NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Evaluation of Stationary Fuel Cell Deployments, Costs, and Fuels




2013 Fuel Cell Seminar and Energy Exposition

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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.

Technology Validation at NREL

- Confirmation of component and system technical targets
- Evaluation, optimization, and demonstration in integrated energy systems
- National Fuel Cell Technology Evaluation Center *(NFCTEC)*

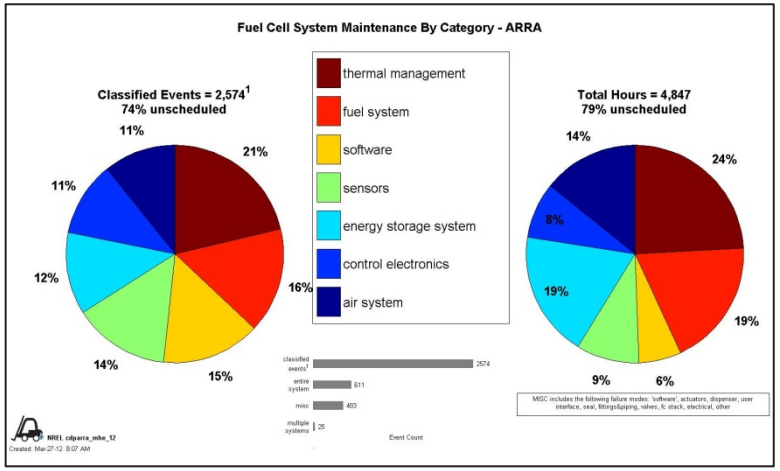
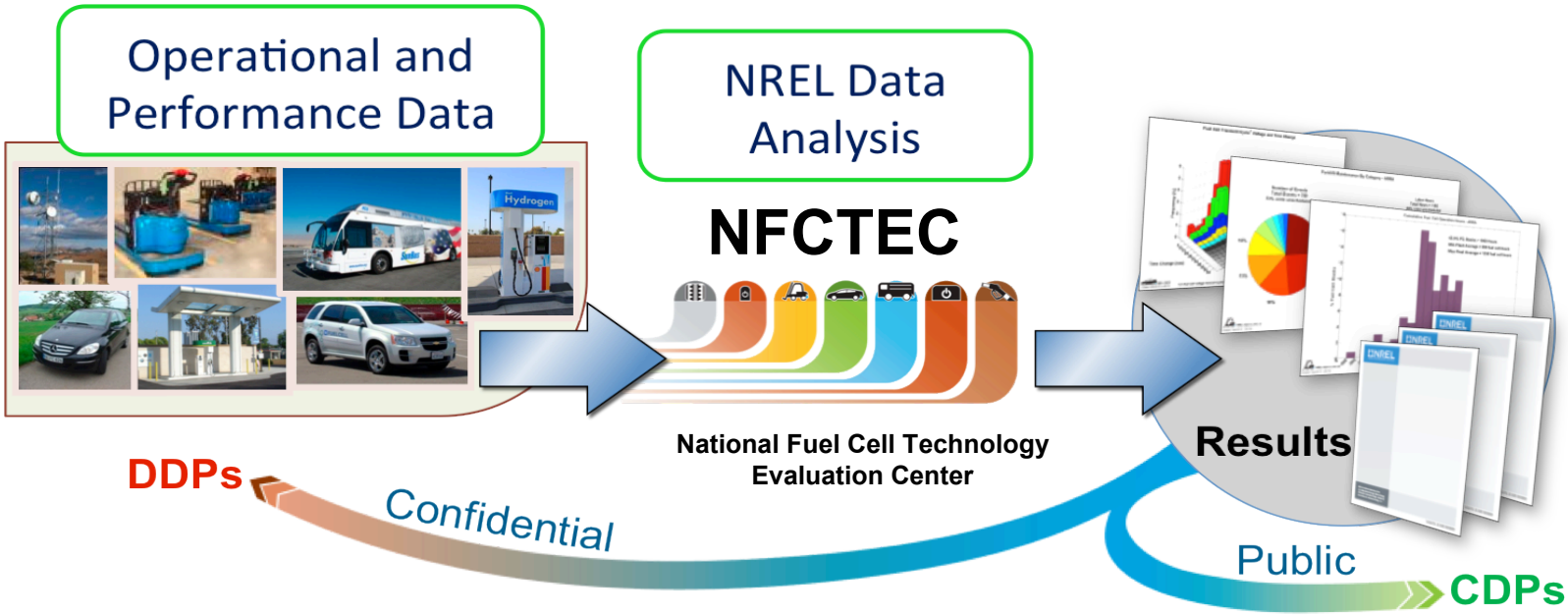


Photo by Dennis Schroeder, NREL
Figures and illustrations: NREL

NFCTEC Analysis Approach

Analysis and reporting of real-world operation data



Detailed Data Products (DDPs)

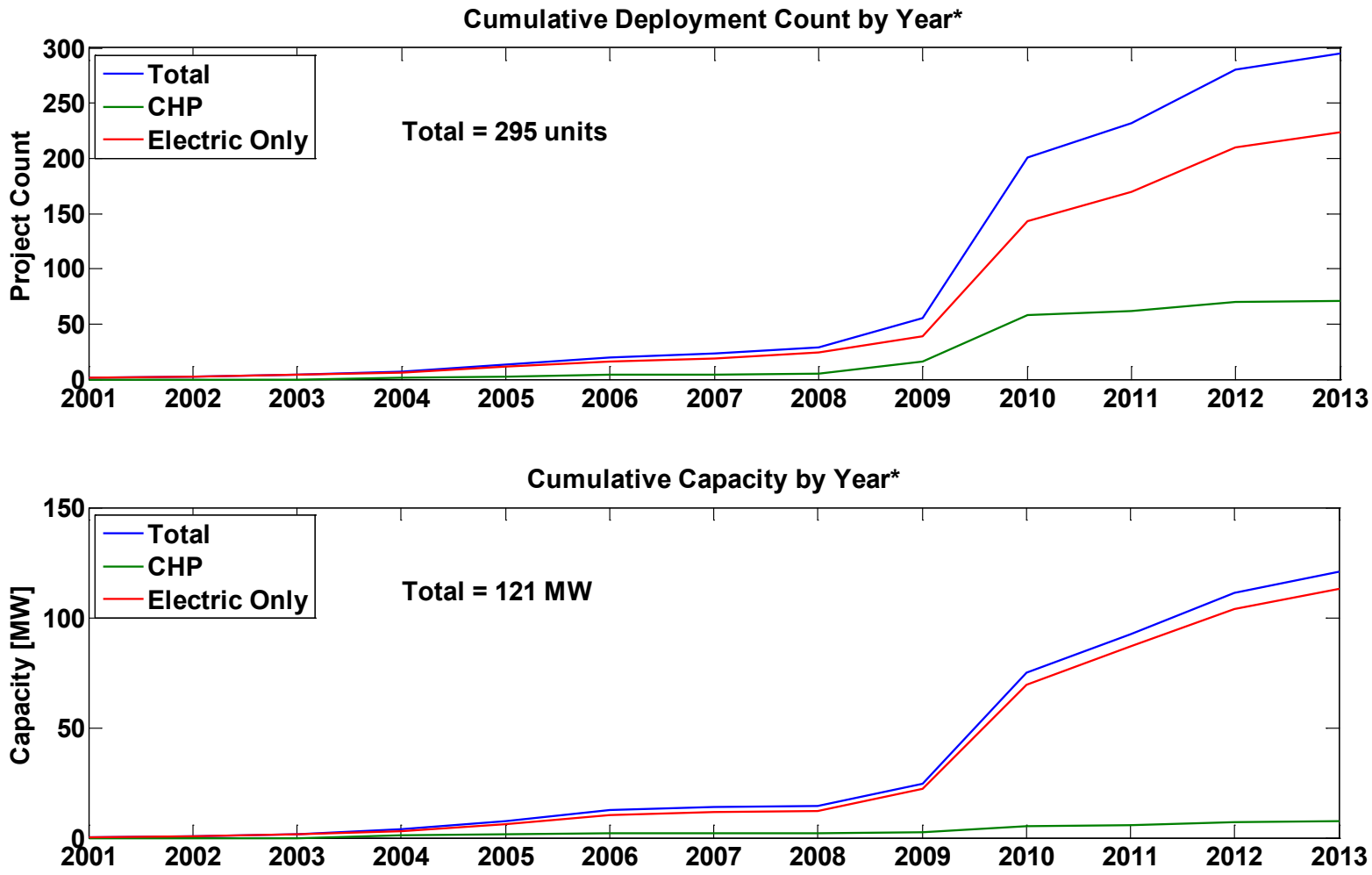
- Individual data analyses, shared only with partner supplying data
- Identify individual contribution to CDPs

Composite Data Products (CDPs)

- Aggregated data across multiple systems, sites, and teams
- Publicly available analyses, published without revealing proprietary data

www.nrel.gov/hydrogen/proj_tech_validation.html

Major Ramp-Up of Fuel Cell Stationary System Deployments Began in 2010



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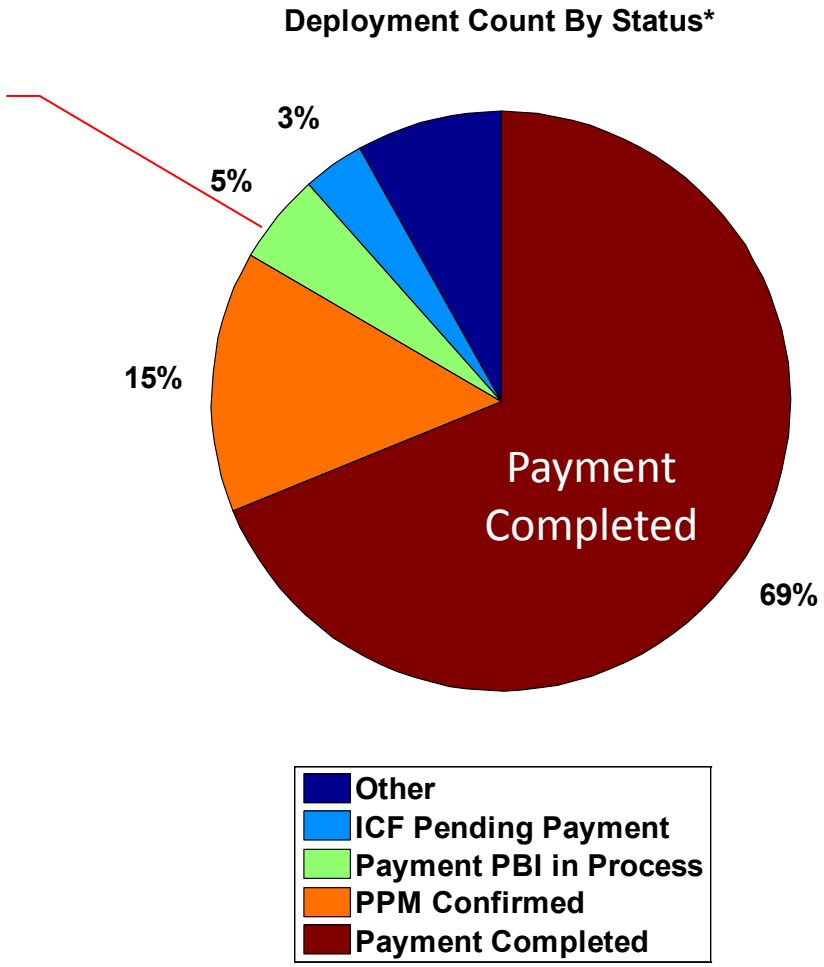
Created: Sep-25-13 9:08 AM | Data Range: 2001Q2-2013Q2

*Data from the California SGIP.

