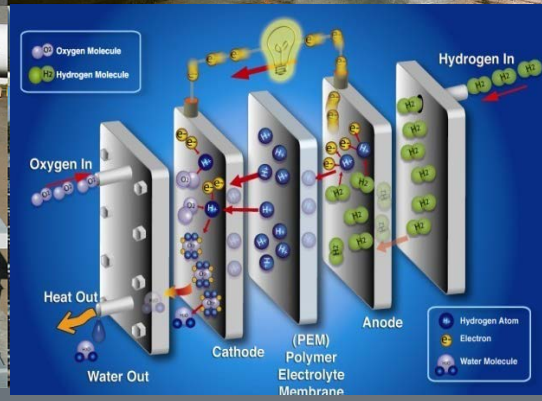
National Fuel Cell Technology Evaluation Center (NFCTEC)

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



Jennifer Kurtz & Sam Sprik

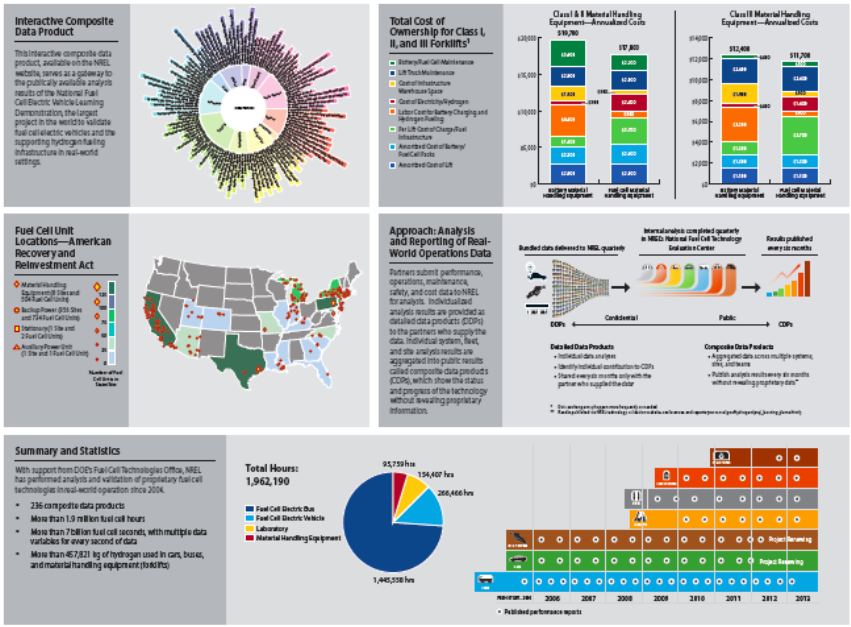
National Renewable Energy Laboratory

Jim Alkire

U.S. Department of Energy
Fuel Cell Technologies Office

Outline

- About NFCTEC
- Benefits to the Hydrogen & Fuel Cell Community
- New Fuel Cell Cost/Price Aggregation Project



NREL
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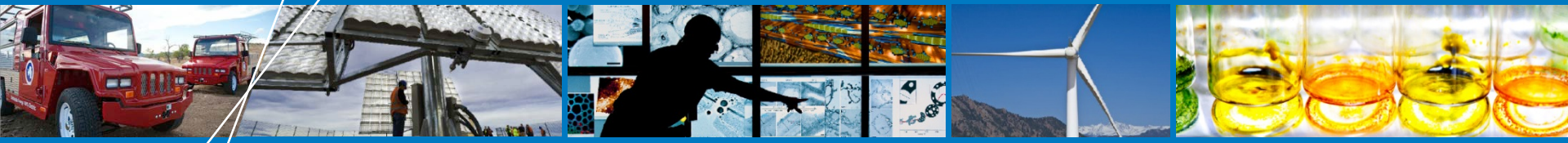


About NFCTEC

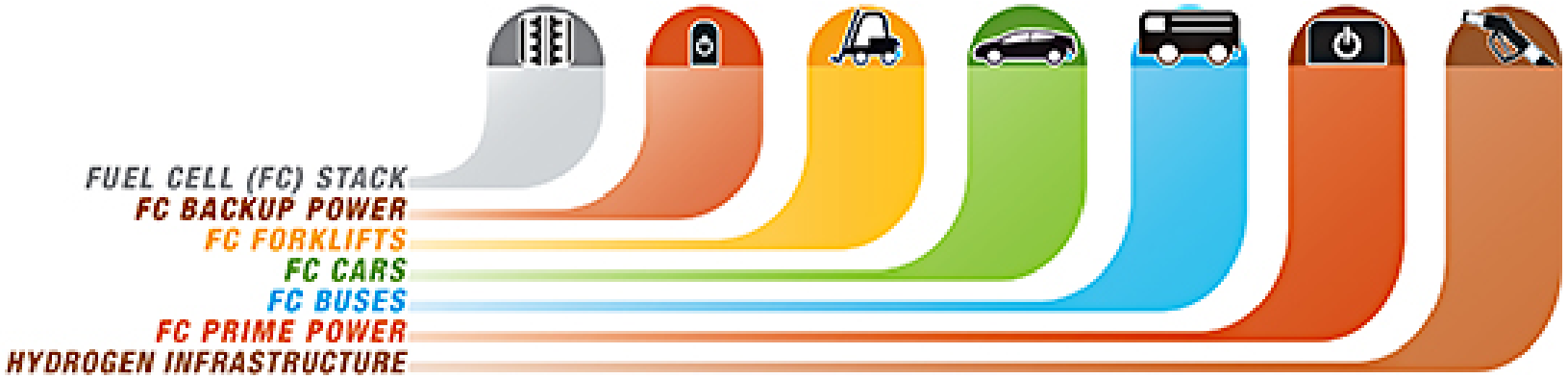
Energy Department Launches National Fuel Cell Technology Evaluation Center to Advance Fuel Cell Technologies

September 2013

Source: http://apps1.eere.energy.gov/news/news_detail.cfm/news_id=19607

Rebranding of HSDC

National Fuel Cell Technology Evaluation Center



a national resource for hydrogen and fuel cell stakeholders
supported through Energy Efficiency and Renewable Energy's Fuel Cell Technologies Office

NFCTEC Objectives

- Independent, secure analysis
- Industry collaboration & benchmarking
- Confirmation of component and system technical targets
- Technology validation
- Evaluation, optimization, and demonstration in integrated energy systems and real-world operation

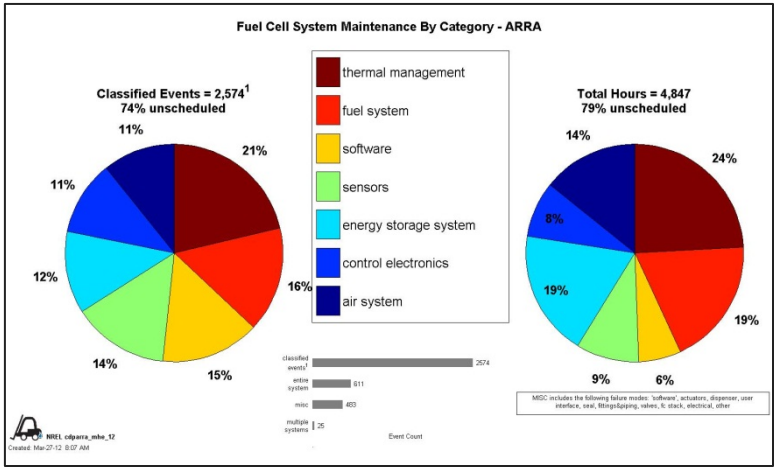
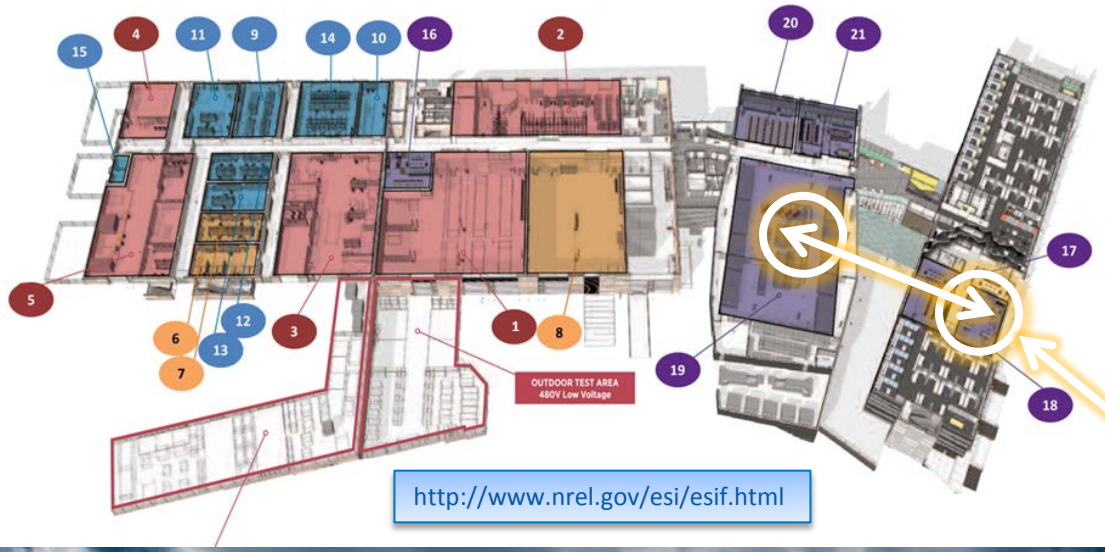
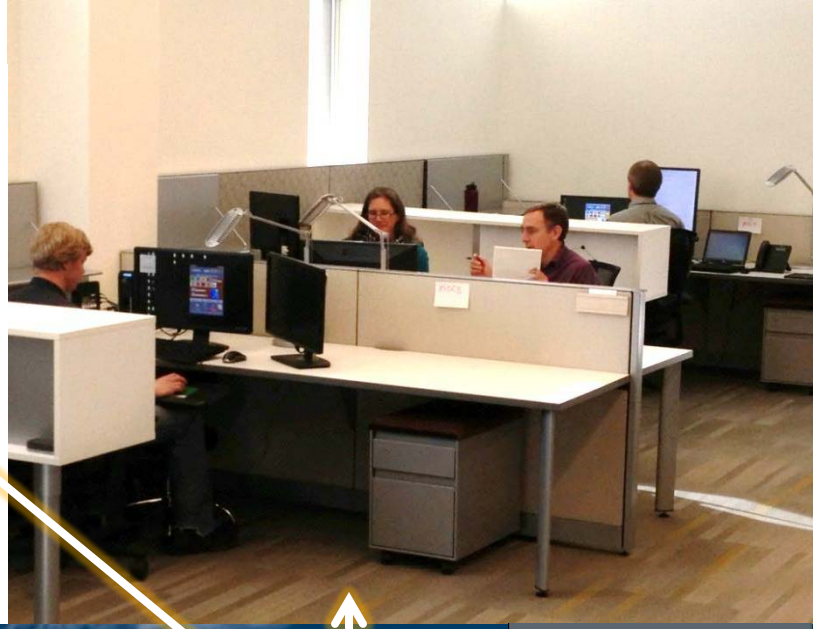


