National Hydrogen Learning Demonstration Status

Keith Wipke, Sam Sprik, Jennifer Kurtz, Todd Ramsden, Chris Ainscough, Genevieve Saur

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NREL is a national laboratory of the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy operated by the Alliance for Sustainable Energy, LLC
Outline

• U.S. DOE Learning Demonstration Project Goals
• Fuel Cell Vehicle and H₂ Station Deployment Status

• Technical Highlights of Vehicle and Infrastructure Analysis Results and Progress

• Next Steps and Project Wrap-up
Fuel Cell Electric Vehicle Learning Demo
Project Objectives, Relevance, and Targets

• Objectives
  – Validate H₂ FC Vehicles and Infrastructure in Real-World Setting
  – Identify Current Status and Evolution of the Technology

• Relevance
  – Objectively Assess Progress Toward Targets and Market Needs
  – Provide Feedback to H₂ Research and Development
  – Publish Results for Key Stakeholder Use and Investment Decisions

Key Targets

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>Interim (2009)*</th>
<th>Ultimate (2020)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Cell Stack Durability</td>
<td>2000 hours</td>
<td>5000 hours</td>
</tr>
<tr>
<td>Vehicle Range</td>
<td>250+ miles</td>
<td>300+ miles</td>
</tr>
<tr>
<td>Hydrogen Cost at Station</td>
<td>$3/gge</td>
<td>$2-4/gge**</td>
</tr>
</tbody>
</table>

*Project extended 2 years through 2011; **Previously $2-3/gge for 2015

Details of each of these 3 results shown later
History: 4 OEM/Energy Teams Selected Competitively through FOA in 2004

DOE funding: $170M
Industry cost share: $189M
Total: $359M

NREL received $6.6M from DOE for analysis and support of this project since FY03
Involvement of Industry Teams Over 7 Years

- Ford/BP and Chevron/Hyundai-Kia Concluded in 2009
- Daimler, GM, and Air Products (CHIP) Demonstrated Vehicles/Stations within Project through CY2011
What is NREL’s Role? Project Approach
Supporting Both DOE/Public as Well as Fuel Cell Developers

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

Internal analysis completed quarterly

Detailed Data Products (DDPs)
- Individual data analyses
- Identify individual contribution to CDPs
- Shared every six months only with the partner who supplied the data
d

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

1) Data exchange may happen more frequently based on data, analysis, & collaboration
2) Results published via NREL Tech Val website, conferences, and reports (http://www.nrel.gov/hydrogen/proj_learning_demo.html)
This Project Analyzed Massive Amounts of Data: 3.5 M miles and >500,000 vehicle trips (second-by-second)
Hence, we'll just cover some highlights today.
Current Vehicle Deployment Status at End of Evaluation Period (9/30/11)

Vehicle Deployment by On-Board Hydrogen Storage Type

- 700 bar on-road
- 350 bar on-road
- Liquid H2 on-road
- 700 bar retired
- 350 bar retired
- Liquid H2 retired

Cumulative Vehicles Deployed/Retired

(1) Retired vehicles have left DOE fleet and are no longer providing data to NREL
(2) Two project teams concluded in Fall/Winter 2009

Large # vehicles required for statistical significance
## 2nd Generation Vehicles Demonstrated Technology Improvements Over Gen 1

<table>
<thead>
<tr>
<th>Generation 1 Vehicles</th>
<th>Generation 2 Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>FC not freeze-capable</td>
<td>FC freeze-capable</td>
</tr>
<tr>
<td>Storage: liquid H2 &amp; 350 and 700 bar</td>
<td>Storage: All 700 bar</td>
</tr>
<tr>
<td>Range: 100-200 miles</td>
<td>Range: 200-250 miles</td>
</tr>
<tr>
<td>Efficiency: 51-58% at ¼ power</td>
<td>Efficiency: 53-59% at ¼ power</td>
</tr>
</tbody>
</table>
Current Infrastructure Status: Demonstration Station Testing Successfully Completed as Planned

Learning Demonstration Hydrogen Stations by Type

- **Delivered**
  - Compressed: 7
  - Liquid: 1
  - Pipeline: 0

- **On-Site Production**
  - Reforming: 1
  - Electrolysis: 1

- Operating Outside of Project
- Operating Within Project
- Historical 2005-2009

Note: Many demonstration stations were taken offline as planned at conclusion of demo. Some stayed open and/or received upgrades (CA and NY).

