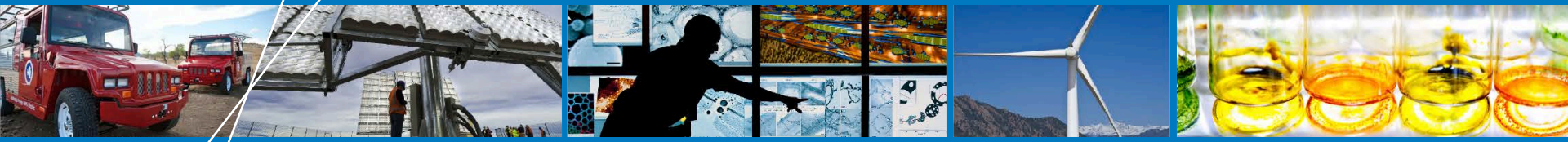
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Stationary Fuel Cell Evaluation



2013 DOE Annual Merit Review

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National Renewable Energy Laboratory

May 16, 2013

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.

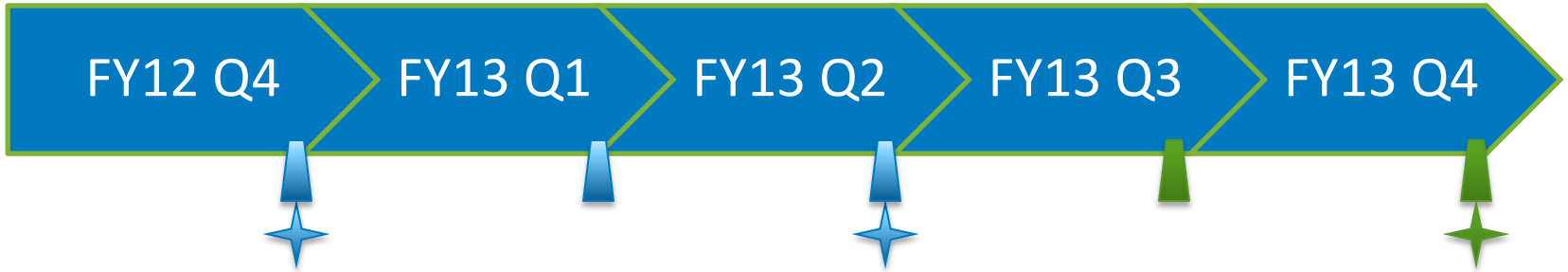
B. Lack of Data on Stationary Fuel Cells in Real-World Applications

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

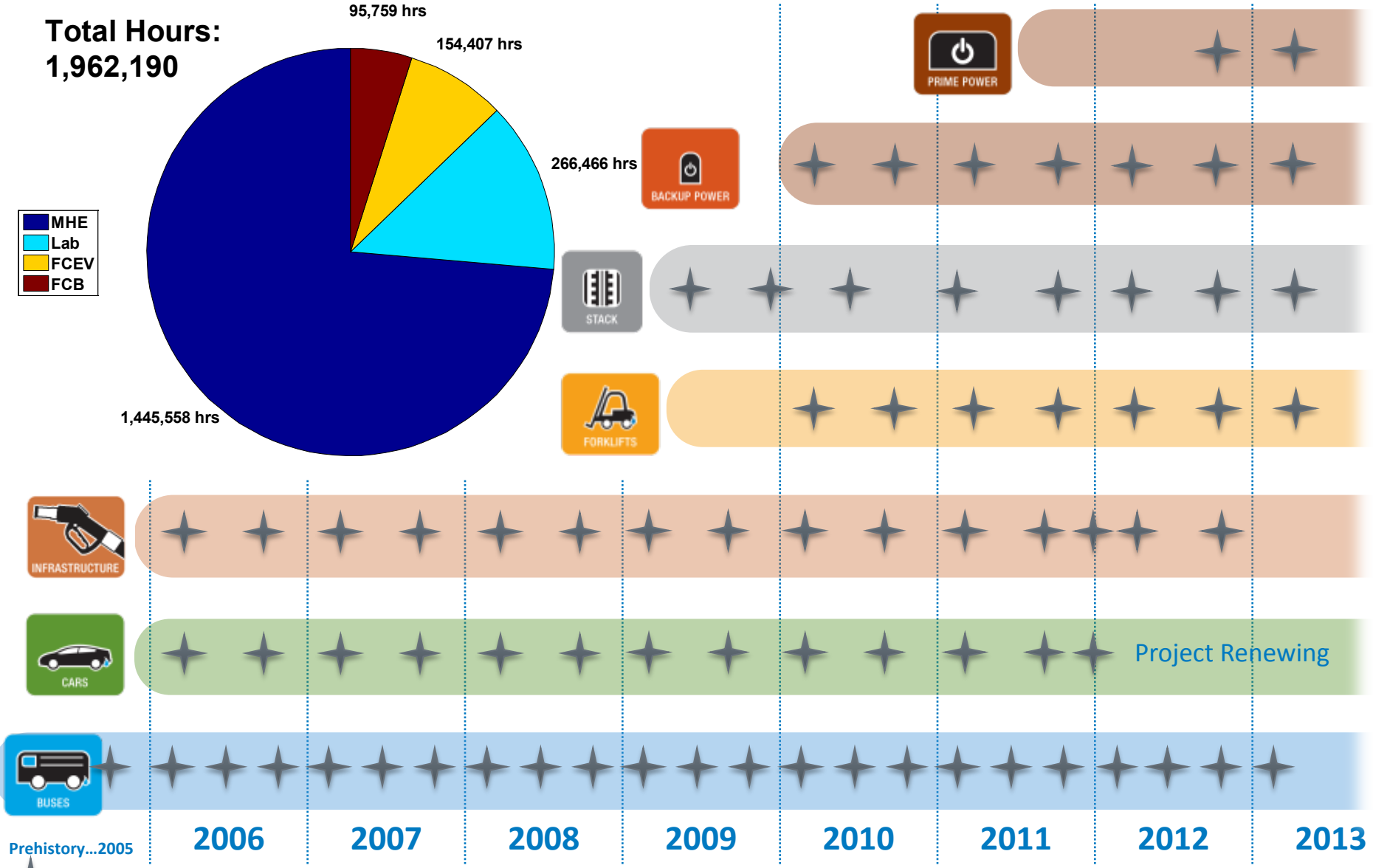


- Quarterly data analysis (based on available data)
- Publication of technical stationary fuel cell composite data products