Photo by Dennis Schroeder, NREL
Figures and illustrations: NREL

NFCTEC @ Energy Systems Integration Facility



http://www.nrel.gov/esi/esif.html



High Performance Computing

Laboratories

NFCTEC

NREL
NATIONAL FUEL CELL TECHNOLOGY EVALUATION CENTER

Golden, Colorado

Photo by Dennis Schroeder, NREL

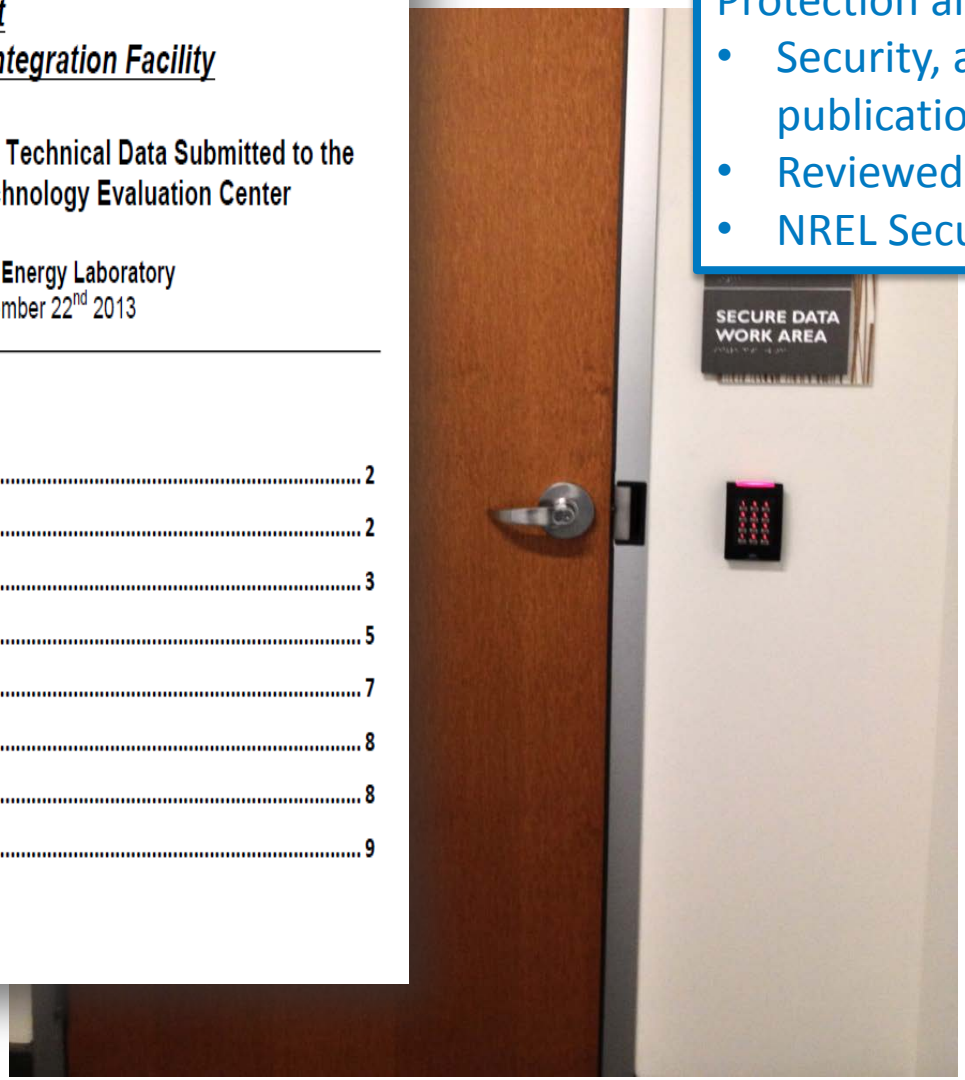
NFCTEC Security Procedures

National Fuel Cell Technology Evaluation Center
at
Energy Systems Integration Facility

Procedures to Protect Proprietary Technical Data Submitted to the NREL National Fuel Cell Technology Evaluation Center

National Renewable Energy Laboratory
Revision C, November 22nd 2013

Table of Contents



Protection and use of data

- Security, access, publications, data transfer
- Reviewed every 2 years
- NREL Security response

NFCTEC Analysis and Reporting of Real-World Operation Data

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

Internal analysis completed quarterly in NFCTEC

NREL's National Fuel Cell Technology Evaluation Center

Results

DDPs

Confidential

Public

CDPs

Detailed Data Products (DDPs)

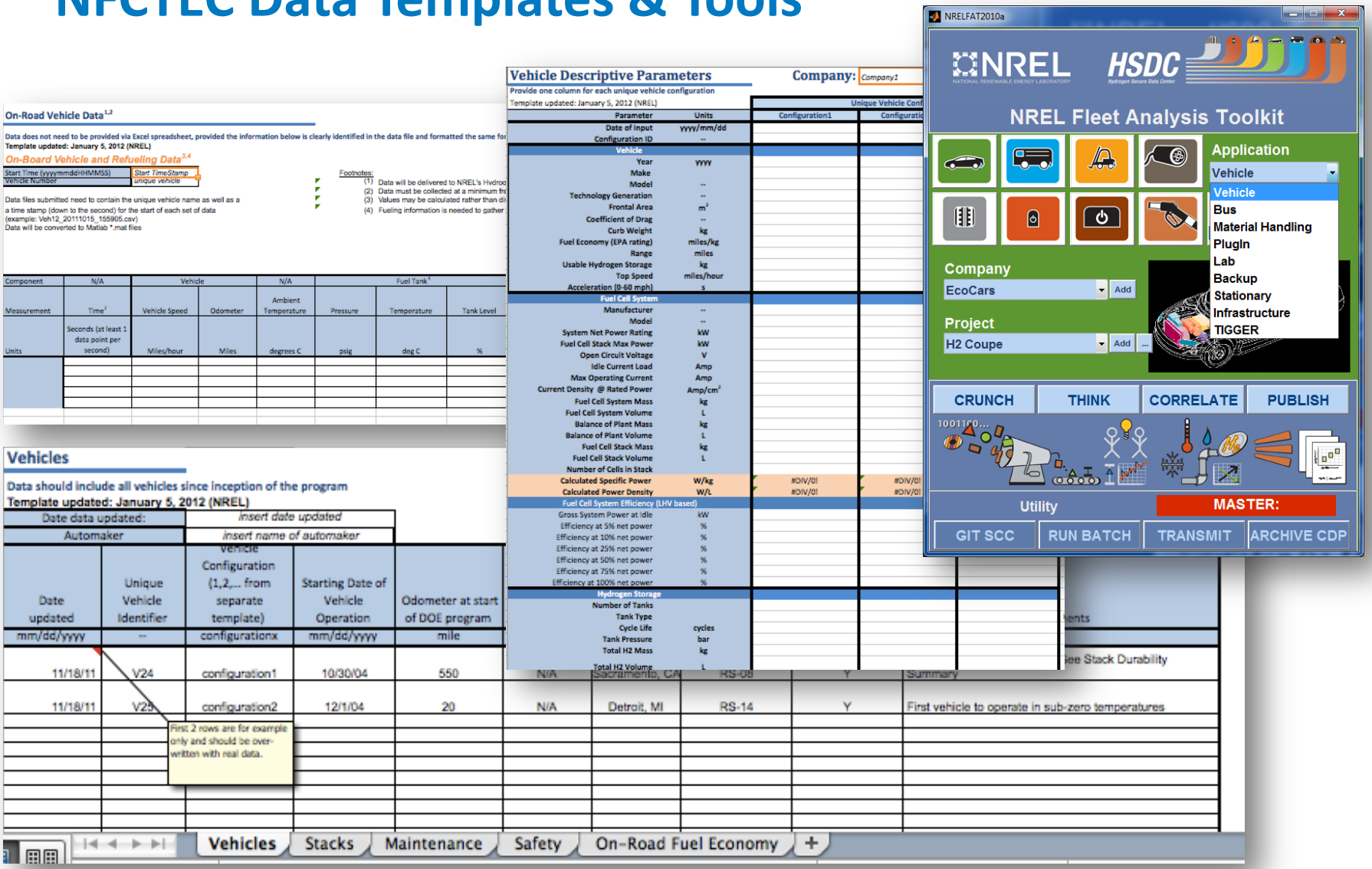
- Individual data analyses
- Identify individual contribution to CDPs
- Shared every six months only with the partner who supplied the data[1]

Composite Data Products (CDPs)

- Aggregated data across multiple systems, sites, and teams
- Publish analysis results every six months without revealing proprietary data[2]