*Some project teams concluded Fall/Winter 2009. Markers show the cumulative stations operated during the 2005-2009 period.
Infrastructure Status: Out of 25 Project Stations, 13 Are Still Operational* (~1/2 outside of DOE project)

* CDP station status is as of 9/30/11

Legend
- Online
- Future**
- 3 mile radius
- 6 mile radius
- Continuing Outside
- Current Project
- CEC
- CARB
- Other

** Funded by state of CA or others, outside of this project

SF Bay Area
- 2 Online
- 3 Future

Los Angeles Area
- 16 Online
- 11 Future

Detroit Area
- 3 Online

DC to New York
- 6 Online

Jan-31-2012

National Renewable Energy Laboratory
## Project Achieved Both Technical Goals; Outside Analysis Used for Cost Evaluation

### Vehicle Performance Metrics

<table>
<thead>
<tr>
<th></th>
<th>Gen 1 Vehicle</th>
<th>Gen 2 Vehicle</th>
<th>2009 Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fuel Cell Stack Durability</strong></td>
<td></td>
<td></td>
<td>2000 hours</td>
</tr>
<tr>
<td>Max Team Projected Hours to 10% Voltage Degradation</td>
<td>1807 hours</td>
<td>2521 hours</td>
<td></td>
</tr>
<tr>
<td>Average Fuel Cell Durability Projection</td>
<td>821 hours</td>
<td>1062 hours</td>
<td></td>
</tr>
<tr>
<td>Max Hours of Operation by a Single FC Stack to Date</td>
<td>2375 hours</td>
<td>1261 hours</td>
<td></td>
</tr>
<tr>
<td><strong>Driving Range</strong></td>
<td></td>
<td></td>
<td>250 miles</td>
</tr>
<tr>
<td></td>
<td>103-190 miles</td>
<td>196-254 miles</td>
<td></td>
</tr>
<tr>
<td><strong>Fuel Economy (Window Sticker)</strong></td>
<td>42 – 57 mi/kg</td>
<td>43 – 58 mi/kg</td>
<td>no target</td>
</tr>
<tr>
<td><strong>Fuel Cell Efficiency at ¼ Power</strong></td>
<td>51 - 58%</td>
<td>53 - 59%</td>
<td>60%</td>
</tr>
<tr>
<td><strong>Fuel Cell Efficiency at Full Power</strong></td>
<td>30 - 54%</td>
<td>42 - 53%</td>
<td>50%</td>
</tr>
</tbody>
</table>

### Infrastructure Performance Metrics

<table>
<thead>
<tr>
<th></th>
<th>On-site natural gas reform</th>
<th>On-site Electrolysis</th>
<th>2009 Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>H₂ Cost at Station (early market)</strong></td>
<td>$7.70 - $10.30</td>
<td>$10.00 - $12.90</td>
<td>$3/gge</td>
</tr>
<tr>
<td>Average H₂ Fueling Rate</td>
<td>0.77 kg/min</td>
<td></td>
<td>1.0 kg/min</td>
</tr>
</tbody>
</table>

Outside of this project, DOE independent panels concluded at 500 replicate stations/year:
- Distributed natural gas reform at 1500 kg/day: $2.75-$3.50/kg (2006)
- Distributed electrolysis at 1500kg/day: $4.90-$5.70 (2009)
1) FC Durability Target of 2000 Hours Met By Gen 2 Projections

Durability is defined by DOE as projected hours to 10% voltage degradation

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(1) Range bars created using one data point for each OEM. Some stacks have accumulated hours beyond 10% voltage degradation.

(2) Range (highest and lowest) of the maximum operating hours accumulated to-date of any OEM’s individual stack in “real-world” operation.

(3) Range (highest and lowest) of the average operating hours accumulated to-date of all stacks in each OEM’s fleet.

(4) Projection using on-road data -- degradation calculated at high stack current. This criterion is used for assessing progress against DOE targets, may differ from OEM’s end-of-life criterion, and does not address “catastrophic” failure modes, such as membrane failure.


