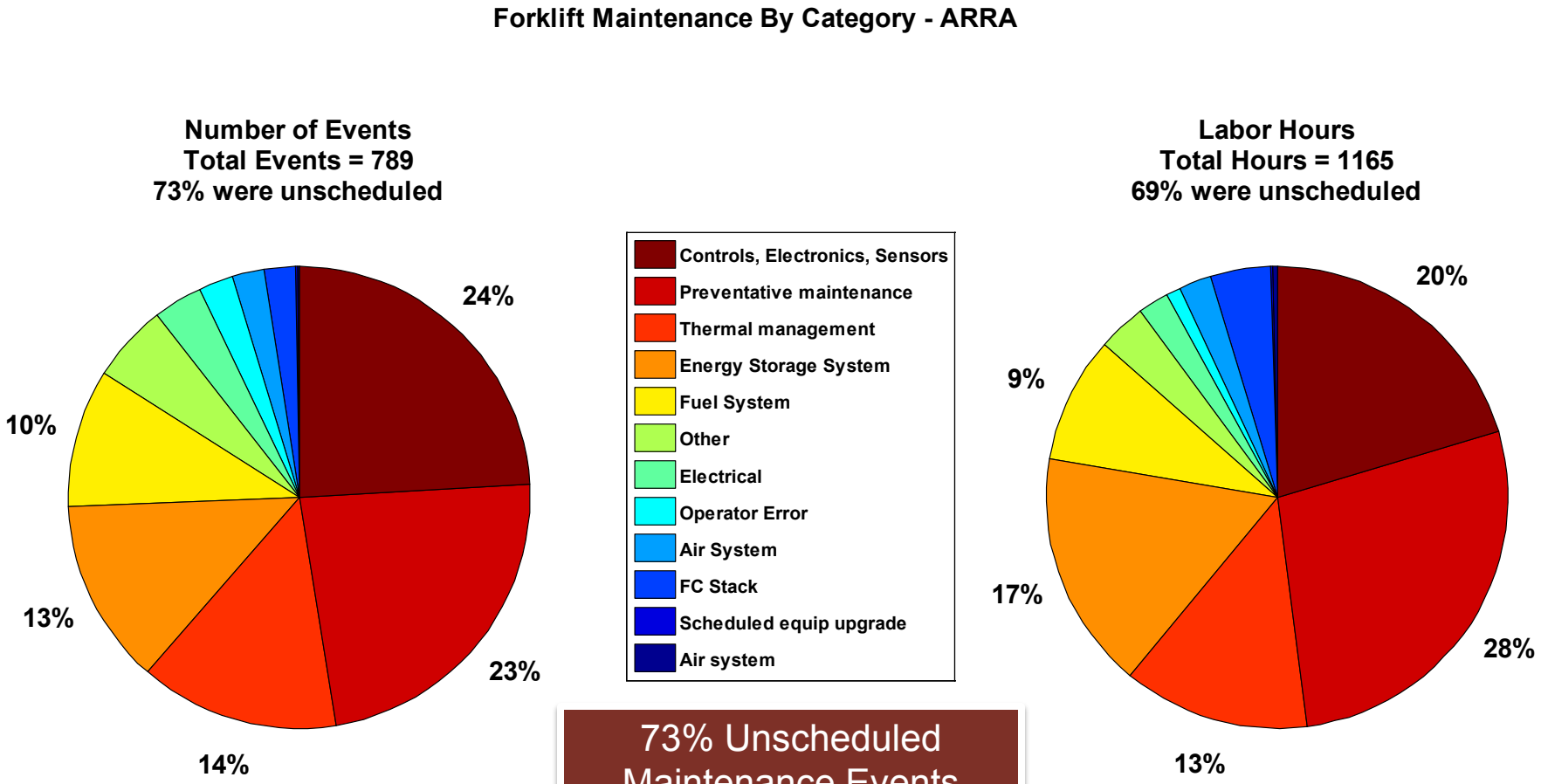
Shaded areas represent the min and max site average hydrogen use and fill frequency

