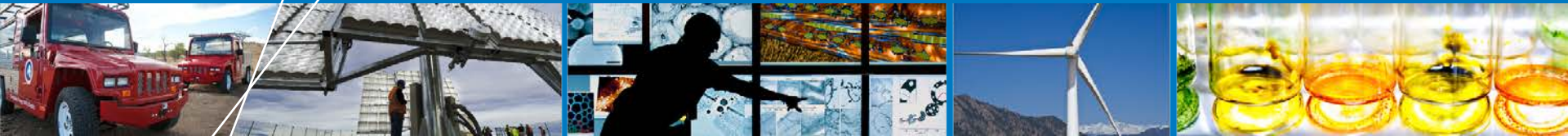


Fuel Cell Backup Power Technology Validation



J. Kurtz, S. Sprik, T. Ramsden, G. Saur

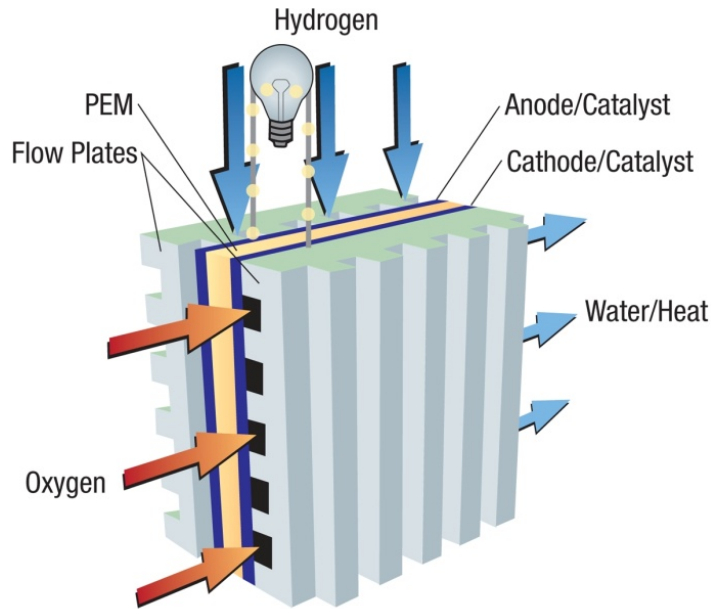
**Intelec 2012: 34th International
Telecommunications Energy Conference
Scottsdale, Arizona**

October 1, 2012

NREL/PR-5600-56785

What is a Fuel Cell?

H₂ PEM Fuel Cell



- Fuel cells efficiently convert chemical energy into electricity through an electrochemical process without burning
- Represent an alternative to batteries, generators, internal combustion engines to provide power for portable electronics, stationary, transportation & other applications

• Advantage

- High efficiencies for energy conversion
 - 40%-50% electrical efficiency (LHV of H₂)
 - ≥80% including utilization of waste heat
- High energy density
- Indefinite operating time as long as fuel is provided (refuel vs. recharge)
- Scalable from mW to MW
- Emission-free for H₂ PEMFC
- Quiet operation

• Disadvantage

- Cost
- Lack of fuel infrastructure
 - Production
 - Storage
 - Distribution

Objectives – Relevance



Assess the technology status in real world operations, establish performance baselines, report on fuel cell and hydrogen technology, and support market growth by evaluating performance relevant to the markets' value proposition.

- **Assess Technology**

- Independent technology assessment in real world operation conditions
- Focused on fuel cell system and hydrogen infrastructure: performance, operation, and safety
- Leverage data processing and analysis capabilities developed under the fuel cell vehicle Learning Demonstration project
- Material handling equipment, backup power, portable power, and stationary power.

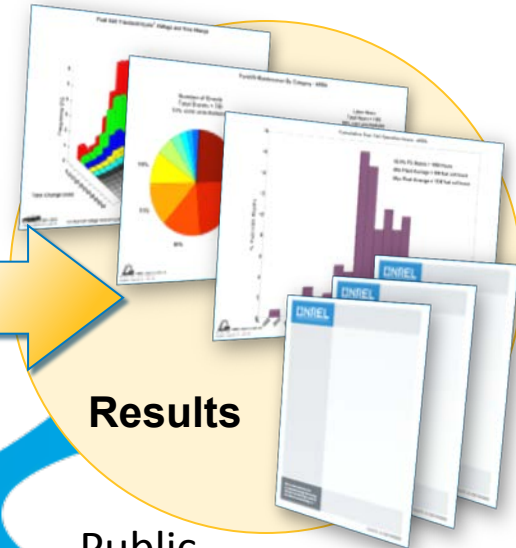
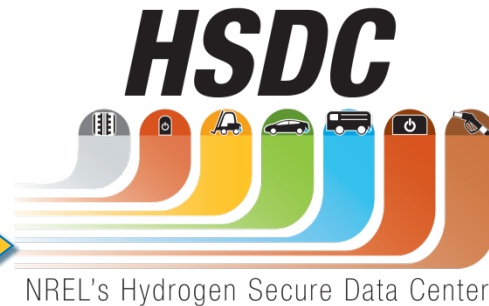
- **Support Market Growth**

- Analyses and results relevant to the markets' value proposition
- Reporting on technology status to fuel cell and hydrogen communities and other key stakeholders like end users

Hydrogen Secure Data Center – Approach

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

Internal analysis completed quarterly



DDPs

Confidential

Results

Public

CDPs

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)

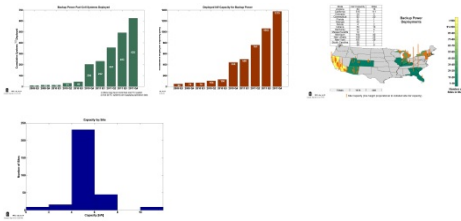
- Aggregated data across multiple systems, sites, and teams
- Publish analysis results without revealing proprietary data every 6 months²

1) Data exchange may happen more frequently based on data, analysis, and collaboration

2) Results published via NREL Tech Val website, conferences, and reports

Backup power CDP count and category

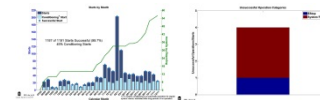
Deployment (1, 2, 3, 14)



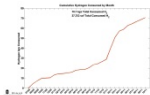
Fuel Cell Operation (5, 7, 8, 9, 11, 12, 13, 15)