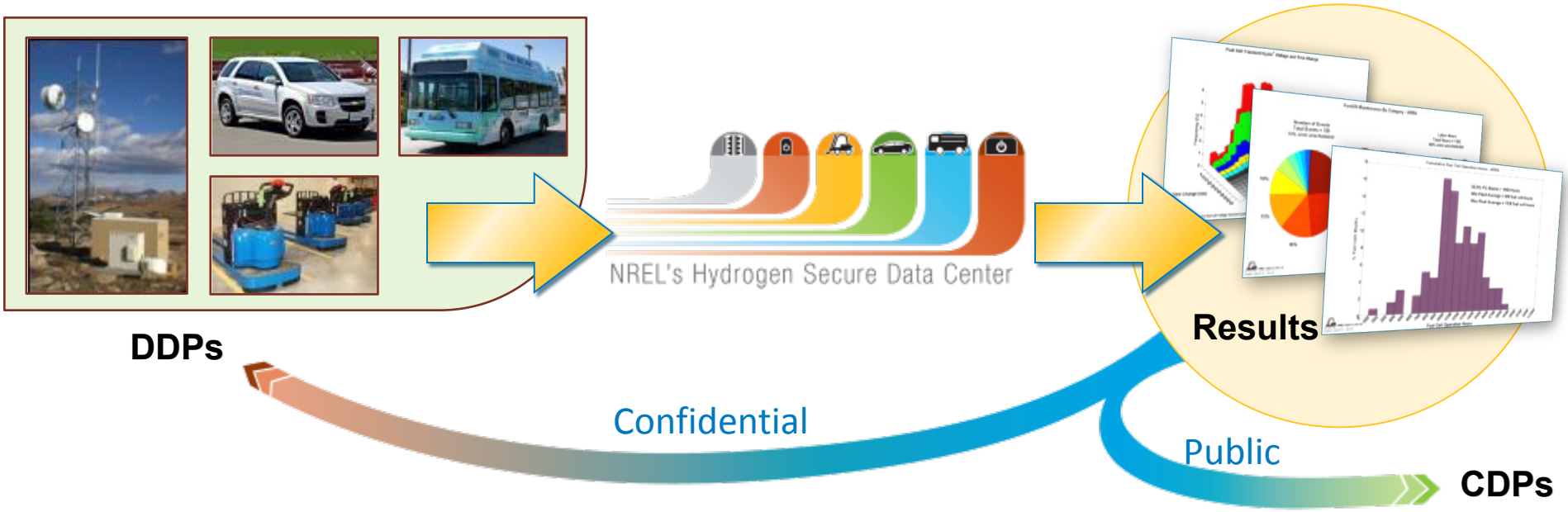
Scheduled

Completed

Approach - Technology Validation Project Leveraging



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 months[1]

Composite Data Products (CDPs)
- Aggregated data across multiple systems, sites, and teams
- Publish analysis results without revealing proprietary data every 6 months[2]

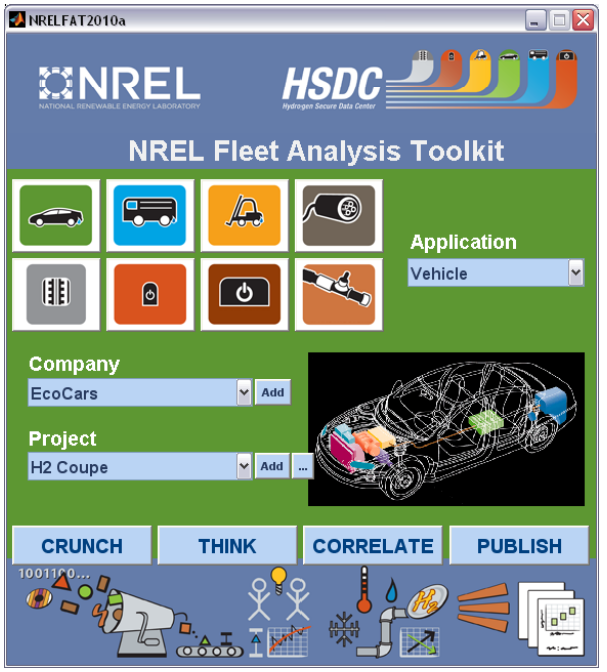
1) Data exchange may happen more frequently based on data, analysis, and collaboration
2) Results published via NREL Tech Val website, conferences, and reports

Approach - Stationary Fuel Cell Systems

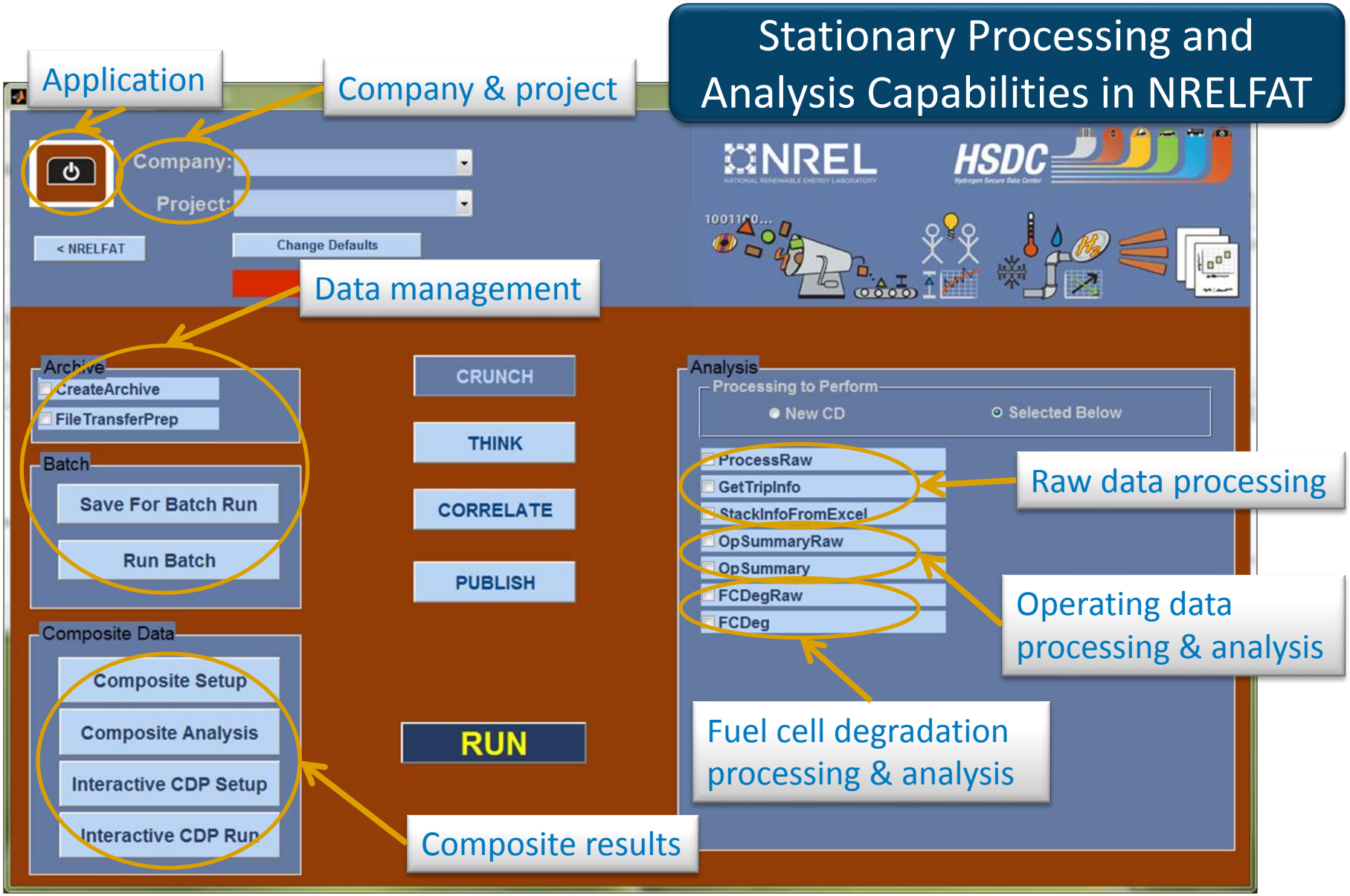
- Includes systems providing prime, continuous, or regular power to a site (not backup power)
- Includes multiple fuel cell types - proton exchange membrane (high and low temperature), solid oxide, phosphoric acid, and molten carbonate
- Small, kilowatt-scale to large, megawatt-scale

