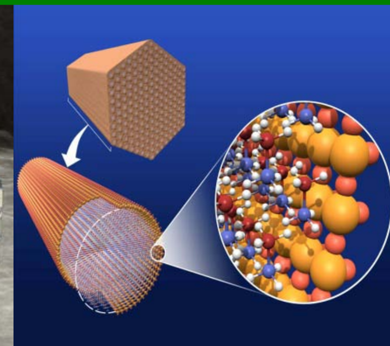
U.S. DEPARTMENT OF ENERGY



Crosscutting and Validation

(Manufacturing R&D; Technology Validation; Safety, Codes & Standards; Education)

Rick Farmer

2012 Annual Merit Review and Peer Evaluation Meeting

May 14, 2012

Goal and Objectives

U.S. DEPARTMENT OF ENERGY

Enable widespread commercialization of hydrogen and fuel cell technologies through manufacturing cost reductions, technology validation, codes and standards development, and education of key stakeholders

Manufacturing

- 2013 - Reduce the manufacturing cost of membrane electrode assemblies by 25% relative to 2008
- 2017 - Develop fabrication and assembly processes for PEM fuel cells that cost $30/kW

Technology Validation

- 2014 - Validate stationary fuel cell systems that co-produce hydrogen and electricity at 40% efficiency and 40,000 hour durability
- 2019 - Validate fuel cell vehicles achieving 5,000 hour durability and 300 mile driving range

Safety, Codes and Standards

- 2015 – Conduct a quantitative risk assessment to address indoor refueling requirements to be adopted by code development organizations
- 2017 - Complete material testing to develop ASME/ASTM hydrogen materials qualification guidelines, including composites

Education and Outreach

- 2012 - Develop an analysis tool to estimate economic impacts of early market fuel cells
- Expand case studies of near-term market applications

Challenges

U.S. DEPARTMENT OF ENERGY

Manufacturing

- Manufacturing processes to produce high volume MEAs, bipolar plates, and balance of plant fuel cell components
- Carbon fiber fabrication techniques for conformable tanks

Technology Validation

- Sufficient data on fuel cell electric vehicle performance and durability data
- Adequate data on refueling infrastructure performance and availability data

Safety, Codes and Standards

- Insufficient data to provide the scientific basis for technically sound codes and standards
- Harmonizing domestic and international regulations, codes and standards

Education and Outreach

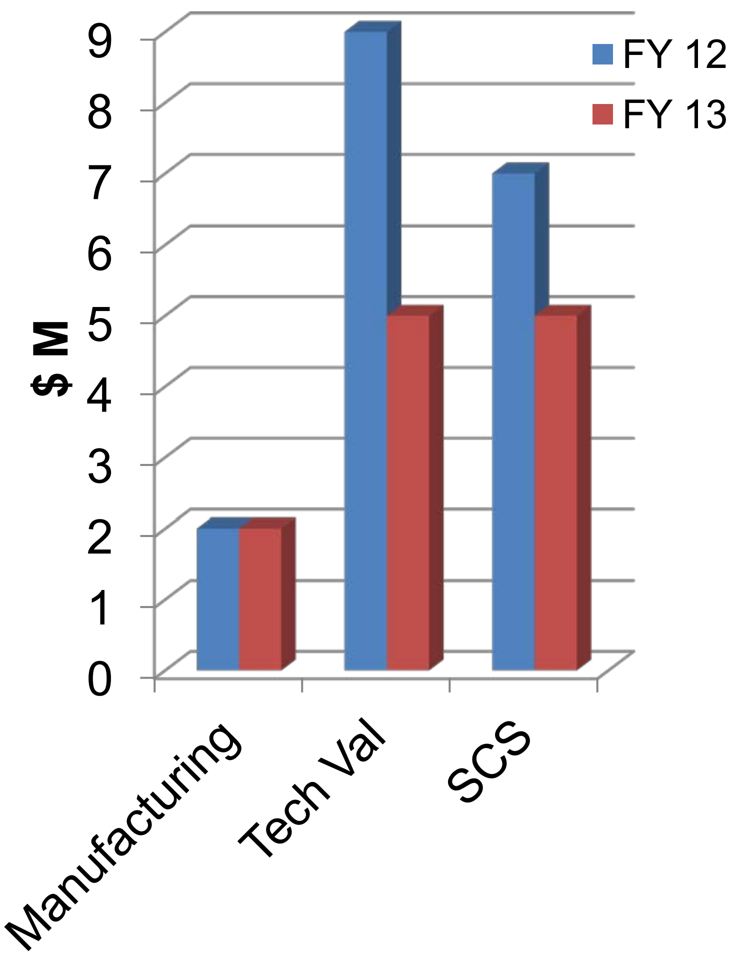
- Resistance to change
- Lack of educated trainers and training opportunities

Crosscutting and Validation Budgets

U.S. DEPARTMENT OF ENERGY

FY 2013 Request - $12.0 M

FY 2012 Appropriation - $18.0 M



EMPHASIS

Manufacturing

- Develop real-time, online measurement tools
- Demonstrate innovative precision fiber placement and filament winding for high-pressure carbon composite tanks
- Collaborate with Advanced Manufacturing Office

Technology Validation

- Data collection and analysis of fuel cells used in vehicles, fork lifts, backup power, buses, and CHHP
- Demonstration and evaluation of advanced fueling components

Safety Codes and Standards

- Develop technical information and performance data to enhance codes and standards
- Facilitate the permitting of hydrogen fueling stations and early market applications