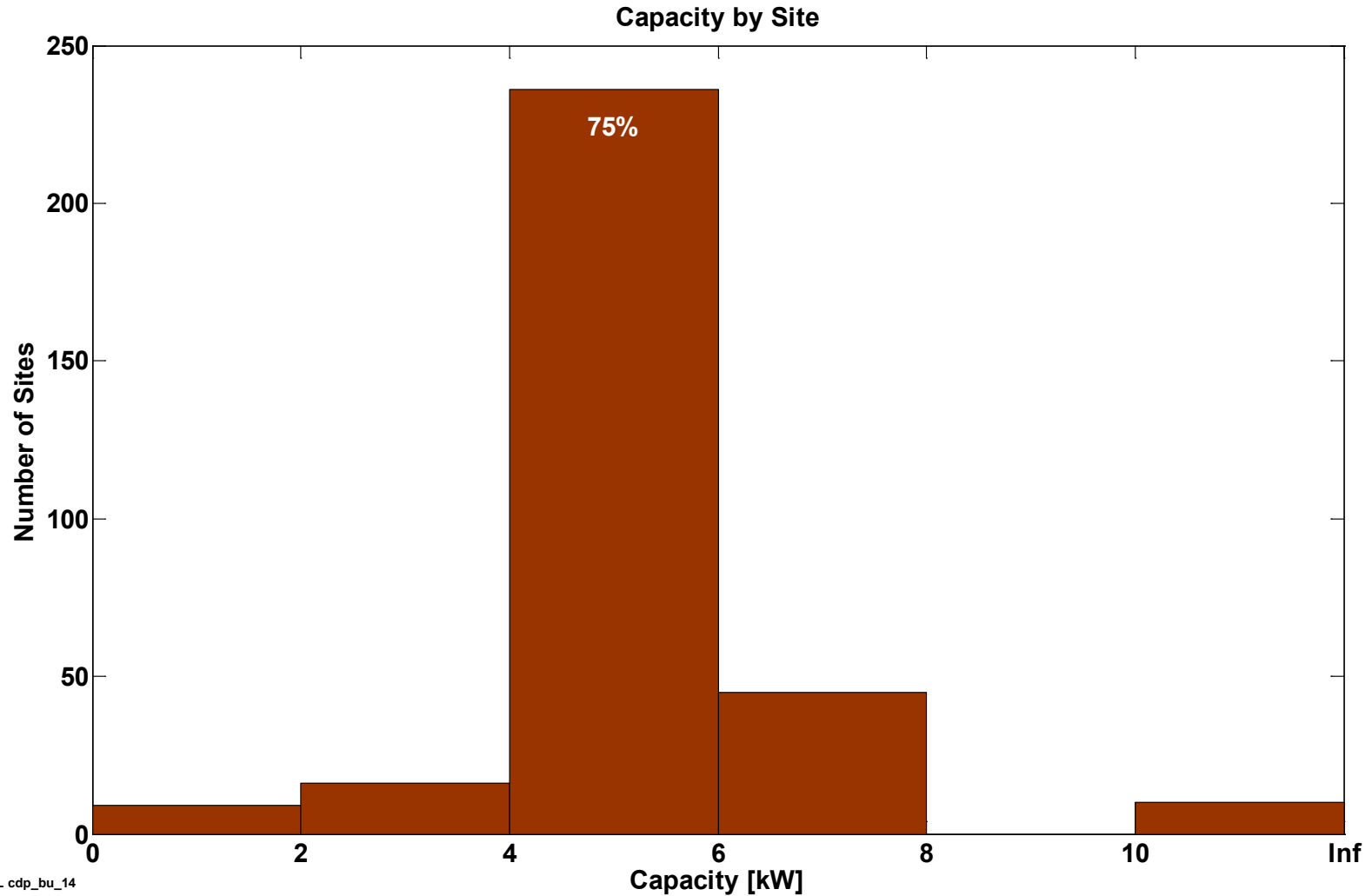
Fuel Cell Reliability (4, 10)



Infra. Operation (6)



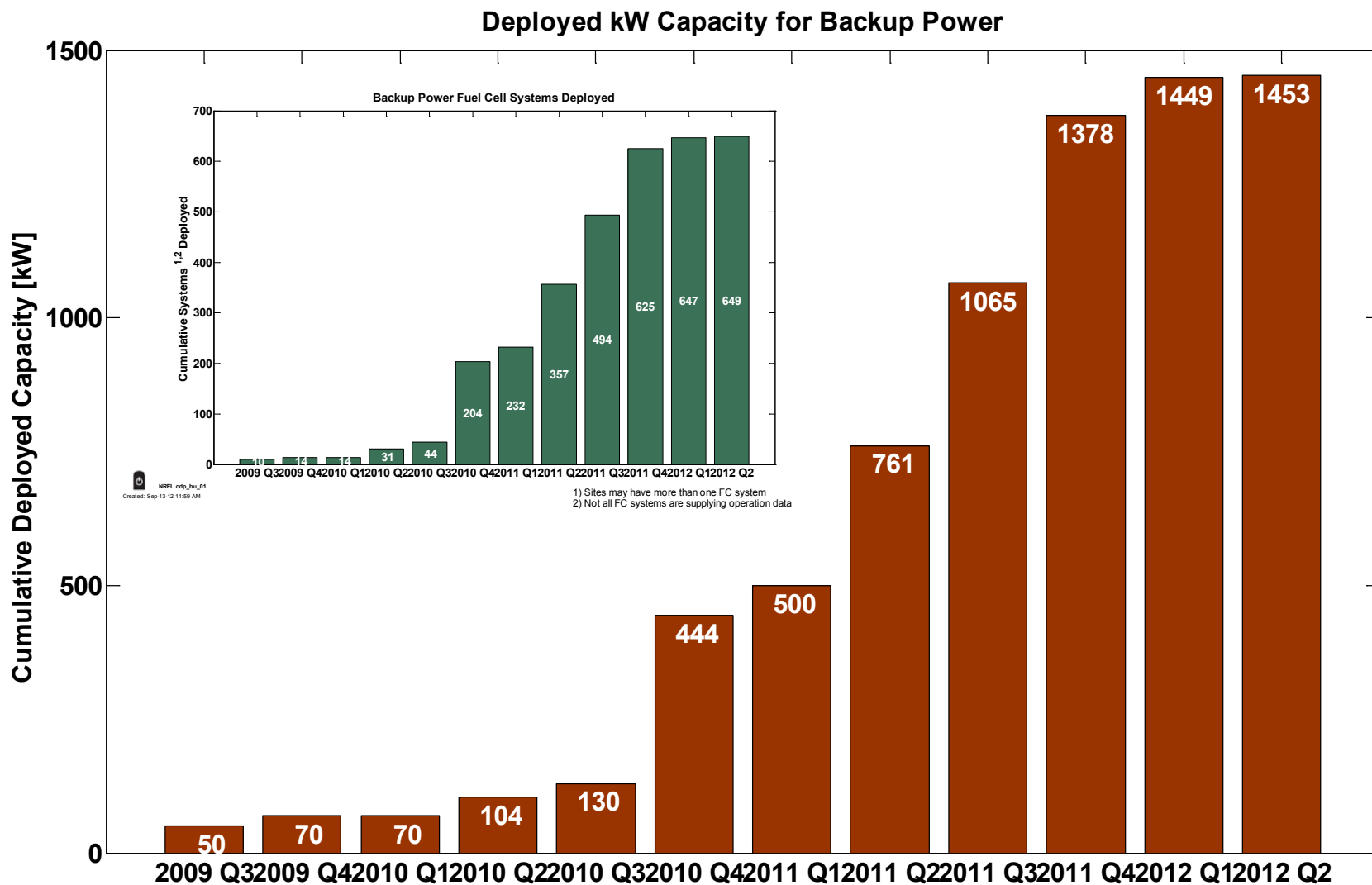
Deployment: 75% sites are between 4 – 6 kW