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



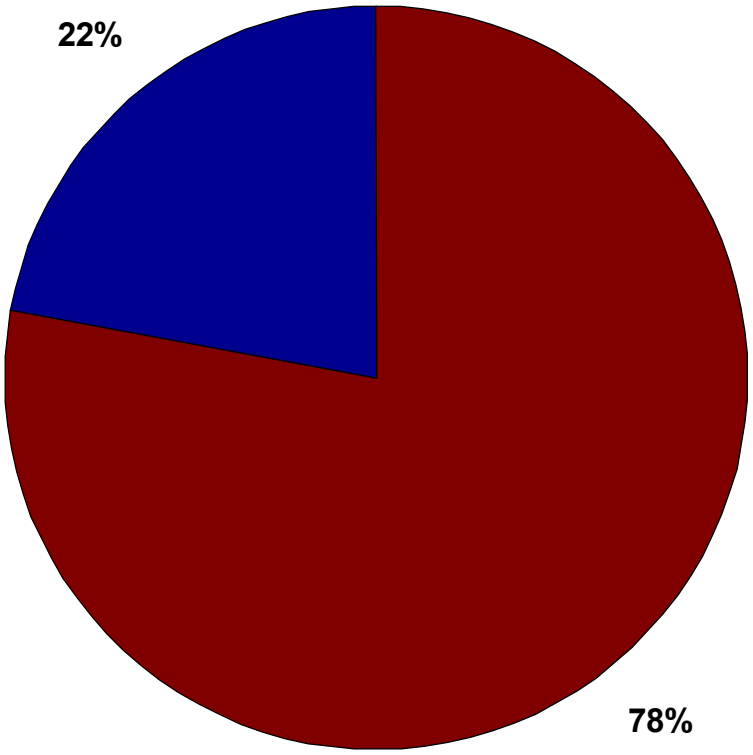
Accomplishment – Web site

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

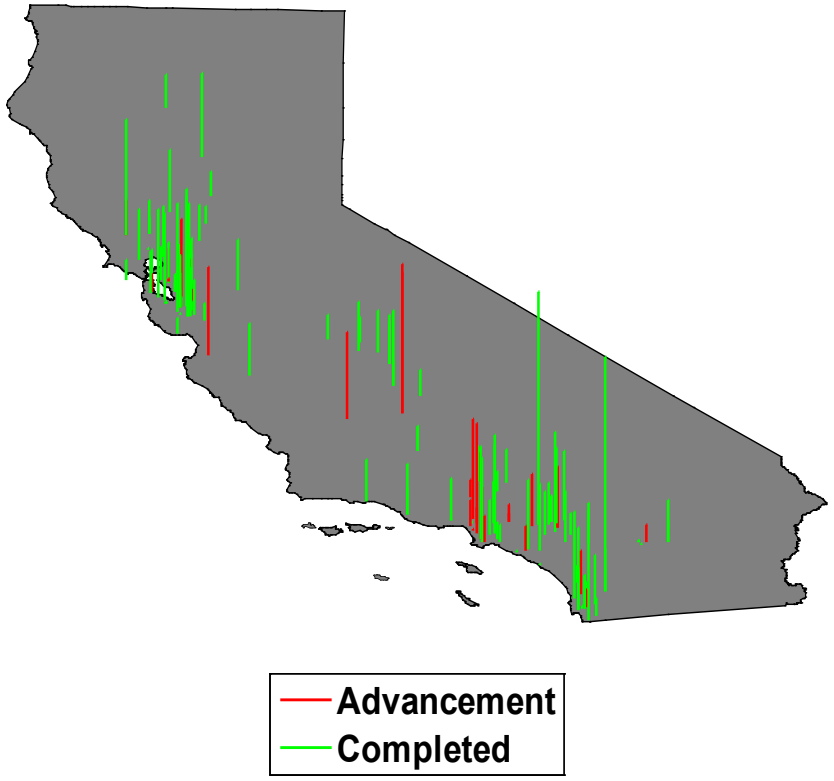
Accomplishment - Location and Status

Installations are clustered around major population centers

Deployment Count By Status*



CA Stationary Fuel Cell Installations* (2001 - 2012)

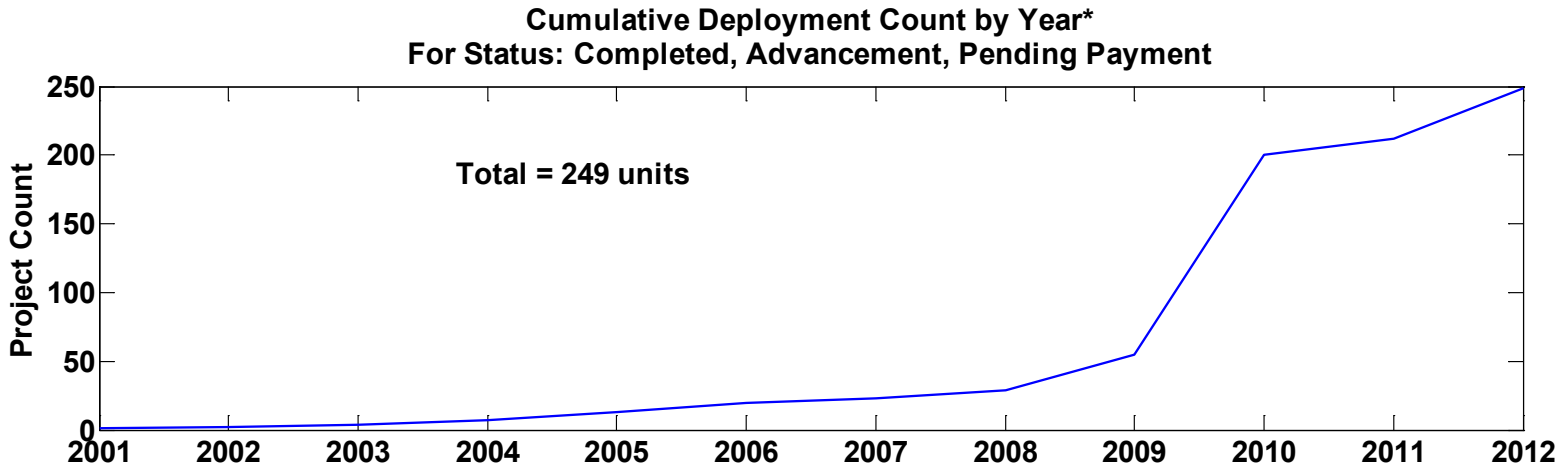


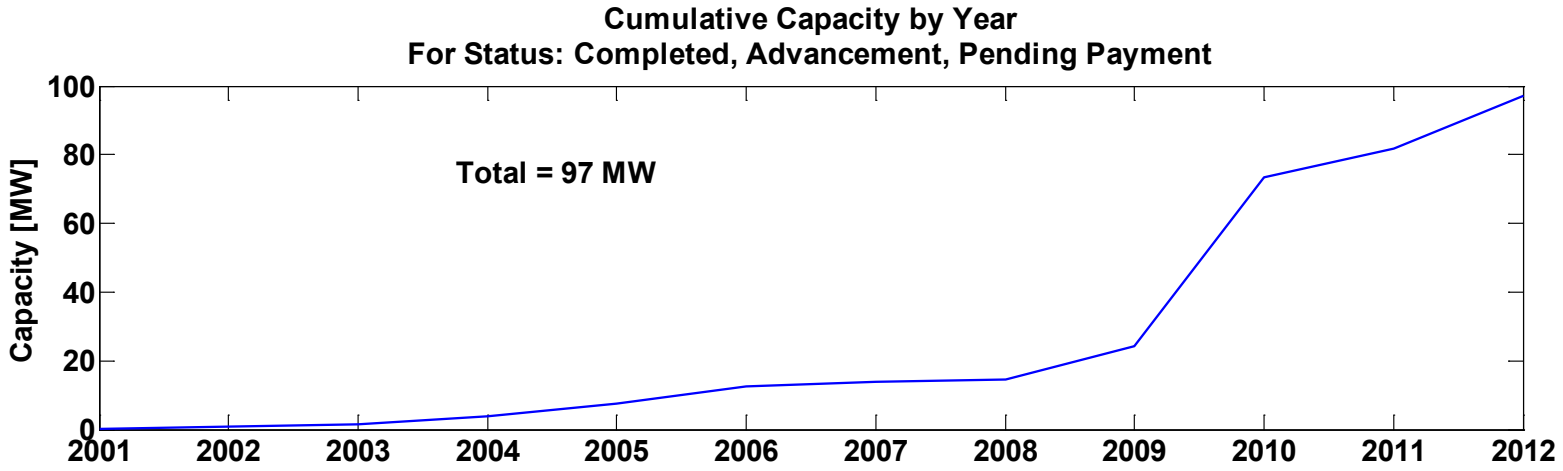
*data from the California SGIP

- 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.