Manufacturing Progress

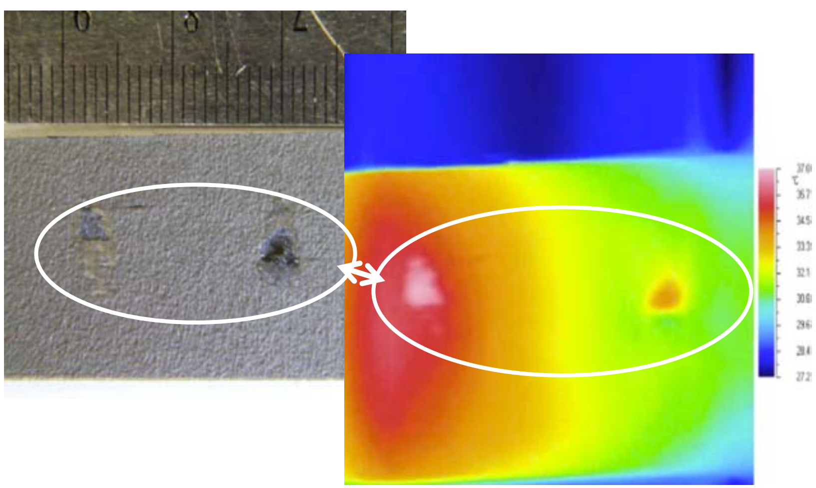
Achieved areal image of catalyst layer uniformity; technique has been scaled up for in-line testing. Sensitivity and detection time characterized for IR/RFT technique.

- Scaled up in-line diagnostics for MEA component quality control to 10 and 30 feet/min
- Detected all defects
- Integrating modeling to support diagnostic development and implementation

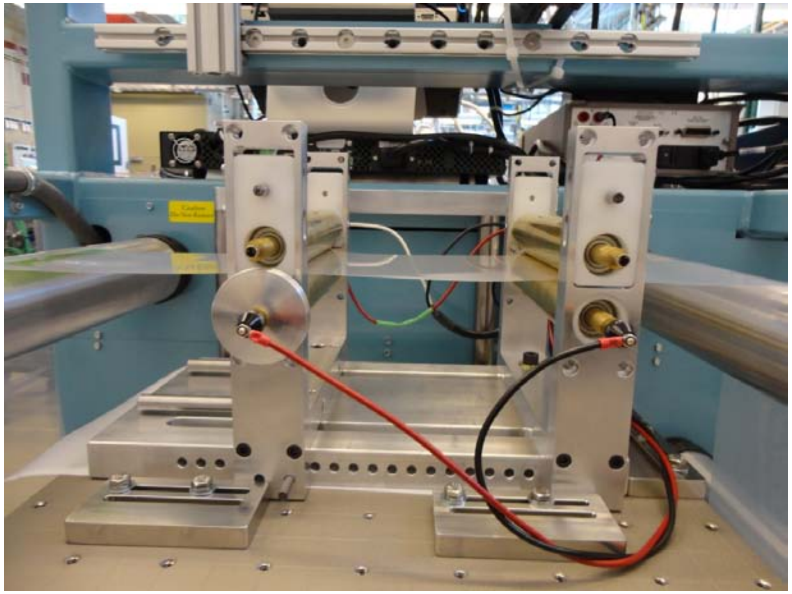
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

BERKELEY LAB

2011 - IR/Direct Current



2012 - IR/Direct Current



Manufacturing Progress

U.S. DEPARTMENT OF ENERGY

Ultrasonic sealing of MEAs provides rapid bonding and the potential for cost savings of >90% compared to thermal sealing.

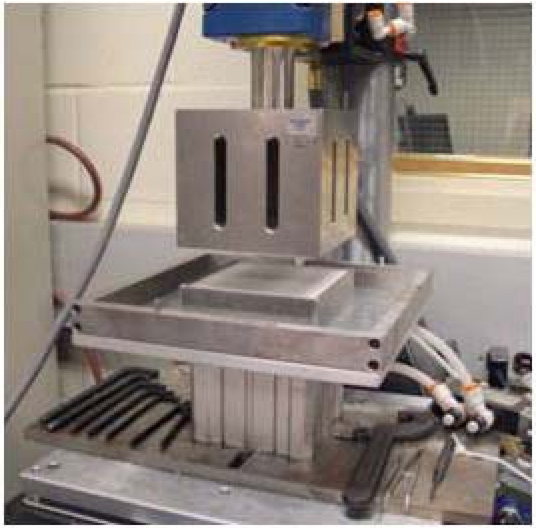
Ultrasonic sealing of membrane electrode assemblies indicates that

- 90% cost reduction may be possible compared to thermal sealing
- U/S sealing (electrodes to membrane) is a very robust process
- U/S welding (subgasket to electrode) will enjoy similar cost savings

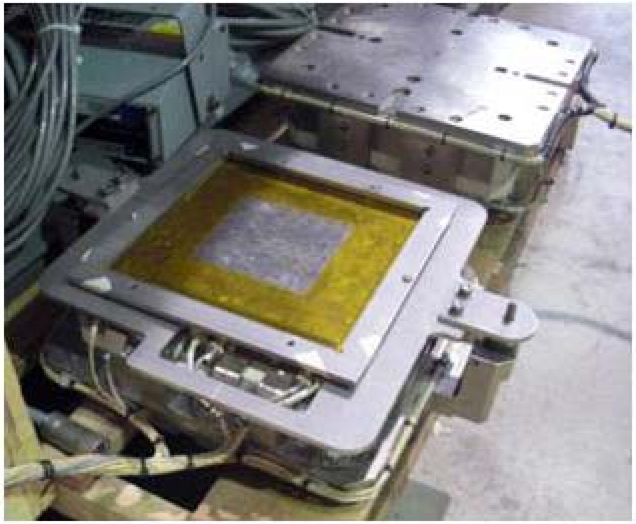
Lab data show the potential for

- 96% energy and 93% cycle time reductions with 50 cm^2 high-temperature MEAs
- 98% energy and 94% cycle time reductions with 10 cm^2 low-temperature MEAs

RENSSELAER POLYTECHNIC INSTITUTE • 1824 •

(a)


Ultrasonic tooling

(b)


Thermal Press Tooling

DOE Input to DPAC: PEMFC Manufacturing

U.S. DEPARTMENT OF ENERGY

On April 13th, 2012, the Fuel Cell Study Group of the Defense Production Act Committee (DPAC) released a request for information.