Fuel Cell System Maintenance by Category



73% Unscheduled Maintenance Events

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

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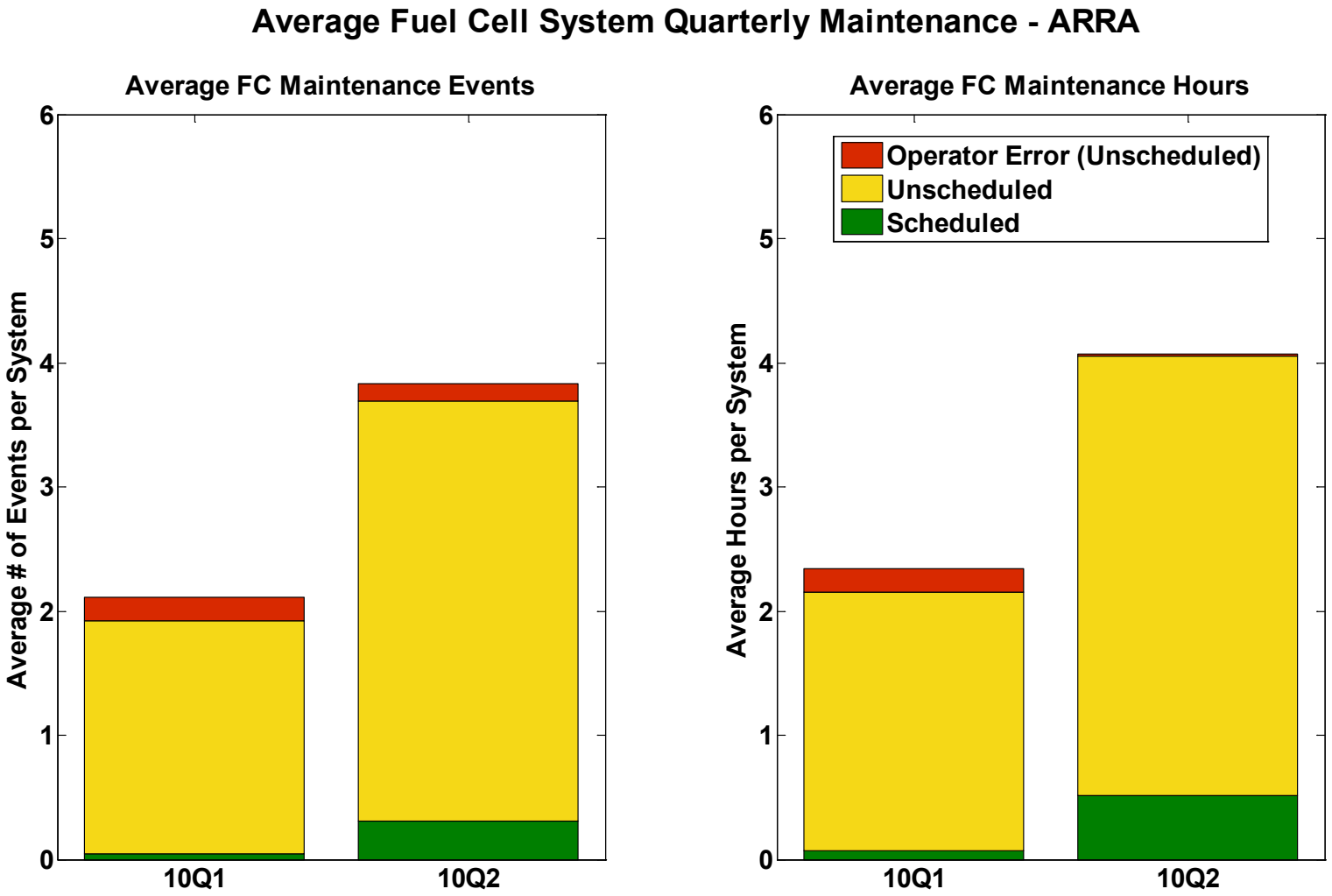
Average Fuel Cell System Maintenance by Quarter



