# Overview

## Timeline
- Project start date: Oct. 2011
- Project end date: Sep. 2013* 
- Percent complete: On-going

## Barriers
- B. Lack of Data on Stationary Fuel Cells in Real-World Applications
- E. Codes & Standards

## Budget
- Total project funding
  - DOE share: $265k
  - Contractor share: $0
- Planned funding in FY13: $200k

## Partners
- California Stationary Fuel Cell Collaborative, (review results)
- National Fuel Cell Research Center (UCI), (subcontractor)
- Four OEM data providers, developing others.

*Project continuation and direction determined annually by DOE*
Relevance - Objectives

Independently assess, validate, and report operation targets and stationary fuel cell system performance under real operating conditions.

B. Lack of Data on Stationary Fuel Cells in Real-World Applications

Addressing the gap in knowledge as stationary fuel cell installations have increased dramatically.

E. Codes & Standards

Providing data and context to C&S activities.
Approach - Milestones

- Quarterly data analysis (based on available data)
- Publication of technical stationary fuel cell composite data products

- FY12 Q4
- FY13 Q1
- FY13 Q2
- FY13 Q3
- FY13 Q4

- Completed
- Scheduled
Approach - Technology Validation Project Leveraging

Total Hours: 1,962,190

- MHE: 1,445,558 hrs
- Lab: 95,759 hrs
- FCEV: 154,407 hrs
- FCB: 266,466 hrs

Published performance reports

Prehistory...2005

2006 2007 2008 2009 2010 2011 2012 2013

Project Renewing

NATIONAL RENEWABLE ENERGY LABORATORY
Approach - Hydrogen Secure Data Center Analysis and Reporting

### Detailed Data Products (DDPs)
- Individual data analyses
- Identify individual contribution to CDPs
- Only shared with partner who supplied data every 6 months¹

### Composite Data Products (CDPs)
- Aggregated data across multiple systems, sites, and teams
- Publish analysis results without revealing proprietary data every 6 months²

¹) Data exchange may happen more frequently based on data, analysis, and collaboration
²) Results published via NREL Tech Val website, conferences, and reports
Approach - Stationary Fuel Cell Systems

• Includes systems providing prime, continuous, or regular power to a site (not backup power)

• Includes multiple fuel cell types - proton exchange membrane (high and low temperature), solid oxide, phosphoric acid, and molten carbonate

• Small, kilowatt-scale to large, megawatt-scale
Approach - Data Processing, Analysis, and Reporting Tools

• **NREL Fleet Analysis Toolkit (NRELFAT)**
  – Developed first under fuel cell vehicle Learning Demonstration
  – Restructured architecture and interface to effectively handle new applications and projects and for flexible analysis
  – Leverage analyses already created

• **Report results**
  – Detailed and composite results
  – Target key stakeholders such as fuel cell and hydrogen developers, and end users
Accomplishment - Stationary Fuel Cell Processing

Stationary Processing and Analysis Capabilities in NREL FAT

Application

Company & project

Data management

Raw data processing

Operating data processing & analysis

Fuel cell degradation processing & analysis

Composite results
Accomplishment – Web site

All public results have been published to NREL’s Technology Validation web site. http://www.nrel.gov/hydrogen/proj_fc_systems_analysis.html

Stationary Fuel Cell Systems Analysis

NREL's technology validation team analyzes the performance of stationary fuel cell systems operating in real-world conditions and reports on the technology's performance, progress, and challenges. This analysis includes multiple fuel cell types—proton exchange membrane, solid oxide, phosphoric acid, and molten carbonate—with system sizes ranging from 5 kW to 2.8 MW.

Stationary fuel cell systems are used for backup power (see related analysis results), power for remote locations, stand-alone power plants for towns and cities, distributed generation for buildings, and co-generation (in which excess thermal energy from electricity generation is used for heat). Systems are currently in operation in states across the nation. One of the leading markets is in California, where NREL works in partnership with the National Fuel Cell Research Center and the California Stationary Fuel Cell Collaborative to analyze and report on stationary fuel cell installations.

Participating partners share raw data with NREL via the Hydrogen Secure Data Center. NREL engineers perform uniform analysis on the detailed data and then report on their findings. While the raw data are secured by NREL to protect proprietary information, individualized data analysis results are provided as detailed data products to the partners who supplied the data. The results are also aggregated into publicly available composite data products (CDPs) that show the status and progress of the technology, but don't identify individual companies.

Composite Data Products

The following CDPs focus on the use of fuel cells in stationary applications.