Defense Production Act Committee/Title III

Three topic areas:

- Fuel Cell Balance-of-Plant: Standardization, Improved Manufacturing, and Improved Design/Performance
- Stack and Stack Components: Standardization and Improved Manufacturing.
- Acquisition and Deployment of Tactical Fuel Cell Systems

Responses were due May 14, 2012

- Late information may be considered by the government reviewers.

RFP may be issued

- Based on responses to the DPAC Fuel Cell RFI, RFP may be issued
- DPAC plans $5 million for this RFP—looks for match from civilian agencies or other DOD entities.

(https://www.fbo.gov/index?s=opportunity&mode=form&id=c0edaf3ff2f5eecc35309ad0f016ad33&tab=core&_cview=0)

Technology Validation Progress

U.S. DEPARTMENT OF ENERGY

Completed the Learning Demonstration, which has provided valuable real-world data from fuel cell electric vehicles and hydrogen infrastructure

Data have been collected from183 fuel cell electric vehicles and 25 hydrogen fueling stations during the Learning Demonstration

- 3.6 million miles traveled
- Over 154,000 total vehicle hours driven
- 152,000 kg of hydrogen produced or dispensed *(including hydrogen used by vehicles not in the Learning Demonstration)*
- Fuel cell efficiency 53 – 59%
- Range 196 – 254 miles
  - separately validated one vehicle with >430-mile range
- Fuel cell durability
  - 2,521 hours projected (~75K miles)
- 5-minute refueling time (for 4 kg of hydrogen)
- H_2 cost* (onsite reformation): $7.70 – $10.30
- H_2 cost* (onsite electrolysis): $10.00 – $12.90

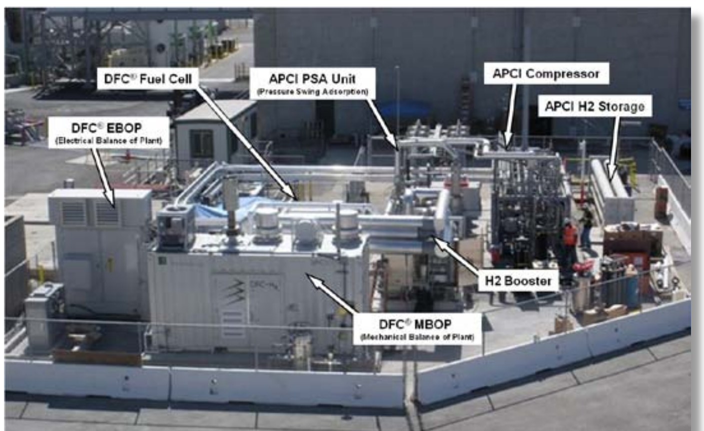
*cost will reduce dramatically with increased number of stations

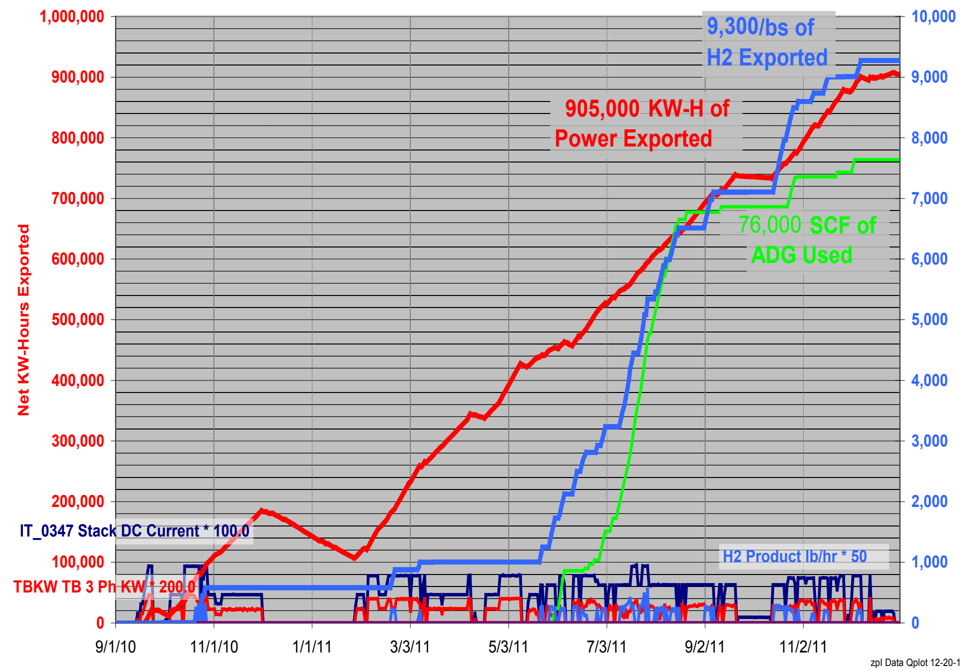
Technology Validation Progress

U.S. DEPARTMENT OF ENERGY

Hydrogen Energy Station at Fountain Valley, CA, achieved 54% efficiency (hydrogen + power) when operating in hydrogen co-production mode.