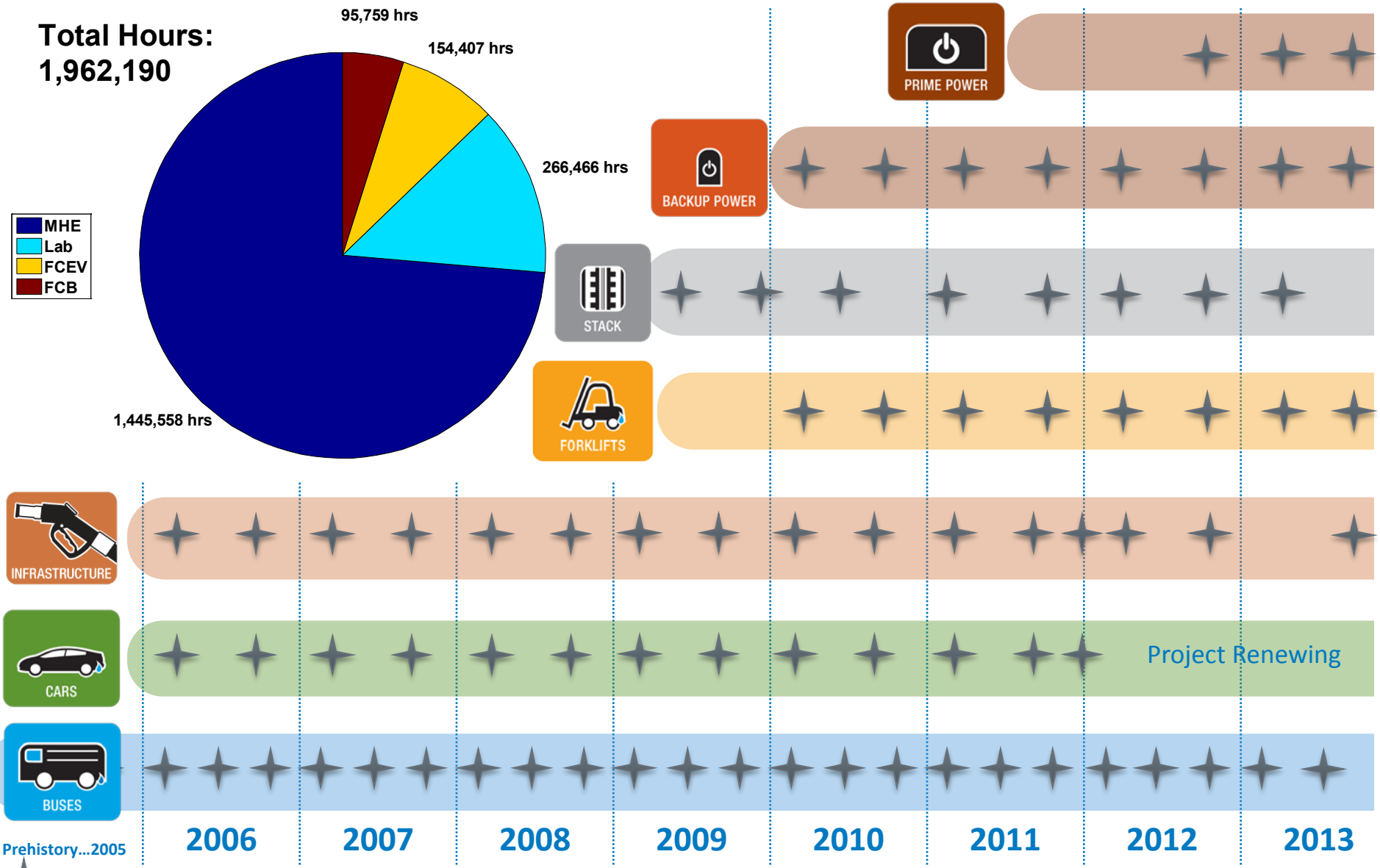
www.nrel.gov/hydrogen/proj_tech_validation.html

NFCTEC Data Templates & Tools



Examples shown for vehicle operation, maintenance, safety, and specification templates

Leveraging Data Process and Analysis Capabilities Across Technology Validation Projects



74 MHE & Infrastructure CDPs—Count and Category

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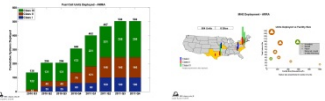
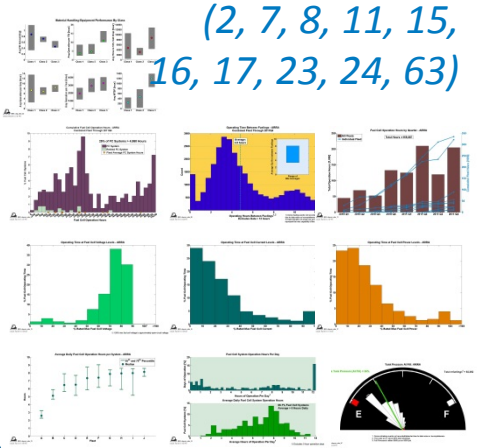
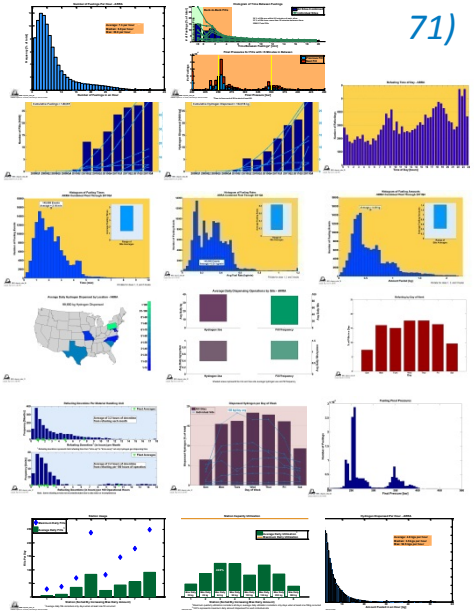
Deployment & Site Overview *(1, 40)*



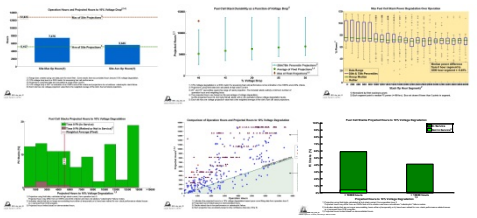
Fuel Cell Operation *(2, 7, 8, 11, 15, 16, 17, 23, 24, 63)*



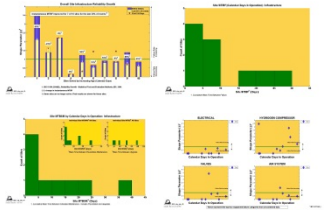
Infra. Operation *(3, 4, 5, 6, 9, 10, 21, 22, 35, 37, 42, 62, 65, 68, 69, 70, 71)*



Fuel Cell Durability *(32, 33, 34, 38, 39, 73)*

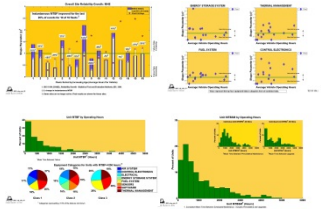


Infra. Reliability *(45, 48, 49, 50)*

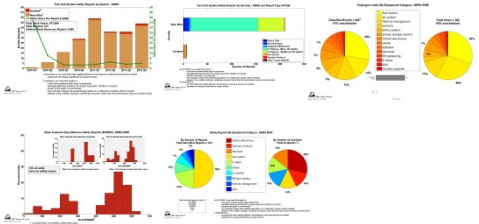


FC Maintenance *(12, 13, 14, 43, 54, 61)*

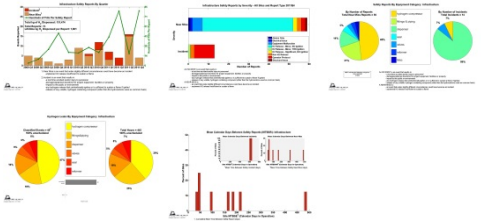
Fuel Cell Reliability *(28, 29, 30, 31)*



Fuel Cell Safety *(26, 27, 53, 56, 57)*



Infra. Safety *(25, 41, 46, 51, 55)*



Infra. Maintenance *(18, 19, 20, 44, 47, 52, 66, 67, 72,76,77)*

Cost of Ownership *(58, 59, 60,64)*

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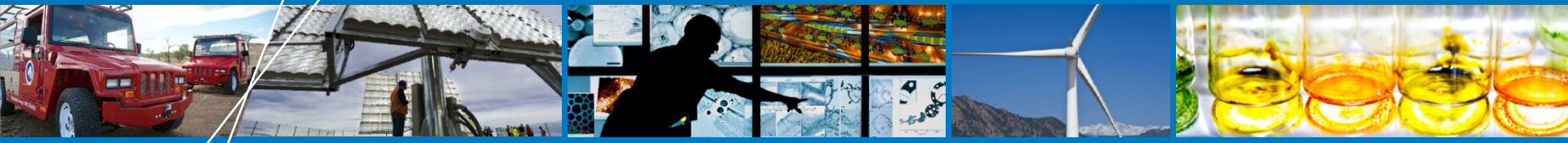
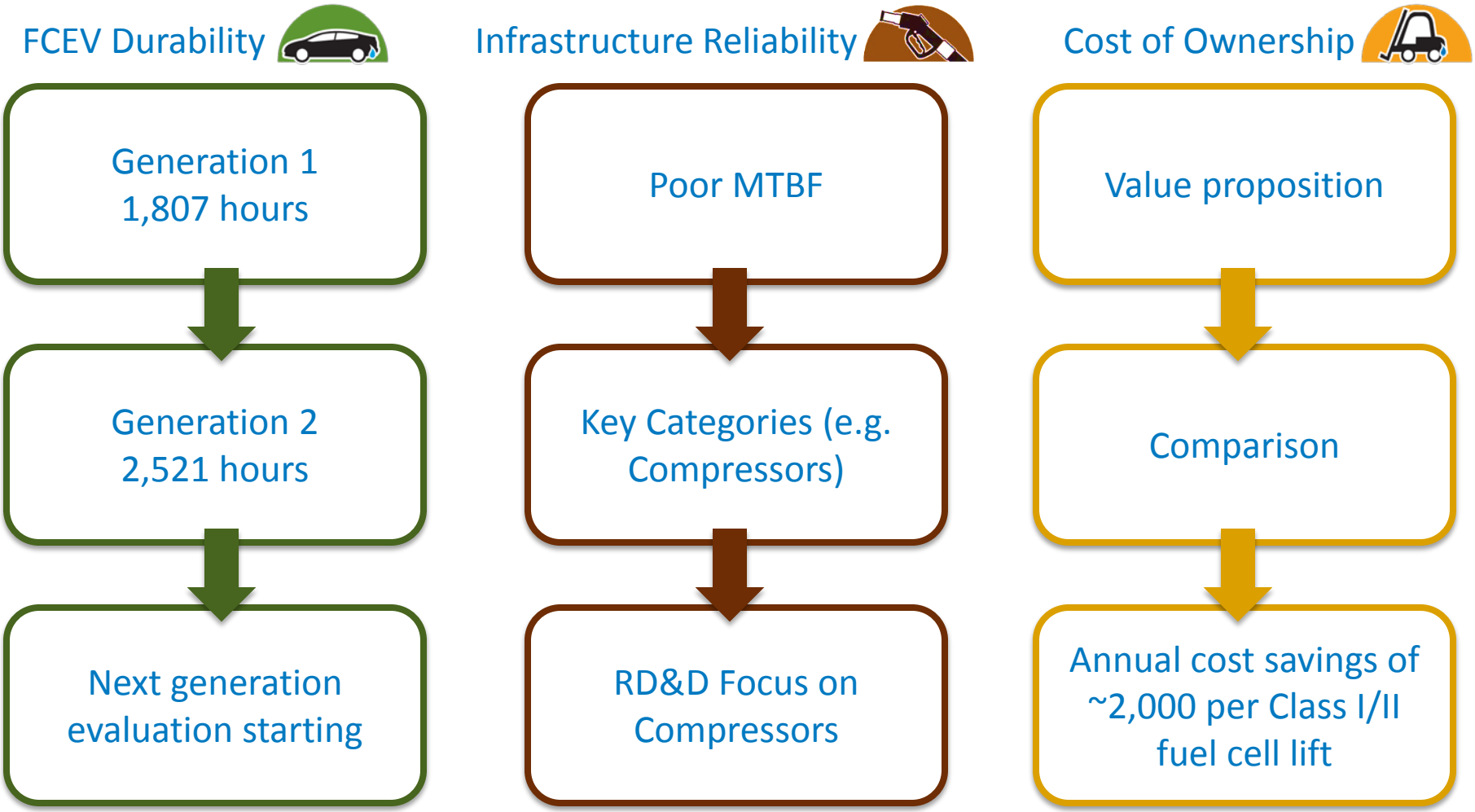