The shaded projection bars represents an engineering judgment of the uncertainty on the “Avg Projection” due to data and methodology limitations. Projections will change as additional data are accumulated.

(6) Projection method was modified beginning with 2009 Q2 data, includes an upper projection limit based on demonstrated op hours.

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NREL CDP01
Created: Mar-23-10 10:39 AM

Spring 2010

National Renewable Energy Laboratory
Innovation for Our Energy Future
2) Vehicle Range Achieved 2009 Target of 250 Miles with Gen 2 Adjusted Fuel Economy

Vehicle Range

(1) Range is based on fuel economy and usable hydrogen on-board the vehicle. One data point for each make/model.
(2) Fuel economy from unadjusted combined City/Hwy per DRAFT SAE J2572.
(3) Fuel economy from EPA Adjusted combined City/Hwy (0.78 x Hwy, 0.9 x City).
(4) Excludes trips < 1 mile. One data point for on-road fleet average of each make/model.
(5) Fuel economy calculated from on-road fuel cell stack current or mass flow readings.
3) Projected Early Market H₂ Production Cost from Learning Demo Energy Partners’ Inputs

**Projected Early Market 1500 kg/day Hydrogen Cost**

![Graph showing projected hydrogen costs for natural gas reforming and electrolysis.](image)

**Key H₂ Cost Elements and Ranges**

<table>
<thead>
<tr>
<th>Input Parameter</th>
<th>Minimum (P10)</th>
<th>Maximum (P90)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility Direct Capital Cost</td>
<td>$10M</td>
<td>$25M</td>
</tr>
<tr>
<td>Facility Capacity Utilization</td>
<td>85%</td>
<td>95%</td>
</tr>
<tr>
<td>Annual Maintenance &amp; Repairs</td>
<td>$150K</td>
<td>$600K</td>
</tr>
<tr>
<td>Annual Other O&amp;M</td>
<td>$100K</td>
<td>$200K</td>
</tr>
<tr>
<td>Annual Facility Land Rent</td>
<td>$50K</td>
<td>$200K</td>
</tr>
<tr>
<td>Natural Gas Prod. Efficiency (LHV)</td>
<td>65%</td>
<td>75%</td>
</tr>
<tr>
<td>Electrolysis Prod. Efficiency (LHV)</td>
<td>35%</td>
<td>62%</td>
</tr>
</tbody>
</table>

*This project provides an excellent learning opportunity, but stations are not meant to emulate high volume replicate stations of the future. Permitting was in transition.*

(1) Reported hydrogen costs are based on estimates of key cost elements from Learning Demonstration energy company partners and represent the cost of producing hydrogen on-site at the fueling station, using either natural gas reforming or water electrolysis, dispensed to the vehicle. Costs reflect an assessment of hydrogen production technologies, not an assessment of hydrogen market demand.

(2) Hydrogen production costs for 1500 kg/day stations developed using DOE’s H₂A Production model, version 2.1. Cost modeling represents the lifetime cost of producing hydrogen at fueling stations installed during an early market rollout of hydrogen infrastructure and are not reflective of the costs that might be seen in a fully mature market for hydrogen installations. Modeling uses default H₂A Production model inputs supplemented with feedback from Learning Demonstration energy company partners, based on their experience operating on-site hydrogen production stations. H₂A-based Monte Carlo simulations (2,000 trials) were completed for both natural gas reforming and electrolysis stations using default H₂A values and 10th percentile to 90th percentile estimated ranges for key cost parameters as shown in the table. Capacity utilization range is based on the capabilities of the production technologies and could be significantly lower if there is inadequate demand for hydrogen.

(3) DOE has a hydrogen cost goal of $2-$3/kg for future (2015) 1500 kg/day hydrogen production stations installed at a rate of 500 stations per year.

**Outside of this project, DOE independent panels concluded at 500 replicate stations/year:**
- Distributed natural gas reforming at 1500 kg/day: $2.75-$3.50/kg (2006)
- Distributed electrolysis at 1500 kg/day: $4.90-$5.70 (2009)
EFFICIENCY: Verified High Gen 2 Fuel Cell System Efficiency Maintained (Compared to Gen 1)

Critical result: Efficiency not sacrificed in order to achieve improved durability and freeze capability.