- Fueled with anaerobic digester gas
- Produces 100 kg/day H_2 (350 and 700 bar)
- Generates approximately 250 kW
- 54% efficiency co-producing H_2 and electricity





- Nearly 1 million kWh of power produced
- Over 4,000 kg of hydrogen produced
- 76,000 SCF of digester gas used

FuelCell Energy

AIR PRODUCTS

Technology Validation Progress – DOE/DOT

U.S. DEPARTMENT OF ENERGY

Fuel cell buses have 2X fuel economy of conventional buses, meeting 8 mpdge target.

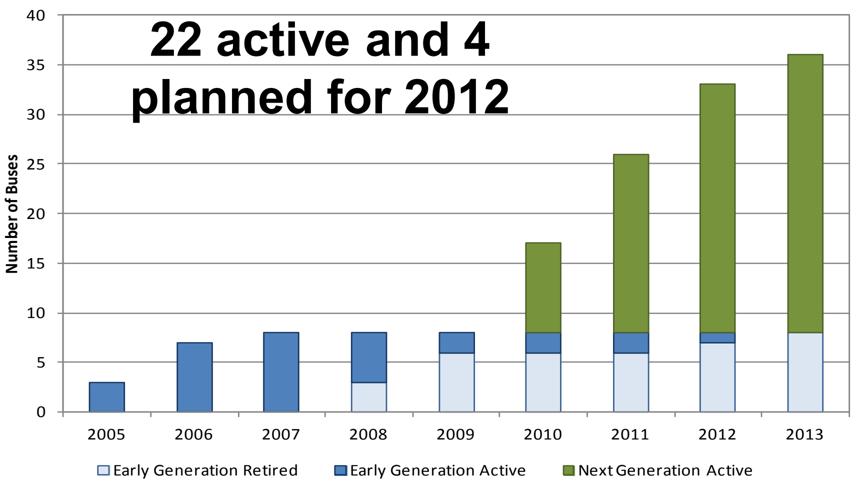
Transit Agency	Project	Location	No. buses	Start-up date
SunLine	Adv. Tech FCEB	Thousand Palms, CA	1	May 2010 *
AC Transit	ZEBA	Emeryville, CA	12	June 2010 *
CTTRANSIT	NFCBP: Nutmeg	Hartford, CT	4	Aug 2010 *
SunLine	NFCBP: AFCB	Thousand Palms, CA	1	Jan 2012
SFMTA	NFCBP: Bus 2010	San Francisco, CA	1	Jun 2012
Cap Metro	NFCBP: Proterra	Austin, TX	1	April 2012

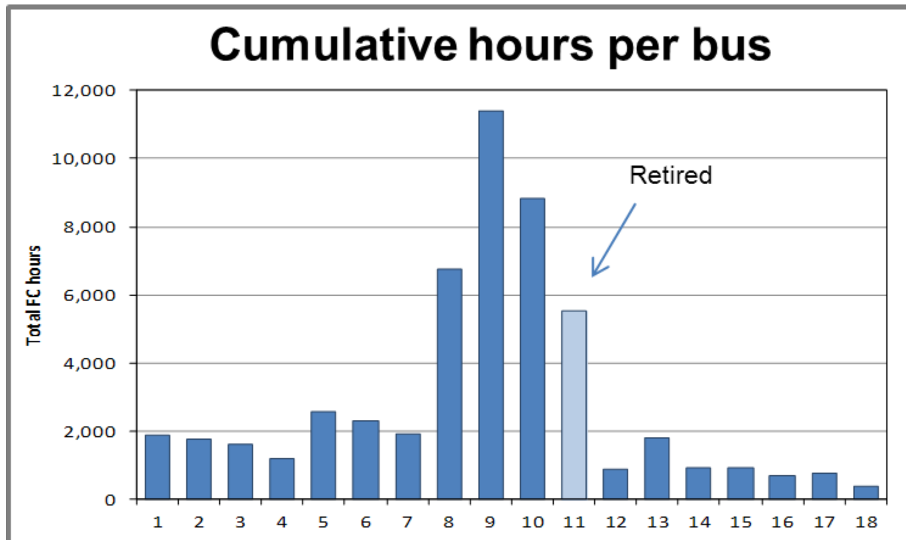
** Analyzed data*

Bus fleet leaders

- 3 FCPPs** over 6,000 hours without repair or cell replacement
- Top FCPP now over 12,000 hours

*** FCPP = Fuel cell power plant*





NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Funding Opportunity Announcement

U.S. DEPARTMENT OF ENERGY

Light-Duty Fuel Cell Electric Vehicle Validation Data

Supply dynamometer and real-world vehicle data to the Hydrogen Secure Data Center (HSDC) at the National Renewable Energy Laboratory (NREL) for analysis and aggregation into composite data products for a minimum of five vehicles of the same model.

$6M ($500k to $2M per award, up to 5 year period)

Applications Due 5/21 (Issue Date 2/29)

Validation of Hydrogen Refueling Station Performance and Advanced Refueling Components

Hydrogen Refueling Station Data Collection

Supply hydrogen refueling station data to the Hydrogen Secure Data Center (HSDC) at the National Renewable Energy Laboratory (NREL) for analysis and aggregation into composite data products. ~$1.2M, $400k (max) per award (up to 5 year period)

Validation of Advanced Refueling Components

Advanced components to be validated may include, but are not limited to, compressors, electrolyzers, hydrogen delivery, hydrogen storage systems, and dispenser systems or components, such as flow meters, nozzles or communications systems.