Benefits to the Hydrogen & Fuel Cell Community

NFCTEC Real World Operation Analyses



Results published via NREL technology validation website (***www.nrel.gov/hydrogen/proj_tech_validation.html***)

Tracking Future Progress Against Previous Demonstration Results for FCEV Evaluation

CARS

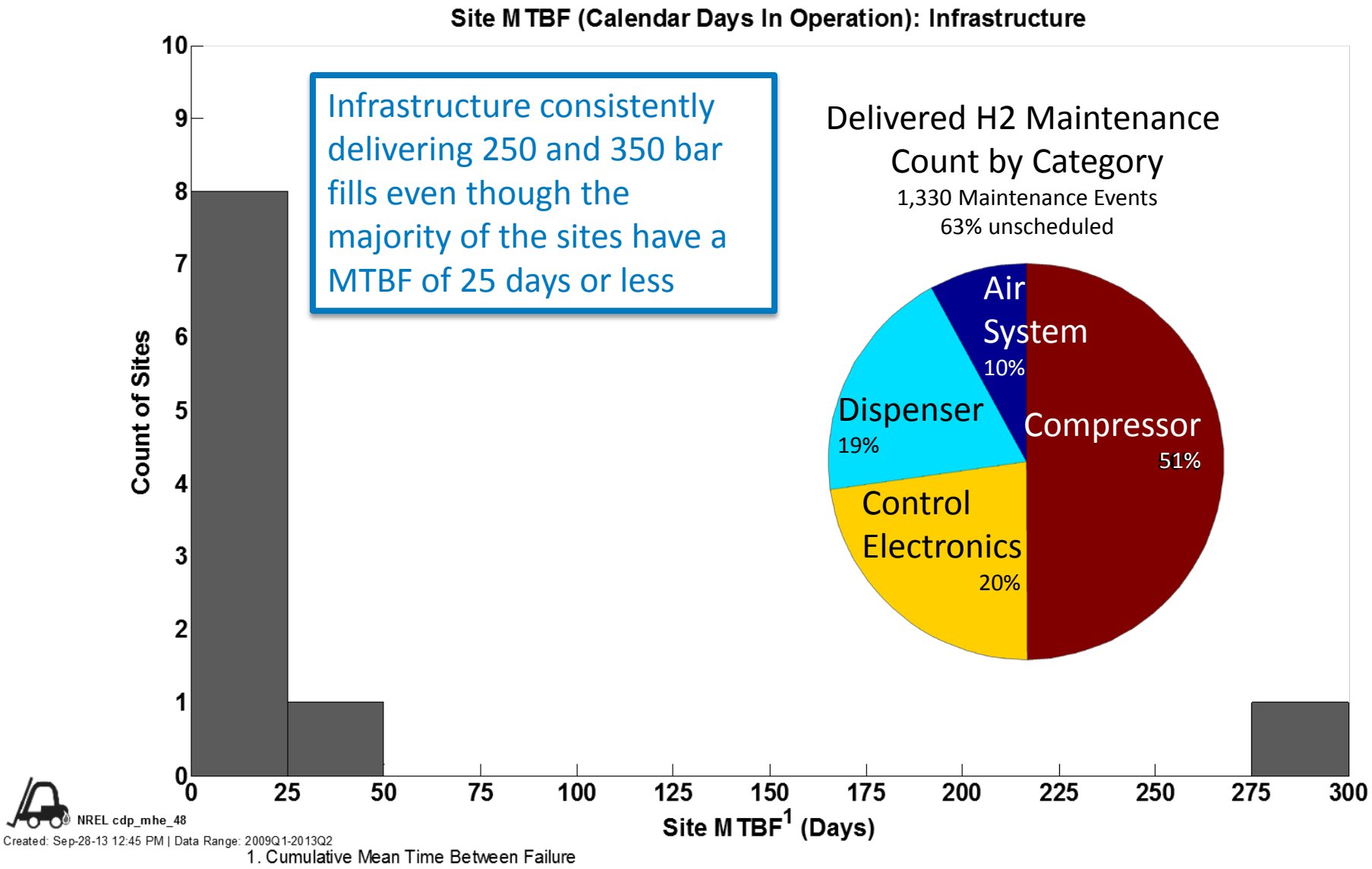
Vehicle Performance Metrics	Gen 1 Vehicle	Gen 2 Vehicle	2009 Target	After 2009Q4
Fuel Cell Stack Durability			**2,000 hours**	
Max Team Projected Hours to 10% Voltage Degradation	**1,807 hours**	**2,521 hours**		--
Average Fuel Cell Durability Projection	821 hours	1,062 hours		1,748 hours
Max Hours of Operation by a Single FC Stack to Date	2,375 hours	1,261 hours		1,582 hours
Driving Range			**250 miles**	
Adjusted Dyno (Window Sticker) Range	**103-190 miles**	**196-254 miles**		--
Median On-Road Distance Between Fuelings	56 miles	81 miles		98 miles
Fuel Economy (Window Sticker)	42 – 57 mi/kg	43 – 58 mi/kg	no target	--
Fuel Cell Efficiency at ¼ Power	51% – 58%	53% – 59%	60%	--
Fuel Cell Efficiency at Full Power	30% – 54%	42% – 53%	50%	--

Infrastructure Performance Metrics			2009 Target	After 2009Q4
H_2 Cost at Station (early market)	On-Site Natural Gas Reformation **$7.70 – $10.30/kg**	On-Site Electrolysis **$10.00 – $12.90/kg**	**$3/gge**	--
Average H_2 Fueling Rate	0.77 kg/min		1.0 kg/min	0.65 kg/min

Outside of this project, DOE independent panels concluded at 500 replicate stations/year:
Distributed natural gas reformation at 1,500 kg/day: **$2.75-$3.50/kg** (2006)
Distributed electrolysis at 1,500kg/day: **$4.90-$5.70** (2009)

Outside review panel

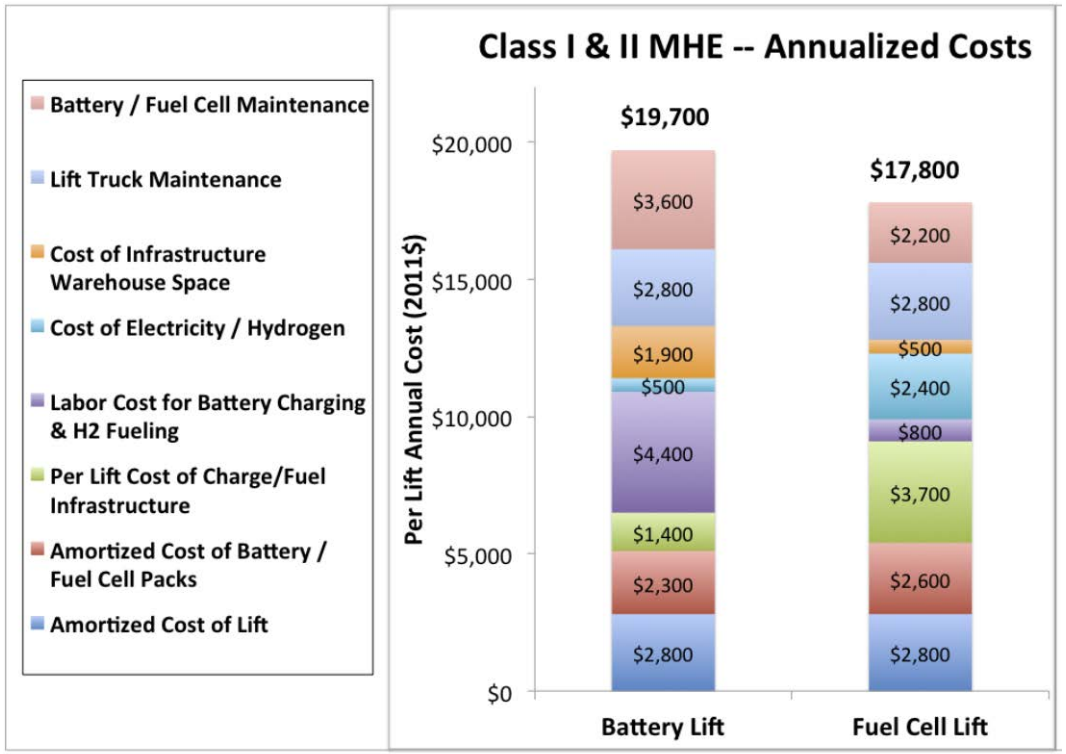
Infrastructure Reliability Analysis Supports Additional R&D Projects (e.g. Compressors, Hoses)



MHE Cost of Ownership Comparison with Incumbent Technology

FORKLIFTS

Cost advantage per unit is ~$2,000/year for the average high-use facility with Class I and II fuel cell lift trucks analyzed by NREL.