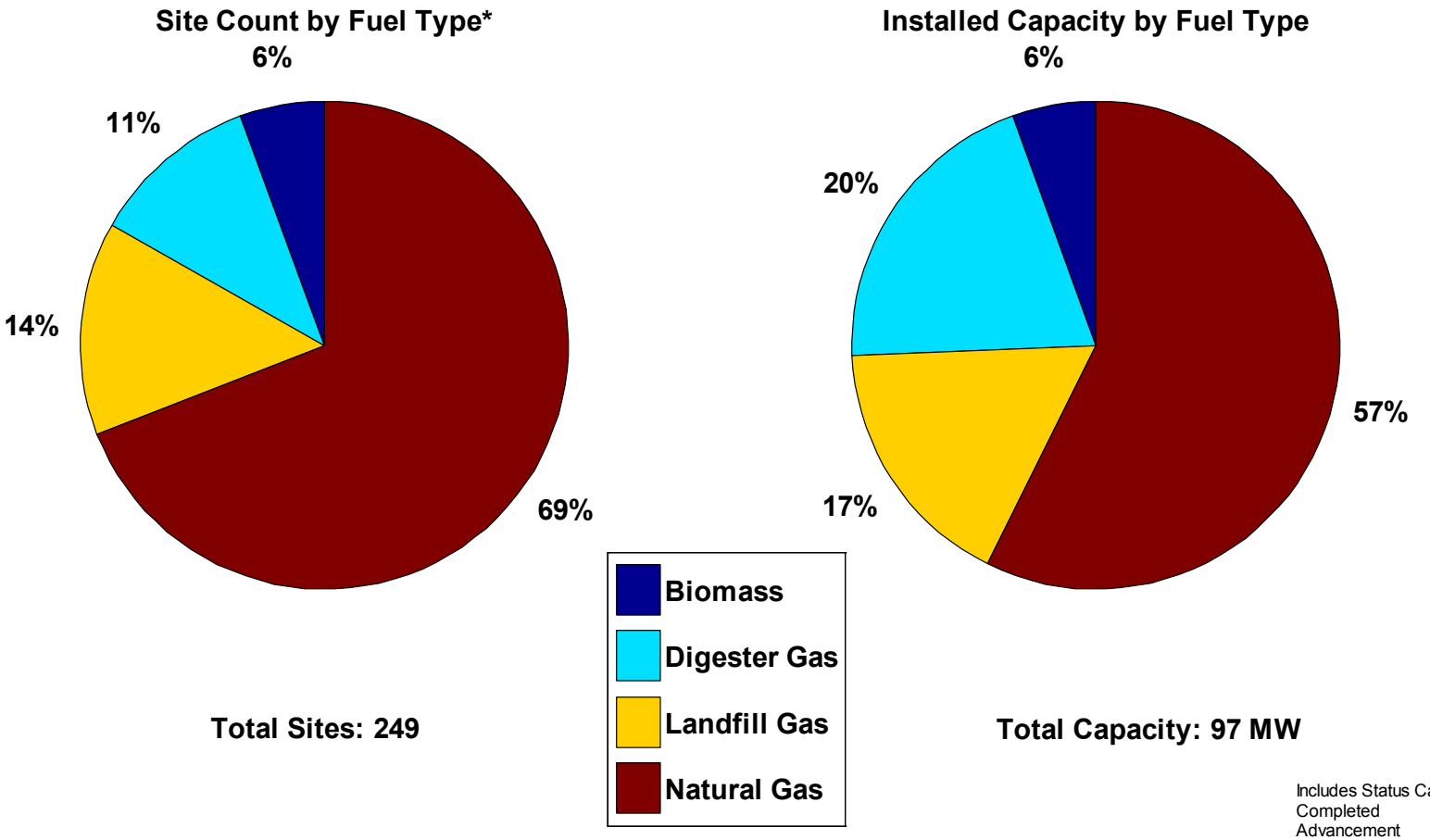
NREL cdp_stat_01
Created: Apr-04-13 2:52 PM | Data Range: 2001Q3-2012Q4

*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.

Installations by Fuel Type



Includes Status Categories:
Completed
Advancement

*Data from the California SGIP.

NREL cdp_stat_04
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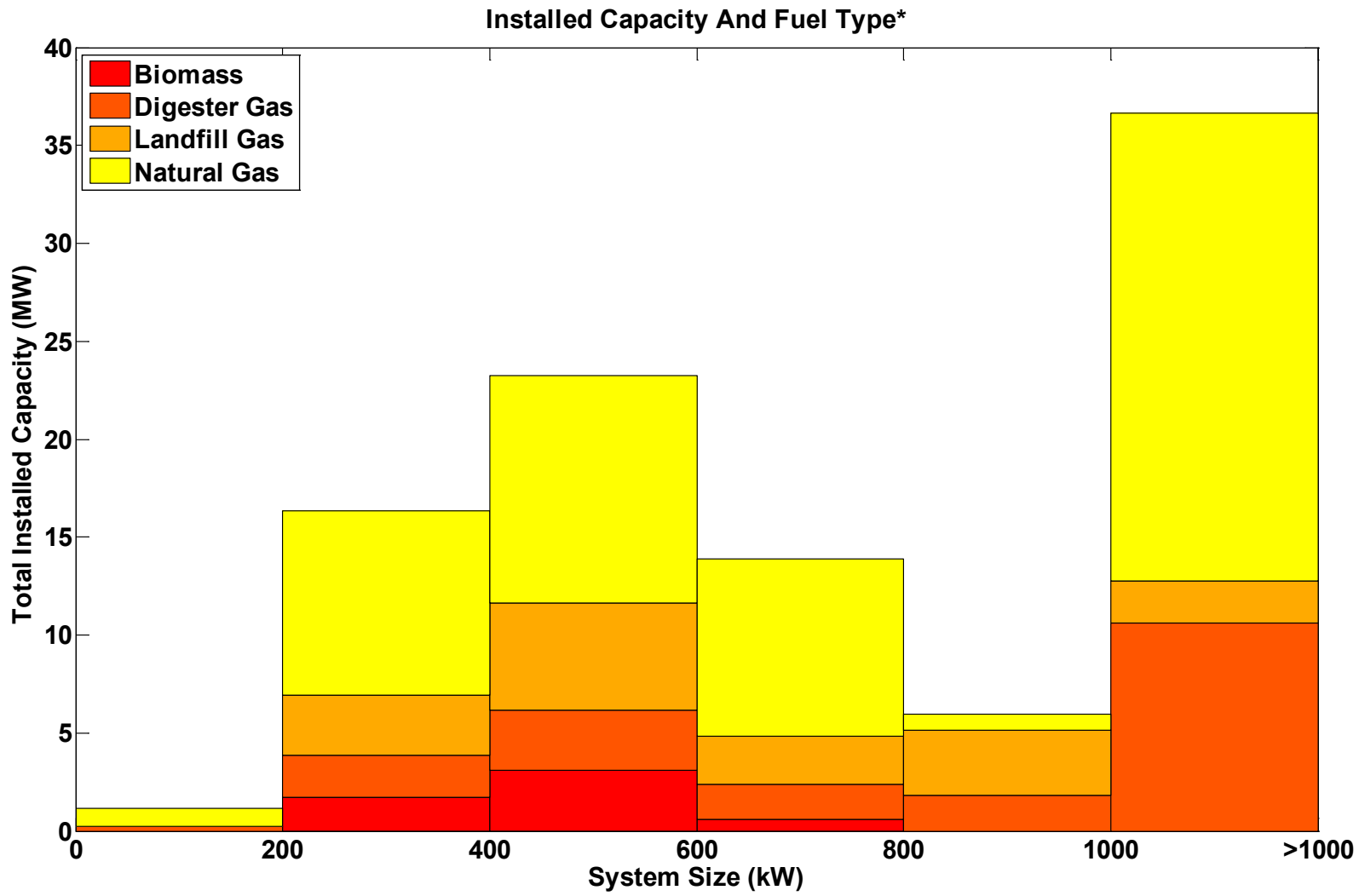
Accomplishment - System Size by Fuel Type