~$3M, $1M (max) per award (up to 5-year period)

Applications Due 5/10 (Issue Date 3/13)

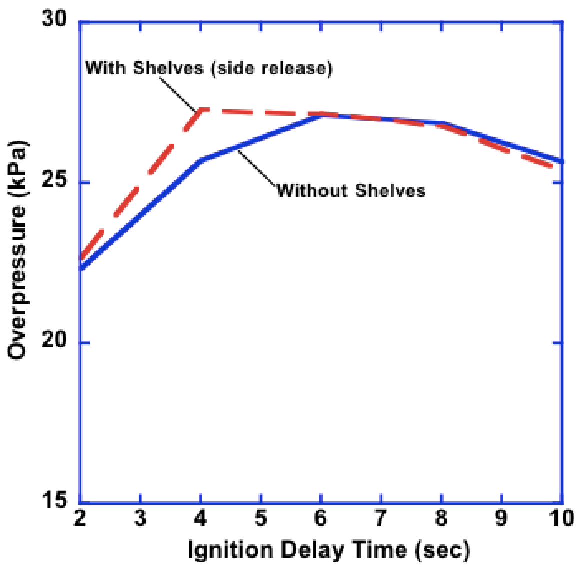
Safety, Codes and Standards Progress

U.S. DEPARTMENT OF ENERGY

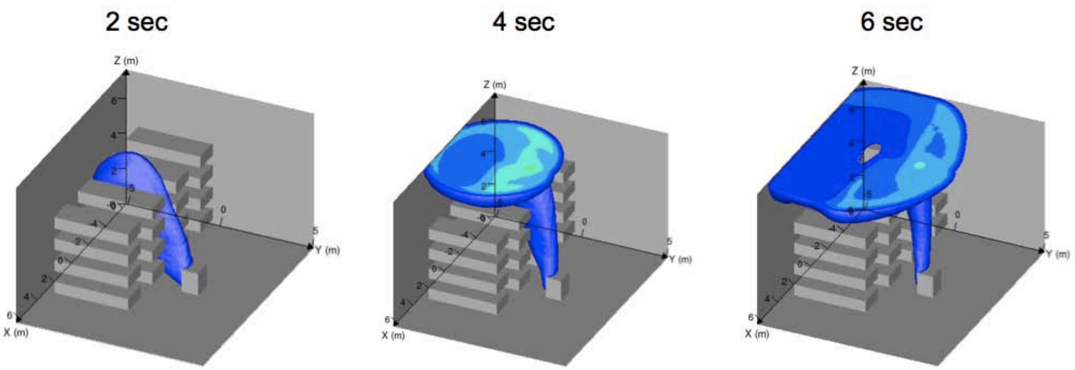
Validated hydrogen release data will impact changes being made to 2014 Edition of NFPA 2.

- Evaluated 0.8 kg H_2 release into a room (e.g., warehouses) with and without obstacles
- Showed that obstacles do not significantly impact release or overpressure characteristics for these conditions

Overpressure with and w/o obstacles



Flammable volume as a function of time for 6.35mm leak



Sandia National Laboratories

Safety, Codes and Standards Progress

U.S. DEPARTMENT OF ENERGY

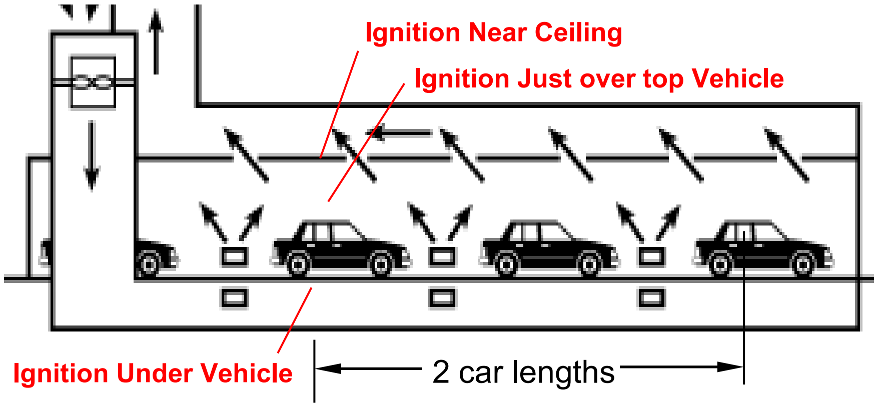
Validated hydrogen release data will aid harmonization of NFPA 2 (Hydrogen) and NFPA 502 (Tunnels).

- Early results show no increase to public risk of hydrogen vehicles in tunnels based on experimentally validated consequence simulation.