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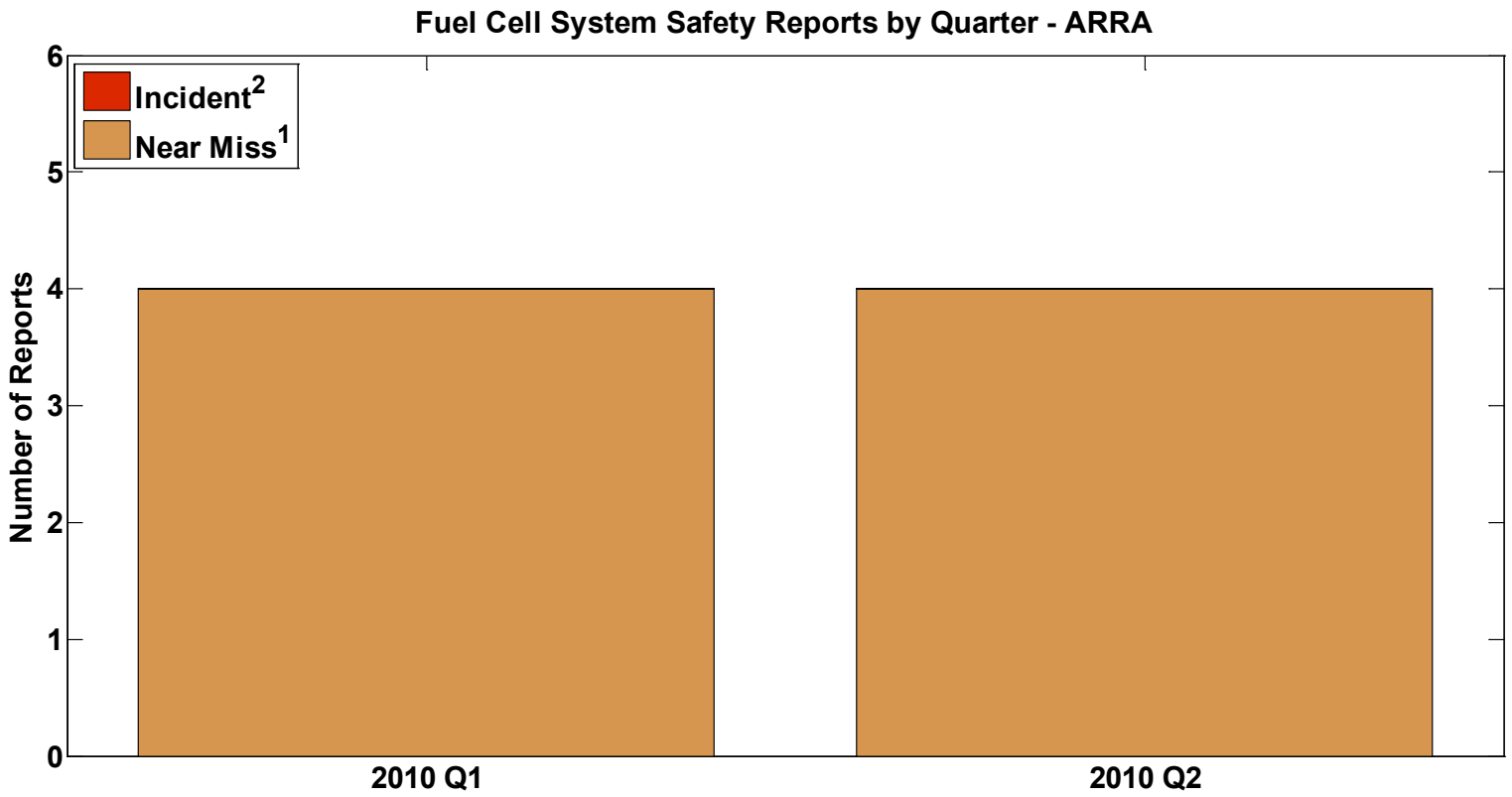
Fuel Cell System Safety Reports by Quarter



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)

