

Stationary Fuel Cell Evaluation



2013 DOE Annual Merit Review

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National Renewable Energy Laboratory

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Project ID# TV016

This presentation does not contain any proprietary, confidential, or otherwise restricted information.

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.



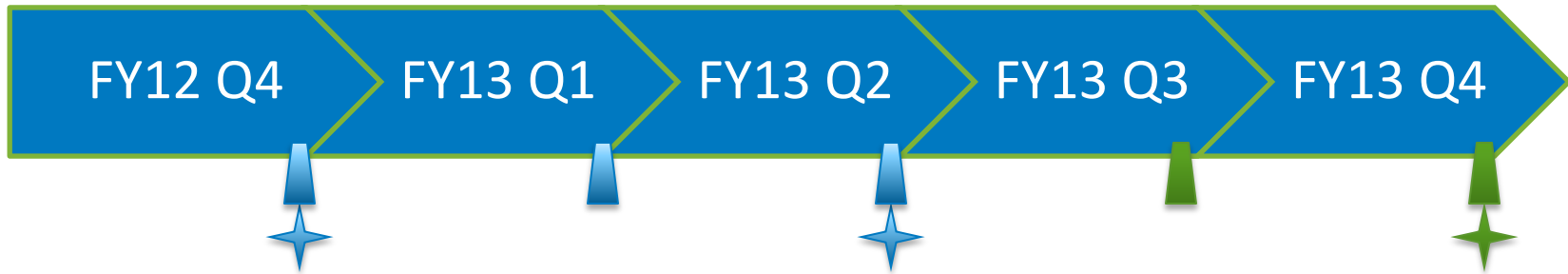
B. Lack of Data on Stationary Fuel Cells in Real-World Applications

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)**

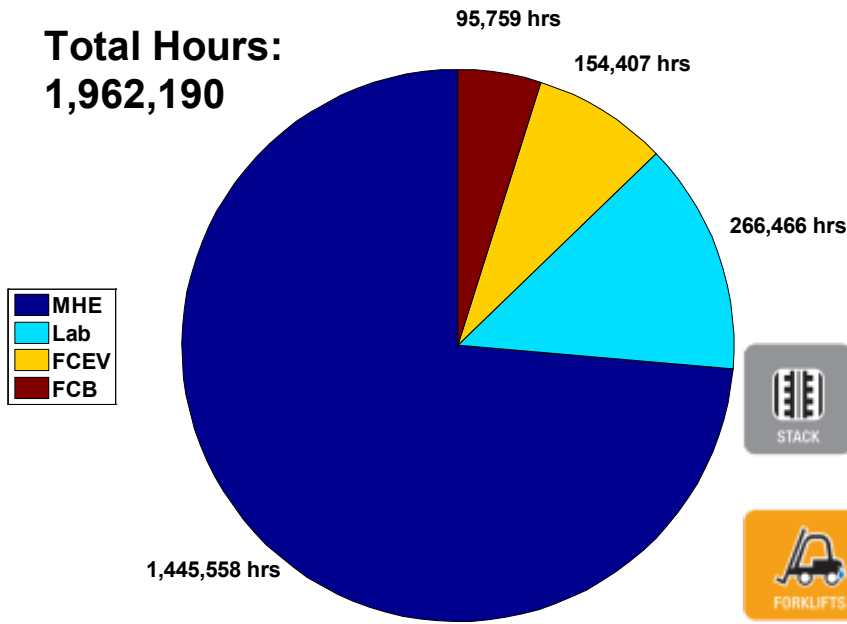
 **Publication of technical stationary fuel cell composite data products**

  Scheduled

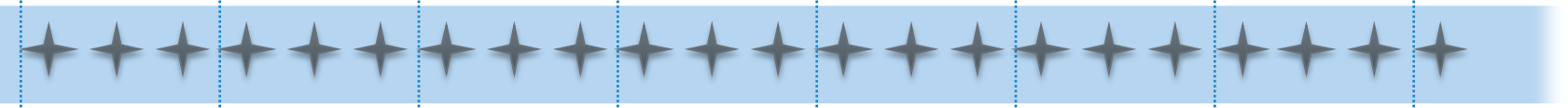
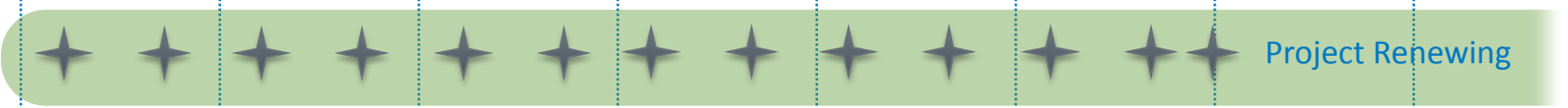
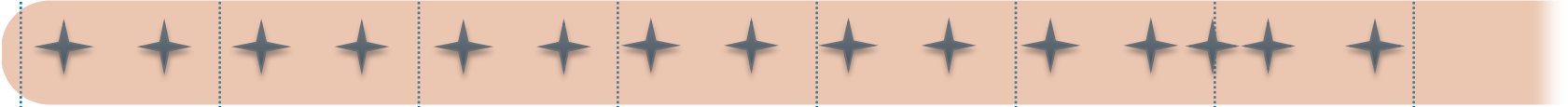
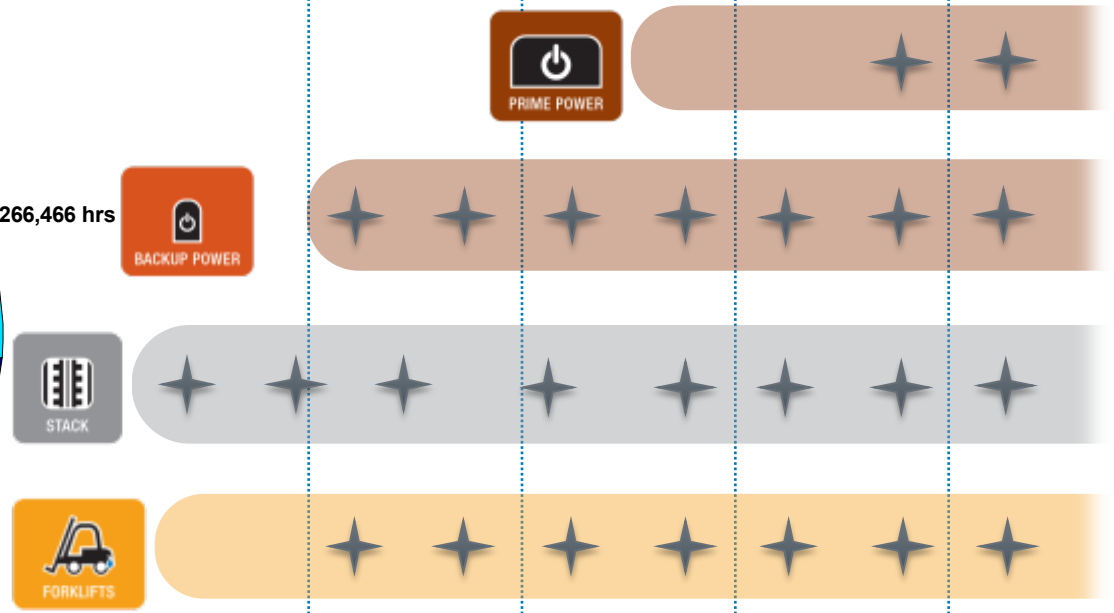
  Completed