<table>
<thead>
<tr>
<th>Efficiency [%]</th>
<th>Fuel Cell System 1 Efficiency 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Eff. at 25% Pwr</td>
</tr>
<tr>
<td>Gen1</td>
<td>51 - 58%</td>
</tr>
<tr>
<td>Gen2</td>
<td>53 - 59%</td>
</tr>
</tbody>
</table>

1 Gross stack power minus fuel cell system auxiliaries, per DRAFT SAE J2615. 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.
FUEL ECONOMY: Ranges of Fuel Economy from Dynamometer and On-Road Data Similar for Gen 1 & 2

(1) One data point for each make/model. Combined City/Hwy fuel economy per DRAFT SAE J2572.
(2) Adjusted combined City/Hwy fuel economy (0.78 x Hwy, 0.9 x City).
(3) Excludes trips < 1 mile. One data point for on-road fleet average of each make/model.
(4) Calculated from on-road fuel cell stack current or mass flow readings.
**RANGE: Results Show Significant Improvement in Real-World Driving Range Between 3 Sets of Vehicles**

Distance Driven Between Refuelings: All OEMs

- **Gen1**
  - Refuelings\(^1\) = 18,941
  - Median distance between refuelings = 56 Miles

- **Gen2**
  - Refuelings\(^1\) = 6,870
  - Median distance between refuelings = 81 Miles

Refuelings after 2009Q4\(^1\) = 9,937
- Median distance between refuelings = 98 Miles

**+45% improvement Gen 1 to Gen 2**

**+71% improvement in real-world driving range with latest adv. tech. vehicles**

1. Some refueling events are not detected/reported due to data noise or incompleteness.
2. Distance driven between refuelings is indicative of driver behavior and does not represent the full range of the vehicle.

**Note:** Actual range possible >200 miles
**RANGE: NREL/SRNL Experiment Verified Toyota FCHV-adv Capable of up to 430-Mile Driving Range Without Refueling on June 30, 2009**

**Test Route**

<table>
<thead>
<tr>
<th>Test Route</th>
<th>TTC-LA (Torrance, CA)</th>
<th>Freeway</th>
<th>San Diego, CA</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Average trip distance (miles)</th>
<th>H₂ consumed (kg)</th>
<th>Remaining usable H₂ (kg)</th>
<th>Calculated remaining range (miles)</th>
<th>Calculated remaining range (miles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>331.50</td>
<td>4.8255</td>
<td>1.4854</td>
<td>102.04</td>
<td>433.55</td>
</tr>
<tr>
<td>#2</td>
<td>331.45</td>
<td>4.8751</td>
<td>1.4328</td>
<td>97.41</td>
<td>428.87</td>
</tr>
</tbody>
</table>


**Toyota video:** http://www.youtube.com/watch?v=iz0vD5E7gIA
DURABILITY: Data from FCEVs After 2009 Q4
Fuel Cell Stack Operation Hours

Some stacks operated up over 1,400 hours, but many still below 600 hours.

1) Stacks that are in service and accumulating operation hours.
2) Stacks retired due to low-performance or catastrophic failure.
3) 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.
4) Only includes systems operating after 2009Q4.
DURABILITY: What Does the Stack Aging Look Like? Max FC Power Degradation Rate Drops with Aging

Max Fuel Cell Stack\(^3\) Power Degradation Over Operation

Median power difference from 0 hour segment to 1300 hour segment = -18.2%

1) Normalized by fleet median value at 200 hours.
2) Each segment point is median FC power (+-50 hrs). Box not drawn if fewer than 3 points in segment.
3) Only includes systems operated after 2009Q4.
1) Projection using field data, calculated at high stack current, from operation hour 0 or a steady operation period. 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.

4) Only includes systems operating after 2009Q4.

5) Not all stacks have a steady operation fit which is calculated from data after 200 hr break-in period. The steady operation starting hour is an approximation of the period after initial break-in where degradation levels to a more steady rate.
DURABILITY: Comparison of Fuel Cell Operation Hours and Projected Hours to 10% Voltage Degradation

Many stacks have projections that we limit to 2X due to minimize extrapolation.

25% of stacks are below the unity line and have operated past 10% voltage degradation. On average, these stacks have operated for 990 hours.