NREL cdp_bu_14

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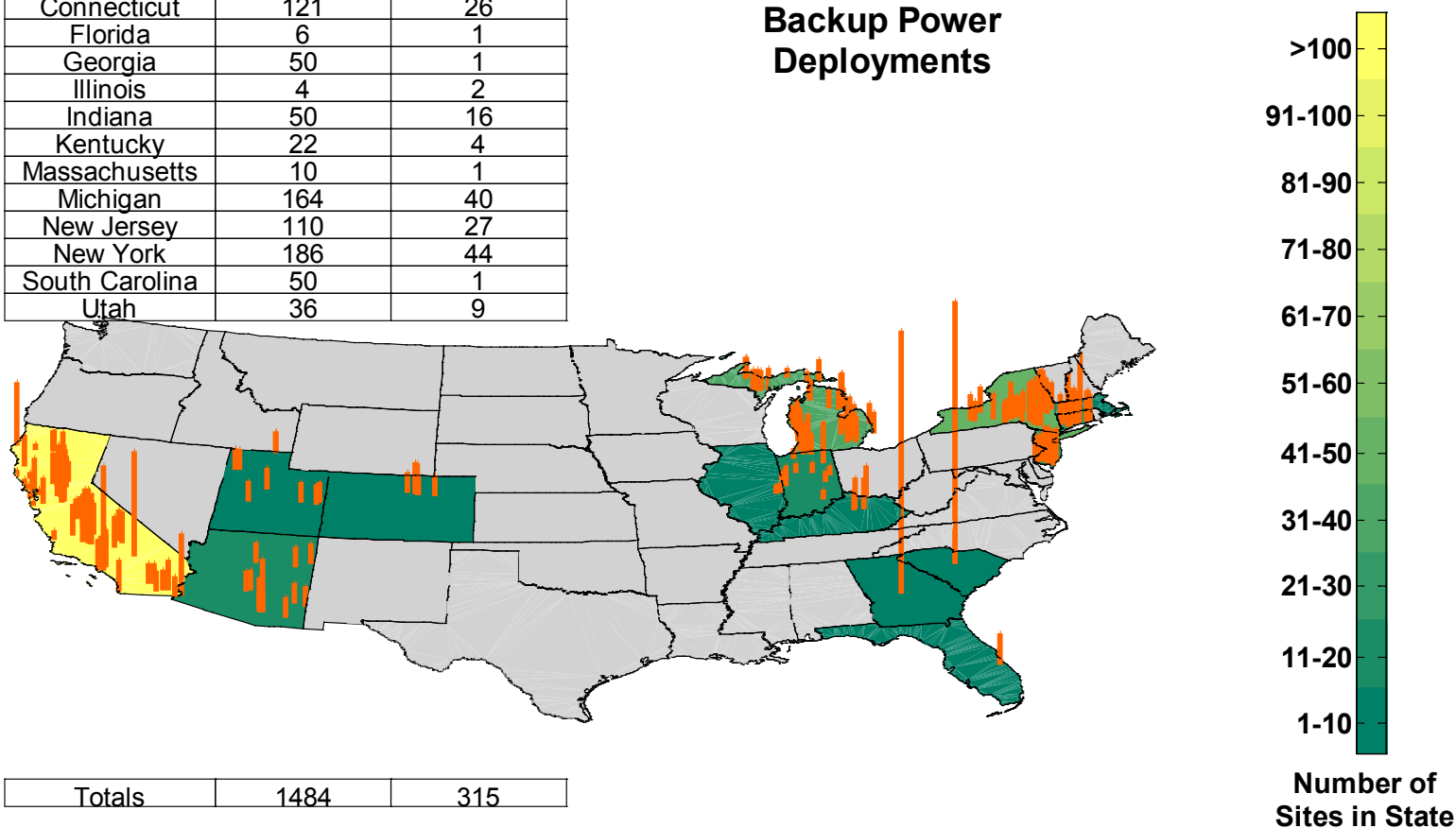
Deployment: Over 1.45 MW capacity is deployed with 649 systems



Deployment: Sites in 15 states

State	kW Capacity	Sites
Arizona	84	16
California	567	122
Colorado	24	5
Connecticut	121	26
Florida	6	1
Georgia	50	1
Illinois	4	2
Indiana	50	16
Kentucky	22	4
Massachusetts	10	1
Michigan	164	40
New Jersey	110	27
New York	186	44
South Carolina	50	1
Utah	36	9

Backup Power Deployments



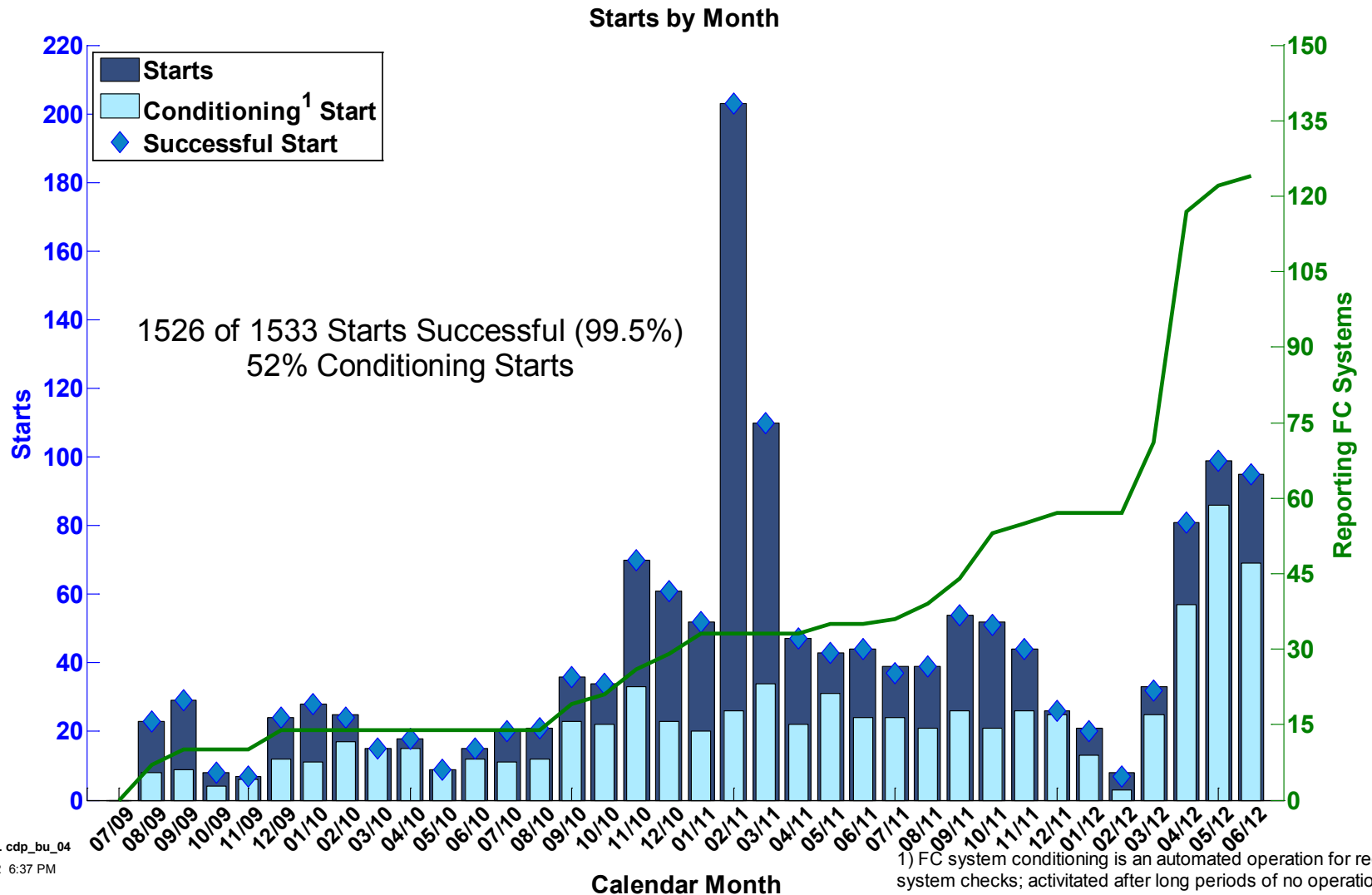
| Site Capacity (line height proportional to installed site kW capacity)