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



NREL cdp_stat_10
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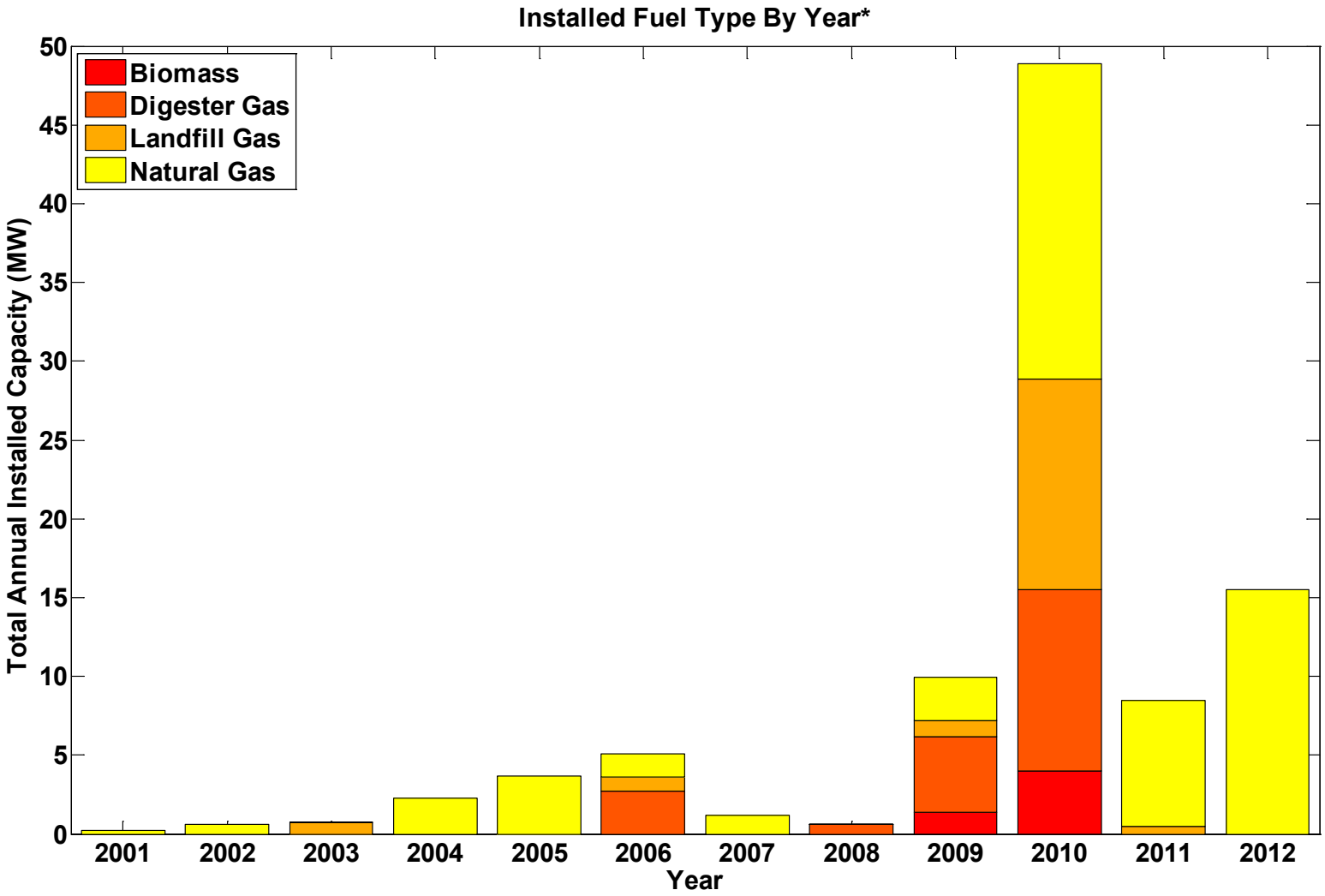
*Data from the California SGIP.

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
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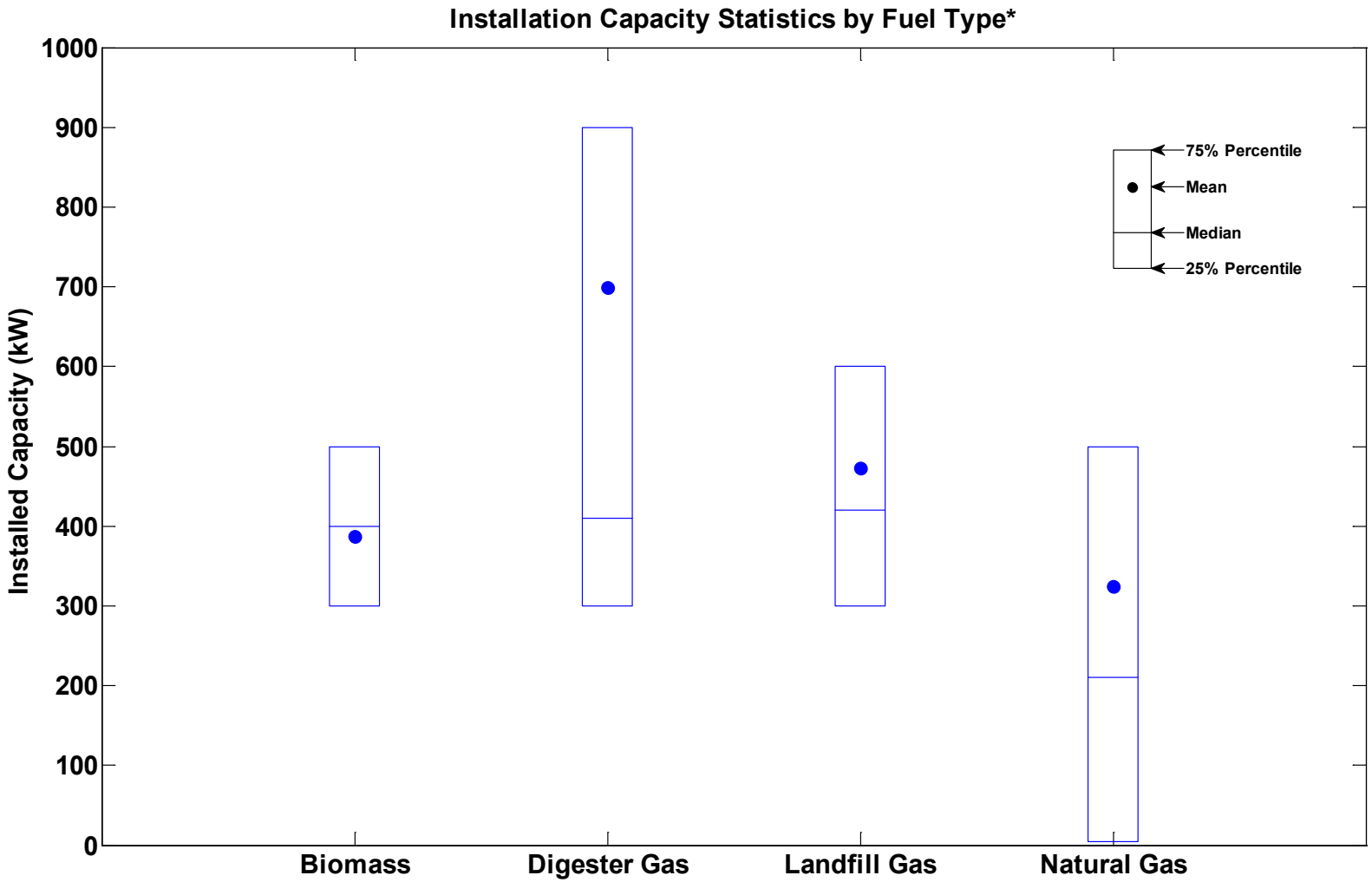
*Data from the California SGIP.