Majority of deployments and nearly all capacity is electric only

Contractual Status of Stationary Fuel Cell Systems in Deployment

New projects since 2011 receiving the performance-based incentive



Other Categories:

ICF Review
ICF Inspection
RRF Technical Review
RRF Reserved
PPM Technical Review
ICF Technical Review

Definitions: RRF = Reservation Request Form, is the first step in the SGIP incentive claim process.
PPM = Proof of Project Milestone; the applicant must prove progress and committment to the project.
ICF = Incentive Claim Form is the step where the appliant, after meeting all SGIP requirements requests payment of the incentive.
PBI = Performance Based Incentive is the way in which the incentive is paid out over time based on performance of the system.

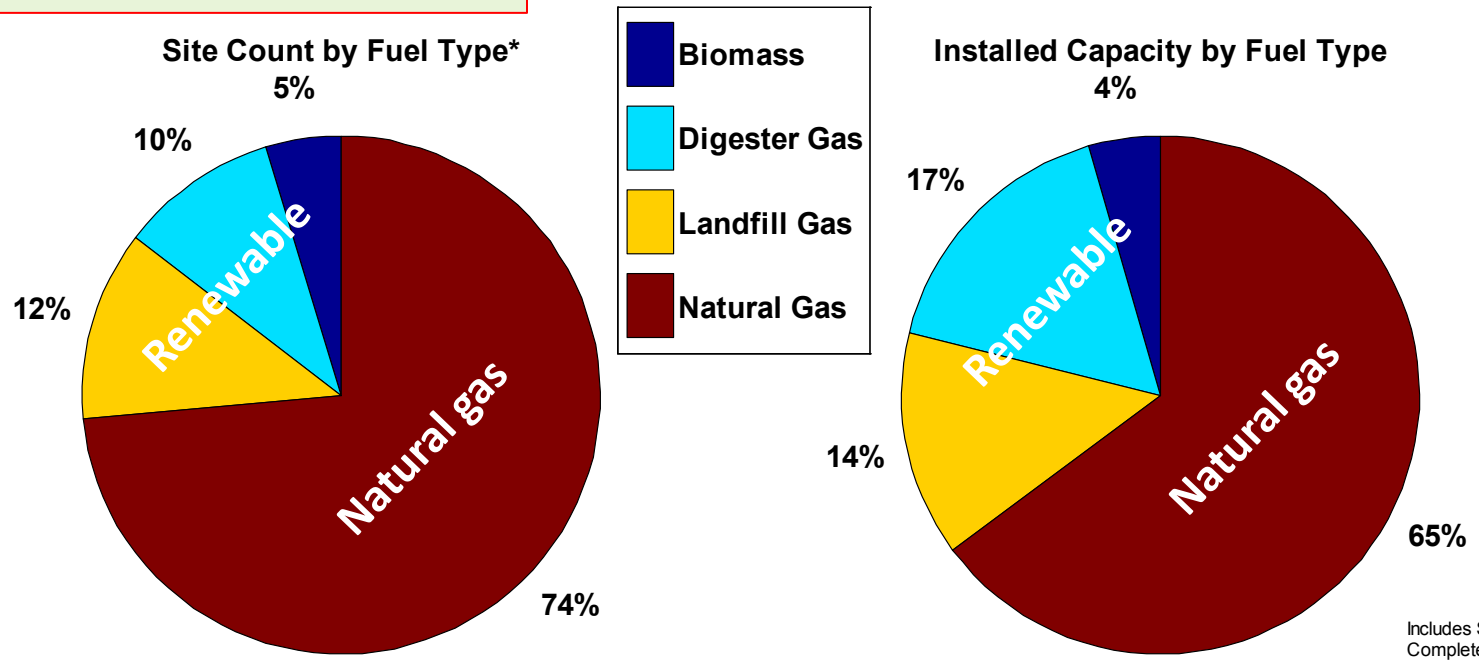
*Data from the California SGIP.

NREL cdp_stat_02
Created: Sep-25-13 9:21 AM | Data Range: 2001Q2-2013Q2

Stationary Fuel Cell System Count and Capacity by Fuel Type (ALL Fuel Cell Systems)

Natural gas is the most-used fuel. However, renewable fuels make up one-third of capacity.

Installations by Fuel Type (All Fuel Cell Systems)



Total Sites: 295

Total Capacity: 121 MW

Includes Status Categories:
Completed
Advancement
Pending Payment
Payment Completed
ICF Inspection
ICF Pending Payment
ICF Review
ICF Technical Review
Payment PBI in Process
PPM Confirmed
PPM Technical Review
RRF Reserved
RRF Technical Review

*Data from the California SGIP.

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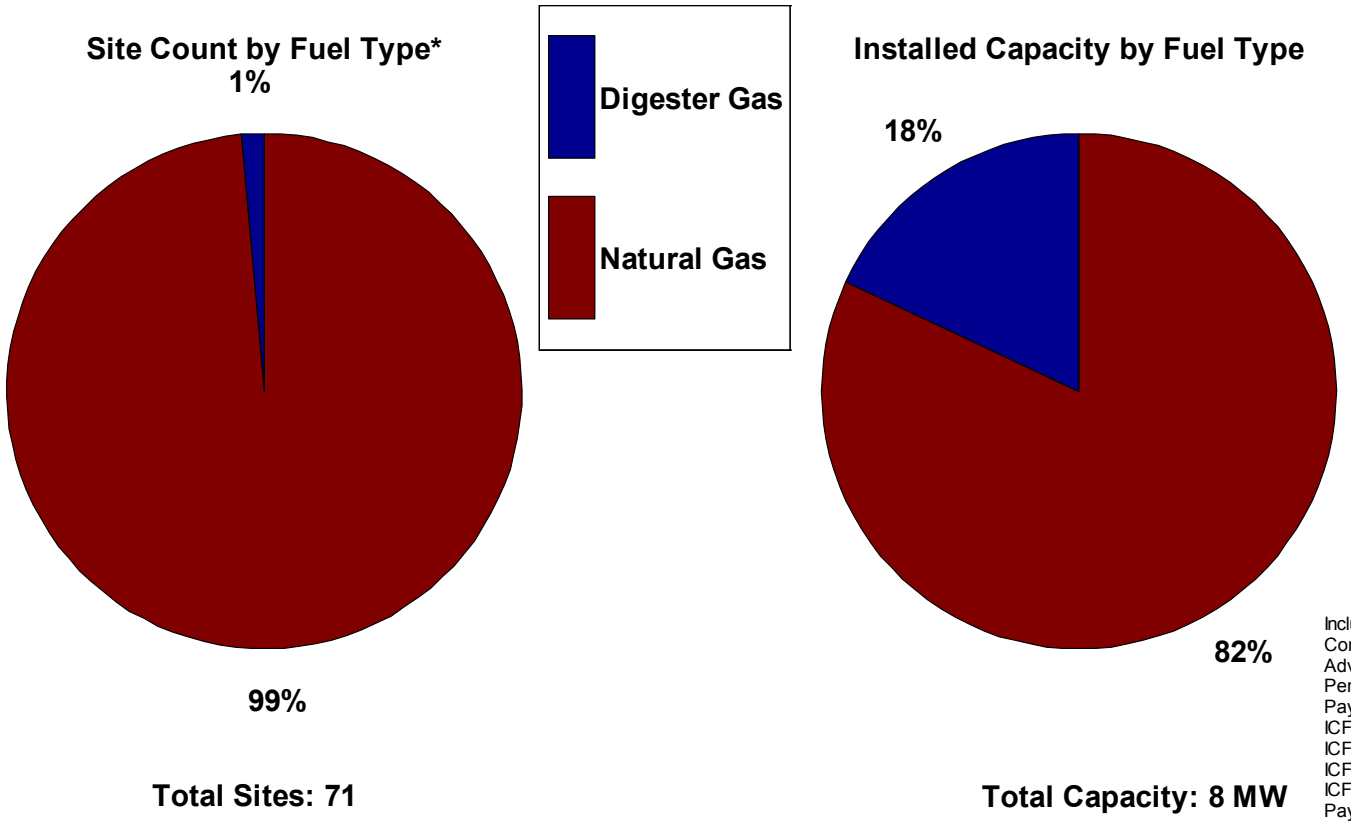
Installations By Fuel Type (CHP Fuel Cells Only)

Nearly all CHP systems use natural gas.

Installations by Fuel Type (CHP Fuel Cell Systems)



Total Sites: 71

Total Capacity: 8 MW

Includes Status Categories:
Completed
Advancement
Pending Payment
Payment Completed
ICF Inspection
ICF Pending Payment
ICF Review
ICF Technical Review
Payment PBI in Process
PPM Confirmed
PPM Technical Review
RRF Reserved
RRF Technical Review

*Data from the California SGIP.