NREL cdp_bu_03

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Reliability: 99.5% successful starts

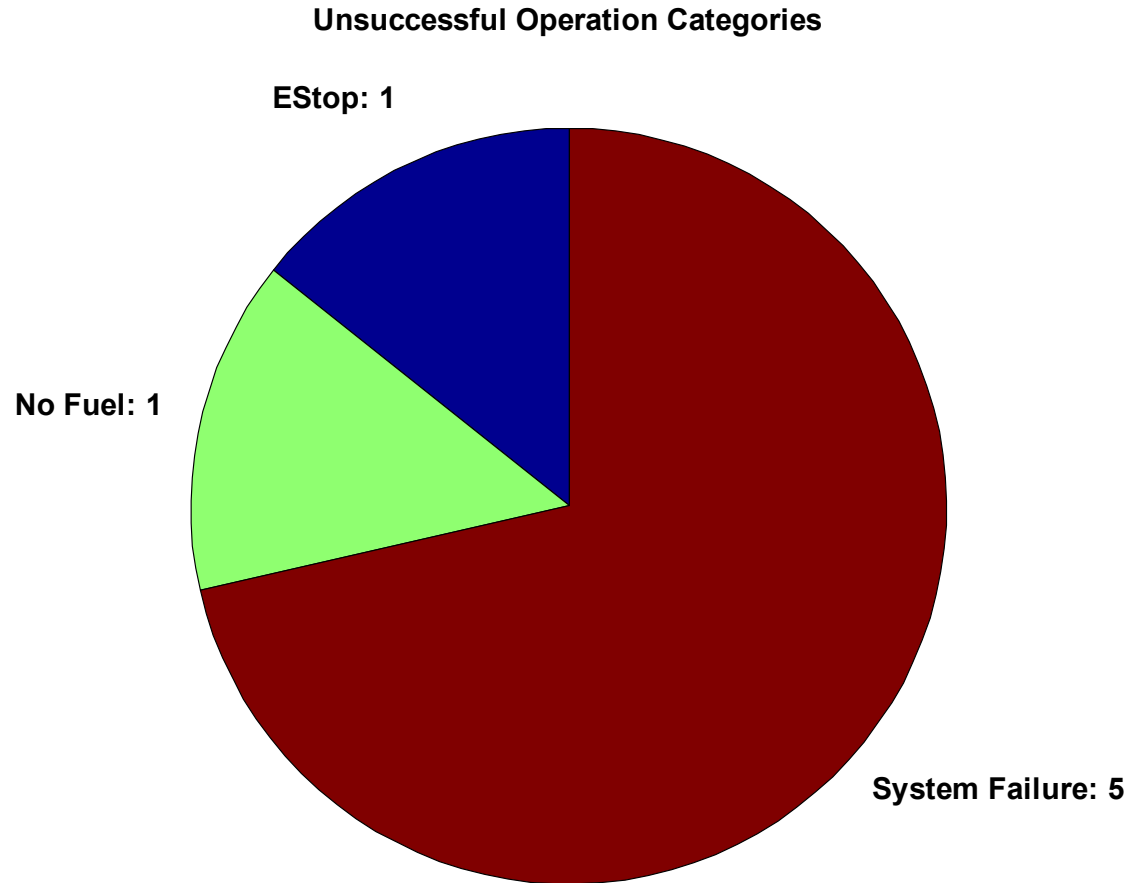


NREL cdp_bu_04

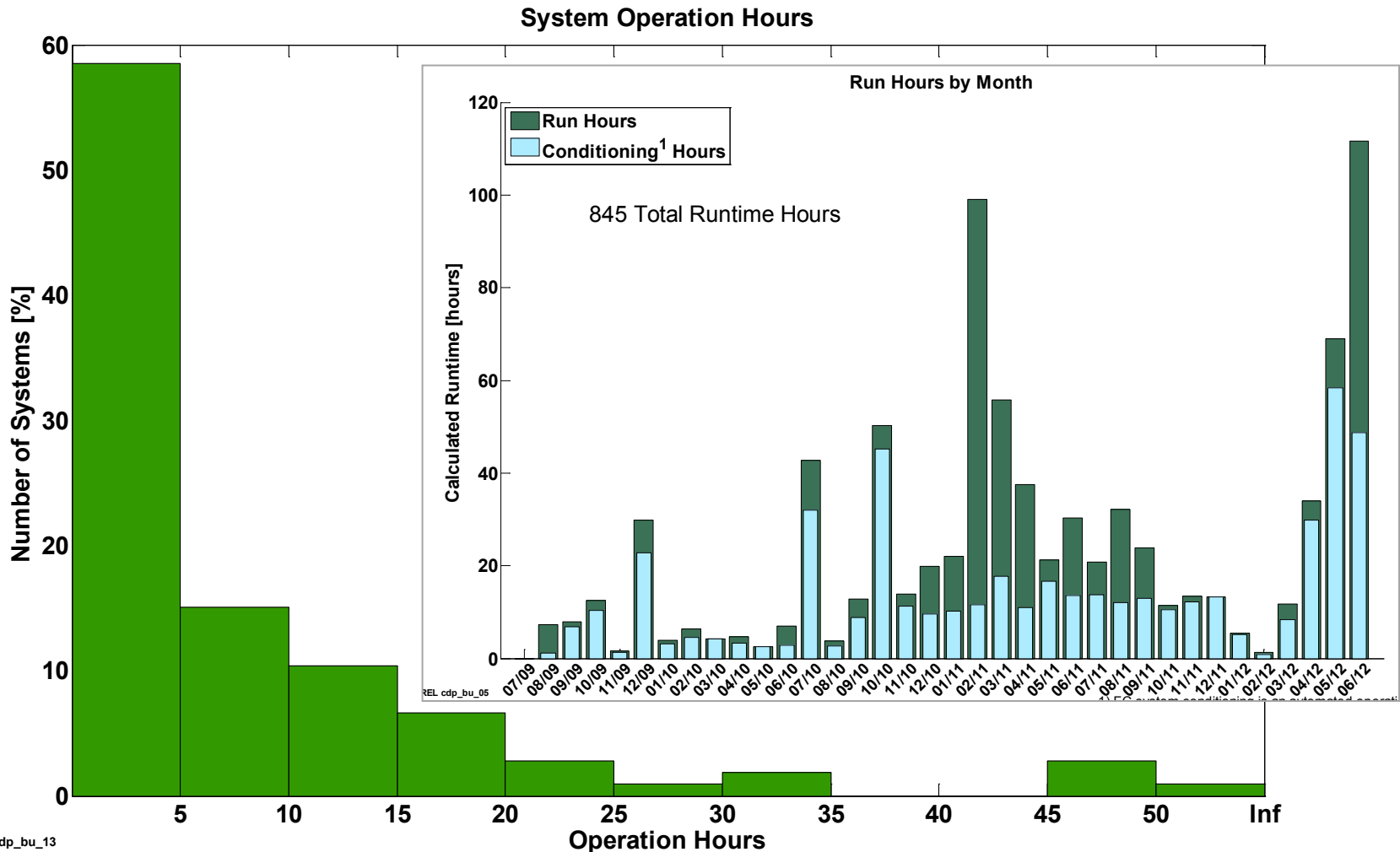
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1) FC system conditioning is an automated operation for regular system checks; activated after long periods of no operation.