Accomplishment - Capacity by Fuel Type

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



NREL cdp_stat_05
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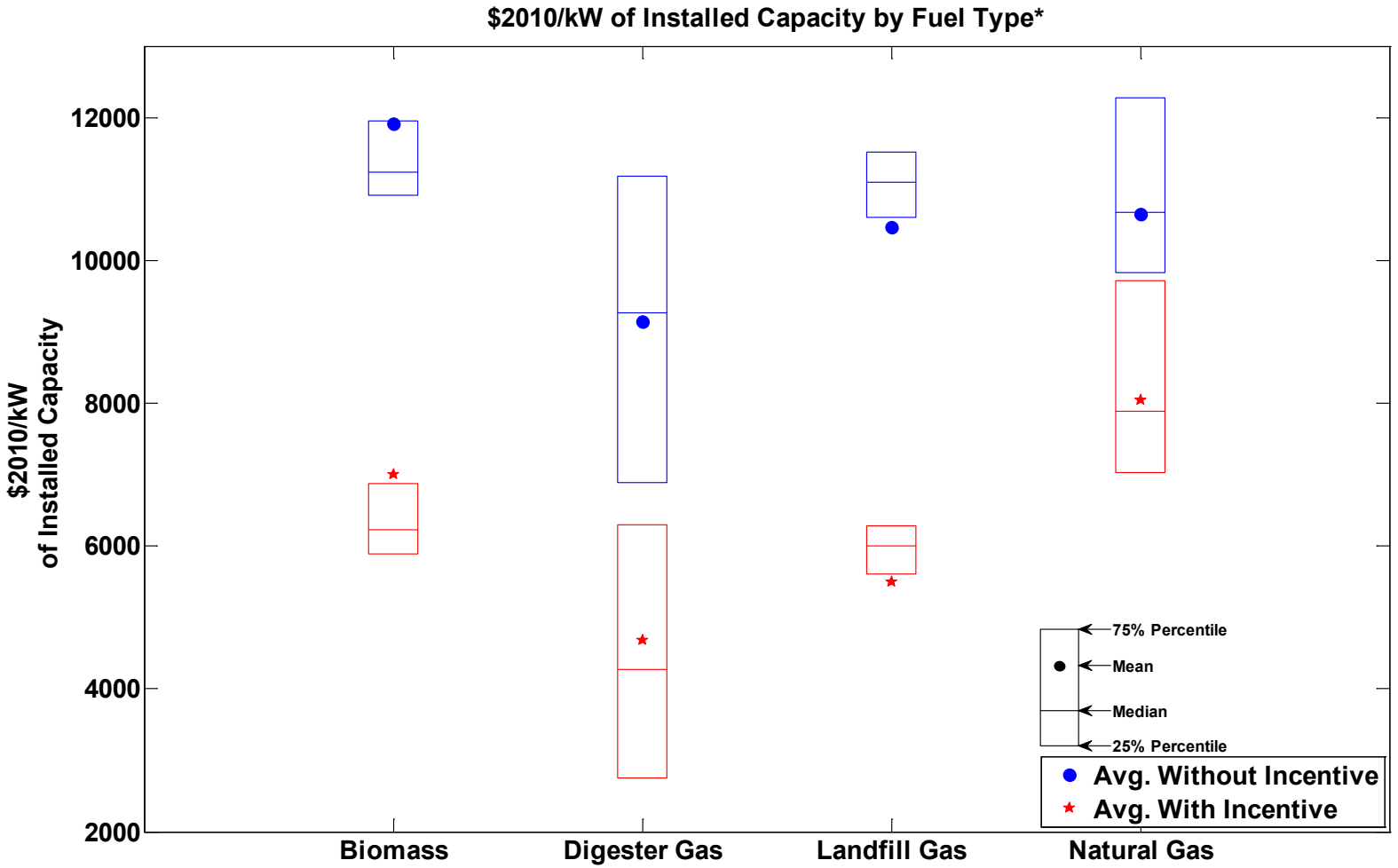
*Data from the California SGIP.

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.