Stacks above the unity line have not operated past 10% voltage degradation.

Comparison of Operation Hours and Projected Hours to 10% Voltage Degradation

1) Indicates the projected hours to a 10% voltage degradation based upon curve fitting data from operation hour 0.
2) Projected hours limited based on demonstrated hours.
3) Stacks retired due to low-performance or catastrophic failure.
4) Each projection has uncertainty based on the confidence intervals of the fit.
5) Only includes systems operated after 2009Q4.
INFRASTRUCTURE: Evaluated On-Site Hydrogen Production Efficiency

Hydrogen Production Conversion Efficiency

- **Average Station Efficiency**
- **Quarterly Efficiency Data**
- **Highest Quarterly Efficiency**
- **Efficiency Probability Distribution**

**Production Efficiency (LHV %)**

**On-Site Natural Gas Reforming**

**On-Site Electrolysis**

1. Production conversion efficiency is defined as the energy of the hydrogen out of the process (on an LHV basis) divided by the sum of the energy into the production process from the feedstock and all other energy as needed. Conversion efficiency does not include energy used for compression, storage, and dispensing.

2. The efficiency probability distribution represents the range and likelihood of hydrogen production conversion efficiency based on monthly conversion efficiency data from the Learning Demonstration.
GHG: Learning Demonstration Vehicle
Greenhouse Gas Emissions (WTW)

1. Well-to-Wheels greenhouse gas emissions based on DOE's GREET model, version 1.8b. Analysis uses default GREET values except for FCV fuel economy, hydrogen production conversion efficiency, and electricity grid mix. Fuel economy values are the Gen 1 and Gen 2 window-sticker fuel economy data for all teams (as used in CDP #6); conversion efficiency values are the production efficiency data used in CDP #13.

2. Baseline conventional passenger car and light duty truck GHG emissions are determined by GREET 1.8b, based on the EPA window-sticker fuel economy of a conventional gasoline mid-size passenger car and mid-size SUV, respectively. The Learning Demonstration fleet includes both passenger cars and SUVs.

3. The Well-to-Wheels GHG probability distribution represents the range and likelihood of GHG emissions resulting from the hydrogen FCV fleet based on window-sticker fuel economy data and monthly conversion efficiency data from the Learning Demonstration.

4. On-site electrolysis GHG emissions are based on the average mix of electricity production used by the Learning Demonstration production sites, which includes both grid-based electricity and renewable on-site solar electricity. GHG emissions associated with on-site production of hydrogen from electrolysis are highly dependent on electricity source. GHG emissions from a 100% renewable electricity mix would be zero, as shown. If electricity were supplied from the U.S. average grid mix, average GHG emissions would be 1330 g/mile.
INFRASTRUCTURE: Station Capacity Utilization

Station nameplate capacity reflects a variety of system design considerations including system capacity, throughput, system reliability and durability, and maintenance. Actual daily usage may exceed nameplate capacity.

Maximum quarterly utilization considers all days; average daily utilization considers only days when at least one filling occurred.

Note: Learning Demonstration priority was for good station coverage not high station utilization.
INFRASTRUCTURE: Some CDPs Are Now Looking at the Transition from Demo to Early Market – Utilization is Important

Several stations are serving 4-5 vehicles/day on average

Some stations still significantly under utilized
INFRASTRUCTURE: Infrastructure Reliability Growth

Overall Site Reliability Growth: Infrastructure

Instantaneous MTBF improved for 5 of 7 sites for the last 20% of events.

Most stations have shown improved reliability recently.

2. % change in instantaneous MTBF
3. Includes data from stations operating after 2009 Q4.
FUELING: Tracking Fueling Rates by Year

Average fueling rate rose up until 2009 when some of the higher throughput stations closed down.