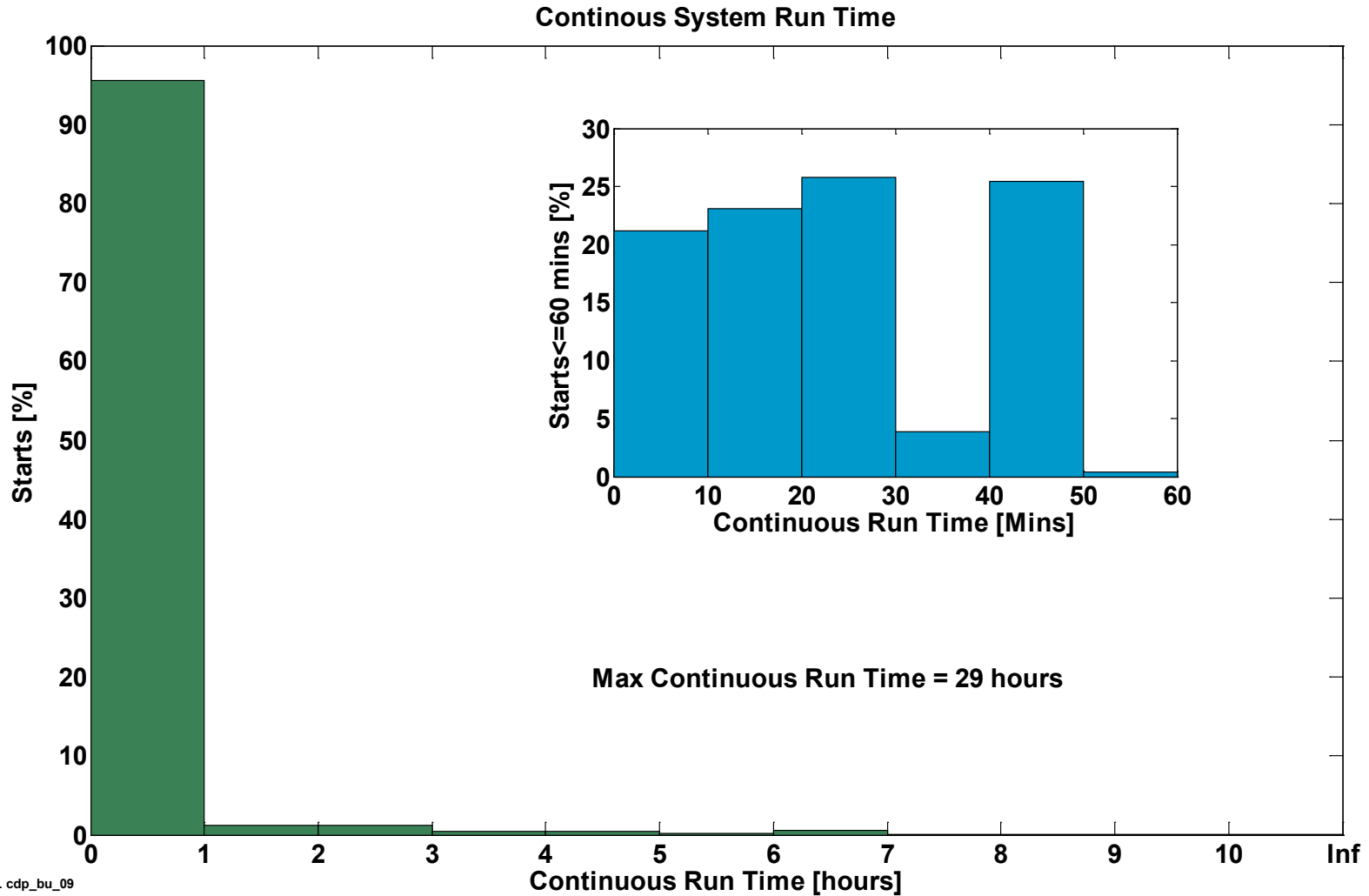
Reliability: Only 7 unsuccessful starts out of 1,533 attempted starts



Operation: Runtime hours tend to be low due to low required operation but some months and systems see high operation time



Operation: Systems are capable of extended runtimes (72-hour capacity)



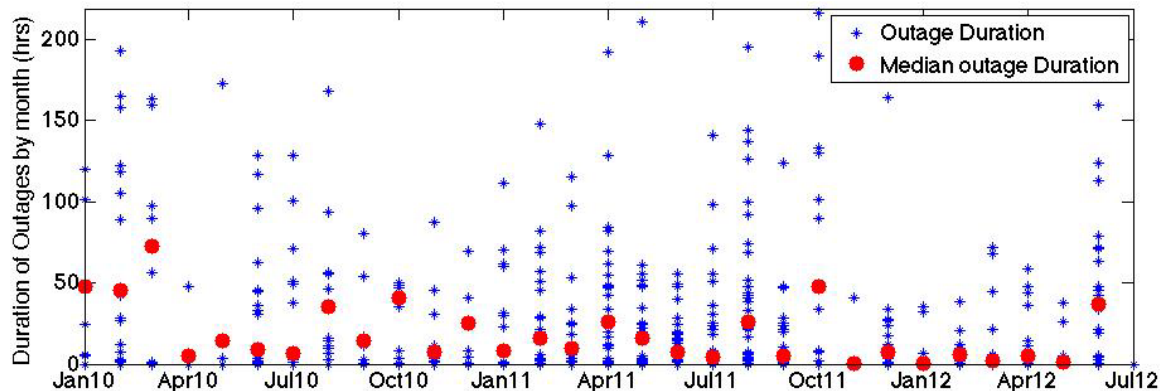
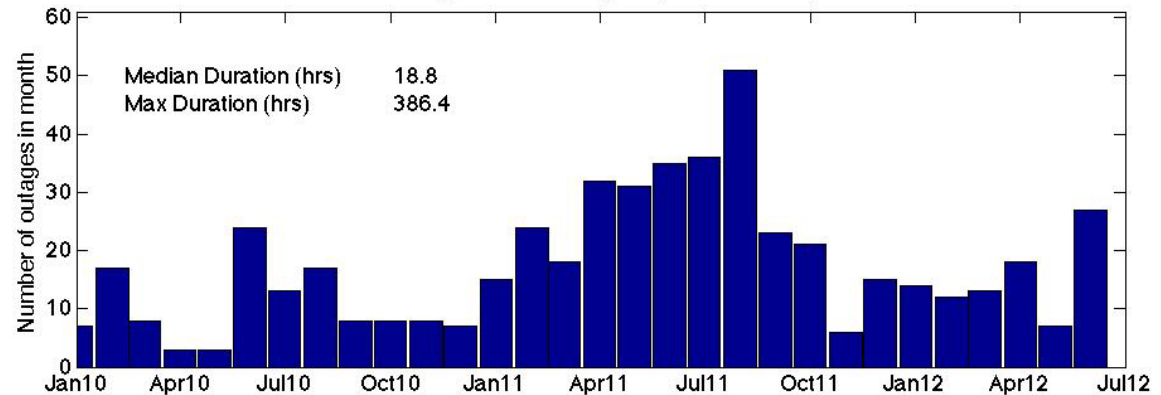
Grid outages: Association of system starts and grid outages

Some states see double digit grid outages a year with a few hours per outage

Often an outage has had extended down time

Couple fuel cell system operation data with OE-417 Electric Emergency and Disturbance (OE-417) Events, 2010-2012*

Histogram of outages (2010-2012)



