U.S. DOE Hydrogen and Fuel Cell Activities

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International Technical Forum on CNG and Hydrogen Fuels Vehicles
Beijing, People’s Republic of China
September 27, 2010
✓ Double Renewable Energy Capacity by 2012

✓ Invest $150 billion over ten years in energy R&D to transition to a clean energy economy

✓ Reduce GHG emissions 83% by 2050

Source: US DOE 09/2010
U.S. Energy Consumption

U.S. Primary Energy Consumption by Source and Sector

- Coal: 23%
- Petroleum: 37%
- Natural Gas: 24%
- Renewable Energy: 7%
- Nuclear Electric Power: 9%

Transportation
Industrial
Residential and Commercial
Electric Power

Share of Energy Consumed by Major Sectors of the Economy, 2008

- Commercial: 19%
- Industrial: 31%
- Residential: 22%
- Transportation: 28%

Total U.S. Energy = 99.3 Quadrillion Btu

Source: US DOE 09/2010
Fuel Cells: Addressing Energy Challenges

Energy Efficiency and Resource Diversity

→ Fuel cells offer a highly efficient way to use diverse fuels and energy sources

Greenhouse Gas Emissions and Air Pollution:

→ Fuel cells can be powered by emissions-free fuels that are produced from clean, domestic resources

**Benefits**

- Efficiencies can be 60% (electrical) and 85% (with CHP)
- > 90% reduction in criteria pollutants

Source: US DOE 09/2010
Fuel Cells — Where are we today?

**Fuel Cells for Stationary Power, Auxiliary Power, and Specialty Vehicles**

The largest markets for fuel cells today are in stationary power, portable power, auxiliary power units, and forklifts.

- **~75,000 fuel cells have been shipped worldwide.**
- **~24,000 fuel cells were shipped in 2009 (> 40% increase over 2008)**

Fuel cells can be a cost-competitive option for critical-load facilities, backup power, and forklifts.

**Production & Delivery of Hydrogen**

In the U.S., there are currently:

- **~9 million metric tons of** $H_2$ produced annually
- **> 1,200 miles of $H_2$ pipelines**

**Fuel Cells for Transportation**

In the United States:

- **> 200 fuel cell vehicles**
- **> 20 fuel cell buses**
- **~ 60 fueling stations**

Several manufacturers—including Toyota, Honda, Hyundai, Daimler, GM, and Proterra (buses)—have announced plans to commercialize vehicles by 2015.

**The Role of Fuel Cells in Transportation**

Source: US DOE 09/2010
Analysis shows DOE’s portfolio of transportation technologies will reduce emissions of greenhouse gases and oil consumption.

Well-to-Wheels Greenhouse Gas Emissions
(life-cycle emissions, based on a projected state of the technologies in 2020)

- Gasoline
- Natural Gas
- Gasoline
- Diesel
- Corn Ethanol – E85
- Cellulosic Ethanol – E85
- Gasoline
- Cellulosic Ethanol – E85
- H₂ from Distributed Natural Gas
- H₂ from Coal w/Sequestration
- H₂ from Biomass Gasification
- H₂ from Nuclear High-Temp Electrolysis
- H₂ from Central Wind Electrolysis

Well-to-Wheels Petroleum Energy Use
(based on a projected state of the technologies in 2020)

- Gasoline
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- H₂ from Central Wind Electrolysis


Source: US DOE 09/2010
The Program has been addressing the key challenges facing the widespread commercialization of fuel cells.

**Technology Barriers**

- **Fuel Cell Cost & Durability**
  - Targets*: Stationary Systems: $750 per kW, 40,000-hr durability
  - Vehicles: $30 per kW, 5,000-hr durability

- **Hydrogen Cost**
  - Target*: $2 – 3 /gge, (dispensed and untaxed)

- **Hydrogen Storage Capacity**
  - Target: > 300-mile range for vehicles—without compromising interior space or performance

**Economic & Institutional Barriers**

- Safety, Codes & Standards Development
- Domestic Manufacturing & Supplier Base
- Public Awareness & Acceptance
- Hydrogen Supply & Delivery Infrastructure

**Technology Validation:**

Technologies must be demonstrated under real-world conditions.

**Market Transformation**

Assisting the growth of early markets will help to overcome many barriers, including achieving significant cost reductions through economies of scale.

* Targets and Metrics are being updated in 2010.

Source: US DOE 09/2010
Projected high-volume cost of fuel cells has been reduced to $51/kW (2010)*

- More than 15% reduction since 2009
- More than 80% reduction since 2002
- 2008 cost projection was validated by independent panel**

As stack costs are reduced, balance-of-plant components are responsible for a larger % of costs.

*Based on projection to high-volume manufacturing (500,000 units/year).

**Panel found $60 – $80/kW to be a “valid estimate”: [http://hydrogendoedev.nrel.gov/peer_reviews.html](http://hydrogendoedev.nrel.gov/peer_reviews.html)

Source: US DOE 09/2010
Technology Validation
2010 Vehicles Progress & Accomplishments

Demonstrations are essential for validating the performance of technologies in integrated systems, under real-world conditions.