Approach - Technology Validation Project Leveraging

Total Hours:
1,962,190



- MHE
- Lab
- FCEV
- FCB

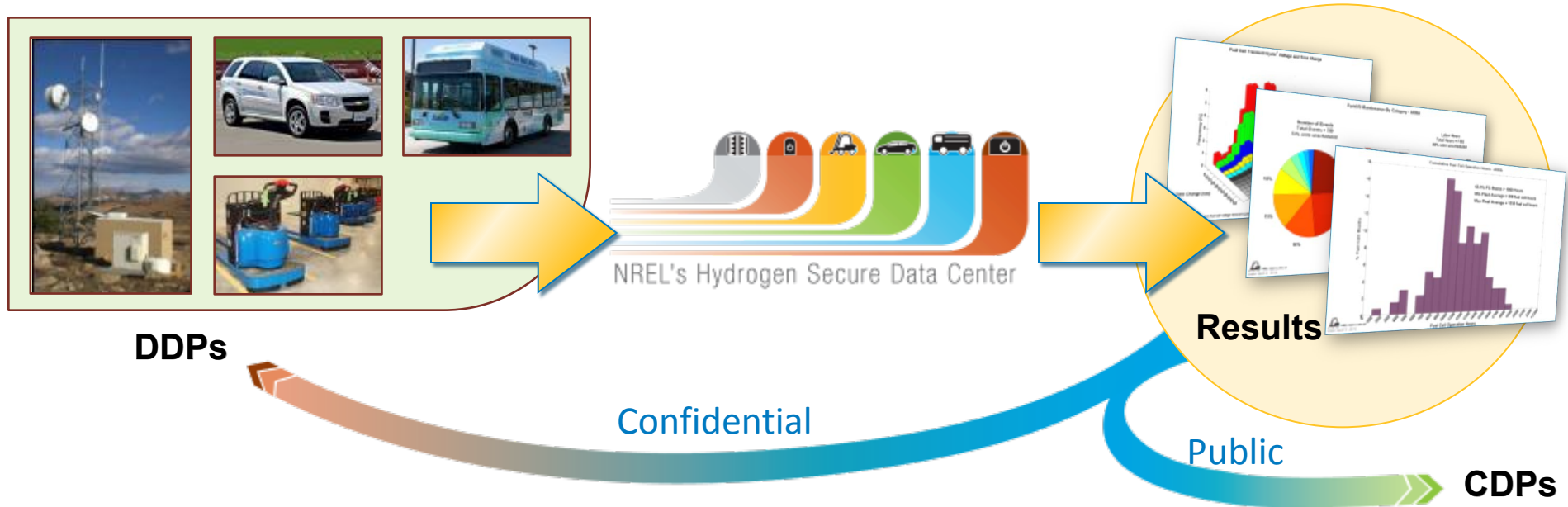


Prehistory...2005

2006 2007 2008 2009 2010 2011 2012 2013

★ Published performance reports

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

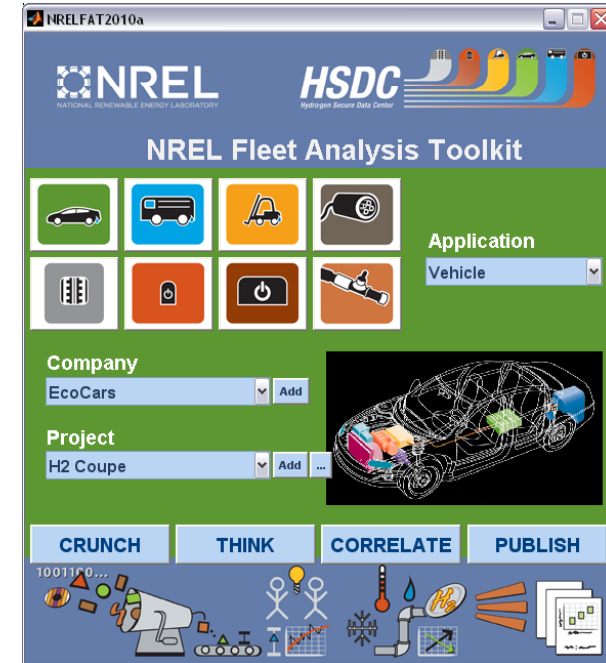
Approach - Data Processing, Analysis, and Reporting Tools

- **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 NRELFAT

The screenshot displays the NRELFAT software interface, which is organized into several functional areas:

- Application:** Located at the top left, it includes a power button icon and a 'Company & project' section with dropdown menus for 'Company:' and 'Project:'. A 'Change Defaults' button is also present.
- Data management:** This central section contains several toolbars:
 - Archive:** Includes 'CreateArchive' and 'FileTransferPrep' buttons.
 - Batch:** Includes 'Save For Batch Run' and 'Run Batch' buttons.
 - Composite Data:** Includes 'Composite Setup', 'Composite Analysis', 'Interactive CDP Setup', and 'Interactive CDP Run' buttons.
- Analysis:** Located on the right, it features a 'Processing to Perform' section with a radio button for 'New CD' and a 'Selected Below' section containing a list of analysis tasks:
 - ProcessRaw
 - GetTriplInfo
 - StackInfoFromExcel
 - OpSummaryRaw
 - OpSummary
 - FCDegRaw
 - FCDeg
- Central Action Buttons:** A vertical column of buttons including 'CRUNCH', 'THINK', 'CORRELATE', 'PUBLISH', and a large 'RUN' button.

Yellow callouts and arrows highlight specific features:

- A callout labeled 'Application' points to the power button icon.
- A callout labeled 'Company & project' points to the dropdown menus.
- A callout labeled 'Data management' points to the Archive, Batch, and Composite Data toolbars.
- A callout labeled 'Raw data processing' points to the 'ProcessRaw' task in the Analysis list.
- A callout labeled 'Operating data processing & analysis' points to the 'OpSummaryRaw' and 'OpSummary' tasks.
- A callout labeled 'Fuel cell degradation processing & analysis' points to the 'FCDegRaw' and 'FCDeg' tasks.
- A callout labeled 'Composite results' points to the 'Composite Analysis' and 'Interactive CDP Run' buttons.

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



The screenshot shows the NREL website's "Hydrogen & Fuel Cells Research" page. At the top is the NREL logo and navigation tabs for "ABOUT NREL", "ENERGY ANALYSIS", "SCIENCE & TECHNOLOGY", "TECHNOLOGY TRANSFER", "TECHNOLOGY DEPLOYMENT", and "ENERGY SYSTEMS INTEGRATION". The main header features the text "Hydrogen & Fuel Cells Research" and a search bar with "More Search Options" and "Site Map" links. A "Printable Version" link is also present.

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 system.

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 analyses 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

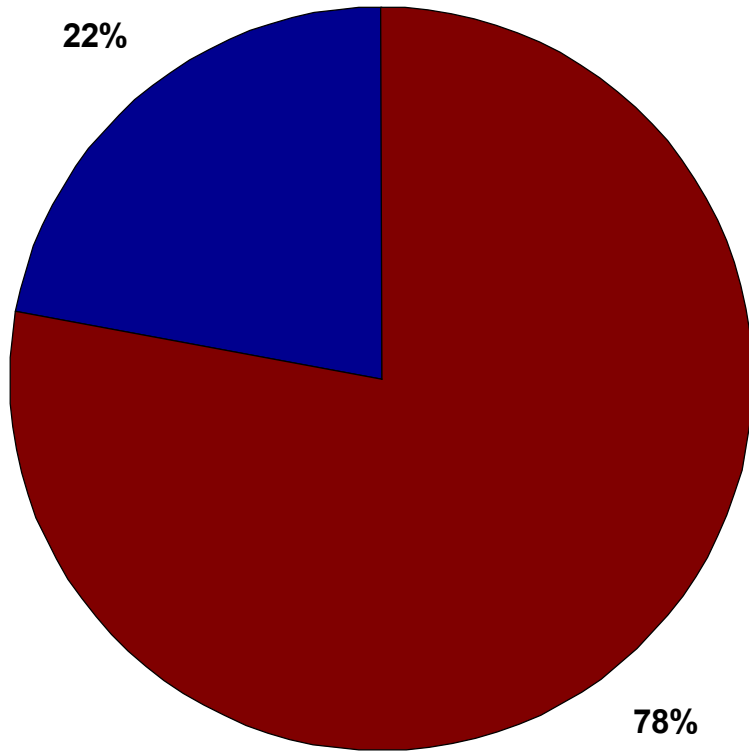
The following CDPs focus on the use of fuel cells in stationary applications.