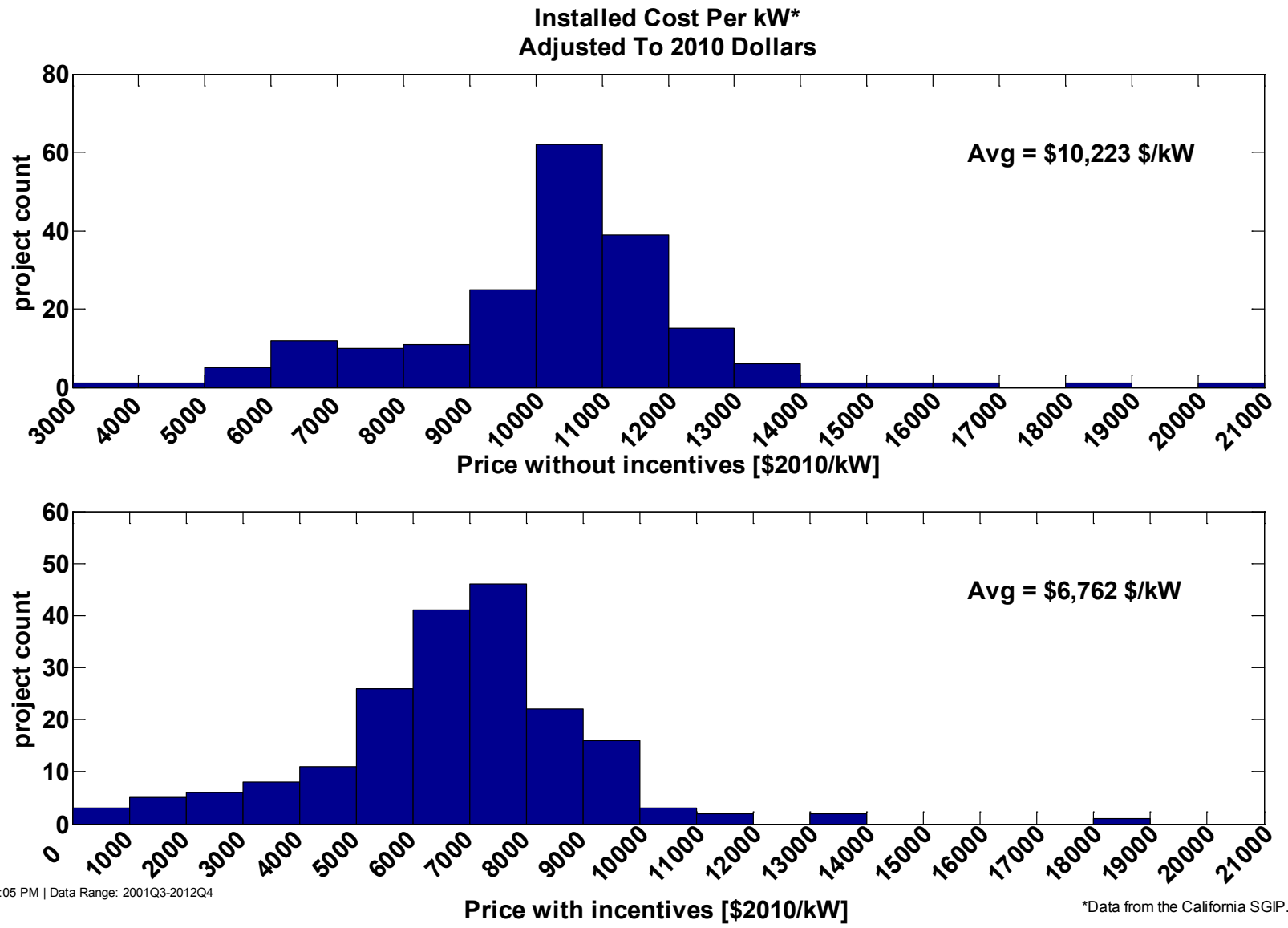
NREL cdp_stat_09
Created: Apr-04-13 3:06 PM | Data Range: 2001Q3-2012Q4

*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.



NREL cdp_stat_07
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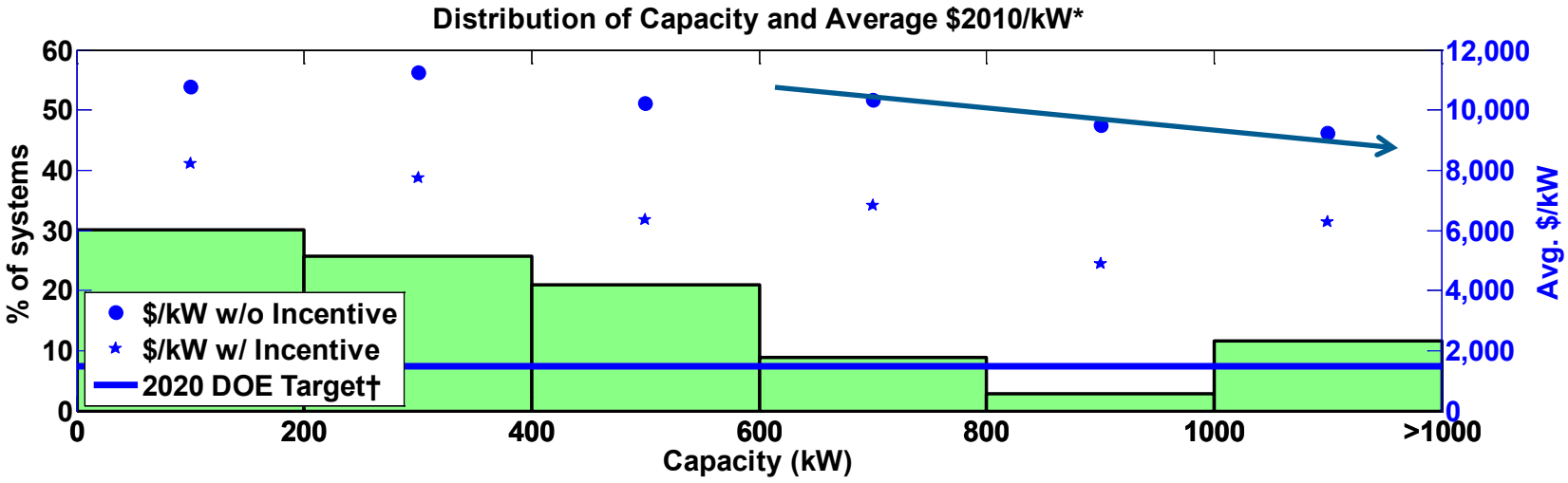
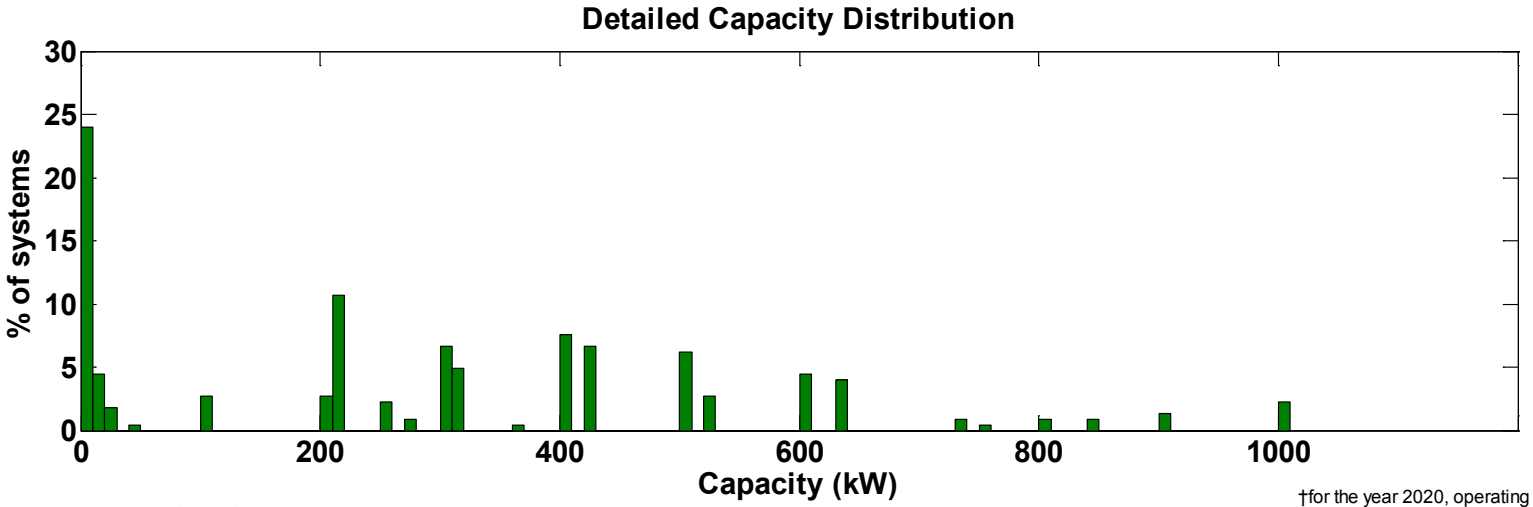
*Data from the California SGIP.