Key Findings

- Cost advantages dependent on deployment size and use (i.e., multi-shift operation per day)
- H_2 fuel cell cost advantages in maintenance, warehouse infrastructure space, and refueling labor cost
- H_2 fuel cell cost disadvantages in infrastructure and fuel cell cost and hydrogen cost

Report Sections

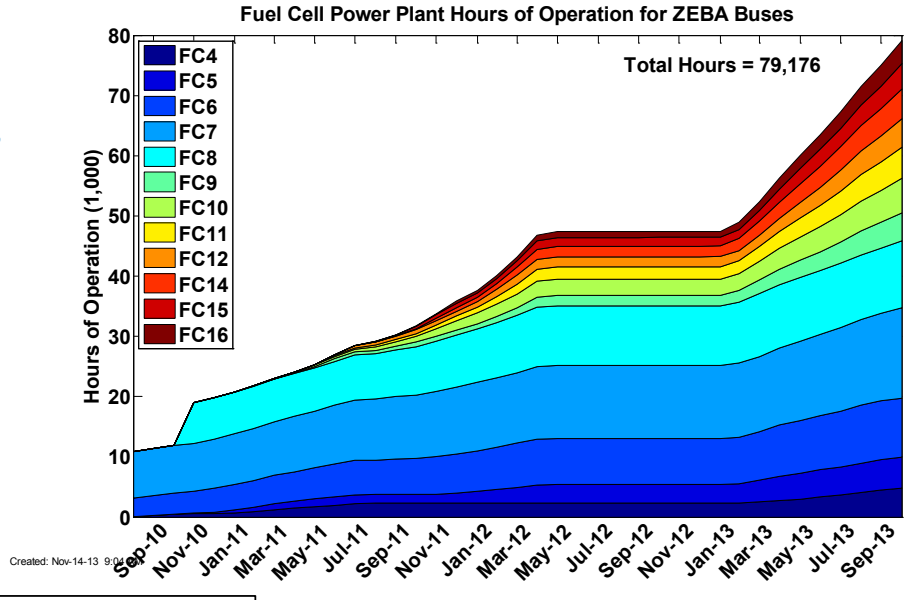
- Inputs, assumptions, and results for Class I/II and Class III
- Sensitivity study
- Intensive deployment scenario

Fuel Cell Bus Evaluation is an International Effort with Many Different Stakeholders

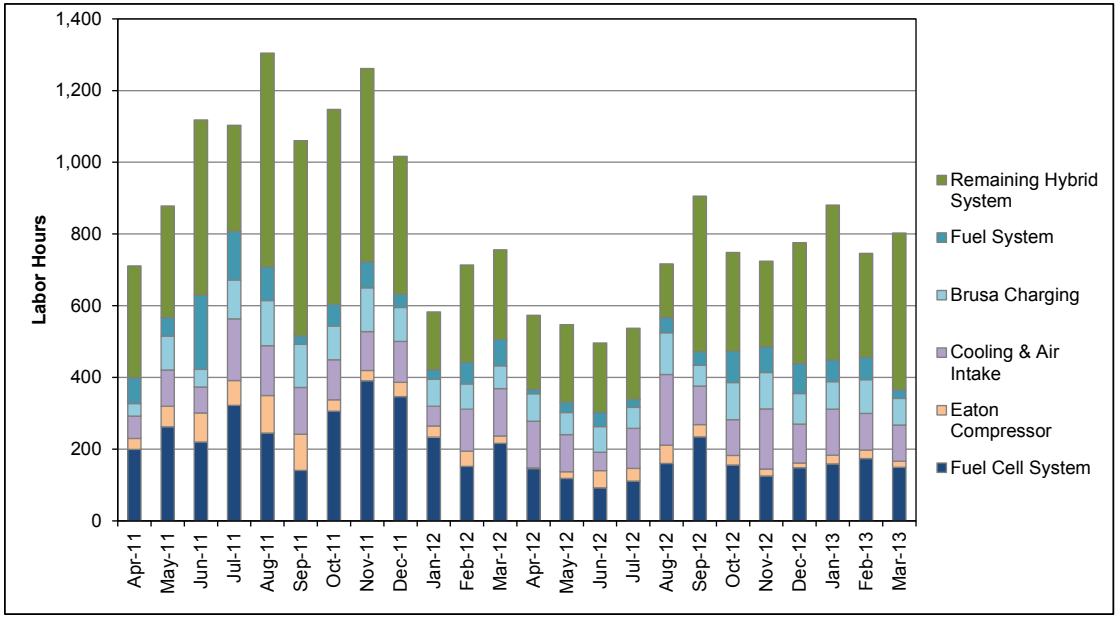
BUSES

ZEBA Fleet Fuel Cell Hours

Leader at 16,216 hours
2nd at 11,908 hours

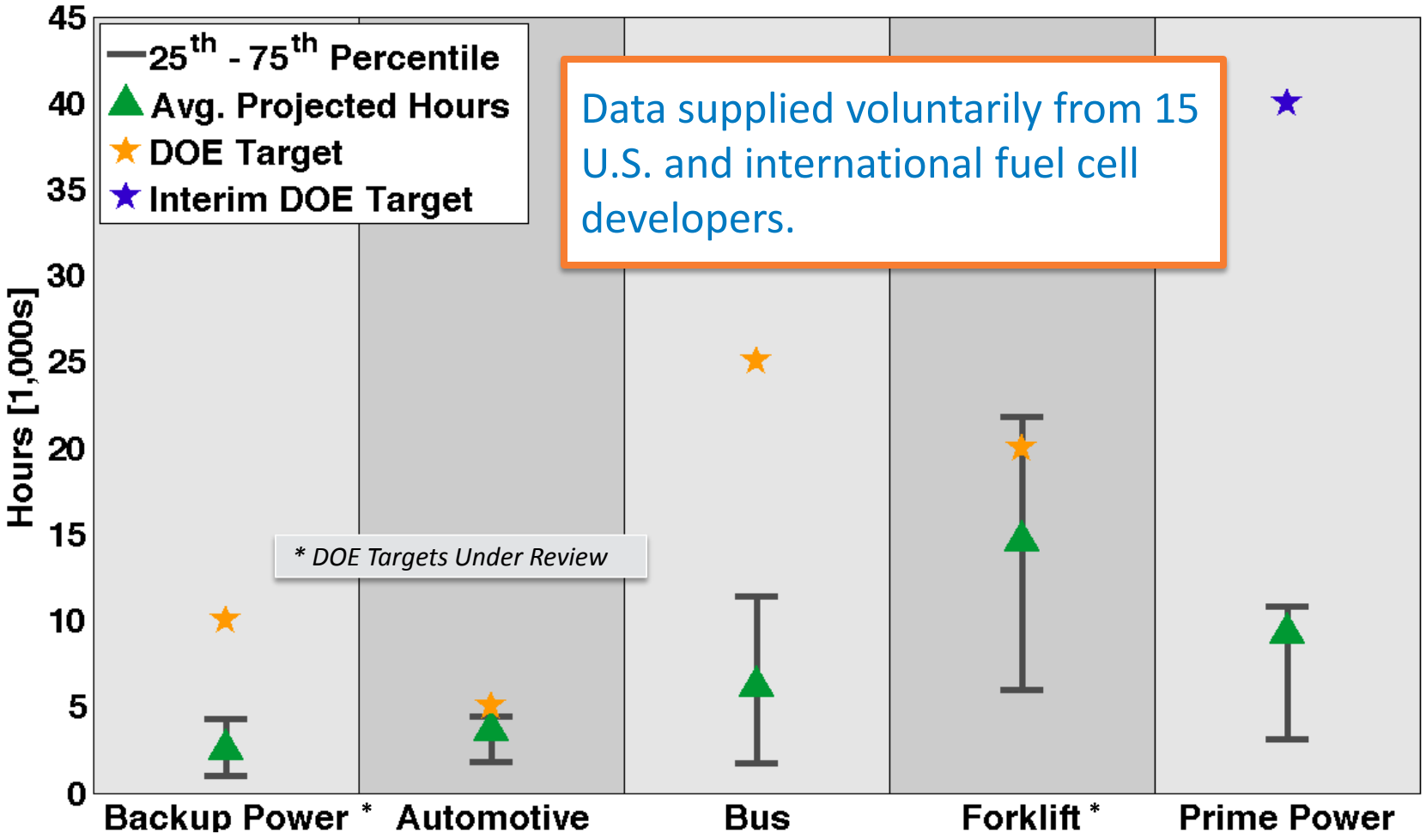


BC Transit propulsion- related labor hours by category



Partners: National Fuel Cell Bus Program, DOE, DOT FTA, California ARB, Public Transit Agencies, Developers & Integrators

Lab Data - Fuel Cell Technology Status



Data supplied voluntarily from 15 U.S. and international fuel cell developers.