- **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, 10/22/2012: [PowerPoint](#) | [JPG](#)

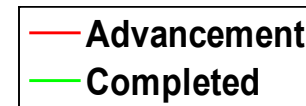
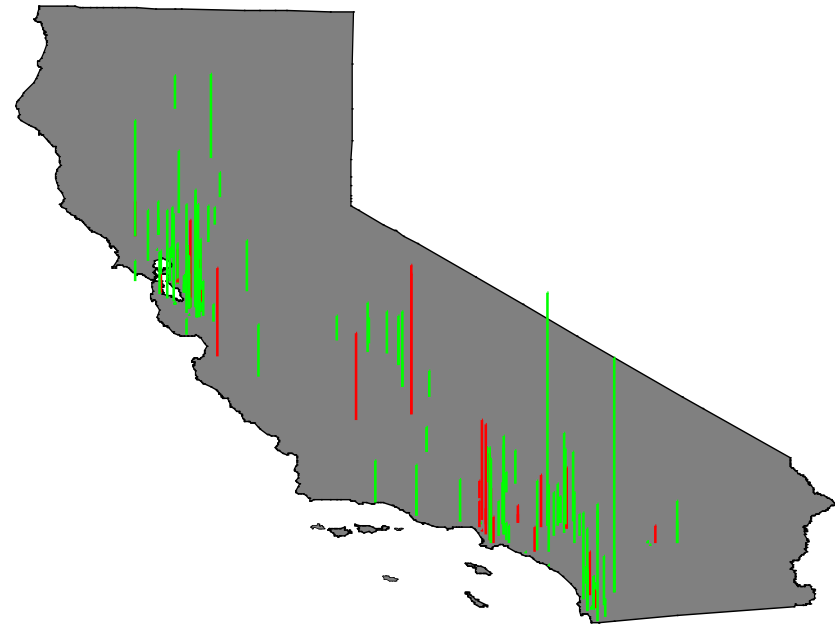
Accomplishment - Location and Status

Installations are clustered around major population centers

Deployment Count By Status*



CA Stationary Fuel Cell Installations* (2001 - 2012)

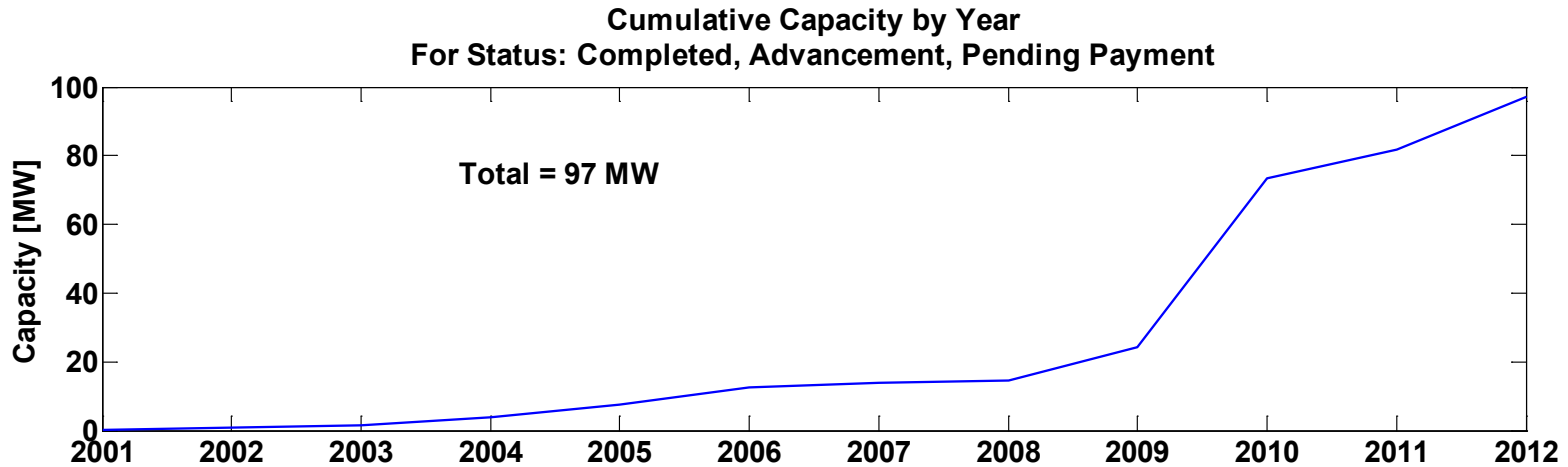
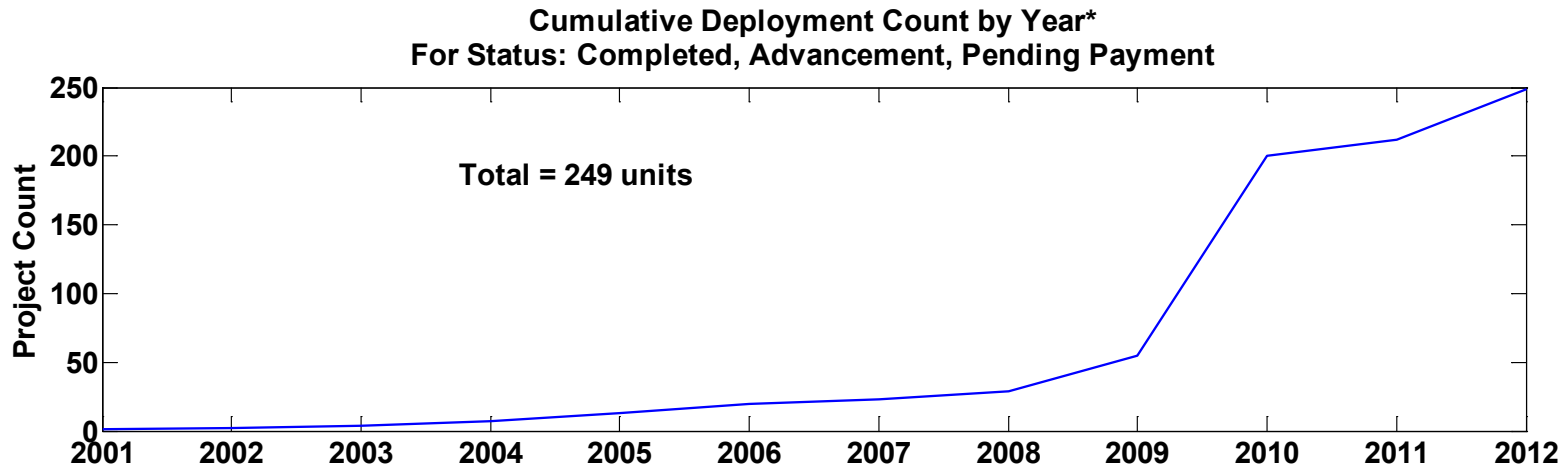


*data from the California SGIP

•Advancement is a final check of permits, insurance, calculations, power purchase agreements and other quality measures prior to funding.