Accomplishment - Installation Costs and Capacity

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





NREL cdp_stat_06
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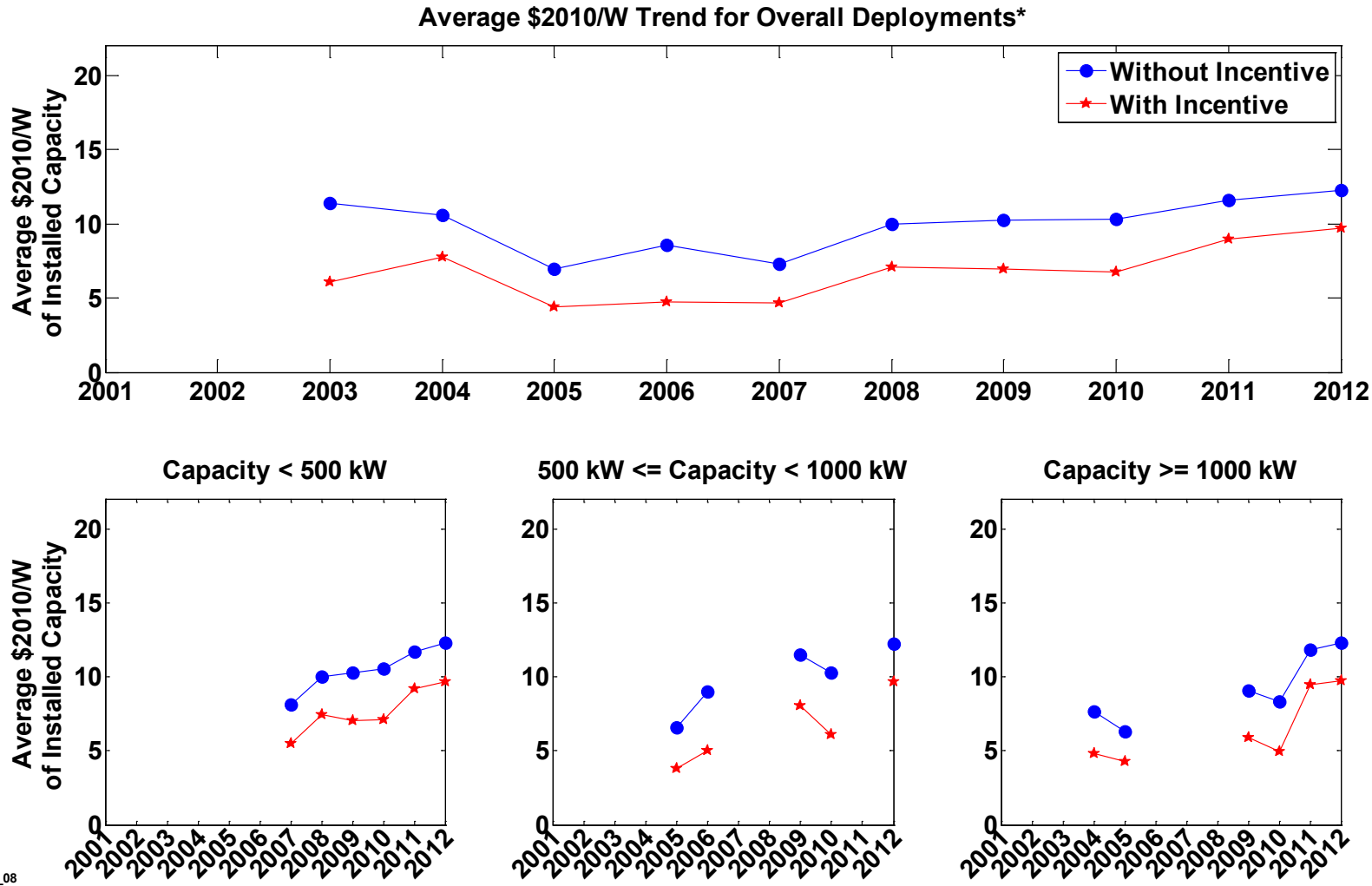
†for the year 2020, operating on natural gas.

*Data from the California SGIP.

Accomplishment - Installation Cost Trend

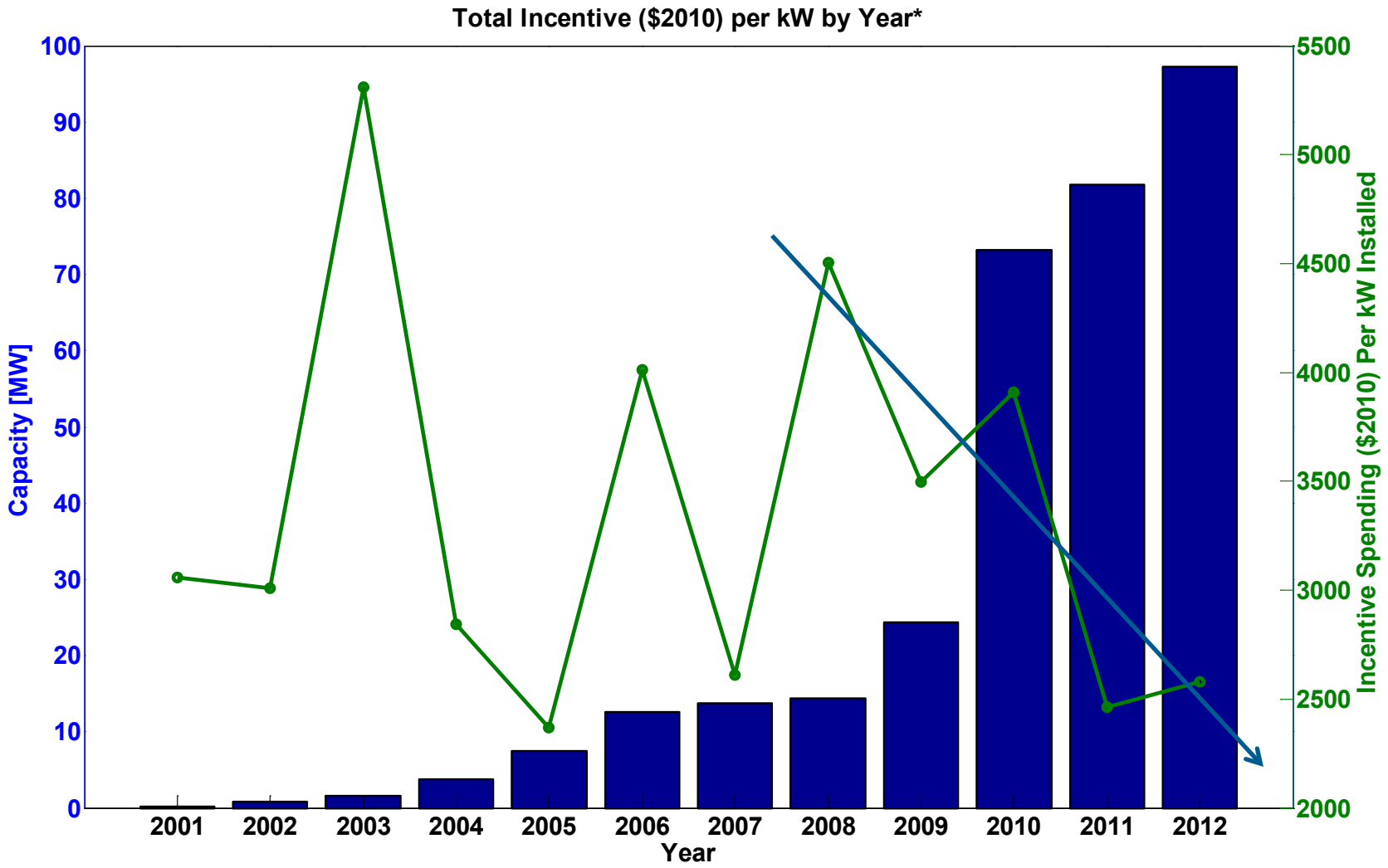
Costs ($2010/kW) are trending up over time regardless of system size.



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
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*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.