Data Analysis for ARRA Early Fuel Cell Market Demonstrations

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Contents

Overview of ARRA Fuel Cell Project

NREL Data Analysis Objectives

Deployment CDPs

Planned Analyses
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

<table>
<thead>
<tr>
<th>COMPANY</th>
<th>AWARD</th>
<th>APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delphi Automotive</td>
<td>$2.4 M</td>
<td>Auxiliary Power</td>
</tr>
<tr>
<td>FedEx Freight East</td>
<td>$1.3 M</td>
<td>Specialty Vehicle</td>
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<tr>
<td>GENCO</td>
<td>$6.1 M</td>
<td>Specialty Vehicle</td>
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<tr>
<td>Jadoo Power</td>
<td>$2.2 M</td>
<td>Backup Power</td>
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<tr>
<td>MTI MicroFuel Cells</td>
<td>$3.0 M</td>
<td>Portable</td>
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<tr>
<td>Nuvera Fuel Cells</td>
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<td>Plug Power, Inc. (1)</td>
<td>$3.4 M</td>
<td>CHP</td>
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<td>Plug Power, Inc. (2)</td>
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<td>ReliOn Inc.</td>
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<tr>
<td>Sprint Comm.</td>
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</tr>
<tr>
<td>Sysco of Houston</td>
<td>$1.2 M</td>
<td>Specialty Vehicle</td>
</tr>
</tbody>
</table>

12 awards with >$40 million ARRA & ~$53 million cost share
ARRA Hydrogen Fuel Cell & Infrastructure Data

Project Team / Site
Operational Data¹

NREL HSDC²
Data Processing & Analysis

Results
Data Products

Composite Data Products (CDPs)
• Aggregated data across multiple systems, sites, and teams
• Publish analysis results without revealing proprietary data every 6 months⁴

Detailed Data Products (DDPs)
• Individual data analyses
• Identify individual contribution to CDPs
• Only shared with partner who supplied data every 6 months³

1) Operation, Maintenance, and Safety data templates are created for each different application/report and are common to all partners in an application.
2) Hydrogen Secure Data Center
3) Data exchange may happen more frequently based on data, analysis, & collaboration
4) Results published via NREL Tech Val website, conferences, and reports

¹) Operational data delivered to NREL quarterly
²) Internal analysis completed quarterly
³) Bundled data delivered to NREL quarterly
⁴) 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

DOE ARRA¹ Funded Early Fuel Cell Markets: Delivered Units

1) American Recovery and Reinvestment Act

Created: Apr-14-10 4:16 PM
Fuel Cell Units in Operation
Current and Projected Quantities

DOE ARRA¹ Funded Early Fuel Cell Markets: Units in Operation

Projected Operation Quantities

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Government Funded Early Fuel Cell Market Deployment Sites (DOE ARRA, DOE IAA, DoD)

Some site locations TBD
**Planned Analyses Examples - Forklifts**

**kWh/kg By Month**

- Jan
- Feb
- Mar
- Apr
- May
- Jun
- Jul
- Aug
- Sep
- Oct
- Nov
- Dec

**Median Tank Level (At Fill) = 35%**

**Total refuelings = 7931**

1. Some refueling events not recorded/detected due to data noise or incompleteness.
2. The outer arc is set at 25% total refuelings.
3. Full = 5000 psi
Planned Analyses Examples - Stationary

FC Backup: Reliability & Availability

- 25th & 75th %
- Median
- Outlier

Reliability

Availability

Net System Power [%]

Efficiency [%]

Fuel Cell System Efficiency

Eff. at 25% Pwr  30% - 54%
Eff. at 100% Pwr  42% - 53%

Gen 1 Efficiency Range
Gen 2 Efficiency Range

DOE Target at 25% Power
DOE Target at 100% Power

1 Gross stack power minus fuel cell system auxiliaries, per DRAFT SAE 2615. Excludes power electronics and electric drive.
2 Ratio of DC output energy to the lower heating value of the input fuel (hydrogen).
3 Individual test data linearly interpolated at 5, 10, 15, 25, 50, 75, and 100% of max net power. Values at high power linearly extrapolated due to steady state dynamometer cooling limitations.
Planned Analysis Activities – Leverage Experience and Analysis from FCV

Primary Factors of Infrastructure Safety Reports Through 2009 Q2

- Calibration/Settings/Software Controls
- Design Flaw
- Electrical Power to Site
- Environment (Weather, Power Disruption, Other)
- False Alarm
- Inadequate Training, Protocol
- Inadequate/Non-working Equipment
- Maintenance Required
- Mischief, Vandalism, Sabotage
- New Equipment Materials
- Not Yet Determined
- Operator/Personnel Error
- System Manually Shutdown

Severities:
- Incident
- Near Miss
- Non-Event

Number of Reports

Number of Fueling Events

Avg Fuel Rate (kg/min)

21854 Events
Average = 0.78 kg/min
24% >1 kg/min

Max Fuel Cell Power Loss vs Op Hours: Gen1

Data Range
25th & 75th Percentiles
Group Median
Outlier

Application specific analysis
Analysis based on FCV:
FCV Learning Demo has 80 Data Results
Data Results Reported to Multiple Stakeholders

Government
Example Results:
- Market Impact
- Environmental Impact

End User
Example Result:
- Value Proposition

Developer
Example Result:
- Stack Durability

Likely Analysis Topics
- Durability
- Efficiency
- Power, Voltage, Energy
- Safety
- Reliability
- Maintenance
- Cost
- Market Application Comparisons

Data Results
Planned Analysis – FC Application & Competing Technology Comparisons

Status of Fuel Cell Technology for a Spectrum of Applications

- **Targets**
- **Best hours demonstrated**
- **Avg hours demonstrated**
- **Best durability projection**
- **Avg durability projection**

*Not Real Data*
Summary

ARRA project expected to deploy ~ 1,000 fuel cell units.

Diverse group of project partners that includes fuel cell developers, hydrogen producers, and end users with sites across the United States.

Forklift sites are first to begin operation

First round of technical results expected later this year

Technical results reported to end users (e.g. Value Proposition), developer (e.g. Stack Durability), and government (e.g. Market Impact)
Contact Information & Website

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303-275-4061


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.

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:

<table>
<thead>
<tr>
<th>Sort by Title ▼</th>
<th>Sort by Category ▼</th>
<th>Sort by CDP No.</th>
<th>Sort by Date Updated</th>
<th>PowerPoint</th>
<th>JPG</th>
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</thead>
<tbody>
<tr>
<td>Operating Hours between Fencing</td>
<td>Fuel Cell Fuel Economy Range and Efficiency</td>
<td>FL08</td>
<td>2009-11-06</td>
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<td>FL02</td>
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<td>Fuel Cell Units in Operation—Current and</td>
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