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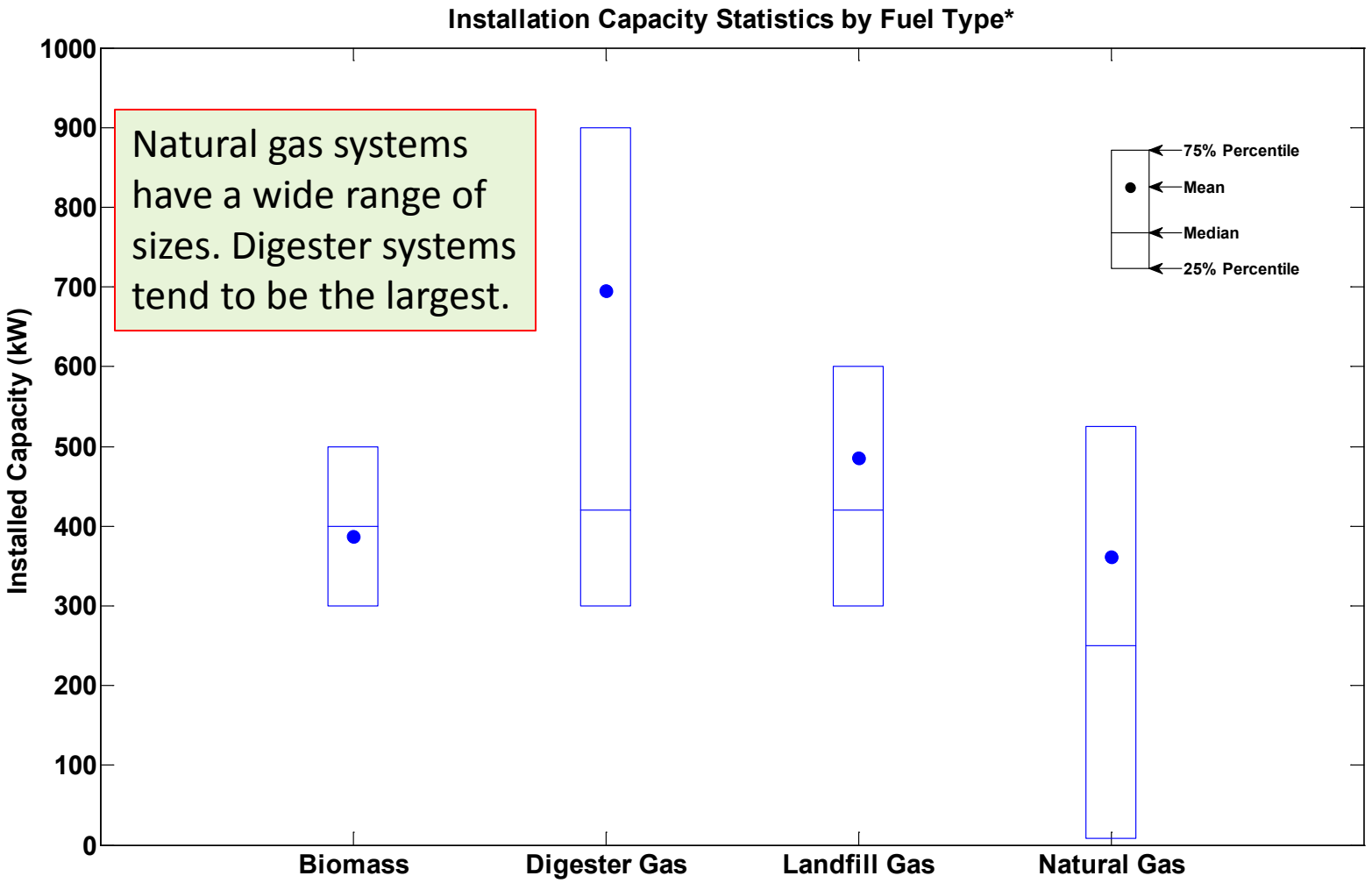
Fuel Type Capacity (All Systems)



NREL cdp_stat_05
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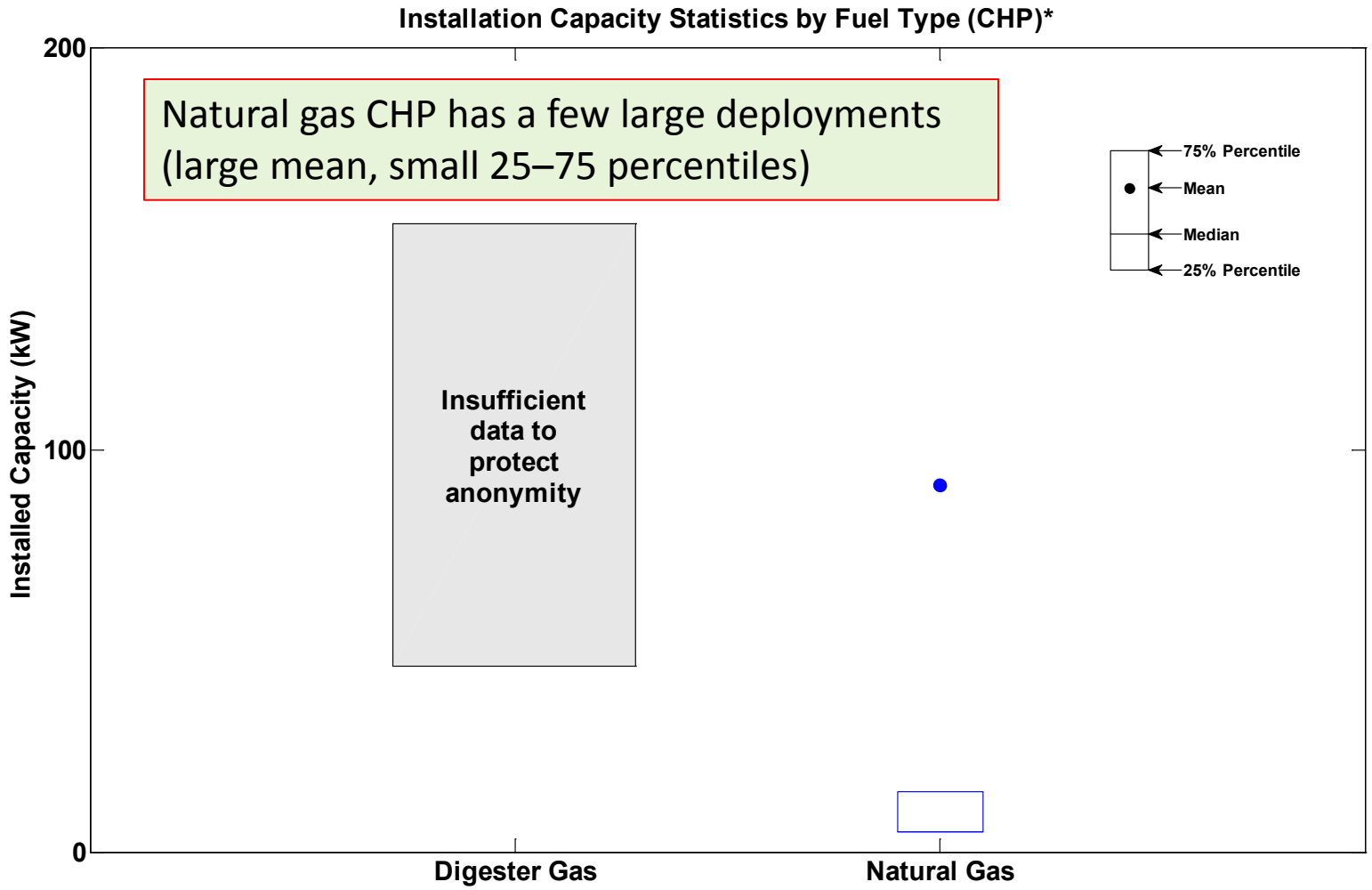
*Data from the California SGIP.

Installation Capacity by Fuel Type (CHP Fuel Cells)



NREL cdp_stat_21
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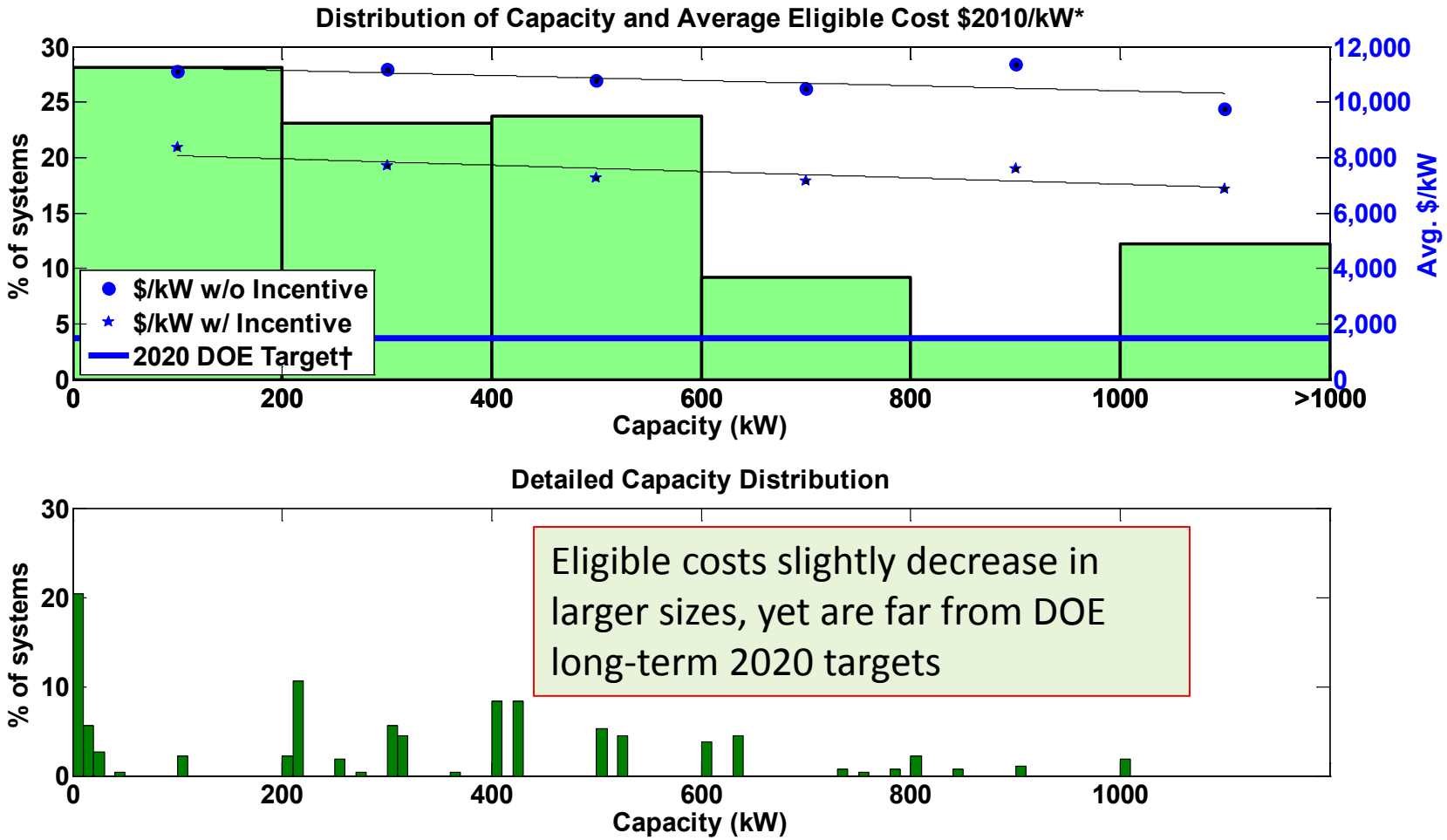
*Data from the California SGIP.