Analysis – hours to 10% voltage degradation

Fuel Cell Material Handling Evaluation

FORKLIFTS

Validation of MHE is based on real-world operation data from high-use facilities

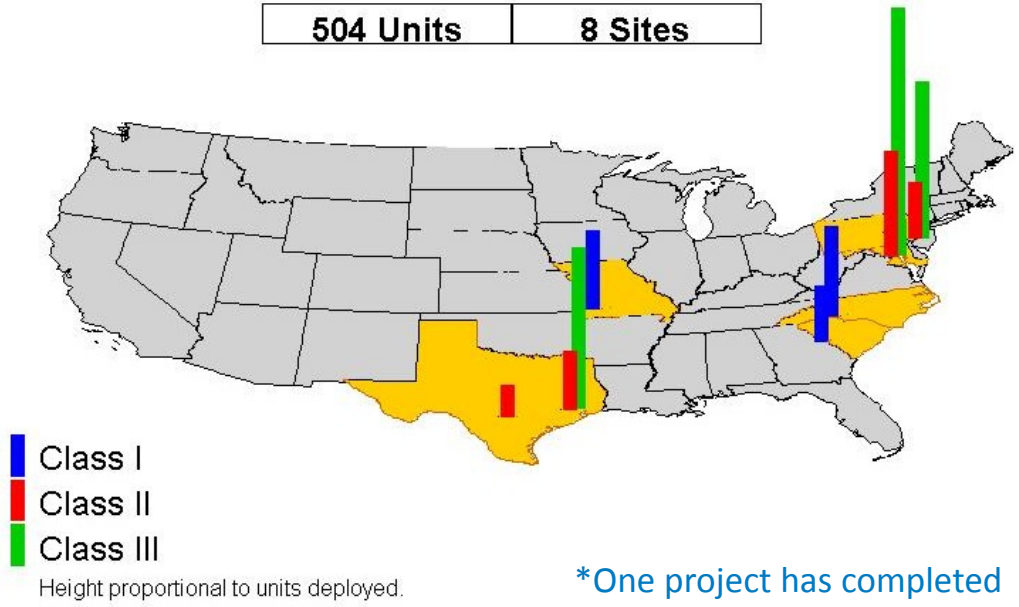
1,859,616
Operation hours

291,114
Hydrogen fills

490
Units in operation*

4.4
Average operation hours between fills

232,551
Hydrogen dispensed in kg



0.6
Average fill amount in kg

2.3
Average fill time in minutes

*One project has completed

Fuel Cell Backup Power Evaluation

BACKUP POWER

1.94
Installed capacity in MW

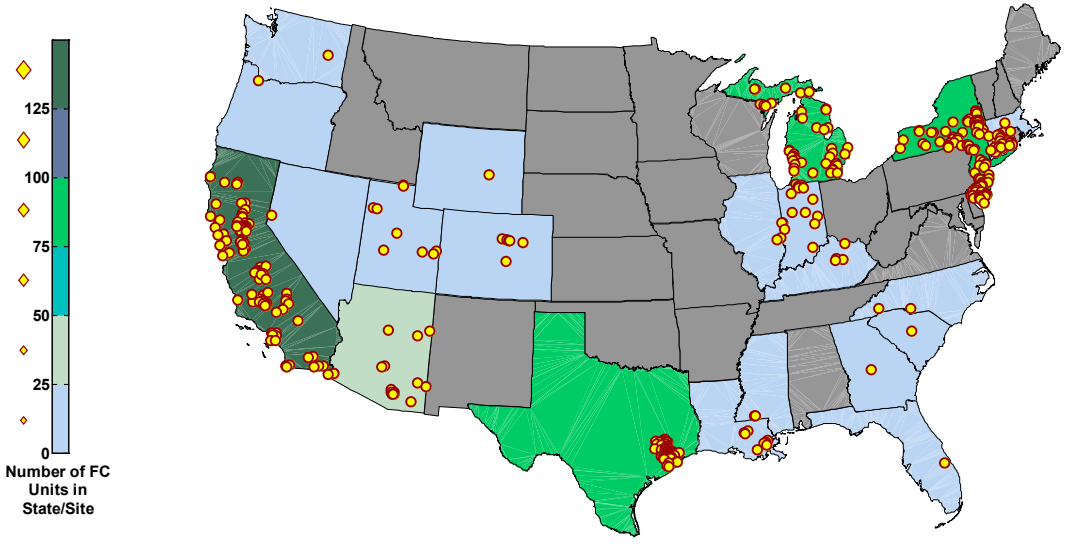
Systems are operating reliably in 23 states. Reasons for unsuccessful starts include an e-stop signal, no fuel, and other system failures.

99.7%
Successful starts

842
Systems in operation*

4–6
Average site capacity in kW

2,579
Start attempts



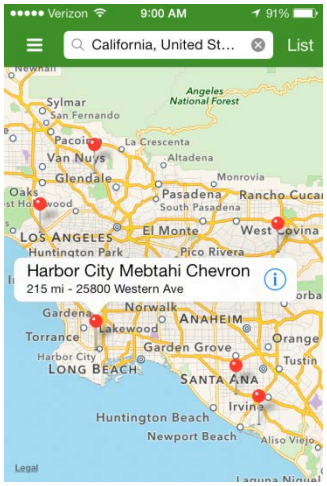
65
Continuous run hours demonstrated

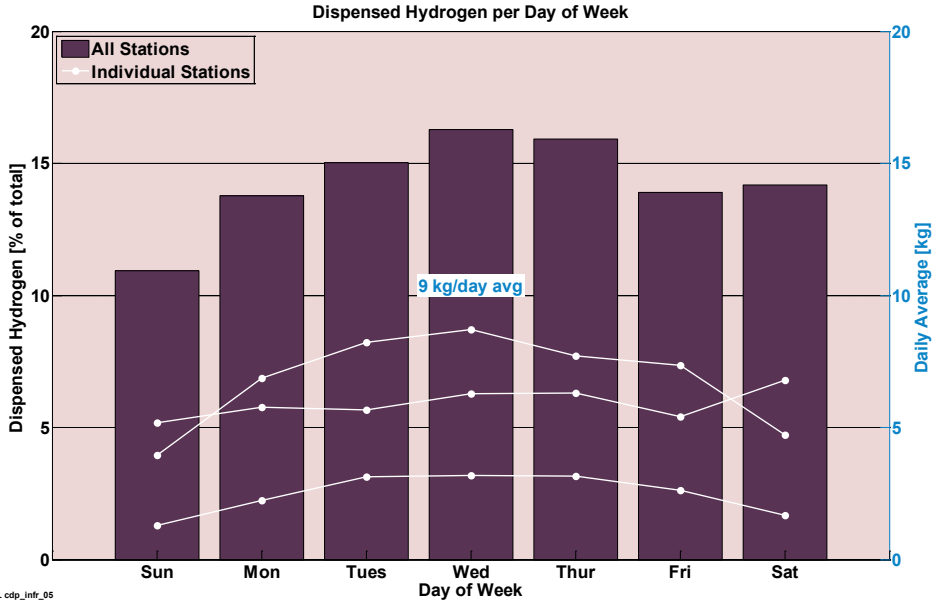
1,683
Operation hours

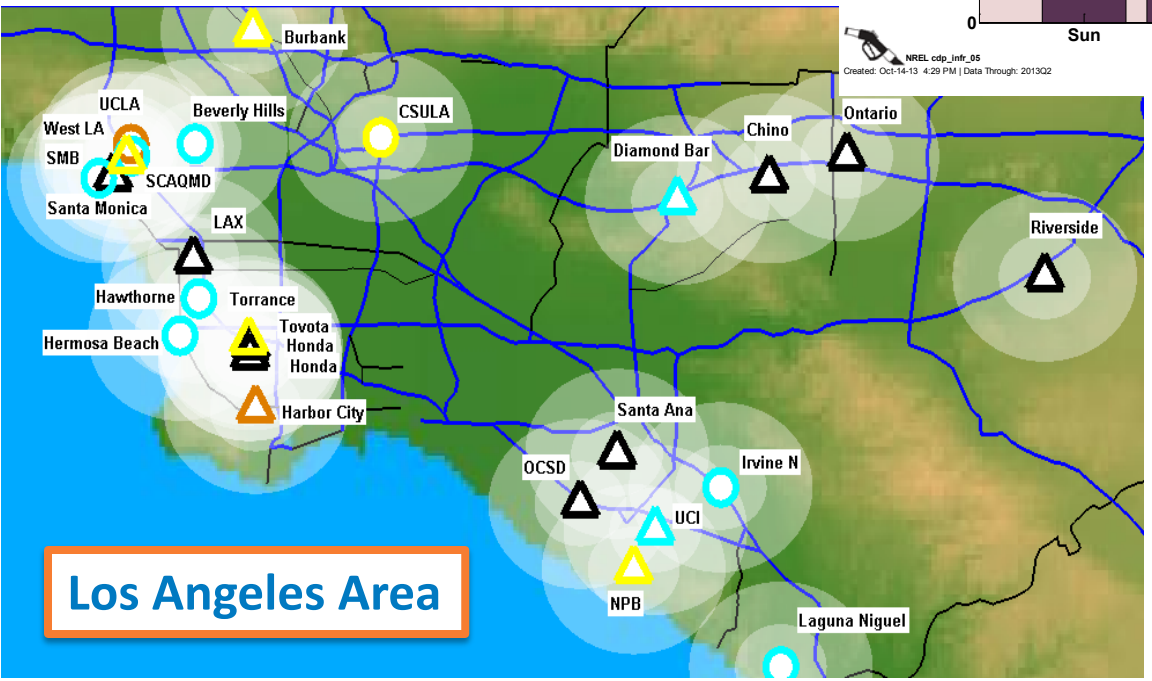
*Not all systems have detailed data reporting to NREL

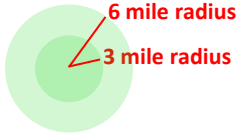
H_2 Infrastructure Evaluation

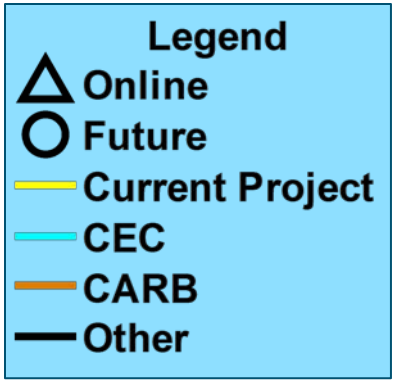
Hydrogen Station Location Data Available through AFDC Mobile App (iPhone)











Data Supports DOE Updates/Records/Status

Examples:

