Fall 2010 Composite Data Products
ARRA Material Handling Equipment
Quarter 3 of 2010
Composite Data Products
Final Version September 30, 2010
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Fall 2010 Composite Data Products
ARRA Material Handling Equipment

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September 30th, 2010
Fuel Cell MHE Systems Deployed

Cumulative Units Deployed

Fuel Cell Units Deployed - ARRA

- Class III
- Class II
- Class I

2010 Q1
- 136 units
- 14 units (Class I)
- 122 units (Class II)

2010 Q2
- 206 units
- 35 units (Class I)
- 49 units (Class II)
- 122 units (Class III)
Cumulative Fuel Cell Operation Hours - ARRA

65.9% FC Stacks > 1000 Hours
Min Fleet Average = 599 fuel cell hours
Max Fleet Average = 1338 fuel cell hours
Fueling Events by Quarter - ARRA

Cumulative Fuelings = 13,329

Number of Fills

- 2009Q1
- 2009Q2
- 2009Q3
- 2009Q4
- 2010Q1
- 2010Q2

Cumulative Fuelings = 13,329
Hydrogen Dispensed to Material Handling Equipment By Quarter - ARRA

Cumulative Hydrogen Dispensed = 6,198 kg

- 2009Q1
- 2009Q2
- 2009Q3
- 2009Q4
- 2010Q1
- 2010Q2

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Refueling Time of Day - ARRA

Number of Refuelings vs Time of Day [hours]

Time of Day: 00:00 to 23:59
Number of Refuelings: 0 to 800
Histogram of Fueling Times

ARRA

13,329 Events
Average = 1.93 min

Fill data for class 1, 2, and 3 trucks
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.
Operating Time Between Fuelings - ARRA

Average of 4.1 op hours between fills

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.
Histogram of Fueling Rates

ARRA

- 13,329 Events
- Average = 0.27 kg/min

Fill data for class 1, 2, and 3 trucks
Histogram of Fueling Amounts

Histogram of Fueling Amounts
ARRA

Average = 0.47 kg

Fill data for class 1, 2, and 3 trucks
Fuel Cell Operation Hours by Quarter

Total Hours = 149,046

2010 Q1: 52,613
2010 Q2: 96,433
Fuel Cell System Maintenance by Category

Number of Events
Total Events = 789
73% were unscheduled

Labor Hours
Total Hours = 1165
69% were unscheduled

- Controls, Electronics, Sensors: 24%
- Preventative maintenance: 10%
- Thermal management: 13%
- Energy Storage System: 23%
- Fuel System: 14%
- Other: 25%
- Electrical: 17%
- Operator Error: 9%
- Air System: 13%
- FC Stack: 28%
- Scheduled equip upgrade: 9%
- Air system: 17%
Fuel Cell System Scheduled and Unscheduled Maintenance by Category

**Fuel Cell System Maintenance Scheduled vs. Unscheduled - ARRA**

Number of Maintenance Events by Category

- Total Events = 789
- 71% were unscheduled

Number of Labor Hours by Category

- Total Hours = 1165
- 68% were unscheduled

**Categories**
- Controls, Electronics, Sensors
- Preventative maintenance
- Thermal management
- Energy Storage System
- Fuel System
- Other
- Electrical
- Operator Error
- Air System
- FC Stack
- Scheduled equip upgrade
- Air system

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Average Fuel Cell System Quarterly Maintenance - ARRA

Average Fuel Cell System Maintenance by Quarter

Average Fuel Cell System Quarterly Maintenance - ARRA

Average FC Maintenance Events

Average FC Maintenance Hours

- Operator Error (Unscheduled)
- Unscheduled
- Scheduled

Average # of Events per System

Average Hours per System

10Q1

10Q2

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1) 100% max fuel cell voltage is approximately open-circuit voltage.
Operating Time at Fuel Cell Current Levels

- The graph shows the operating time at different fuel cell current levels.
- The x-axis represents the percentage of the rated max fuel cell current, ranging from 0% to 110%.
- The y-axis represents the percentage of fuel cell operating time, ranging from 0% to 30%.

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Operating Time at Fuel Cell Power Levels

Operating Time at Fuel Cell Power Levels - ARRA

% Fuel Cell Operating Time

% Rated Max Fuel Cell Power

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National Renewable Energy Laboratory
Innovation for Our Energy Future
Average Daily Hydrogen Dispensed by Location - ARRA

6321 kg Hydrogen Dispensed

The map shows the average daily hydrogen dispensed by location across the United States. The color scale indicates the range of dispensed hydrogen, with darker shades representing higher dispensed quantities. The states with the highest dispensed hydrogen are highlighted in blue.
Average Daily Dispensing Operations by Site - ARRA

Shaded areas represent the min and max site average hydrogen use and fill frequency.
Average Daily Fuel Cell Operation Hours per Fleet - ARRA

25th and 75th Percentile
Median
Average Daily Fuel Cell Operation Hours per System

50.4% Fuel Cell Systems Average 5-7 Hours Daily
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)

This presentation summarizes Fall 2010 composite data products ARRA material handling equipment.