Accomplishment - Deployments by Year

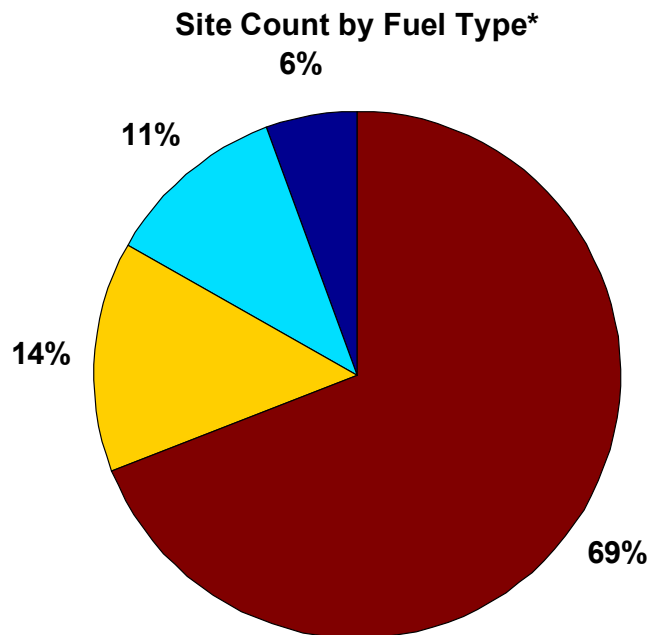
Some of the momentum gained in 2009-2010 appears to remain in the market.



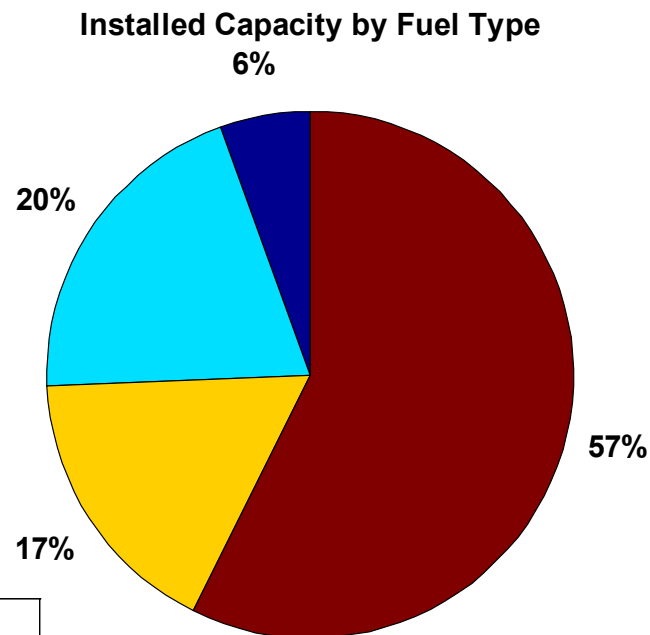
Accomplishment - Count by Fuel Type

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

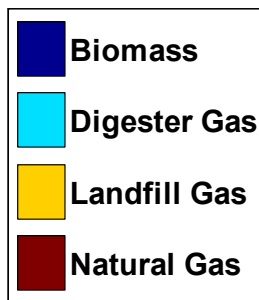
Installations by Fuel Type



Total Sites: 249



Total Capacity: 97 MW

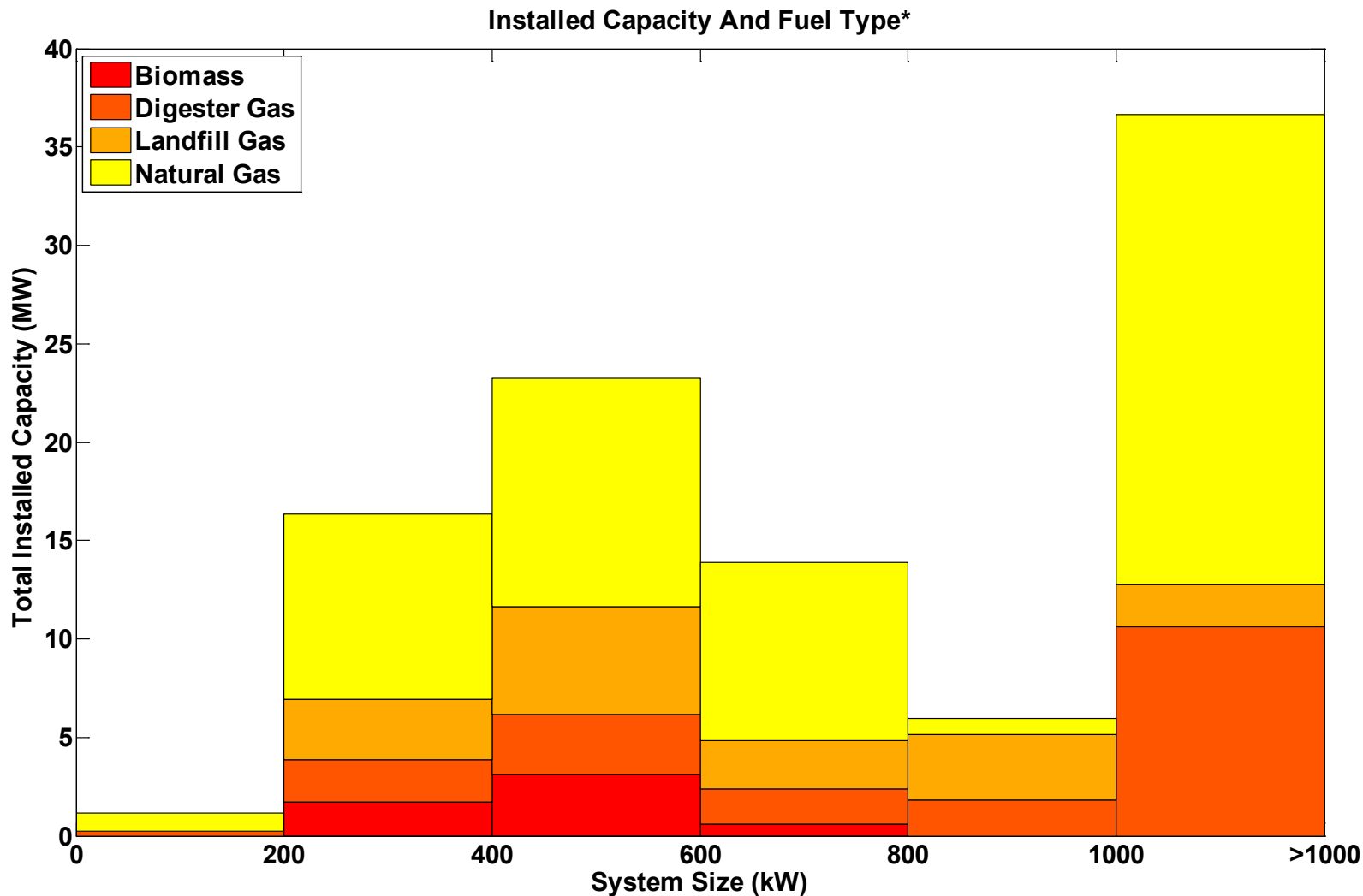


Includes Status Categories:
Completed
Advancement

*Data from the California SGIP.

Accomplishment - System Size by Fuel Type

Natural gas is the most popular fuel choice, regardless of system size.