Fuel Cell Stationary Capacity and Average Eligible Costs (All Systems)—Incentive Range $3K–$4K/kW



Eligible Costs May Include: Planning & Feasibility Study, Engineering & Design, Permitting, Self-Generation Equipment Waste Heat Recovery Costs, Construction & Installation Costs, Gas & Electric Interconnection, Warranty, Maintenance Contract Metering, Monitoring & Data Acquisition System, Emission Control Equipment Capital Gasline Installation, Fuel Gas Clean-up Equipment, Electricity Storage Devices, Bond to Certify Renewable Fuel Sales Tax, Fuel Supply (digesters, gas gathering, etc.), Thermal Load, & Other Eligible Costs

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

NREL cdp_stat_06
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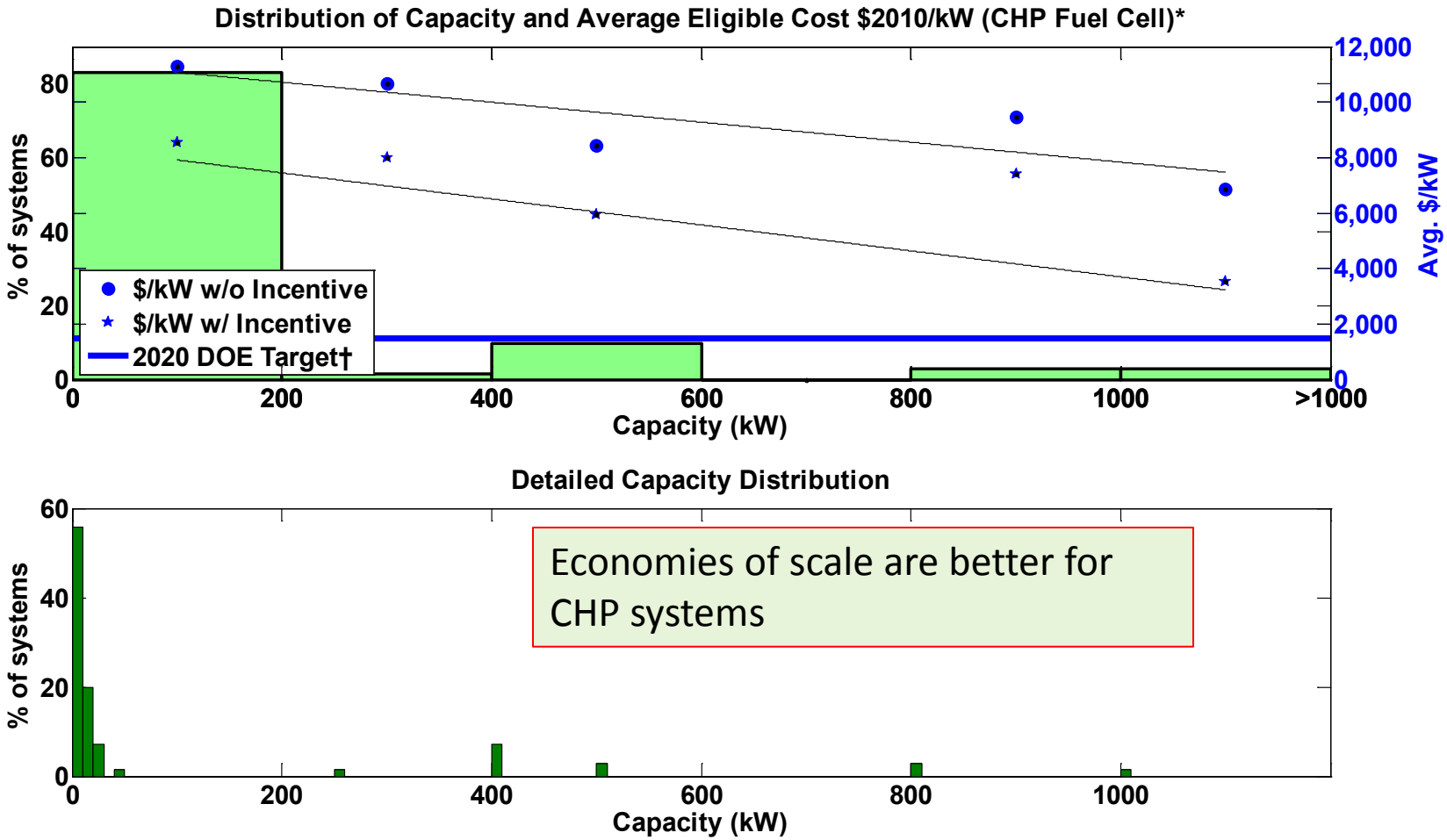
Distribution of Capacity and Eligible Cost (CHP FC Only)



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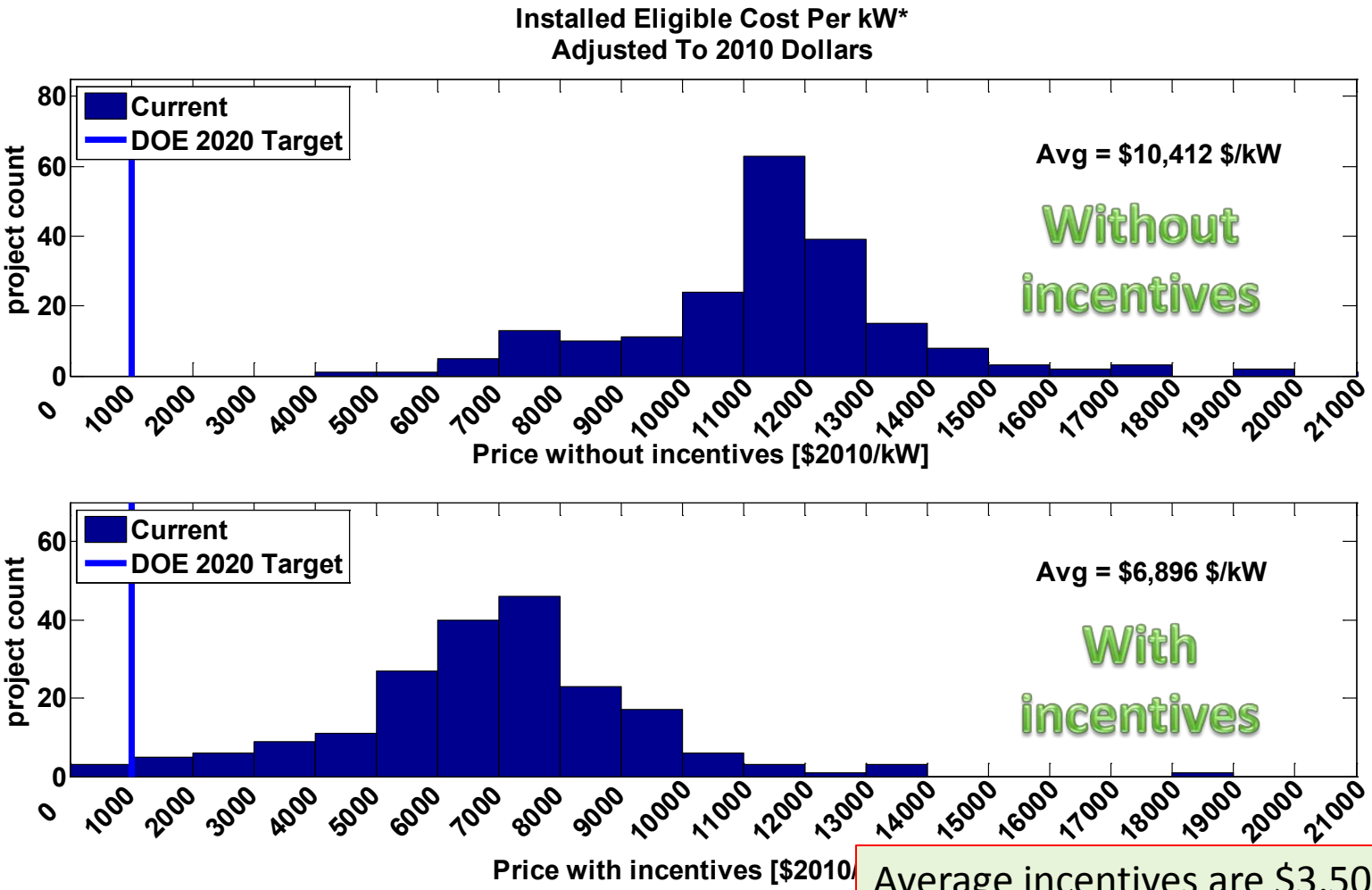
†for the year 2020, operating on natural gas.
*Data from the California SGIP.

NREL cdp_stat_22
Created: Sep-27-13 11:23 AM | Data Range: 2001Q2-2013Q2

Distribution of Stationary Fuel Cell Install Cost With and Without Incentives



Eligible Costs May Include: Planning & Feasibility Study, Engineering & Design, Pe
Waste Heat Recovery Costs, Construction & Installation Costs, Gas & Electric Interc
Metering, Monitoring & Data Acquisition System, Emission Control Equipment Capi
Gasline Installation, Fuel Gas Clean-up Equipment, Electricity Storage Devices, Bo
Sales Tax, Fuel Supply (digesters, gas gathering, etc.), Thermal Load, & Other Eligi

Average incentives are $3,500/kW historically; fuel cell incentives are now set to decrease 10% per year.

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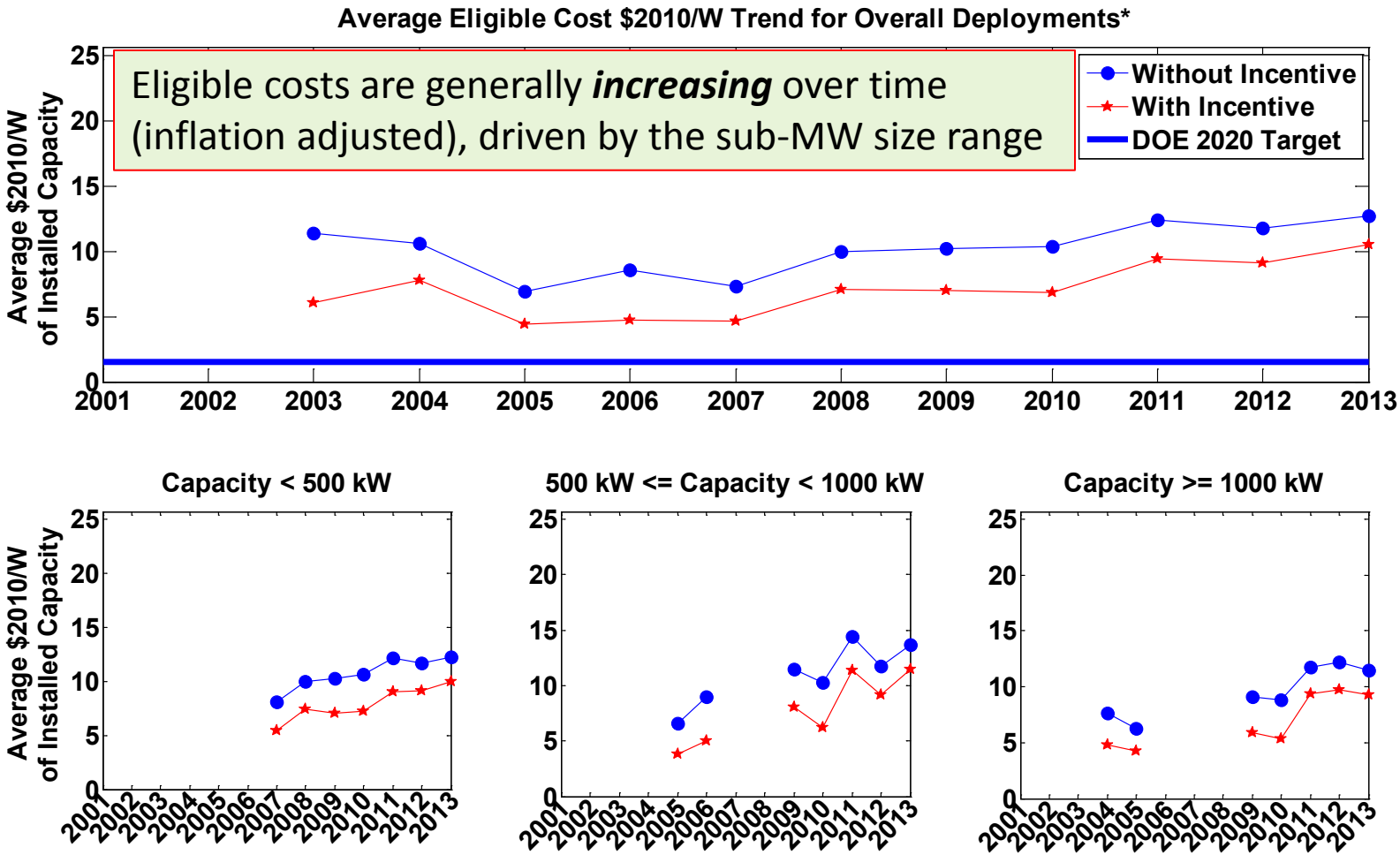
Stationary Fuel Cell Install Cost Over Time With and Without Incentives