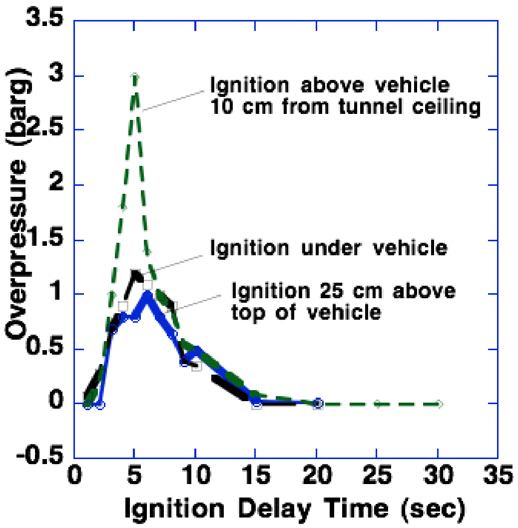
Discussion with NFPA 502:

- Presented consequence modeling results and analysis to NFPA 502 committee
- Committee accepts risk analysis results
- Acknowledged confidence in results based on thorough scientific approach

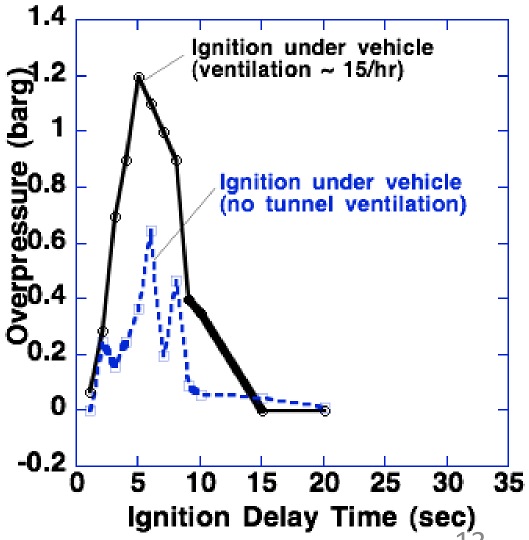
Case: Transversely-Ventilated Tunnel



Effect of Moving Ignition Point Vertically



Effect of Ventilation



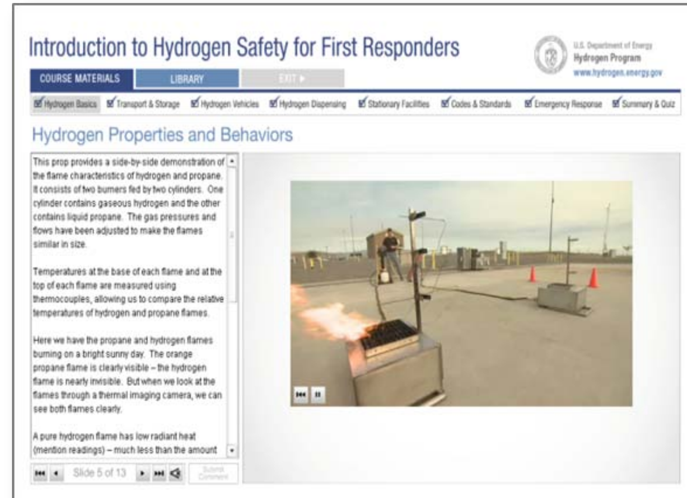
Sandia National Laboratories

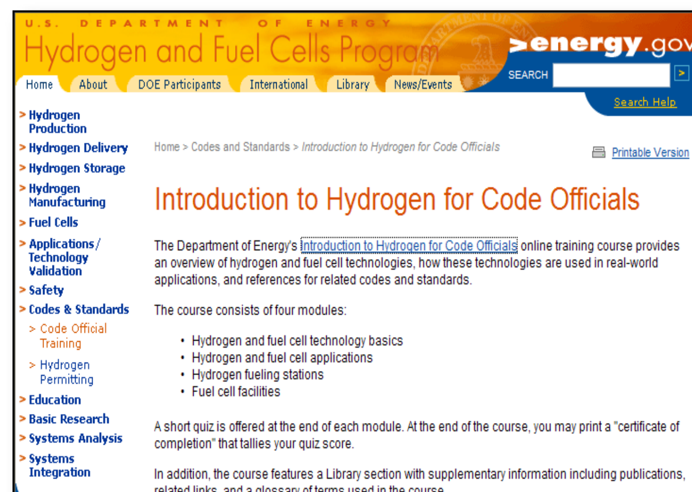
Safety, Codes and Standards Progress

U.S. DEPARTMENT OF ENERGY

Safety training of more than 23,000 first responders, researchers, and code officials to expand hydrogen knowledge base and to help expedite permitting

Training	Participants
Basic Hydrogen Education for First Responders (Hydrogen characteristics, behavior, and emergency response)	21,000
Code Official Training Workshop (Conveys information to help expedite permitting process)	1,000 (on line) 350 (in person)
Hands-on Training for First Responders (1-day classroom and live-fire training using a fuel cell vehicle prop)	710
Hydrogen Safety Training for Researchers and Technical Personnel (Covers all aspects of hydrogen safety, such as pressure devices)	100