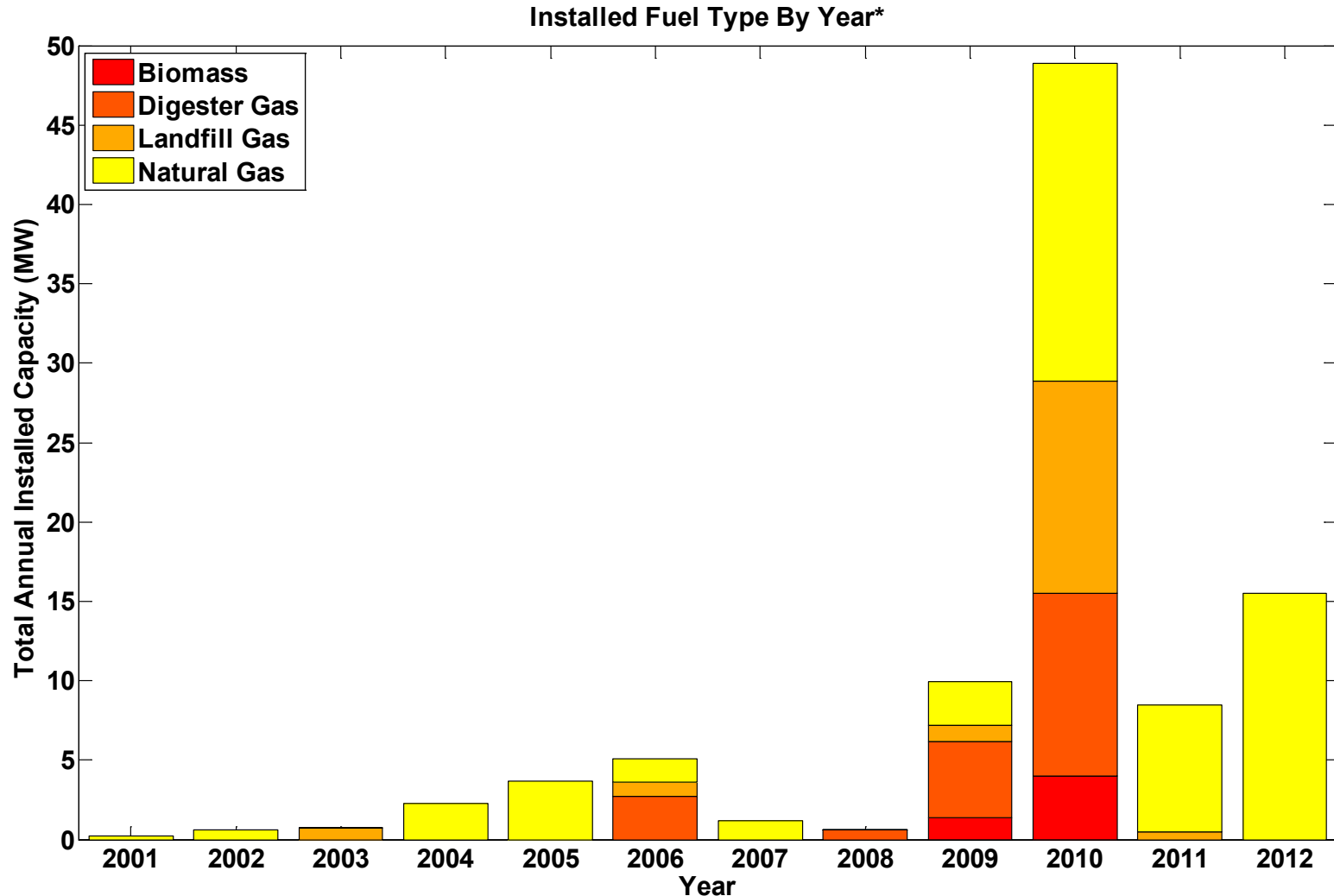
NREL cdp_stat_10
Created: Apr-04-13 3:06 PM | Data Range: 2001Q3-2012Q4

*Data from the California SGIP.

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

Accomplishment - Fuel Type Trends

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

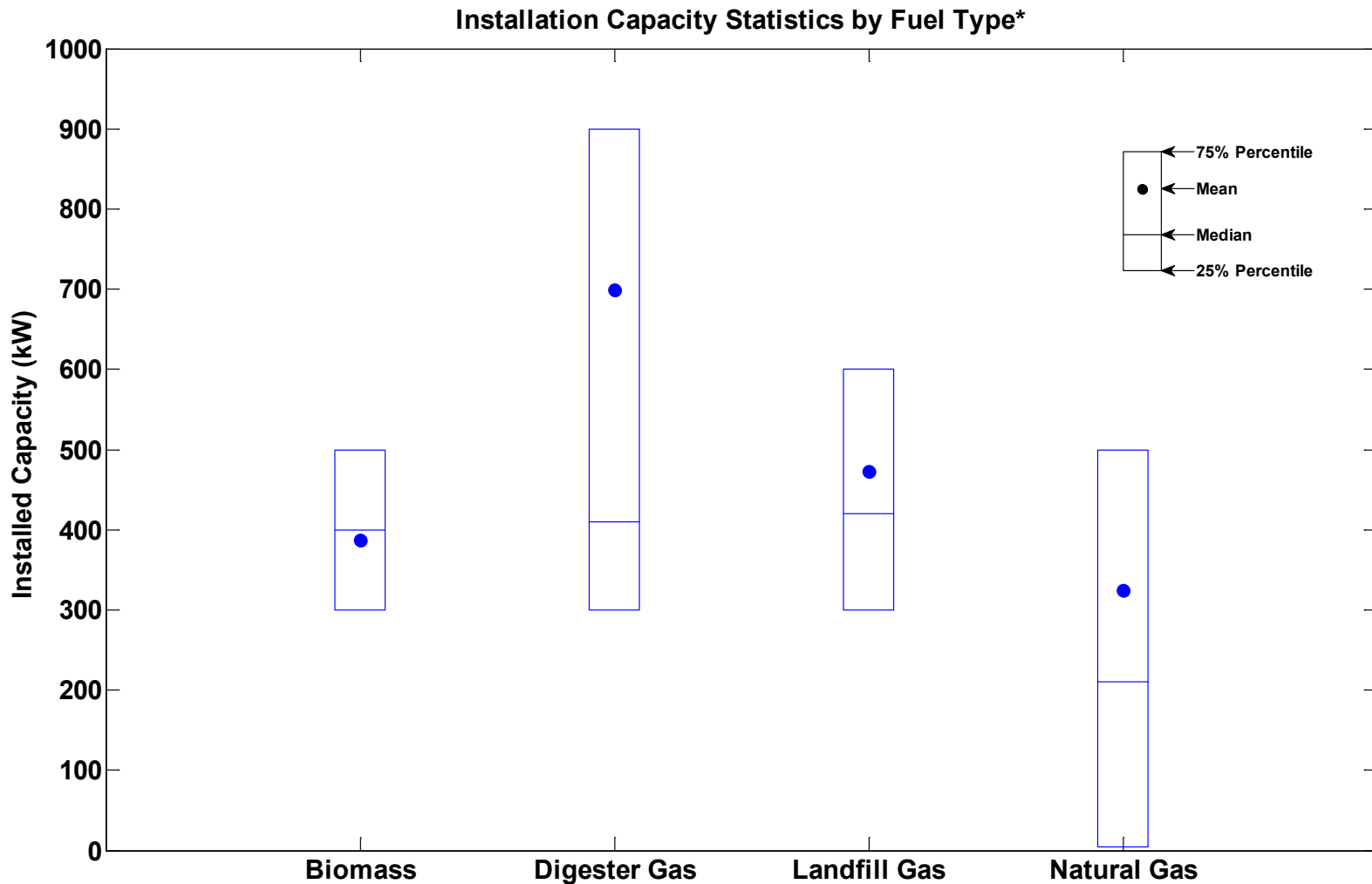


NREL cdp_stat_13
Created: Apr-04-13 3:07 PM | Data Range: 2001Q3-2012Q4

*Data from the California SGIP.