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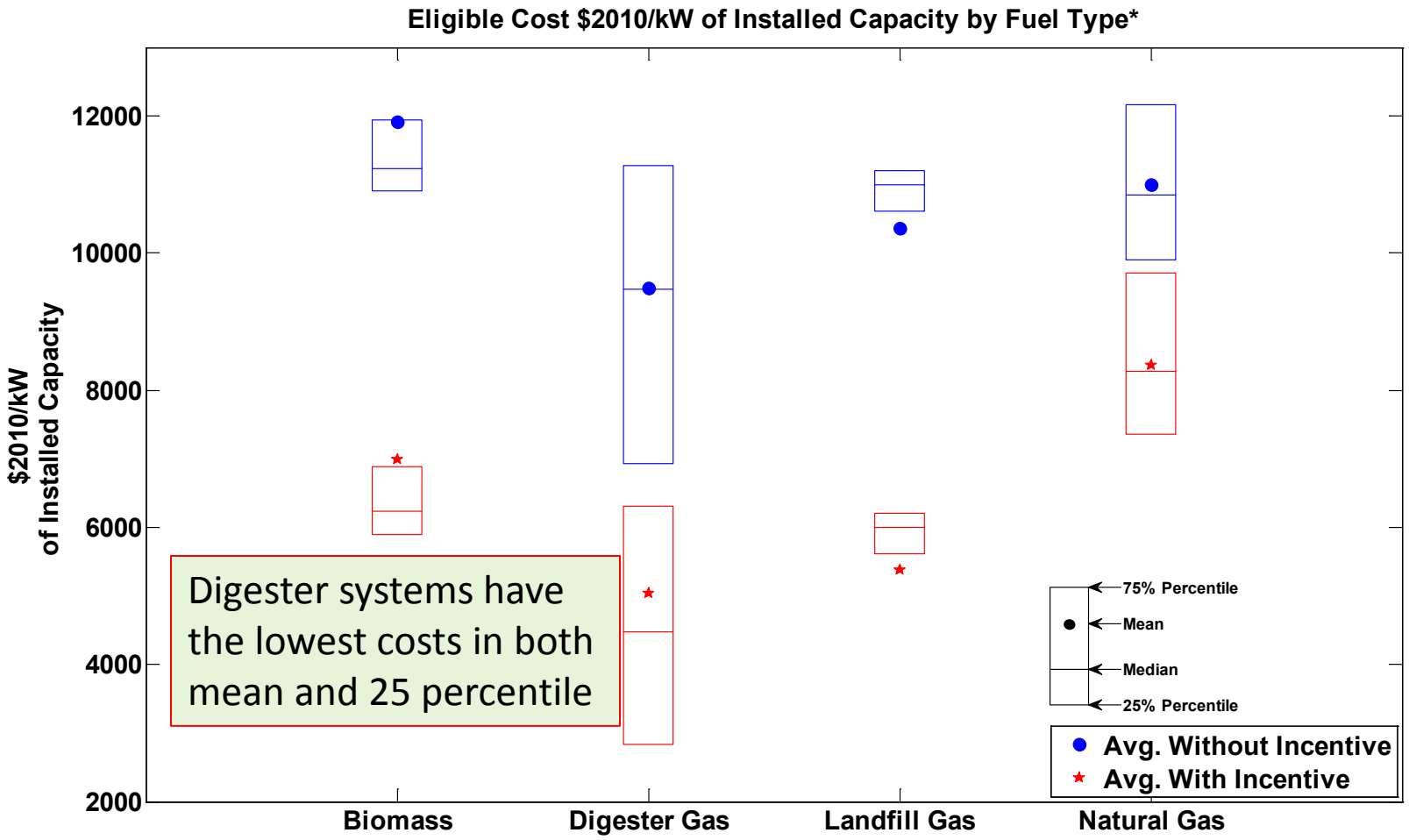
*Data from the California SGIP.

NREL cdp_stat_08
Created: Sep-25-13 9:08 AM | Data Range: 2001Q2-2013Q2

Stationary Fuel Cell Install Cost by Fuel Type With and Without Incentives



NREL cdp_stat_09
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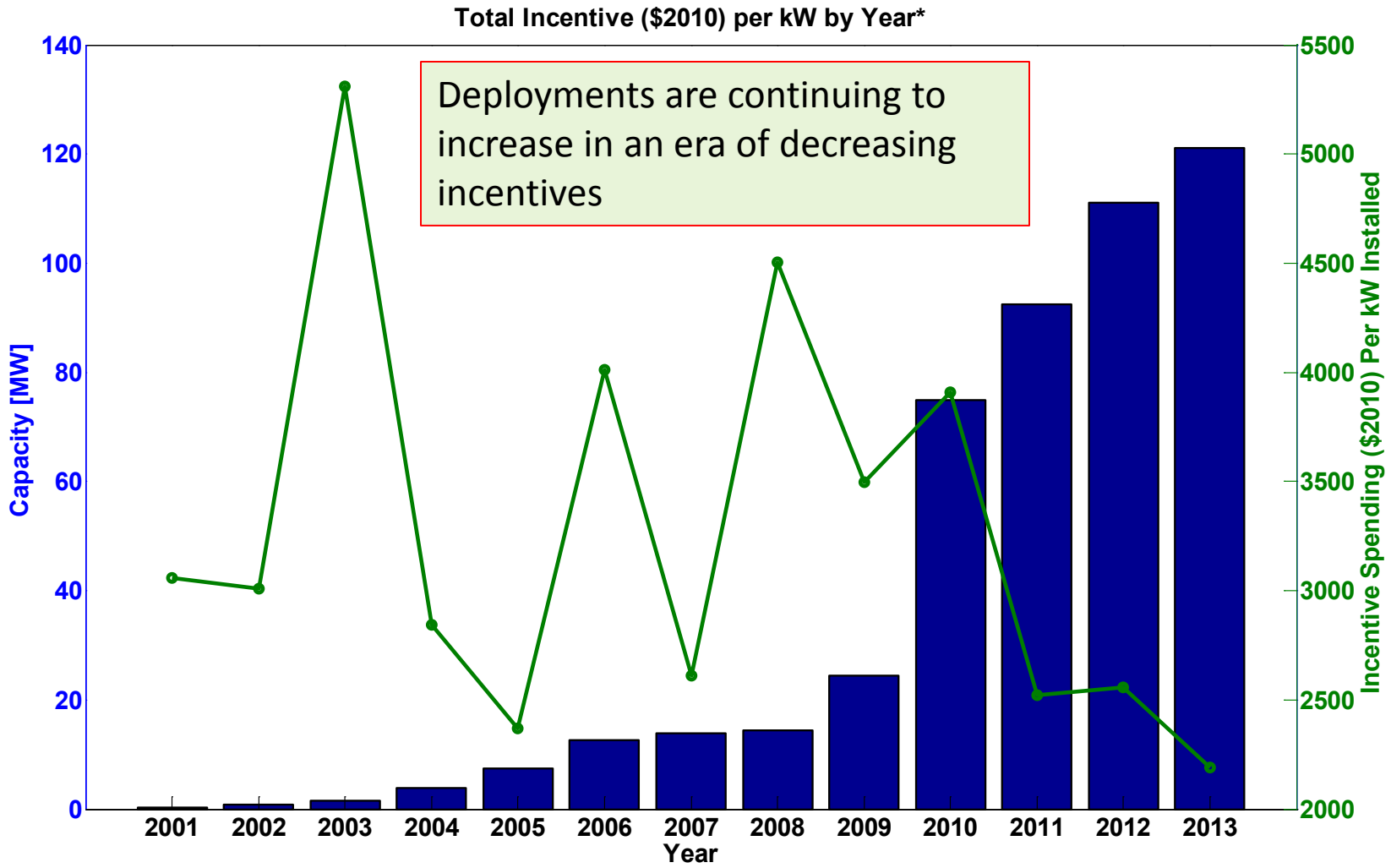
Eligible Costs May Include: Planning & Feasibility Study, Engineering & Design, Permitting, Self-Generation Equipment Waste Heat Recovery Costs, Construction & Installation Costs, Gas & Electric Interconnection, Warranty, Maintenance Contract Metering, Monitoring & Data Acquisition System, Emission Control Equipment Capital Gasline Installation, Fuel Gas Clean-up Equipment, Electricity Storage Devices, Bond to Certify Renewable Fuel Sales Tax, Fuel Supply (digesters, gas gathering, etc.), Thermal Load, & Other Eligible Costs

*Data from the California SGIP.