### Histogram of Fueling Rates
All Light Duty by Year

<table>
<thead>
<tr>
<th>Year</th>
<th>Avg (kg/min)</th>
<th>% &gt; 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>0.66</td>
<td>16%</td>
</tr>
<tr>
<td>2006</td>
<td>0.74</td>
<td>21%</td>
</tr>
<tr>
<td>2007</td>
<td>0.81</td>
<td>26%</td>
</tr>
<tr>
<td>2008</td>
<td>0.77</td>
<td>23%</td>
</tr>
<tr>
<td>2009</td>
<td>0.77</td>
<td>22%</td>
</tr>
<tr>
<td>2010</td>
<td>0.63</td>
<td>2%</td>
</tr>
<tr>
<td>2011</td>
<td>0.68</td>
<td>12%</td>
</tr>
</tbody>
</table>
FUELING: Changes in Refueling Rate Trends – Average Refueling Rate Decreased 16%

Histogram of Fueling Rates
Vehicle and Infrastructure

Decrease is result of average H₂ per fill increasing 25%, but average fueling time increasing by 37%
### FUELING: Fueling Rates by Fill Pressure and Communication vs. Non-communication – Fueling infrastructure in transition

#### Histogram of Fueling Rates

<table>
<thead>
<tr>
<th>Fill Type</th>
<th>Avg (kg/min)</th>
<th>%&gt;1</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Through 2009Q4</td>
<td>0.82</td>
<td>29%</td>
<td>19659</td>
</tr>
<tr>
<td>700 bar</td>
<td>0.63</td>
<td>4%</td>
<td>5590</td>
</tr>
<tr>
<td>After 2009Q4</td>
<td>0.70</td>
<td>8%</td>
<td>2594</td>
</tr>
<tr>
<td>700 bar</td>
<td>0.64</td>
<td>7%</td>
<td>5208</td>
</tr>
</tbody>
</table>

- **350 bar fueling rates dropped from 0.82 to 0.70 kg/min**
- **700 bar fueling rates holding constant at ~0.63 kg/min**

Comm fill rates dropped while non-comm fill rates increased.
Analysis at NREL Leveraged Across Applications; Being Applied to Compare Similarities/Differences

Fueling rates vary by application, driven by constraints on nominal pressure, volume, tank materials.

Other data sources: FC bus, forklift, lab data, and backup power.
Example of Analysis Results Informing R&D Activities and Codes and Standards Development

Delta Temperature: Tank minus Ambient

- This CDP created in support of SAE J2601 related to refueling
- Temperatures are prior to refueling and exclude data within 4 hours of a previous fill
- The plot to the left excludes ambient temperatures less than -5 deg C

FCEVs arrive at station with a tank temperature that is 3.8 degrees C colder than ambient temp
Technical Summary

- Project has completed ~7 years of real-world validation
- **Vehicle operation**: 183 vehicles, 154,000 hours, 3.5 million miles, 500,000 trips
- **H₂ station operation**: 25 stations, 151,000 kg produced or dispensed, 33,000 fuelings
- DOE Key Technical Targets Validated and Met:
  - FC Durability >2,000 hours and Range >250 miles
Learning Demo Project Wrap-Up

- Winter 2011 CDPs just posted on NREL web site
- Draft final report in March 2012, to be published in April
- Continuing to receive data on H2 infrastructure with support from DOE (primarily in CA: stations funded by CEC and ARB). New results to follow.
- In discussions with how to continue to assess FCEV progress in the coming years
- This project is the 1st time such comprehensive data was collected by an independent 3rd-party and consolidated for public dissemination
  - Successful framework being used for other projects
NREL Has Built the Infrastructure and Framework for Other Projects to Follow

Learnign Demo
Conclusion

Final Public Report

OBJECTIVE CREDIBLE EVALUATIONS HELPED LEAD TO INFORMED DECISIONS

Spring 2006 CDPs
Fall 2006 CDPs
Spring 2007 CDPs
Fall 2007 CDPs
Spring 2008 CDPs
Fall 2008 CDPs
Spring 2009 CDPs
Fall 2009 CDPs
Spring 2010 CDPs
Fall 2010 CDPs
Spring 2011 CDPs
Fall 2011 CDPs
Winter 2011 CDPs
To Learn More on Your Own…
It’s All Online on NREL’s web site
New Graphical Way of Viewing Results Will Soon Be Online

Online Questions and Discussion

Project Contact: Keith Wipke, National Renewable Energy Lab
303.275.4451 keith.wipke@nrel.gov

All public Learning Demo papers and presentations are available online at http://www.nrel.gov/hydrogen/proj_tech_validation.html

DOE FCT Program website:
http://www1.eere.energy.gov/hydrogenandfuelcells/index.html