Accomplishment - Capacity by Fuel Type

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



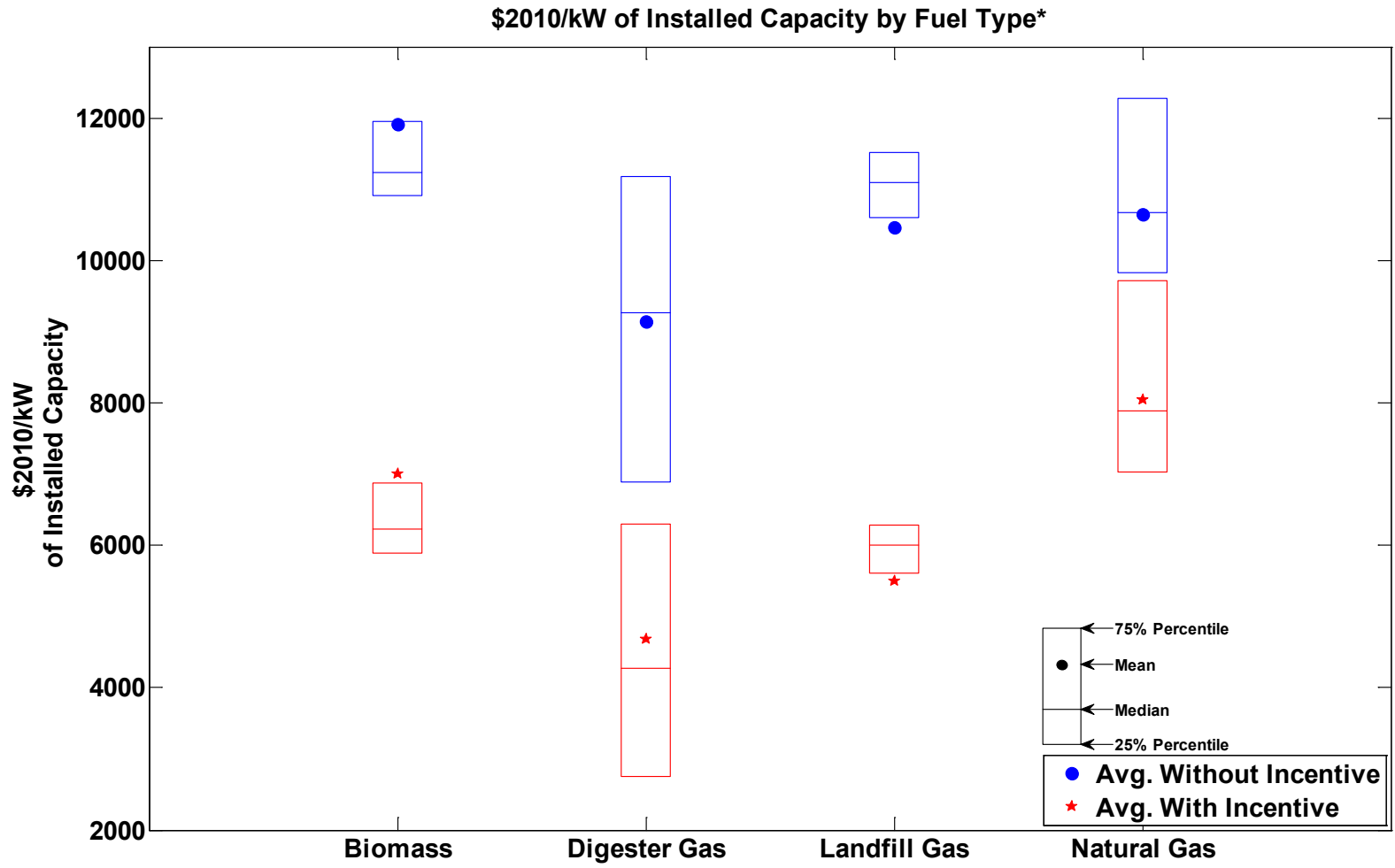
NREL cdp_stat_05
Created: Apr-04-13 2:52 PM | Data Range: 2001Q3-2012Q4

*Data from the California SGIP.

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.



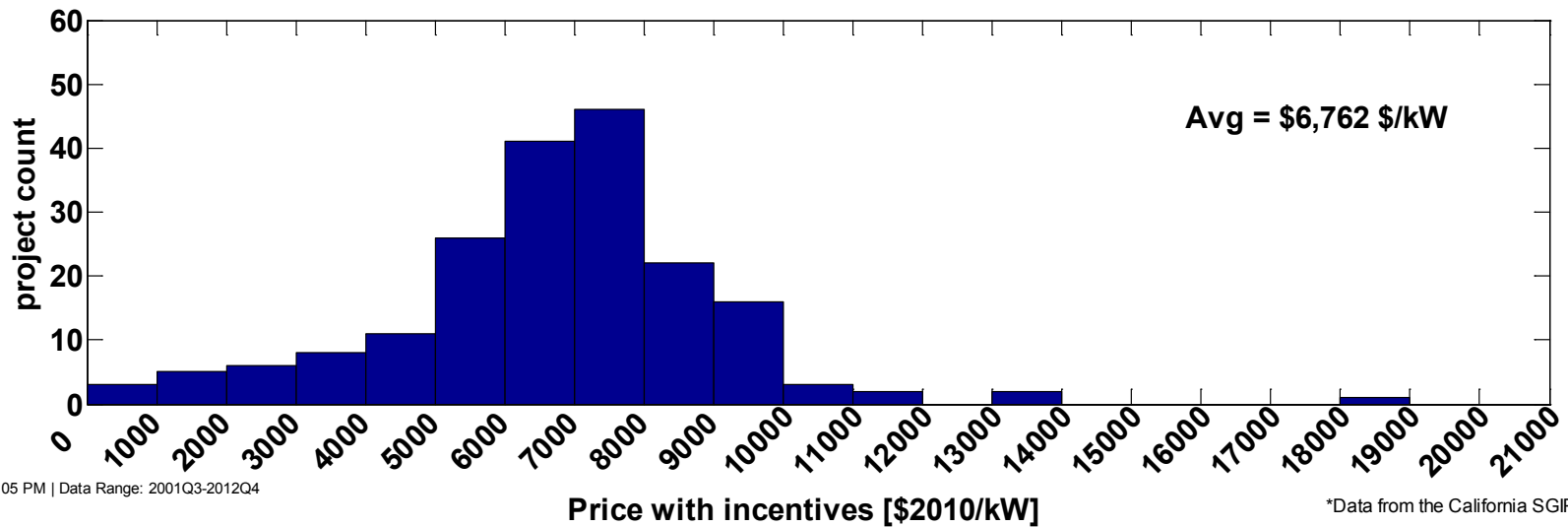
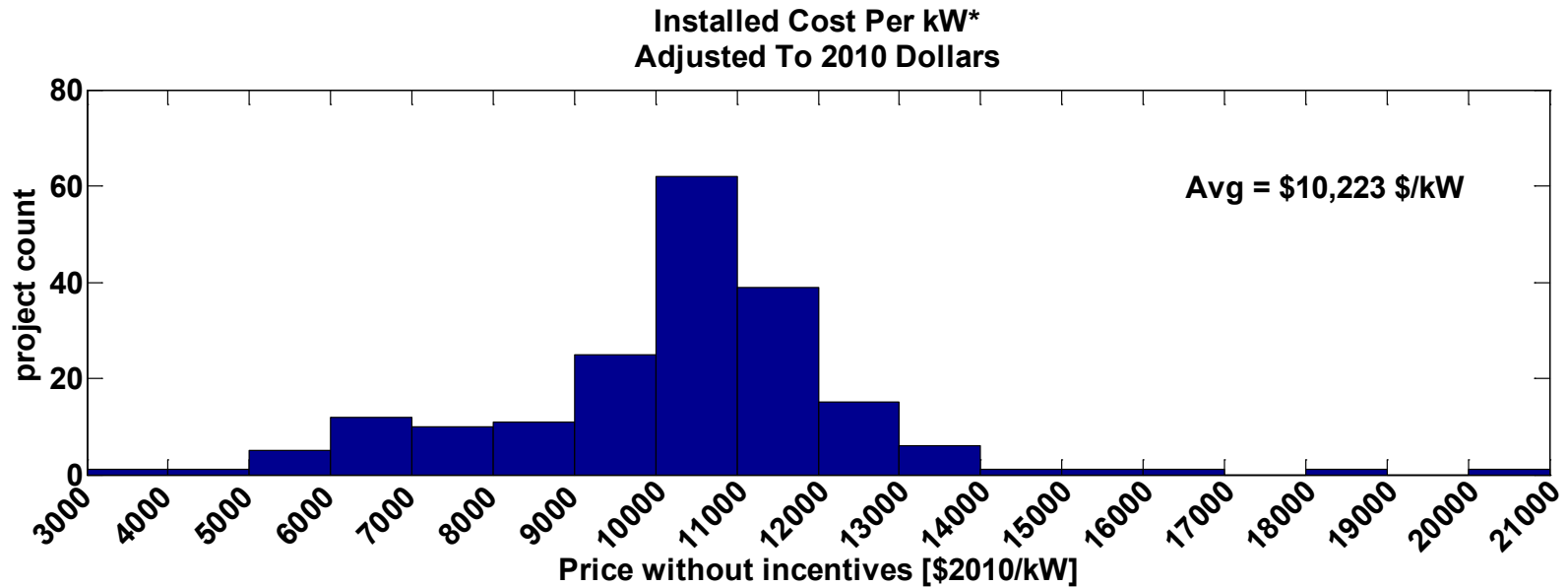
NREL cdp_stat_09
Created: Apr-04-13 3:06 PM | Data Range: 2001Q3-2012Q4