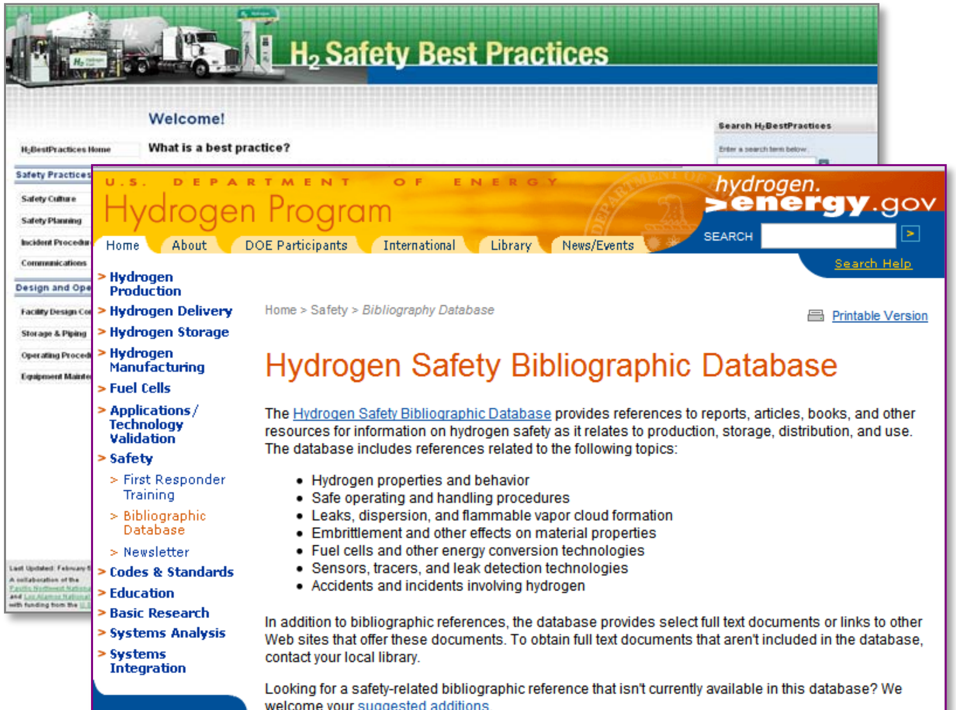


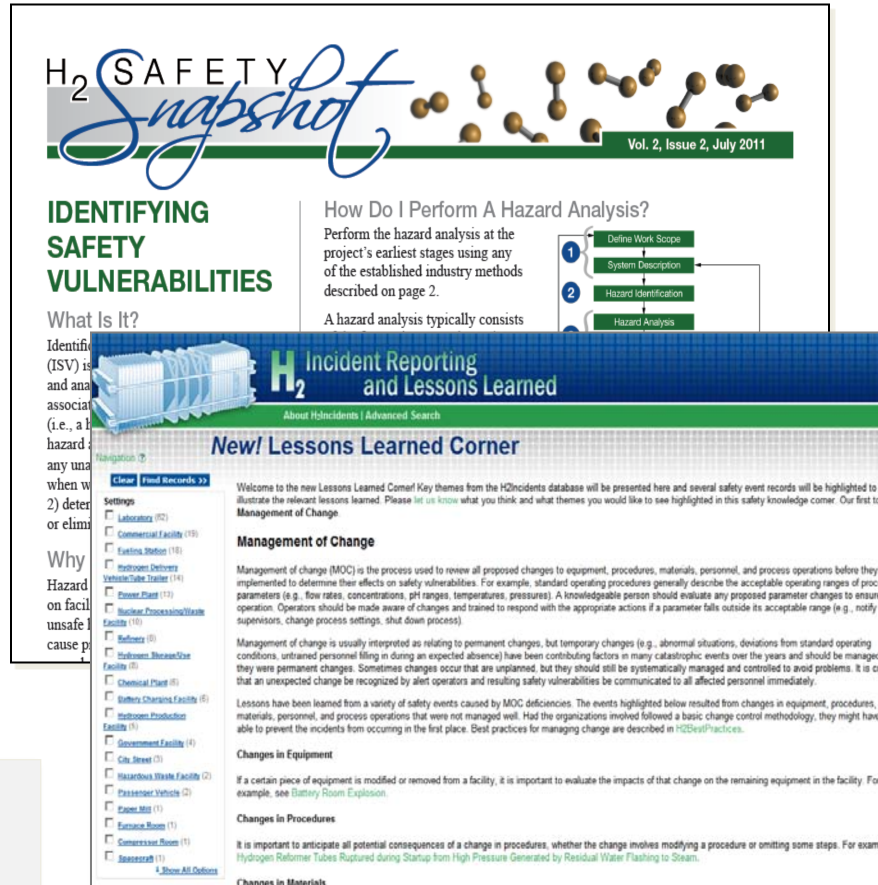
www.hydrogen.energy.gov/firstresponders.html

Safety, Codes and Standards Progress

U.S. DEPARTMENT OF ENERGY

Safety databases provide lessons-learned and promote safe operation when using and working with hydrogen.





- Approximately 750 entries in the Hydrogen Safety Bibliographic Database
- 200 safety event records in the hydrogen incident database and now global input

http://h2bestpractices.org/
http://www.hydrogen.energy.gov/biblio_database.html
www.eere.energy.gov/hydrogenandfuelcells/codes/
http://h2incidents.org/

Education and Outreach Progress

U.S. DEPARTMENT OF ENERGY

Studies identify impact of early market applications and deployments.

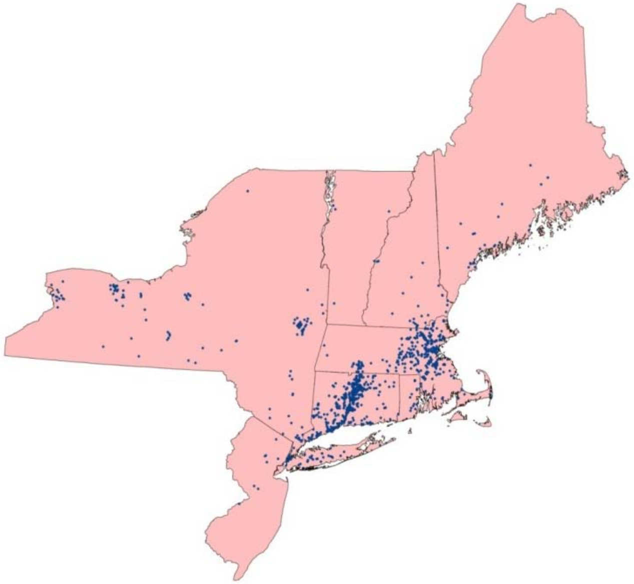
Connecticut Center for Advanced Technology*

Developed web-based virtual resource center

- Identified state economic impacts
- Mapped favorable deployment targets for environmental and energy reliability performance
- Deployment reinforces economic value

Organized event to "match" suppliers and manufacturers

Initiated Northeast Cluster group for state leader collaboration



Connecticut Center for Advanced Technology, Inc.