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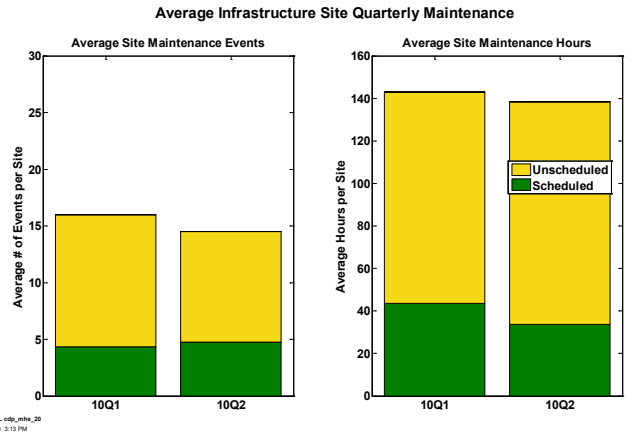
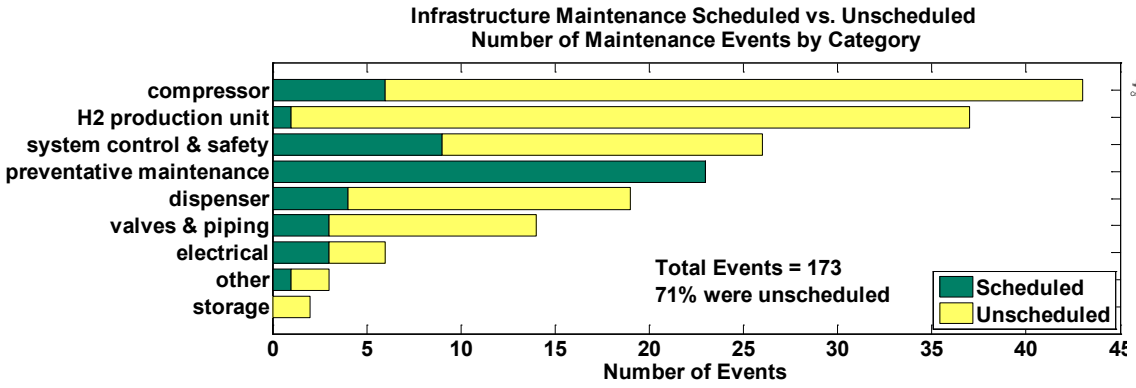
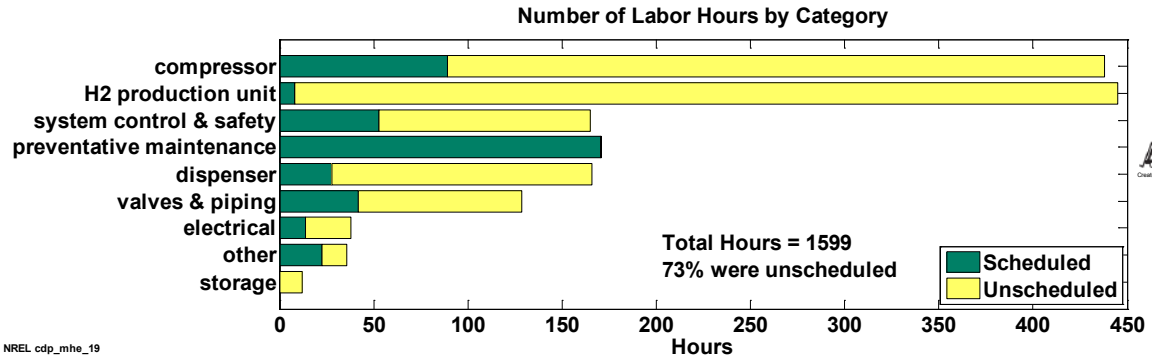
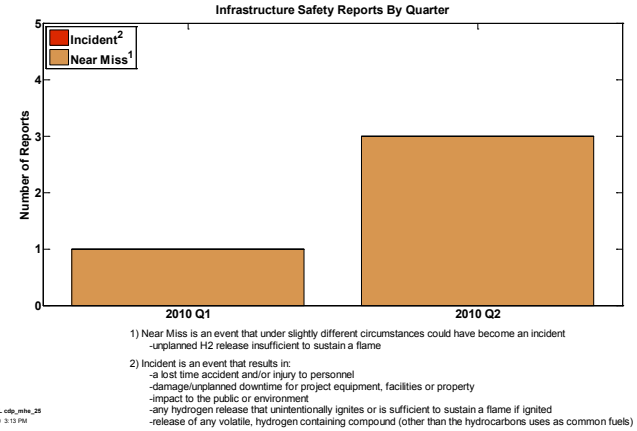
Infrastructure Maintenance

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









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-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

- 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

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303-275-4061

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