Early Market Fuel Cells for Material Handling Fact Sheet

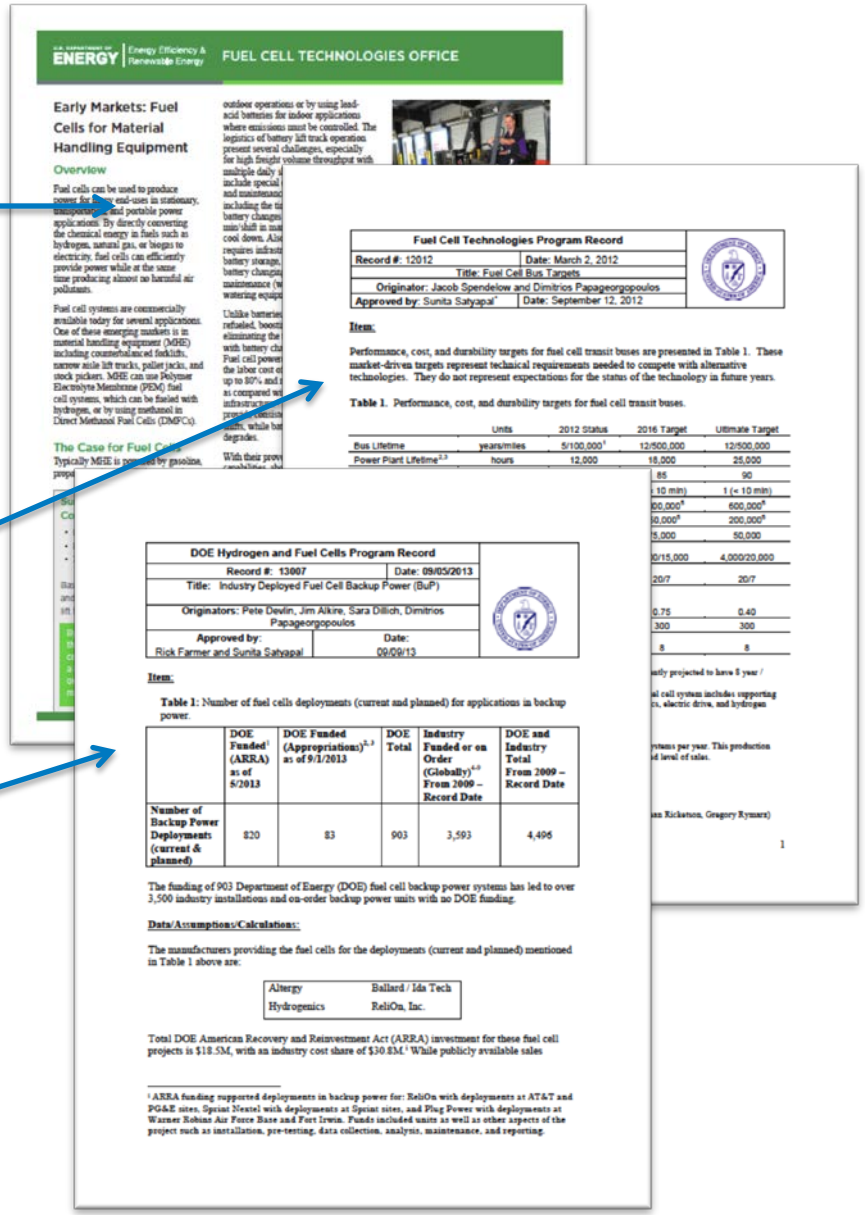
http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/early_markets_mhe_fact_sheet.pdf

Fuel Cell Bus Targets Record

http://hydrogen.energy.gov/pdfs/12012_fuel_cell_bus_targets.pdf

Fuel Cell Backup Power Deployments Record

http://hydrogen.energy.gov/pdfs/13007_industry_bup_deployments.pdf



Examples of Peer Review Feedback

"Other areas of strength include industry's confidence and trust in NREL's team and approach to the project, and the continuous improvement and enhancement of project products, particularly CDPs and DDPs…"

"This is a good national approach to fuel cell analysis. There are early warnings of commercial problems, such as compressors…"

The ability to leverage the capabilities established by NREL for its implementation of other technology validation projects is a strength of this project..."

"NREL is uniquely set up to compare data sets from a variety of fuel cell developers for a range of applications. Without this project, such comparative analysis would not be available."

"This is a great way to put all the data together and get information back to the industry and potential customers."

"This project is essential to benchmarking the progress of fuel cell systems over time and across industries."

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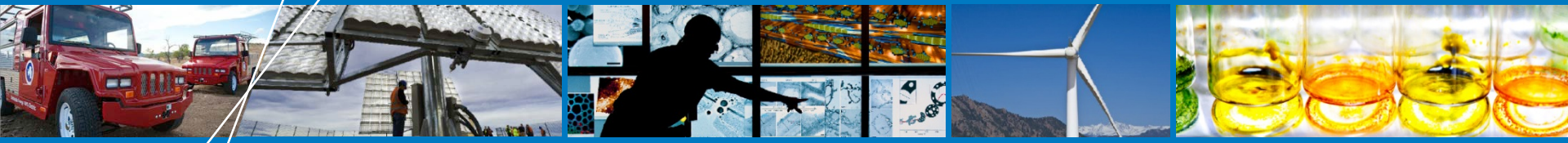
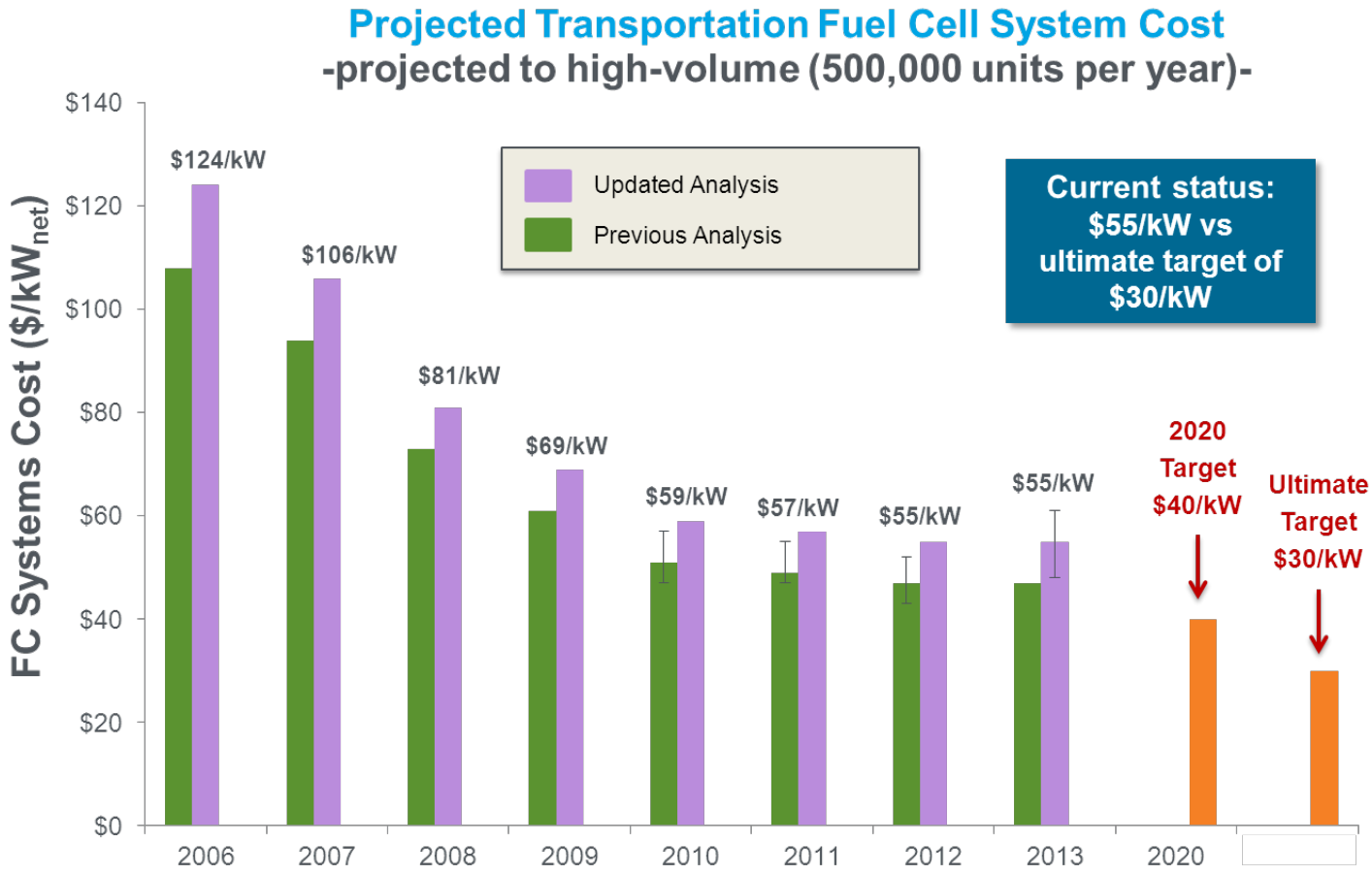


Fuel Cell Cost & Price Aggregation Project

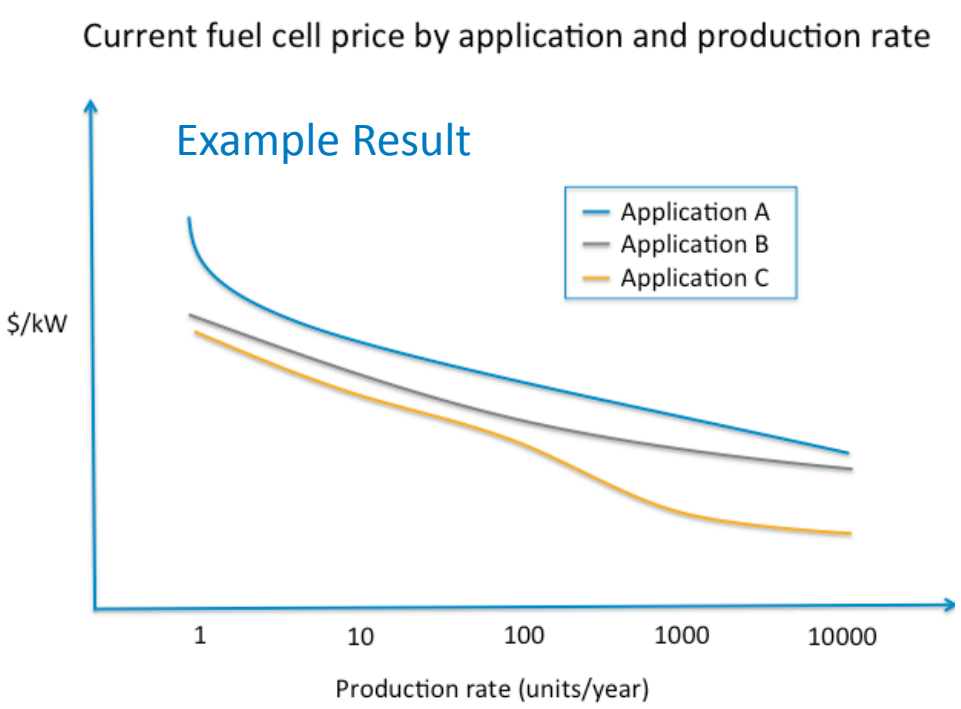
DOE Fuel Cell System Cost Based on Models for High Volume