	CT	NY	MA	ME	NH	RI	VT	NJ	Regional
Total Employment	2,529	1,728	964	18	45	32	16	111	**5,443**
Total Revenue / Investment ($ million)	$496	$292	$171	$2.9	$8.7	$6.9	$3.3	$26.5	**$1,009**
Total Supply Chain Companies	599	183	322	28	25	19	5	8	**1189**

* All Education projects funded using FY 2010 funds

Education and Outreach Progress

U.S. DEPARTMENT OF ENERGY

Videos and webinars expand the Program's reach to a wider audience with over 1,500 webinar attendees in the past year.

Virginia Clean Cities - PBS *Motorweek* Series

Vehicles and Infrastructure Update - Began airing 10/22/2011

http://video.pbs.org/video/2165096277

Webinars:

- Past topics have included:
  - Federal Facilities Guide to Fuel Cells (May 2012)
  - America's Next Top Energy Innovator Runner Up (April 2012)
  - National Hydrogen Learning Demonstration Status (Feb 2012)
- Upcoming Webinars:
  - May 22, 2012: Jobs Tool
  - June 2012: Recent fuel cell licenses
  - July 2012: Portable power
  - August 2012: Mobile lighting

(http://www1.eere.energy.gov/hydrogenandfuelcells/webinars.html)

* All Education projects funded using FY 2010 funds

Education and Outreach Progress

U.S. DEPARTMENT OF ENERGY

Published more than 70 news articles in FY 2011 to continue communication of program accomplishments

News Items

- "Energy Department Awards More than $5 Million to Reduce Cost of Advanced Fuel Cells"
- "Energy Department Announces up to $10 Million to Promote Zero Emission Cargo Transport Vehicles"
- "SBIR/STTR Phase I Release 3 Technical Topics Announced, Fuel Cells and Hydrogen Storage Included"
- "DOE Announces up to $2 Million to Collect Data from Hydrogen Fueling Stations and Demonstrate Innovations in Hydrogen Infrastructure Technologies"

"These technologies are part of a broad portfolio that will create new American jobs, reduce carbon pollution, and increase our competitiveness in today's global clean energy economy."

Blogs Published to Energy.gov Website

- "Leaders of the Fuel Cell Pack"
- "Fuel Cell Lift Trucks: A Grocer's Best Friend"

Hydrogen fuel cells providing critical backup power

Education and Outreach Progress

U.S. DEPARTMENT OF ENERGY

Launched the Fuel Cell Technologies Program Newsletter

Monthly newsletter recaps news and events and previews upcoming activities.

Visit the web site to register or to see archives (http://www1.eere.energy.gov/hydrogenandfuelcells/newsletter.html)

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

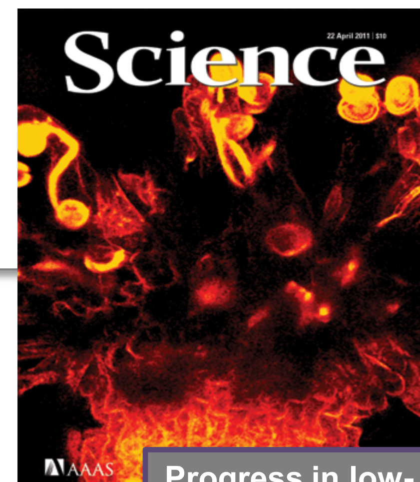
Fuel Cell Technologies Program

January 2012 Newsletter

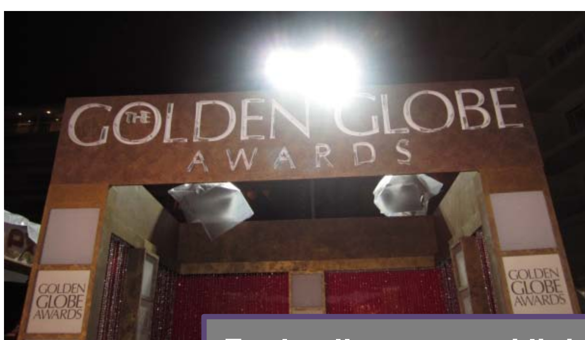
Welcome to the inaugural issue of the Fuel Cell Technologies Program newsletter. This newsletter will be issued monthly to our Fuel Cell News subscribers and will include a recap of the previous month's news and events as well as a preview of upcoming activities.

In this issue:

- In the News
- Funding Opportunities
- Recent Blogs
- Webinars and Workshops
- Events Calendar
- Studies, Reports, and Publications



Progress in low- and zero-Pt catalysts highlighted in *Science*



Fuel cell – powered lights at the *2011 Golden Globe Awards*

Funding Opportunity Announcements & Request for Information

FY 2012 FOAs	FY 2012 Funding
Collect Performance Data on Fuel Cell Electric Vehicles	$6.0 million
Hydrogen Fueling Stations and Innovations in Hydrogen Infrastructure Technologies	$2.0 million
Zero-Emission Cargo Transport Vehicles (Vehicle Technologies)	$10.0 million

Request for Information

Potential Topics for H-Prize—*extended to May 31, 2012*
(www.hydrogenandfuelcells.energy.gov/m/news_detail.html?news_id=18182)

For More Information

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