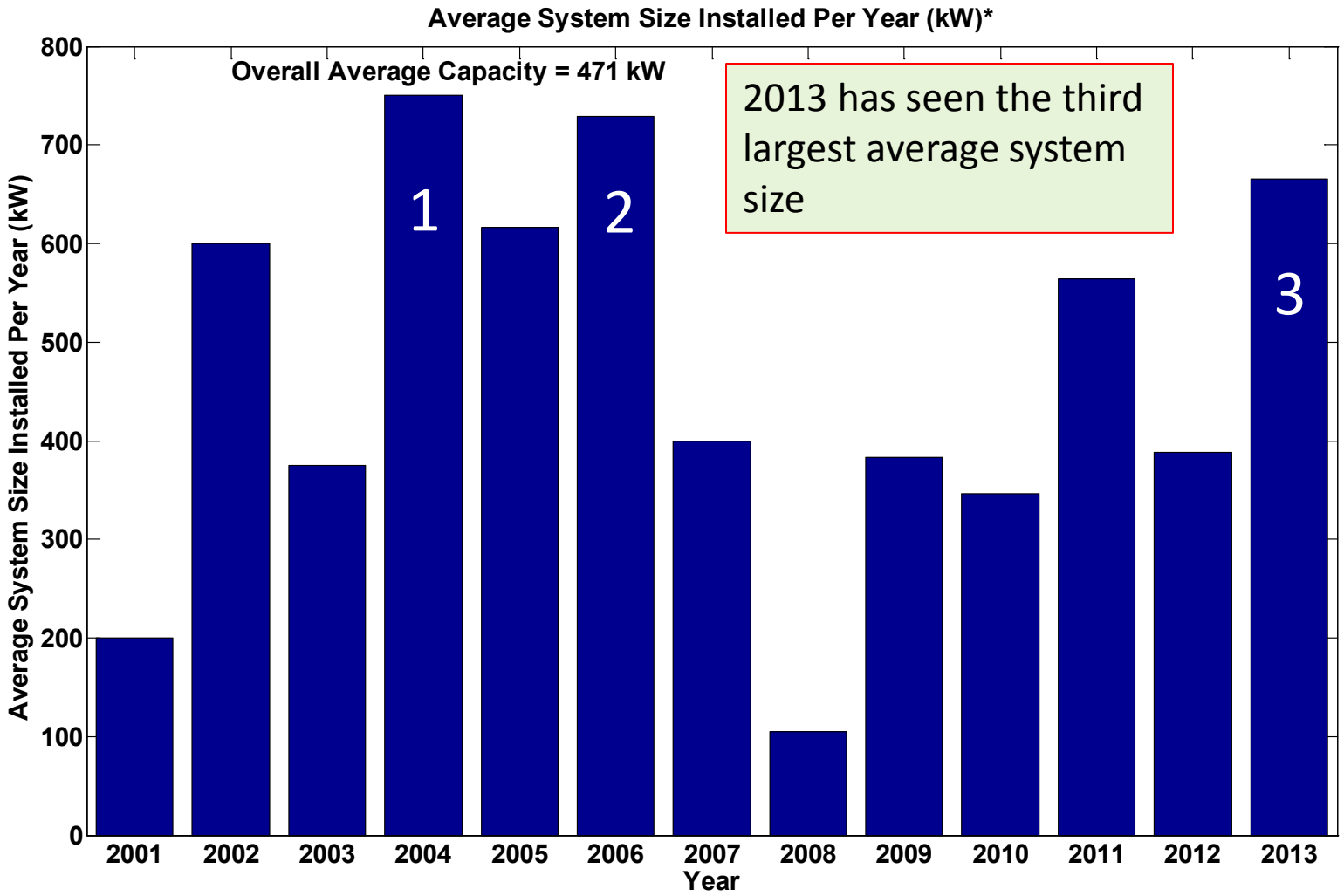
Total Incentive Spending ($2010) per kW by Year



NREL cdp_stat_11
Created: Sep-25-13 9:09 AM | Data Range: 2001Q2-2013Q2

*Data from the California SGIP.

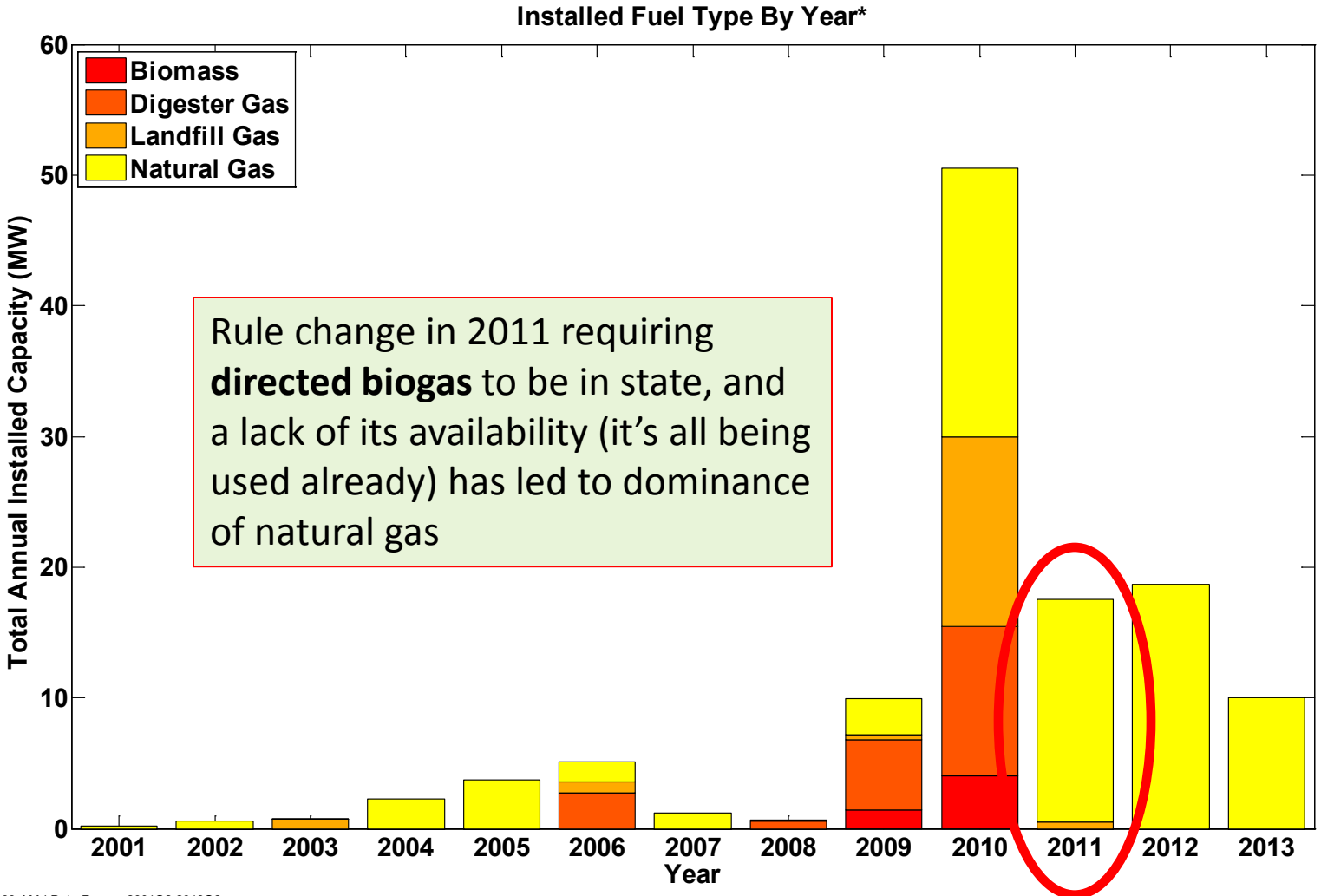
Average System Size Installed Per Year (kW)



NREL cdp_stat_12
Created: Sep-25-13 9:09 AM | Data Range: 2001Q2-2013Q2

*Data from the California SGIP.

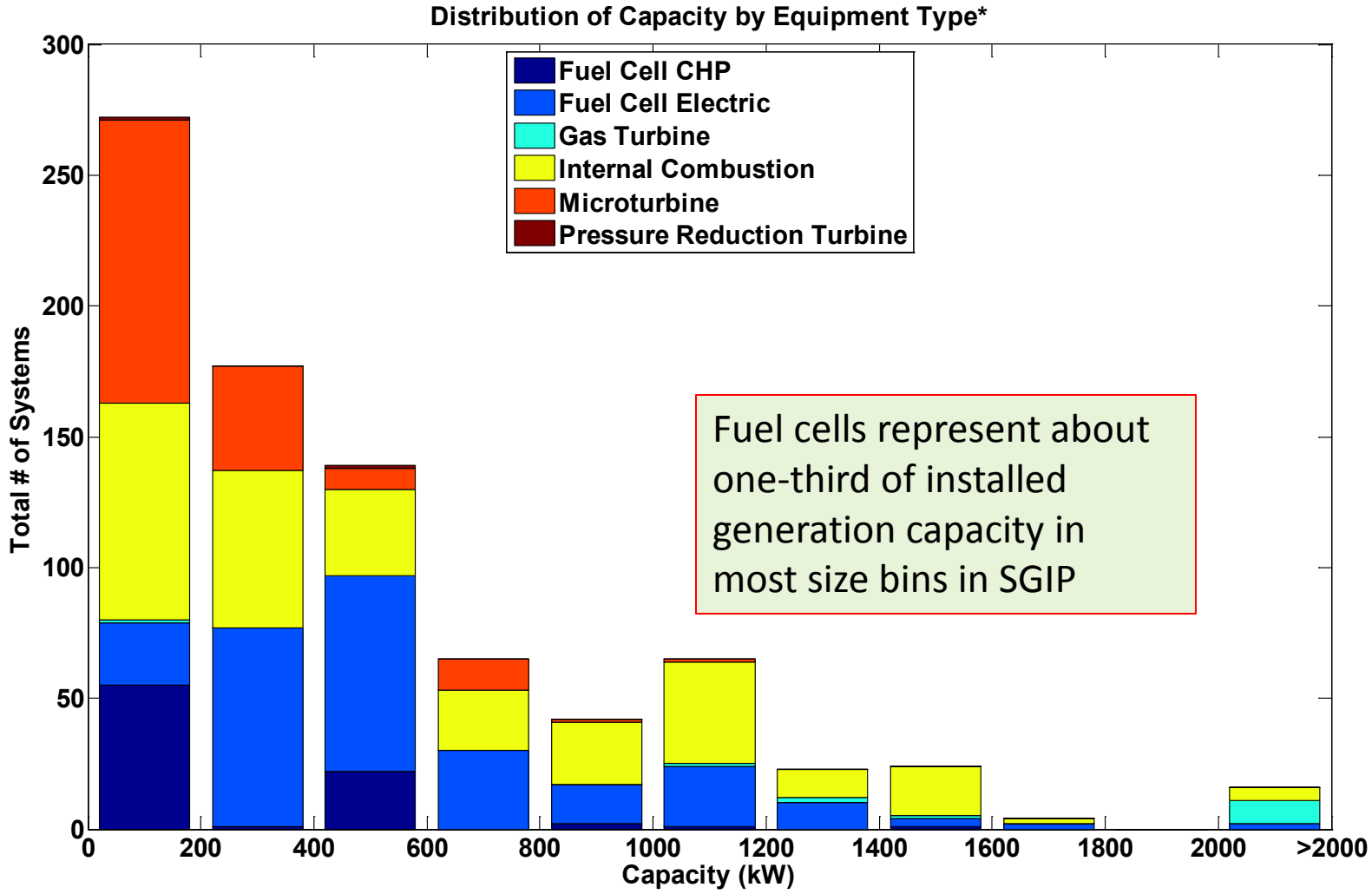
Installed Annual Capacity by Fuel Type



NREL cdp_stat_13
Created: Sep-25-13 9:09 AM | Data Range: 2001Q2-2013Q2

*Data from the California SGIP.