*Data from the California SGIP.

Landfill and biomass have less variability.

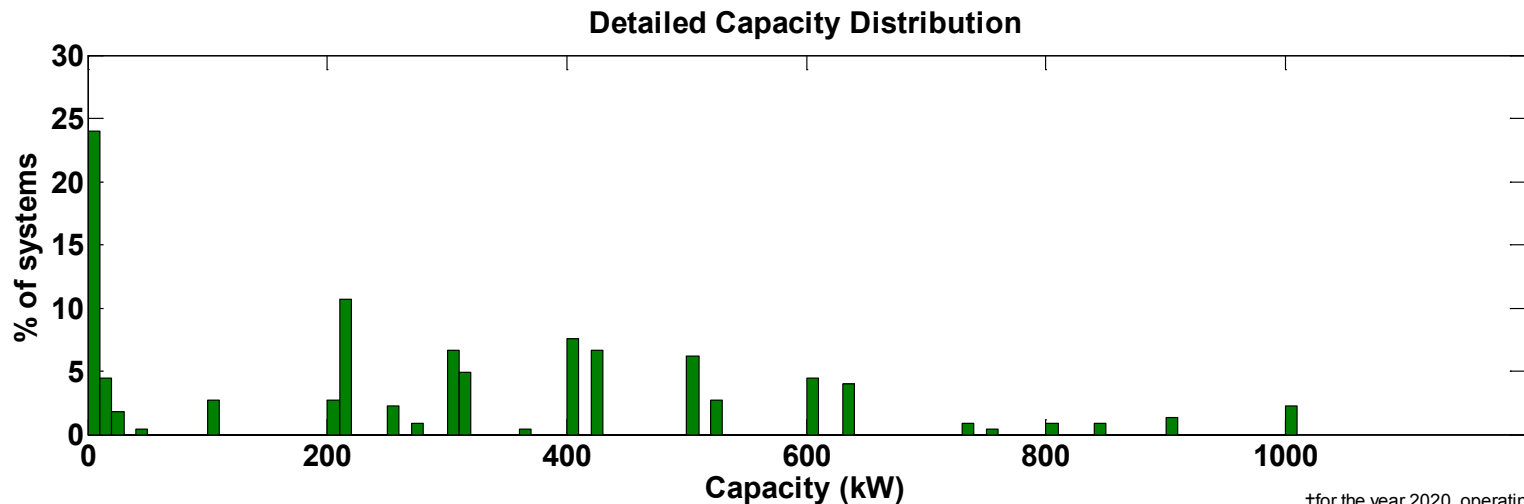
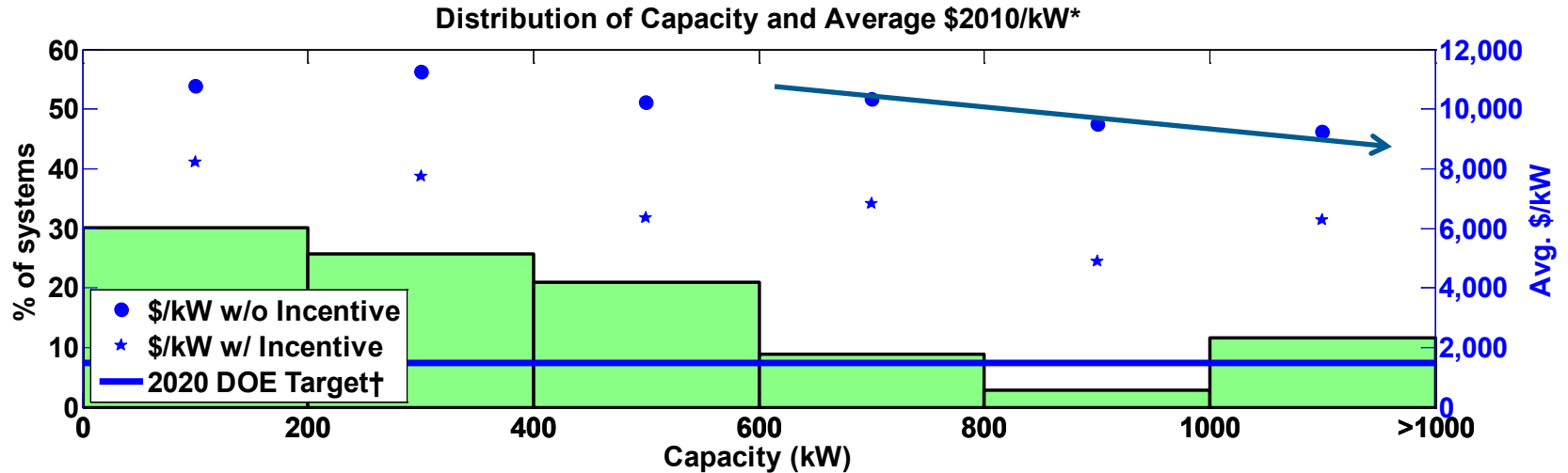
Accomplishment - Installation Costs

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



Accomplishment - Installation Costs and Capacity

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



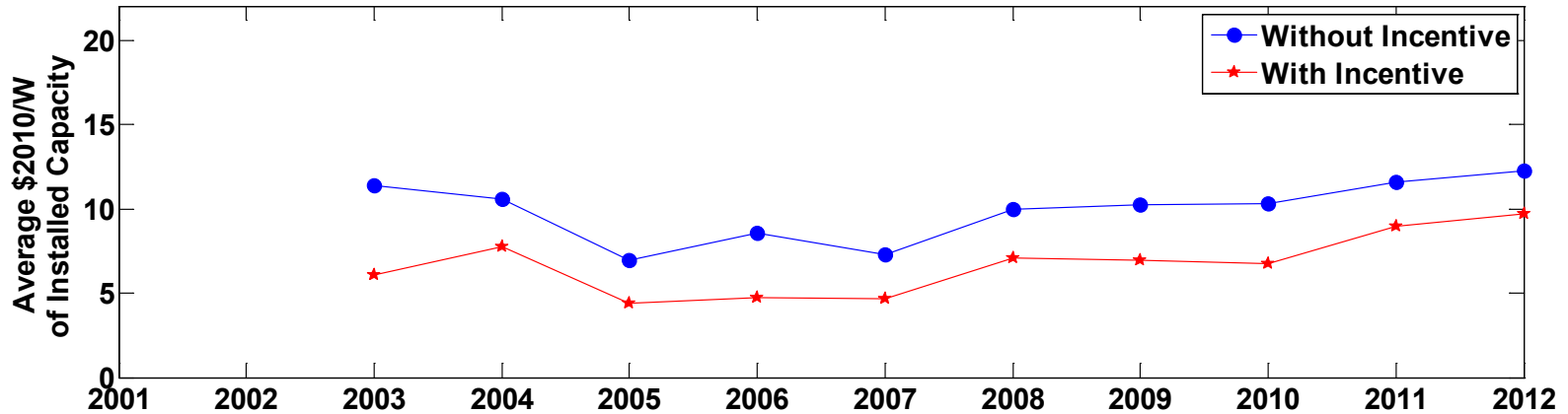
NREL cdp_stat_06
Created: Apr-04-13 3:05 PM | Data Range: 2001Q3-2012Q4

†for the year 2020, operating on natural gas.
*Data from the California SGIP.