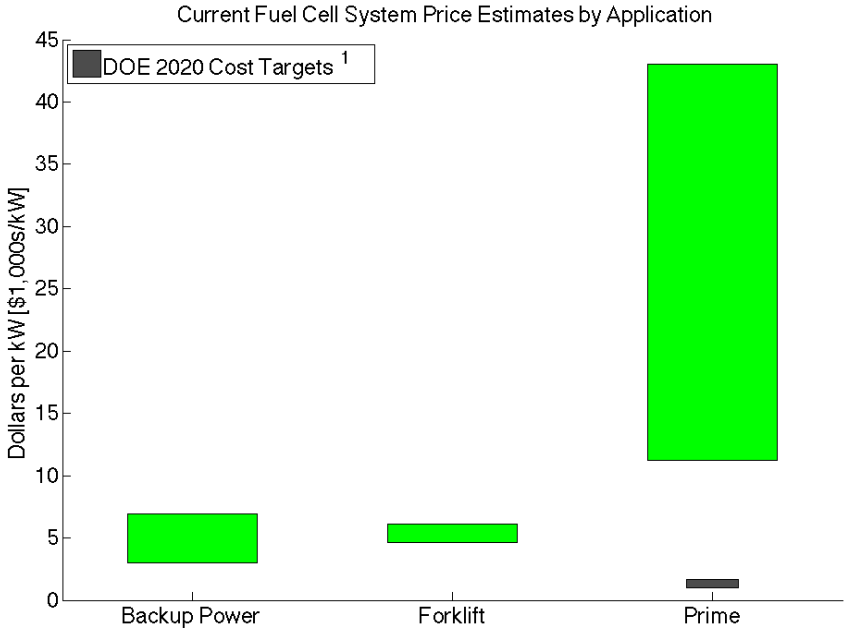


Record Source: http://www.hydrogen.energy.gov/pdfs/13012_fuel_cell_system_cost_2013.pdf

Fuel Cell Technology Status – Cost/Price

The U.S. Department of Energy's National Renewable Energy Laboratory is seeking fuel cell industry partners from the United States and abroad to participate in an objective and credible analysis of commercially available fuel cell product cost/price to benchmark the current state of the technology and support industry growth.





Cost/Price Data Template

	A	B	C	D
7	System	ProductName1	ProductName2	ProductName32
8	Current Price (US $)			
9	Availability			
10	Market			
11	Application			
12	Fuel Cell Type	PEMFC	PEMFC	
13	Fuel			
14	Comments			
15	Power Rating (kW)			
16	Other features			
17	# systems sold to date			
18	2010 Price (US $)			
19	2011 Price (US $)			
20	2012 Price (US $)			
21	Current system cost (US $)			
22	Current fuel cell stack cost (US $)			
23	Cell count			
24	Active area			
25	Turndown capability			
26	Spec sheet link or Product brochure PDF attached			

Benefits of Cost/Price Analysis

External

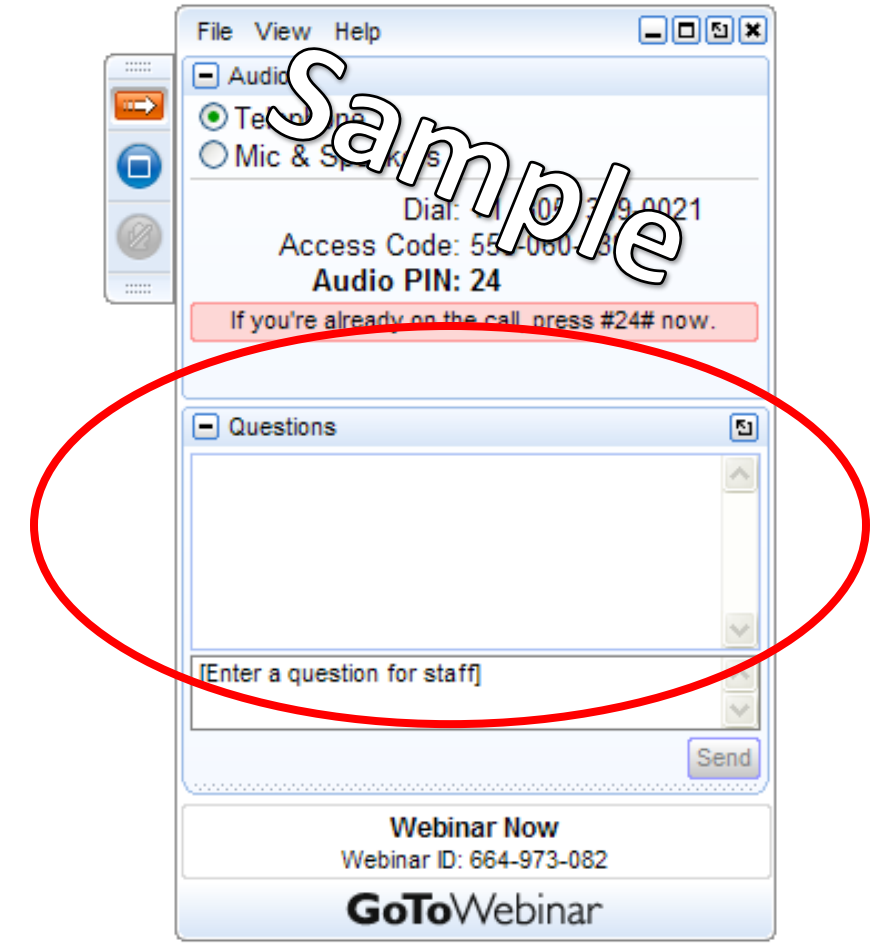
- Provide current cost status of fuel cell products that fill the gap with high volume cost numbers
- Help set realistic price expectations at small volume production
- One source of realistic cost/price status for DOE from the leading fuel cell developers
- Highlights technology successes
- Helps adoption of fuel cell technology

Internal

- Provide independent, credible and consistent product cost/price information that is very useful for external partners (e.g. DOE and industry) without revealing proprietary information
- Benchmarking against CDPs
- Collaboration with NREL's technology validation team; dedicated analysis team with experience in multiple fuel cell applications

Question and Answer

- Please type your question into the question box

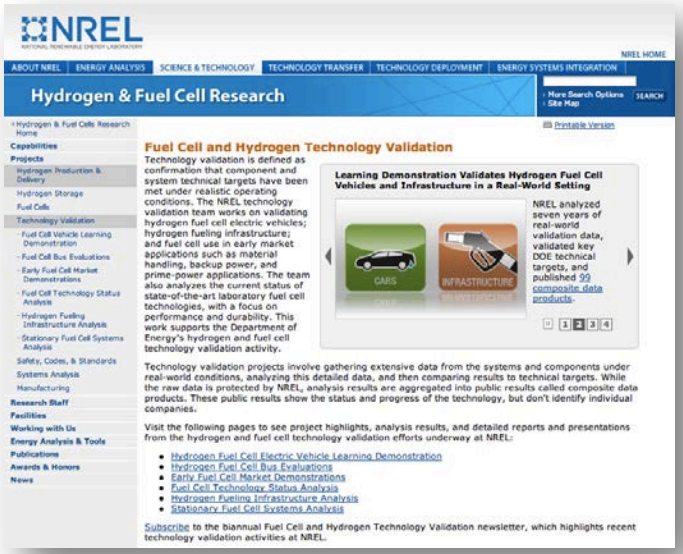


hydrogenandfuelcells.energy.gov

NFCTEC Contacts

Website

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



Email

techval@nrel.gov

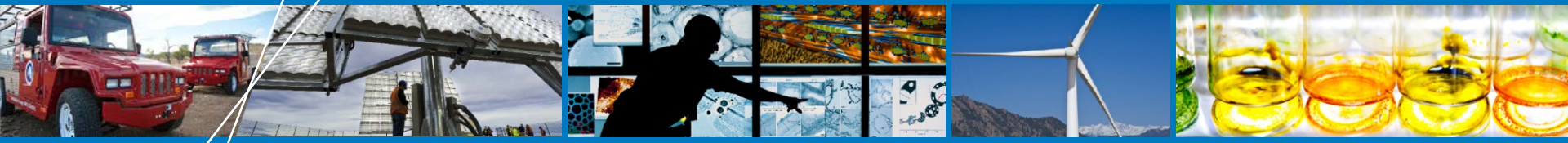
jennifer.kurtz @nrel.gov

Thank You

James.Alkire@go.doe.gov

hydrogenandfuelcells.energy.gov

NREL
NATIONAL RENEWABLE ENERGY LABORATORY



Backup

NFCTEC Partners

AC Transit	FedEx	Proterra
Auto OEMs	GENCO	Proton OnSite
Ballard Power Systems	Golden Gate Transit	ReliOn Inc.
Bluways	GTI	San Francisco Metropolitan Transit Agency
CaFCP	H2 Frontier	San Mateo Transit Authority
California Stationary Fuel Cell Collaborative (CaSFCC)	H2Pump	Santa Clara Valley Transportation Authority
CARB/Shell	H2USA	SCAQMD
CEC	Hydrogenics	Sprint Communications
CHBC	Linde	SunLine Transit Agency
City of Burbank	National Fuel Cell Research Center (NFCRC)	Sysco of Houston
ClearEdge Power	Nuvera Fuel Cells	US Hybrid
CSULA	PDC Machines	
FCHEA	Plug Power	