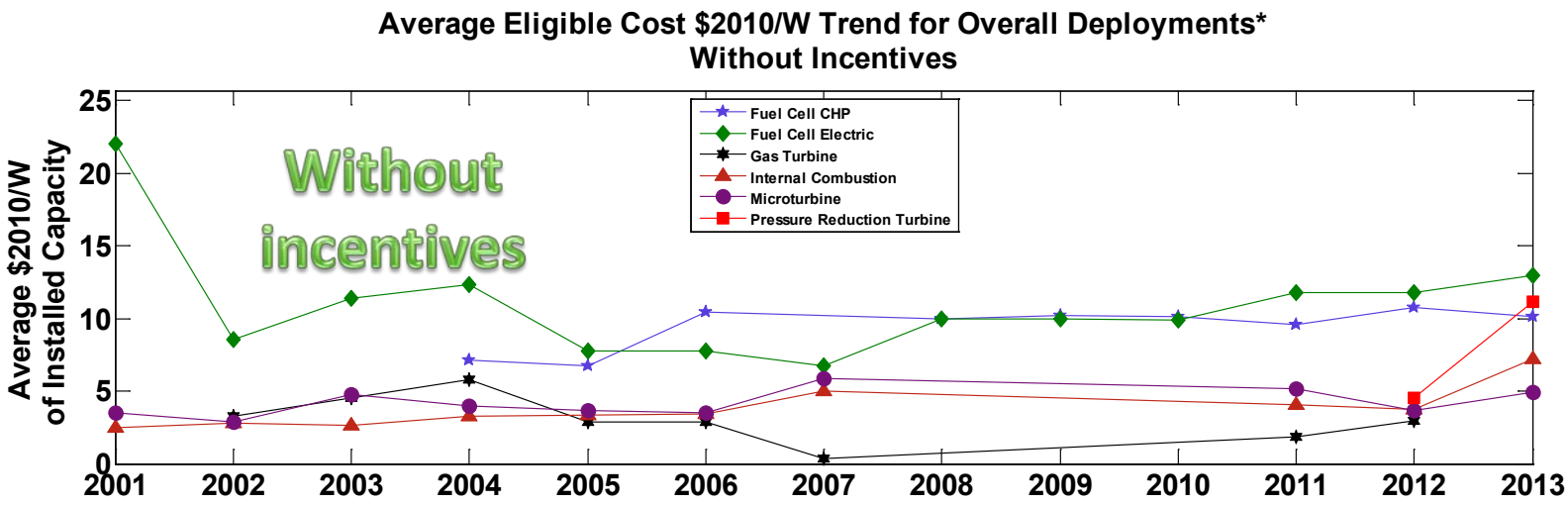
Comparing FC to Other Distributed Generation (DG): Distribution of Capacity by Equipment Type

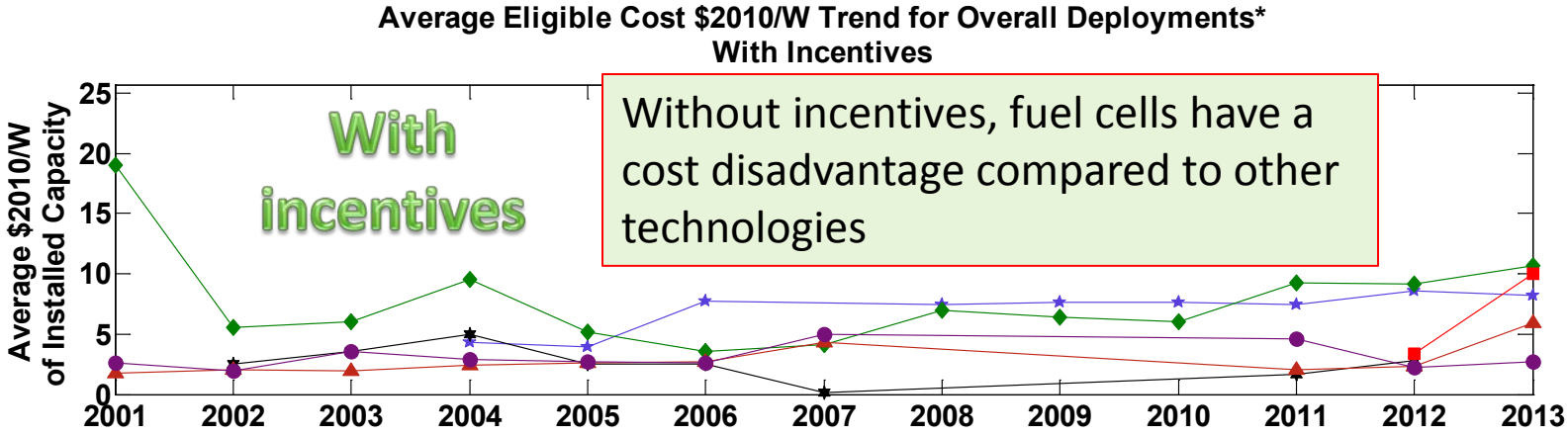


NREL cdp_stat_14
Created: Sep-30-13 1:57 PM | Data Range: 2010Q10-2013Q2

*Data from the California SGIP.

Comparing FC to Other DG: Average Eligible Cost by Equipment Type





Without incentives, fuel cells have a cost disadvantage compared to other technologies

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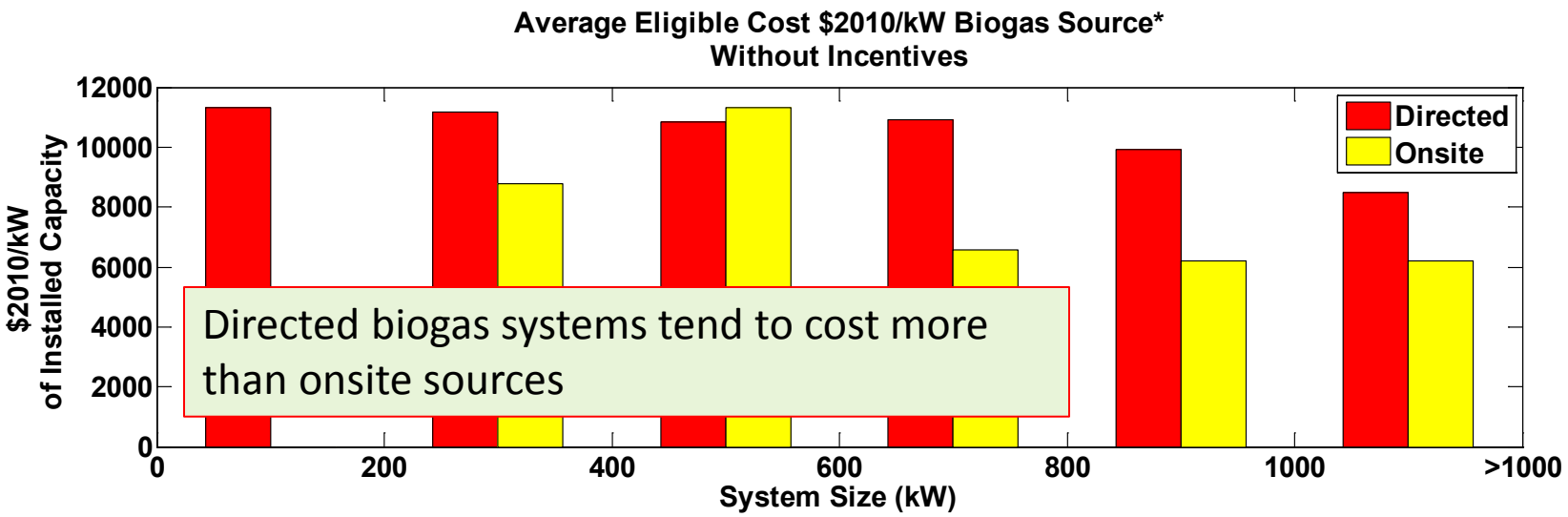
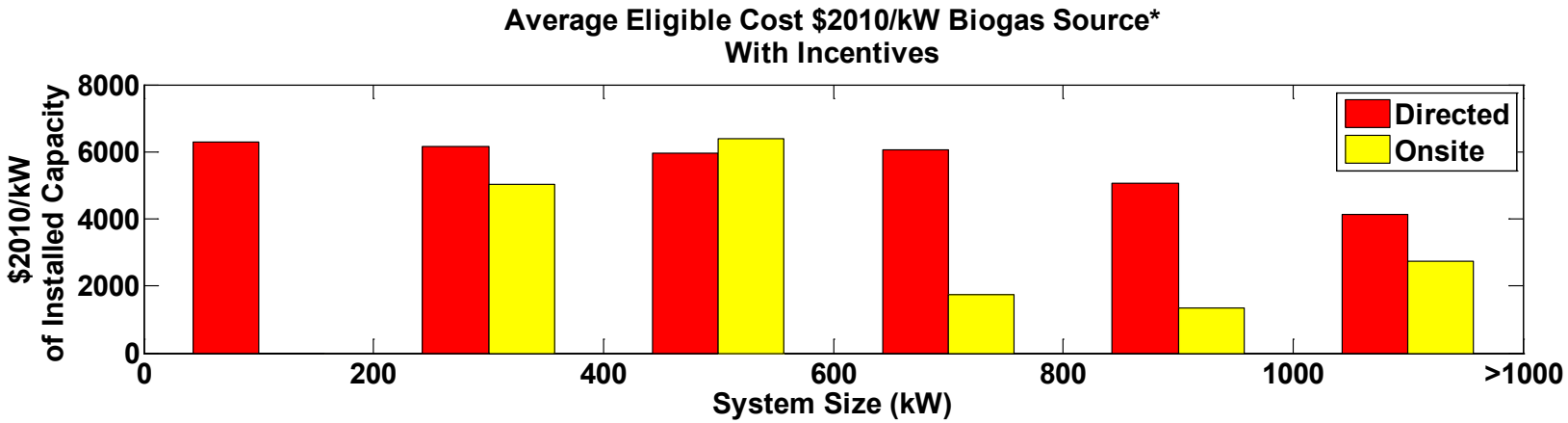
NREL cdp_stat_15
Created: Sep-30-13 1:57 PM | Data Range: 2010Q10-2013Q2

*Data from the California SGIP.