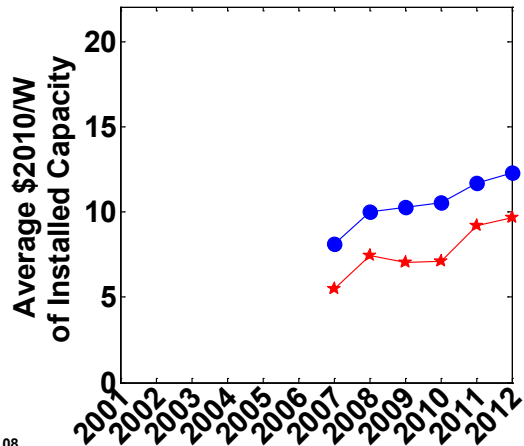
Accomplishment - Installation Cost Trend

Costs (\$2010/kW) are trending up over time regardless of system size.

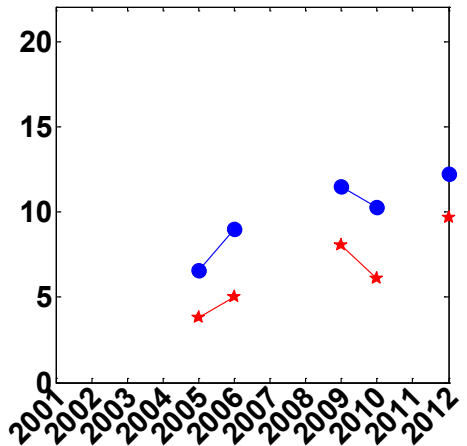
Average \$2010/W Trend for Overall Deployments*



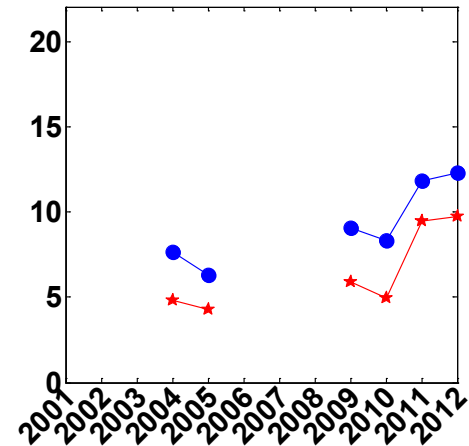
Capacity < 500 kW



500 kW <= Capacity < 1000 kW



Capacity >= 1000 kW



NREL cdp_stat_08
Created: Apr-04-13 3:27 PM | Data Range: 2001Q3-2012Q4

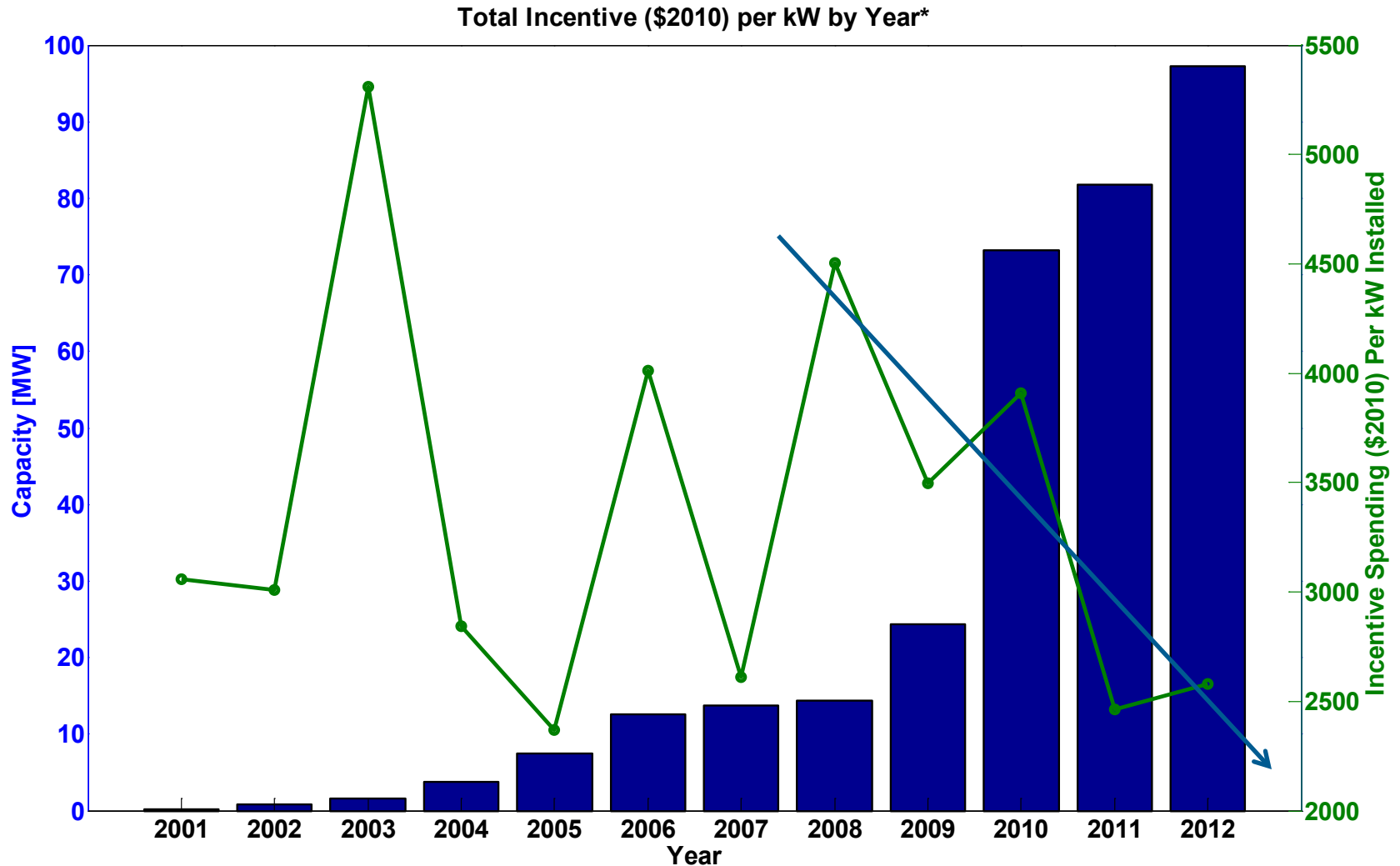
Note: Data points are omitted where only one system would be represented in a given year.

*Data from the California SGIP.

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.



NREL cdp_stat_11
Created: Apr-04-13 3:06 PM | Data Range: 2001Q3-2012Q4

*Data from the California SGIP.

Collaborations

- **Partners for data delivered at the end of 2012**
 - National Fuel Cell Research Center
 - California Stationary Fuel Cell Collaborative
 - Four fuel cell OEMs
- **Communicating with several organizations to establish agreements for sharing data with NREL**
 - State and regional fuel cell organizations
 - 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**
 - Maintenance data
 - 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.