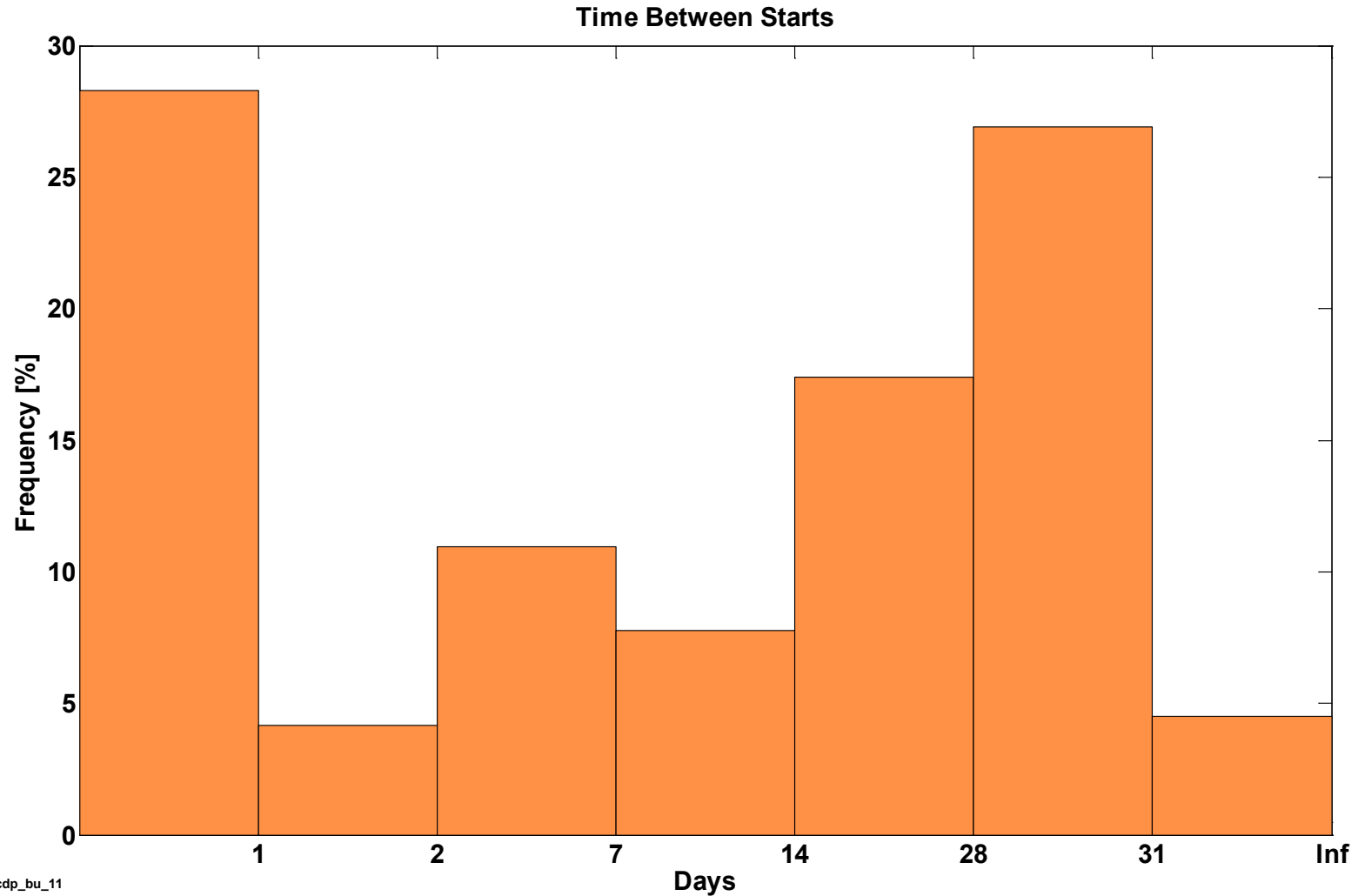
Submissions of all Electric Emergency Incident and Disturbance Reports (OE-417), <http://www.oe.netl.doe.gov/oe417.aspx>







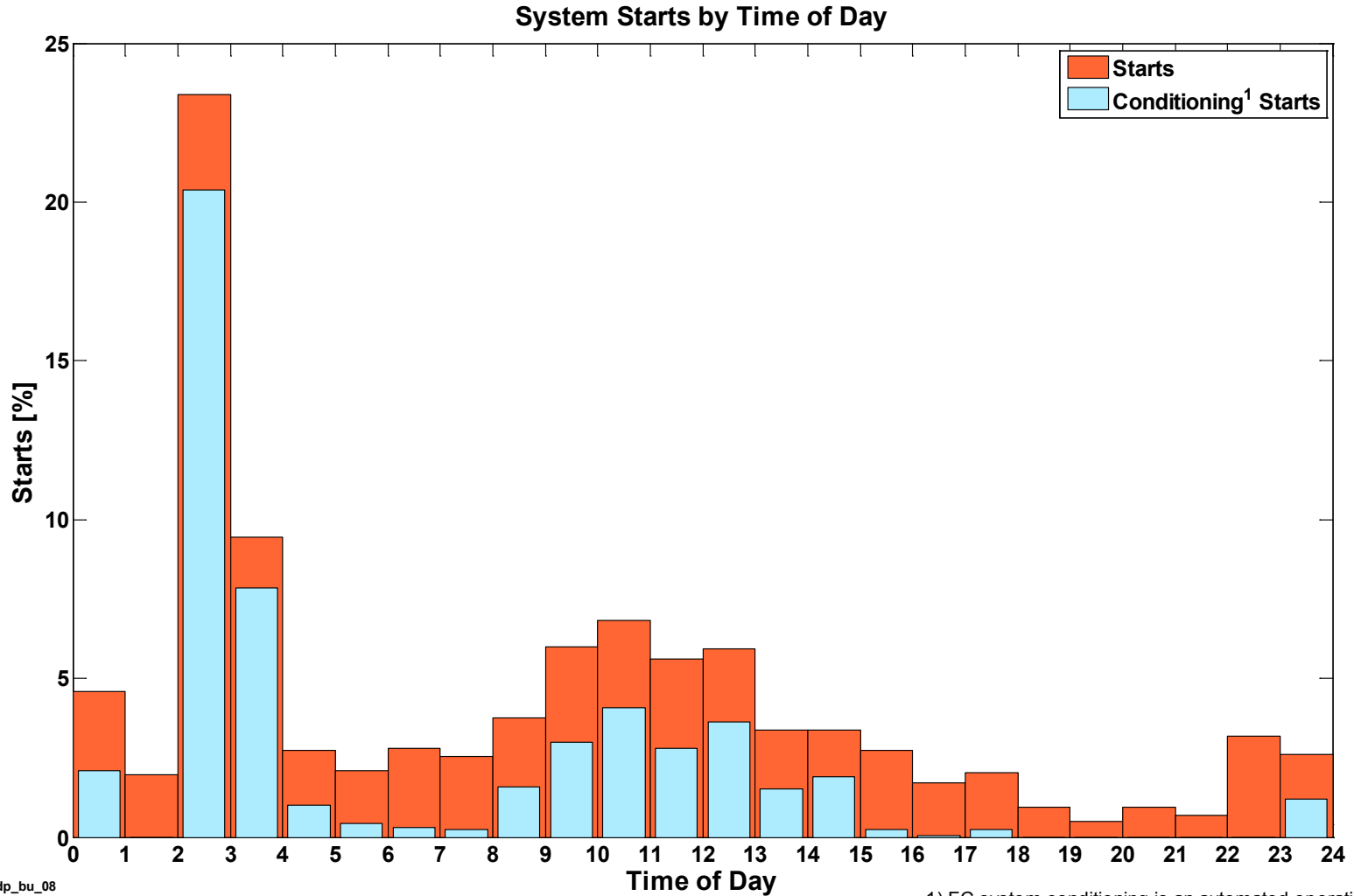
Operation: Automatic system operation is capable of rapid restarts as well as long durations between starts



NREL cdp_bu_11

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Operation: 42% of starts occur off-peak between midnight and 5 a.m.