- Stationary Fuel Cell Systems Deployed by Year, CDP STAT 01, 9/21/2012: PowerPoint | JPG
- Stationary Fuel Cell System Count by Status, CDP STAT 02, 9/21/2012: PowerPoint | JPG
- Location of Stationary Fuel Cell Systems Analyzed, CDP STAT 03, 9/21/2012: PowerPoint | JPG
- Stationary Fuel Cell System Count and Capacity by Fuel Type, CDP STAT 04, 9/21/2012: PowerPoint | JPG
- Fuel Cell Capacity, CDP STAT 05, 9/21/2012: PowerPoint | JPG
- Stationary Fuel Cell Capacity and Average Costs, CDP STAT 06, 9/21/2012: PowerPoint | JPG
- Distribution of Stationary Fuel Cell Install Cost with and without Incentives, CDP STAT 07, 9/21/2012: PowerPoint | JPG
- Stationary Fuel Cell Install Cost over Time with and without Incentives, CDP STAT 08, 9/21/2012: PowerPoint | JPG
Accomplishment - Location and Status
Installations are clustered around major population centers

Deployment Count By Status*

<table>
<thead>
<tr>
<th>Status</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advancement</td>
<td>22%</td>
</tr>
<tr>
<td>Completed</td>
<td>78%</td>
</tr>
</tbody>
</table>

CA Stationary Fuel Cell Installations* (2001 - 2012)

*data from the California SGIP

• Advancement is a final check of permits, insurance, calculations, power purchase agreements and other quality measures prior to funding.
Accomplishment - Deployments by Year
Some of the momentum gained in 2009-2010 appears to remain in the market.

Cumulative Deployment Count by Year*
For Status: Completed, Advancement, Pending Payment

Total = 249 units

Cumulative Capacity by Year
For Status: Completed, Advancement, Pending Payment

Total = 97 MW

*Data from the California SGIP.
Accomplishment - Count by Fuel Type

Natural gas is the most popular fuel choice, although renewable fuels account for almost 1/3 of capacity.

Site Count by Fuel Type*

- Biomass: 6%
- Digester Gas: 11%
- Landfill Gas: 14%
- Natural Gas: 69%

Total Sites: 249

Installed Capacity by Fuel Type

- Biomass: 6%
- Digester Gas: 20%
- Landfill Gas: 17%
- Natural Gas: 57%

Total Capacity: 97 MW

*Data from the California SGIP.
Natural gas is the most popular fuel choice, regardless of system size.

Digester gas makes a serious challenge to NG at larger sizes.

*Data from the California SGIP.*
Accomplishment - Fuel Type Trends

The recent low cost of natural gas may be contributing to a decline in the adoption of other fuel types.

*Data from the California SGIP.
Accomplishment - Capacity by Fuel Type

Digester gas has a few large systems (mean>> median).

Natural gas has a wide application range and many smaller systems.
Accomplishment - Cost Statistics by Fuel Type

There is a wide range of installed costs ($2010/kW) for digester and NG systems.

$2010/kW of Installed Capacity by Fuel Type*

Landfill and biomass have less variability.

*Data from the California SGIP.
Accomplishment - Installation Costs

Incentives account for ~$3400/kW, on average across system types and over time.

Installed Cost Per kW*
Adjusted To 2010 Dollars

Avg = $10,223 $/kW

Price without incentives [$2010/kW]

Avg = $6,762 $/kW

Price with incentives [$2010/kW]

*Data from the California SGIP.
Accomplishment - Installation Costs and Capacity

Deployment totals favor systems < 200 kW. There is a modest decrease in cost ($2010/kW) as system sizes increase.

*Data from the California SGIP.

†for the year 2020, operating on natural gas.
Accomplishment - Installation Cost Trend
Costs ($2010/kW) are trending up over time regardless of system size.

Causes are unknown, but may include increased materials costs, increased value from fuel cells, increased cost of competing technologies in the market pushing prices up.
Accomplishment - Incentive Trend

Total incentive spending is declining in the last five years, yet installed capacity continues to increase.

*Data from the California SGIP.*
Collaborations

• Partners for data delivered at the end of 2012
  o National Fuel Cell Research Center
  o California Stationary Fuel Cell Collaborative
  o Four fuel cell OEMs

• Communicating with several organizations to establish agreements for sharing data with NREL
  o State and regional fuel cell organizations
  o Fuel cell developers
Proposed Future Work

• Continue establishing partnerships with end-users, state collaborations, and fuel cell developers to create data sets of stationary fuel cell systems operating in real-world conditions

• Continue to develop relationships with other partners in order to expand analysis to include
  o Maintenance data
  o Degradation data
Summary

**Relevance:** Validating the performance and cost of technologies in stationary fuel cell systems, under real-world conditions supports market growth, product awareness, and technology growth.

**Approach:** Leverage capabilities established under other technology validation activities like NRELFAT to address a gap in data for stationary fuel cell systems.

**Accomplishments:** NREL has published thirteen results, and included a website where results are publically available.

**Collaborations and Future Work:** Continue to develop relationships and additional results.