Average Eligible Cost for Biogas Sources





NREL cdp_stat_16
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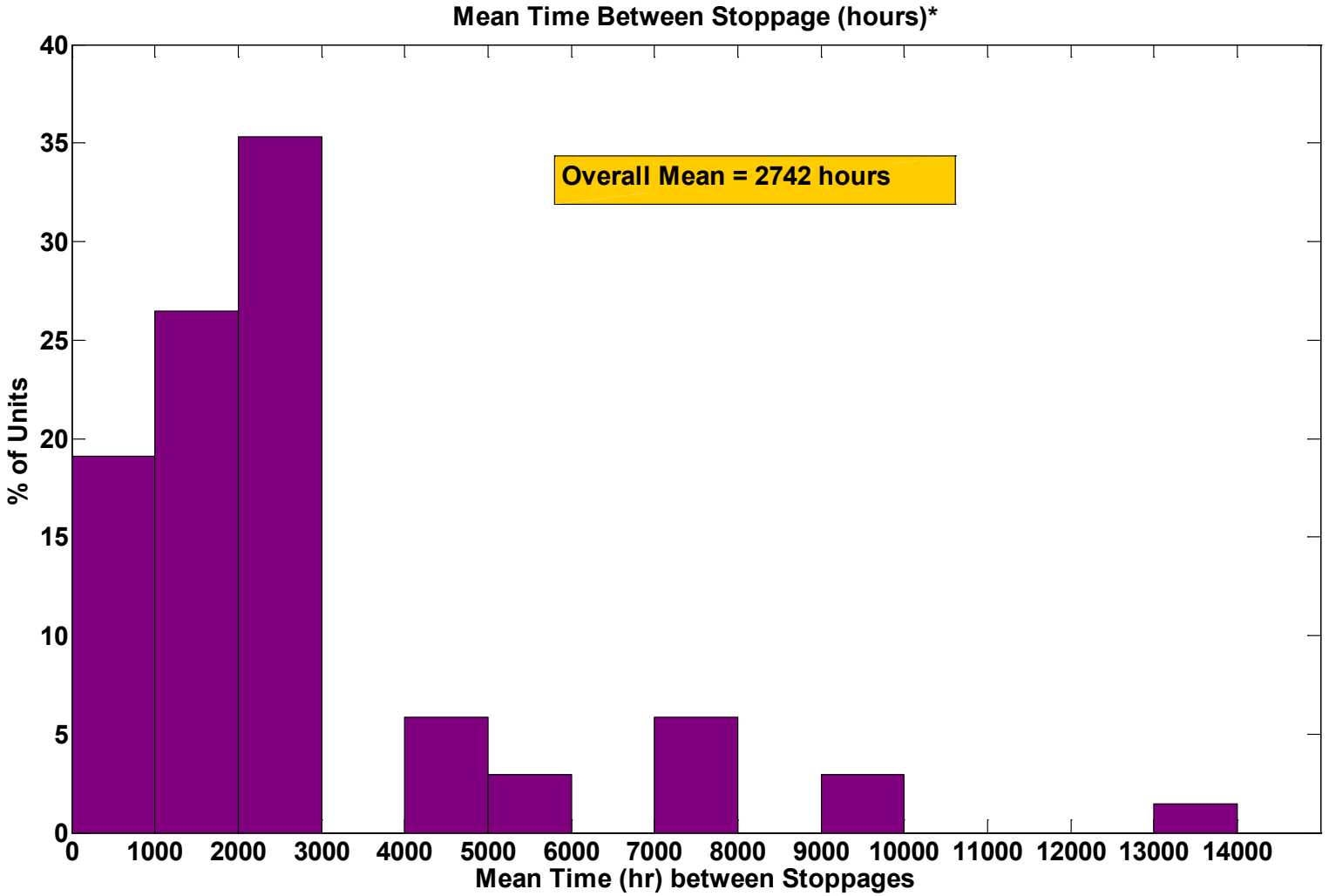
*Data from the California SGIP.

Mean Time Between Stoppage (For Any Reason)



NREL cdp_stat_17
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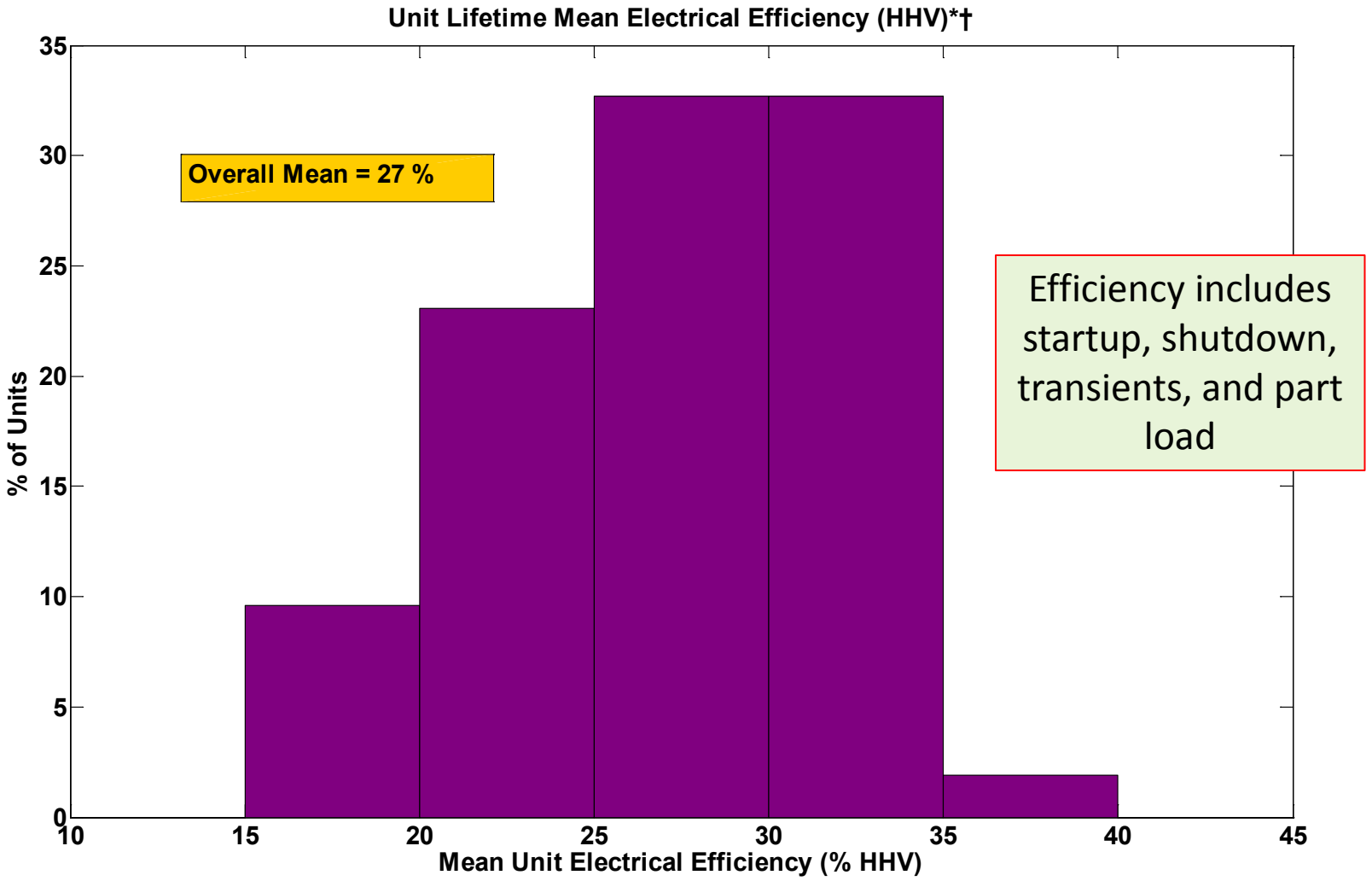
*Data from outside the SGIP.

Mean Unit Lifetime Electrical Efficiency (%HHV)



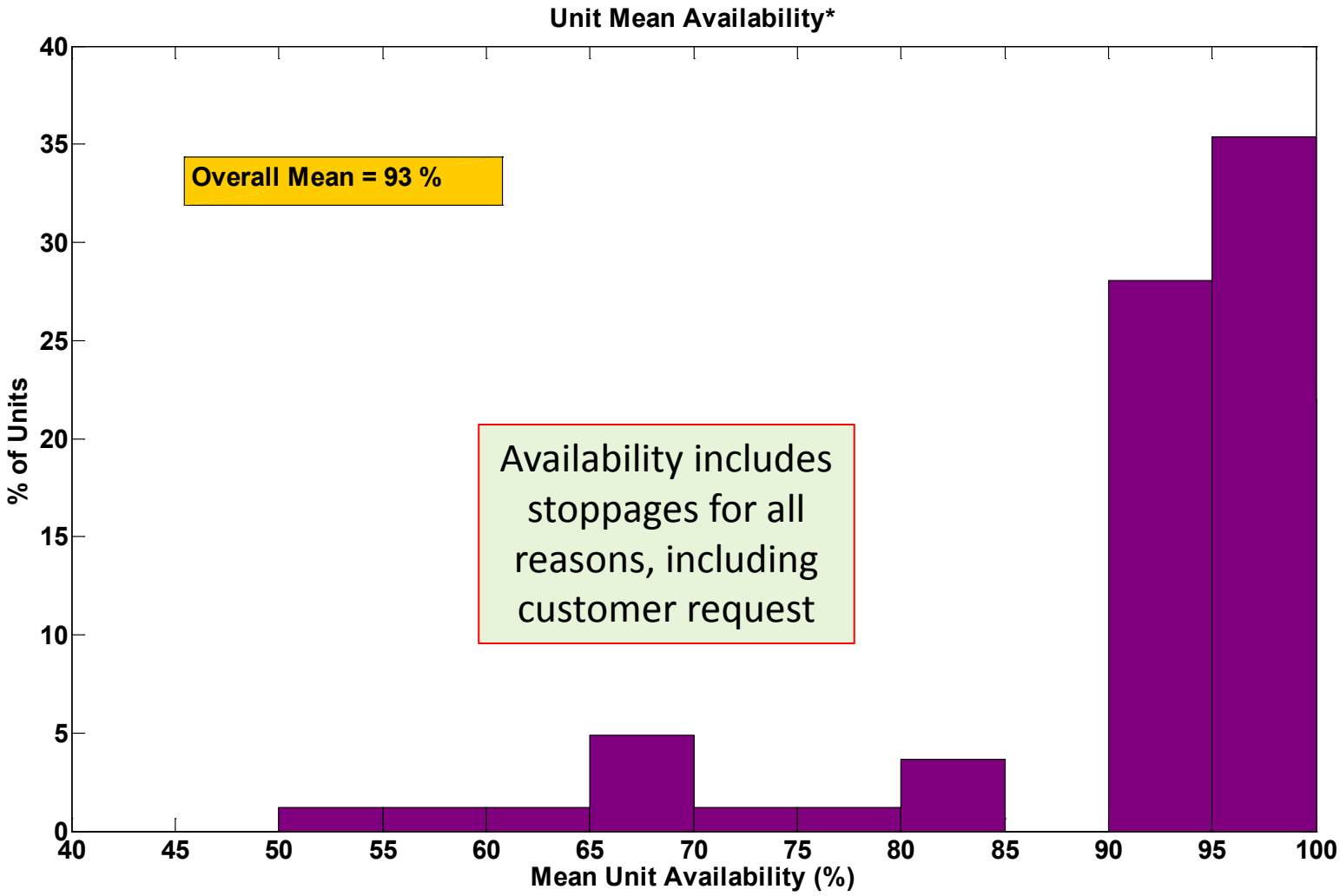
Efficiency includes startup, shutdown, transients, and part load

NREL cdp_stat_18
Created: Sep-30-13 2:04 PM | Data Range: 2010Q10-2013Q2

†Includes startup, shutdown, transient and partial power operation

*Data from outside the SGIP.

Mean Unit Lifetime Availability



NREL cdp_stat_19
Created: Sep-30-13 1:57 PM | Data Range: 2010Q10-2013Q2

*Data from outside the SGIP.

Conclusions

- Stationary fuel cell deployments are accelerating despite decreasing incentives
- Current SGIP incentives make FC systems more competitive with other distributed generation systems
- Lack of available directed biogas in CA has caused new SGIP installations to be natural gas
- Cost curves need to begin going down (not up) to accommodate decreasing incentives
- NREL will continue to update results as new data are available

Acknowledgements

This project was supported by the Technology Validation subprogram of the U.S. Department of Energy's Fuel Cell Technologies Office.