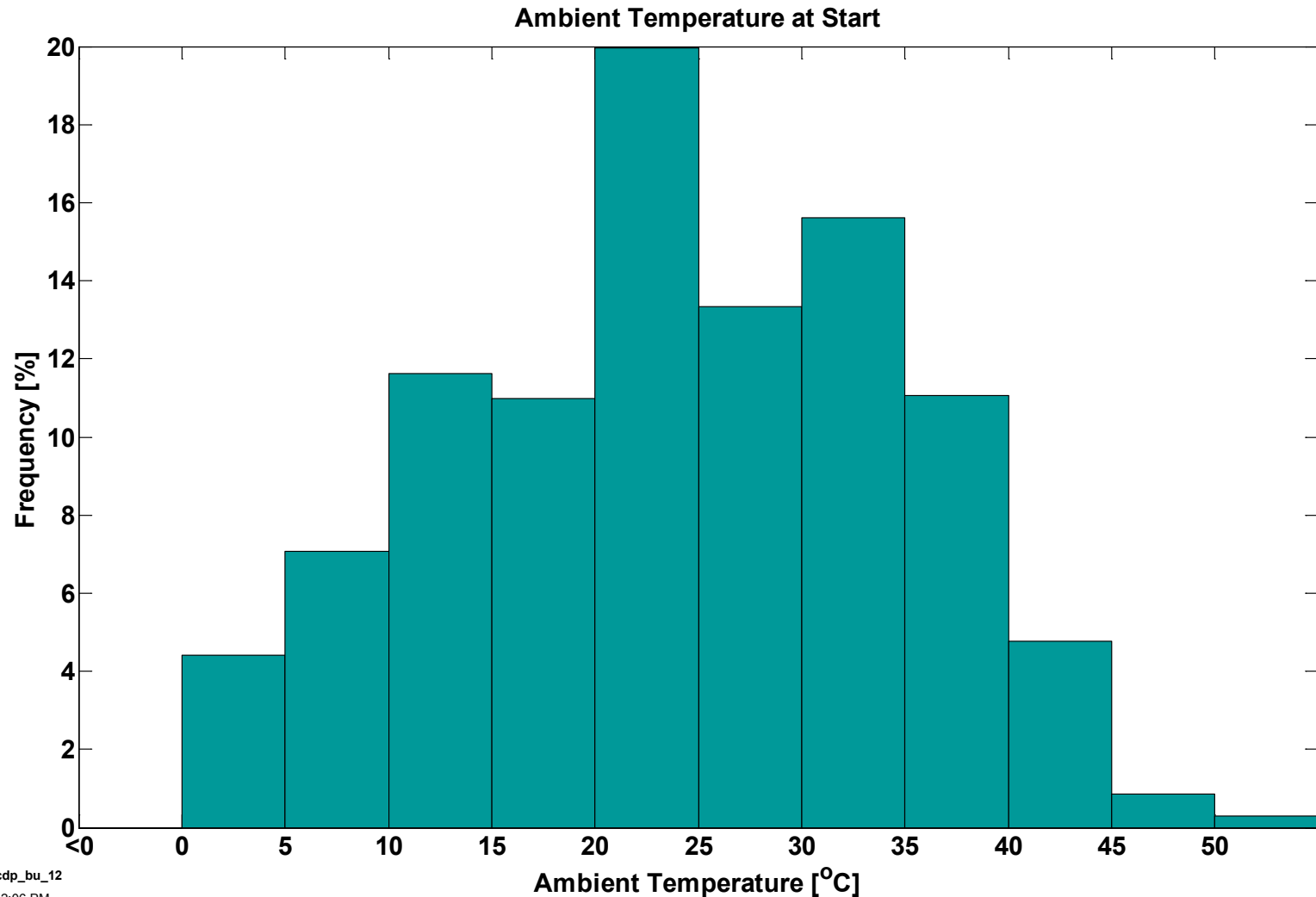


NREL cdp_bu_08

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1) FC system conditioning is an automated operation for regular system checks; activated after long periods of no operation.

Operation: Systems demonstrated operation in a wide range of ambient temperature with a keep warm strategy in ambient conditions below freezing



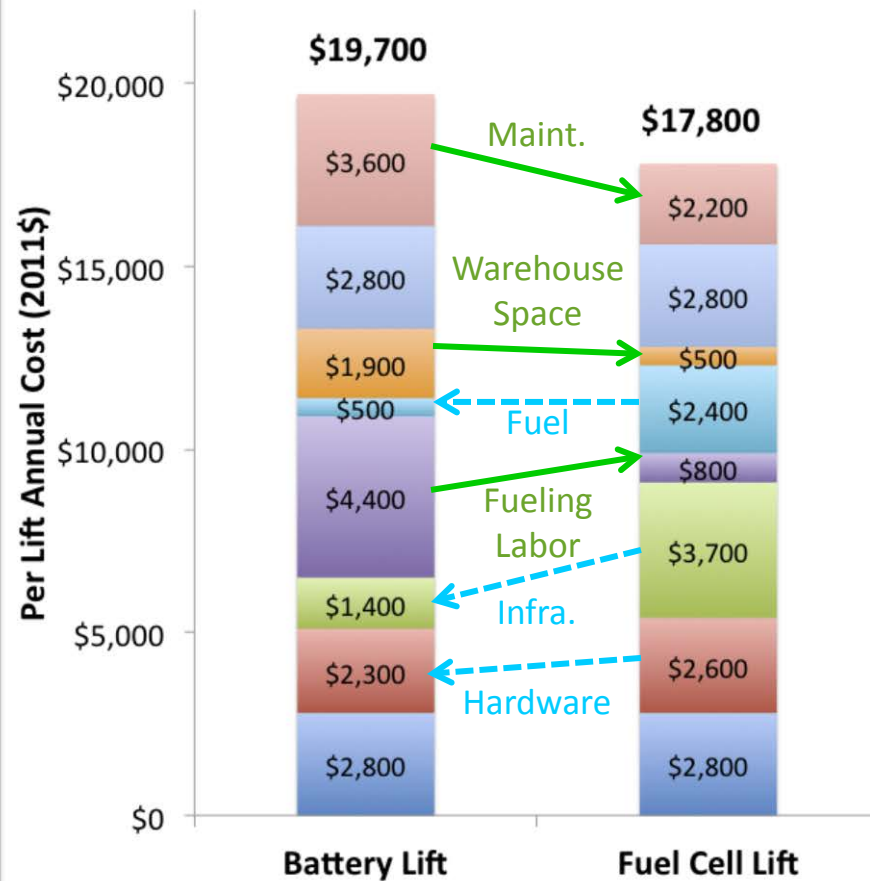
Cost of ownership: Example of annualized cost analysis for material handling that will be applied to backup power systems



- Battery / Fuel Cell Maintenance
- Lift Truck Maintenance
- Cost of Infrastructure Warehouse Space
- Cost of Electricity / Hydrogen
- Labor Cost for Battery Charging & H2 Fueling
- Per Lift Cost of Charge/Fuel Infrastructure
- Amortized Cost of Battery / Fuel Cell Packs
- Amortized Cost of Lift

