ARRA Material Handling Equipment
Composite Data Products
Data through Quarter 3 of 2014

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CDP-MHE-102

Fuel Cell System Operation Hours

Cumulative Fuel Cell Operation Hours
Combined Fleet Through 2014Q3

25% of FC Systems > 5,920 Hours
Max Stack Hours = 16,610
Average Stack Hours = 4,170

- FC System
- Retired FC System
- Fleet Average FC System Hours

Dataset includes concluded ARRA projects and voluntarily-supplied data.
Cumulative Fuelings = 352,527

Note: Dataset includes concluded ARRA projects and voluntarily-supplied data.
CDP-MHE-104
Hydrogen Dispensed by Quarter

Cumulative Hydrogen Dispensed = 287,967 kg

Note: Dataset includes concluded ARRA projects and voluntarily-supplied data.
CDP-MHE-105
Refueling Time of Day

Note: Dataset includes concluded ARRA projects and voluntarily-supplied data
Histogram of Fueling Times

Combined Fleet

307,340 Events
Average = 2.52 min

Note: Dataset includes concluded ARRA projects and voluntarily-supplied data
Median Tank Pressure (At Fill) = 24%
CDP-MHE-108
Operation Time between Fueling

Operating Time Between Fuelings
Combined Fleet

Average: 3.7 hours

Operating Hours Between Fuelings
Excludes Data > 12 hours

Note: Dataset includes concluded ARRA projects and voluntarily-supplied data

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

Combined Fleet

299,062 Events
Average = 0.34 kg/min

Note: Dataset includes concluded ARRA projects and voluntarily-supplied data

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

Combined Fleet

Average = 0.70 kg

Note: Dataset includes concluded ARRA projects and voluntarily-supplied data

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

Total Hours = 2,683,567

Note: Dataset includes concluded ARRA projects and voluntarily-supplied data.
Operating Time at Fuel Cell Voltage Levels

Note: Dataset includes concluded ARRA projects and voluntarily-supplied data.

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

Note: Dataset includes concluded ARRA projects and voluntarily-supplied data.
Operating Time at Fuel Cell Power Levels

Note: Dataset includes concluded ARRA projects and voluntarily-supplied data

% Fuel Cell Operating Time

% Rated Max Fuel Cell Power
Average Daily Dispensing Operations by Site

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

Note: Dataset includes concluded ARRA projects and voluntarily-supplied data.
Average Daily Fuel Cell Operation Hours per Fleet

Note: Dataset includes concluded ARRA projects and voluntarily-supplied data.
CDP-MHE-124
Average Daily Fuel Cell Operation Hours per System

Fuel Cell System Operation Hours Per Day

Average Daily Fuel Cell System Operation Hours

36.1% Fuel Cell Systems Average > 6 Hours Daily

1) Excludes 0 hour operation days

Note: Dataset includes concluded ARRA projects and voluntarily-supplied data
CDP-MHE-135

Refuel Events by Day of Week

Note: Dataset includes concluded ARRA projects and voluntarily-supplied data.
CDP-MHE-142

Amount of Hydrogen Dispensed by Day of Week

Dispersed Hydrogen per Day of Week

Note: Dataset includes concluded ARRA projects and voluntarily-supplied data

- 82 kg/day avg

Dispensed Hydrogen [% of total]

Daily Average [Kg]

Sun Mon Tues Wed Thur Fri Sat

0 5 10 15 20

0 25 50 75 100

Created: Apr-01-15 8:04 AM | Data Range: 2009Q4-2014Q3

NATIONAL RENEWABLE ENERGY LABORATORY
200 bar Fills (200 to 315 bar)

Avg Final Pressure = 256 bar
% of Fills > 250 bar = 70%
Number of Fills = 161004

350 bar Fills (> 315 bar)

Avg Final Pressure = 355 bar
% of Fills > 350 bar = 52%
Number of Fills = 90114

*The line at 315 bar separates 250 bar fills from 350 bar fills. It is slightly over the allowable 125% of nominal pressure (312.5 bar) from SAE J2601.
CDP-MHE-165
Details of Back-to-Back Fills

Histogram of Time Between Fuelings

- 33% of fills are within 0-5 minutes of each other
- 27% of fills have more than 20 minutes between them
- 314,453 Total Fills

Final Pressures for Fills with <5 Minutes in Between

*Note: Dataset includes concluded ARRA projects and voluntarily-supplied data

*Time is from end of fill to start of next fill.
Average: 6.4 per hour
Median: 5.0 per hour
Max: 39.0 per hour
CDP-MHE-169

Fill Amount per Hour

Hydrogen Dispensed Per Hour

Average: 4.8 kgs per hour
Median: 3.4 kgs per hour
Max: 53.0 kgs per hour

Note: Dataset includes concluded ARRA projects and voluntarily-supplied data
Projected Hours to 10% Voltage Degradation

1) Projection using field data, calculated at high stack current, from operation hour 0.
   Projected hours may differ from an OEM’s end-of-life criterion and does not address “catastrophic” failure modes.
2) Indicates stacks that are no longer accumulating hours either a) temporarily or b) have been retired for non-stack performance related issues or c) removed from DOE program.
3) Projected hours limited based on demonstrated hours.