CDP Ref #: 58

Class I & II MHE -- Annualized Costs



Cost of ownership: Backup power

Gathering data on:

- Site Description
 - System Description
 - System Requirements
 - Capital Cost
 - Operating & Maintenance Cost
 - Operating Lifetime
- for fuel cells, batteries, and generators

	Fuel Cell*	Diesel	Battery
Reliability	+	o	+
Capital Cost (\$/kW)	-	+	++
Extended Run Time	++	++	--
Emissions	++	-	++
Noise	+	+	++
Environmental	~	-	~
Weight	+	-	-
Efficiency	+	-	++
Annual Fuel Cost	+	-	++
Annual Maintenance Cost	+	-	++
Maintenance Frequency	++	-	?
Refurbishment	+	+	--
Conditioning Tests	+	-	~
Operation Lifetime	+	++	--

*Tax credit \$3,000/kW or 30% total

Fuel Cell Backup Power

- Operating reliability in 15 states with 99.5% successful starts
- Maximum continuous run time of 29 hours due to an unplanned grid outage
- Aggregated data showcases growth over the last two years

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Capabilities

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- Hydrogen Storage
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- Technology Validation
- Fuel Cell Vehicle Learning Demonstration
- Fuel Cell Bus Evaluations
- Early Fuel Cell Market Demonstrations
- Fuel Cell Technology Status Analysis
- Safety, Codes, & Standards Analysis
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News

Early Fuel Cell Market Demonstrations

Early fuel cell market demonstrations focus primarily on fuel cell backup power and prime power applications as well as material handling equipment (i.e., fuel cell forklifts). Department of Energy-sponsored demonstration projects support fuel cell market transformation activities and help foster the growth of fuel cell markets. In addition, the Department of Defense funds early fuel cell demonstration projects.

NREL receives operational data from these early market fuel cell demonstrations, analyzes, and reports on these data. By aggregating data across numerous industry teams and sites, NREL develops composite data products (CDPs), which provide relevant data results on the technology status and fuel cell performance without revealing proprietary data. These publicly available CDPs help the development community understand the state of fuel cell technologies, identify areas for continued improvement, and provide data metrics that are important to the business case for these fuel cell markets.

This page provides the following resources:

- [Composite Data Products](#)
- [Publications](#)
- [Presentations Containing All CDPs](#)

Composite Data Products

The public technical analysis results are generated in the form of composite data products. The following CDPs can be sorted by title, category, CDP number, and date updated. Download the CDPs as PowerPoint or JPG files using the links in the two columns on the right. Download the current presentation containing all [ARRA CDPs](#) and [DLA CDPs](#) or see the archived [presentations containing all CDPs](#).

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Hydrogen PEM fuel cells are leading candidates for use in fuel cell vehicles. Today's commercially available PEM fuel cells are particularly appropriate for low-power applications requiring intermittent backup. Fuel cell backup power systems offer longer continuous runtime and greater durability than traditional batteries in harsh outdoor environments. And with fewer moving parts, fuel cell backup power systems typically require less maintenance than generators or batteries. For specialty vehicles such as forklifts, fuel cells can be a cost-competitive alternative to traditional lead-acid batteries.

Learn More

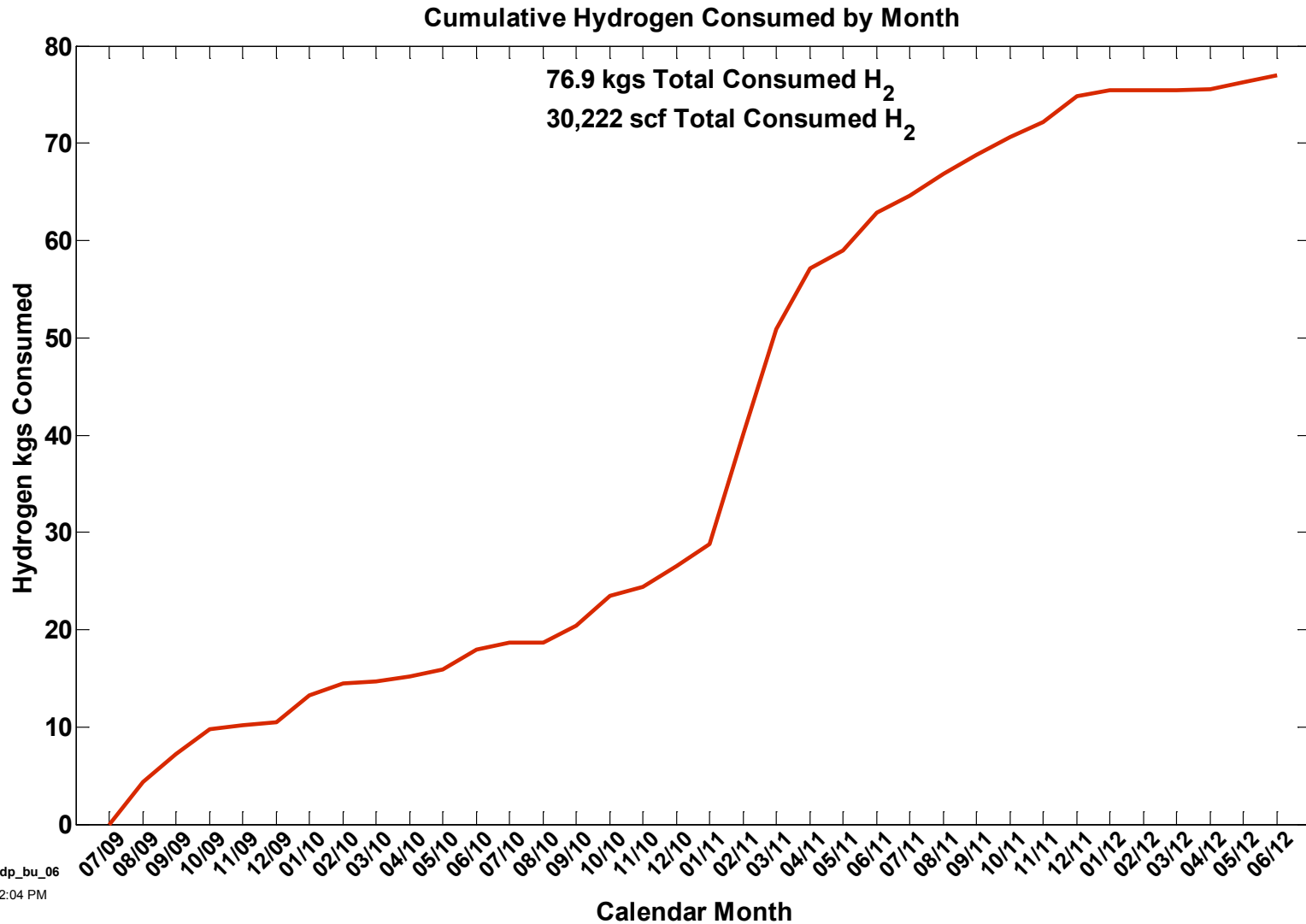
[Subscribe](#) to the biannual Fuel Cell and Hydrogen Technology Validation newsletter, which highlights recent technology validation activities at NREL.

All published results can be found at

http://www.nrel.gov/hydrogen/proj_fc_market_demo.html

Backup Slides

Cumulative Hydrogen Consumed by Month



Fuel Cell System Starts by Day of Week