RECENT ACCOMPLISHMENTS

Vehicles & Infrastructure

• Fuel cell durability
  – 2,500 hours projected (nearly 75K miles)
• Over 2.8 million miles traveled
• Over 114 thousand total vehicle hours driven
• Fuel cell efficiency 53-59%
• Vehicle Range: ~196 – 254 miles
• Over 134,000 kg- H₂ produced or dispensed*
• 152 fuel cell vehicles and 24 hydrogen fueling stations have reported data to the project

Buses

• DOE is evaluating real-world bus fleet data (DOT collaboration)
  – H₂ fuel cell buses have a range of 39% to 141% better fuel economy when compared to diesel & CNG buses

Forklifts

• Forklifts at Defense Logistics Agency site have completed more than 18,000 refuelings

Recovery Act

• NREL is collecting operating data from deployments for an industry-wide report

* Not all hydrogen produced is used in vehicles

Source: US DOE 09/2010
Recovery Act Funding for Fuel Cells

DOE announced more than $40 million from the American Recovery and Reinvestment Act to fund 12 projects, which will deploy up to 1,000 fuel cells — to help achieve near term impact and create jobs in fuel cell manufacturing, installation, maintenance & support service sectors.

FROM the LABORATORY to DEPLOYMENT:

DOE funding has supported R&D by all of the fuel cell suppliers involved in these projects.

<table>
<thead>
<tr>
<th>COMPANY</th>
<th>AWARD</th>
<th>APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delphi Automotive</td>
<td>$2.4 M</td>
<td>Auxiliary Power</td>
</tr>
<tr>
<td>FedEx Freight East</td>
<td>$1.3 M</td>
<td>Specialty Vehicle</td>
</tr>
<tr>
<td>GENCO</td>
<td>$6.1 M</td>
<td>Specialty Vehicle</td>
</tr>
<tr>
<td>Jadoo Power</td>
<td>$2.2 M</td>
<td>Backup Power</td>
</tr>
<tr>
<td>MTI MicroFuel Cells</td>
<td>$3.0 M</td>
<td>Portable</td>
</tr>
<tr>
<td>Nuvera Fuel Cells</td>
<td>$1.1 M</td>
<td>Specialty Vehicle</td>
</tr>
<tr>
<td>Plug Power, Inc. (1)</td>
<td>$3.4 M</td>
<td>CHP</td>
</tr>
<tr>
<td>Plug Power, Inc. (2)</td>
<td>$2.7 M</td>
<td>Backup Power</td>
</tr>
<tr>
<td>Univ. of N. Florida</td>
<td>$2.5 M</td>
<td>Portable</td>
</tr>
<tr>
<td>ReliOn Inc.</td>
<td>$8.5 M</td>
<td>Backup Power</td>
</tr>
<tr>
<td>Sprint Comm.</td>
<td>$7.3 M</td>
<td>Backup Power</td>
</tr>
<tr>
<td>Sysco of Houston</td>
<td>$1.2 M</td>
<td>Specialty Vehicle</td>
</tr>
</tbody>
</table>

Approximately $54 million in cost-share funding from industry participants for a total of about $96 million.

Source: US DOE 09/2010
ARRA Fuel Cell Units in Operation

DOE ARRA-funded Early Market Fuel Cell Installations
(actual and projected)

Projected Operation Quantities

$42 million from ARRA with approximately $54 million in cost-share funding from industry participants for a total of about $96 million

APU
Backup Power
Forklift
Stationary

Created: Feb-19-10  3:26 PM
Some site locations TBD

From National Renewable Energy Laboratory
Source: US DOE 09/2010
U.S. Fuel Cell Deployments Using Market Transformation and Recovery Act Funding

Source: US DOE 09/2010
• Hydrogen Fueling Stations
  > 20 stations currently operating
  ~ 10 additional stations planned

• Hydrogen Fuel Cell Vehicle Deployments: CA Fuel Cell Partnership is assessing the potential to deploy over
  4,000 vehicles by 2014
  50,000 vehicles by 2017

http://www.fuelcellpartnership.org/

Source: US DOE 09/2010
**ACTIVITIES**

Educate target audiences to facilitate near-term demonstration, commercialization, and long-term market acceptance

Focus on high-priority audiences:
- Safety & code officials
- Local communities
- State & local government officials
- End-users/early adopters
- Students

**PROGRESS**

- Launched advanced first responder training with hands-on prop (original online course has had > 17,000 users since its launch)
- Conducted more than 80 workshops to help state and local leaders identify deployment opportunities
- Launched “Introduction to Hydrogen for Code Officials” web course
- Trained more than 8,000 middle school and high school teachers
- 25 courses and modules under development at 5 universities
- Conducted educational seminars for lift-truck users
- Developed fact sheets and case studies

Source: US DOE 09/2010
Objectives

- Support critical R&D for the development of scientifically and technically sound codes and standards that enable the safe use of hydrogen and fuel cell technologies and facilitate harmonization of domestic and international regulation, codes and standards (RCS).

- Develop and implement safety practices and procedures to ensure the safe operation, handling and use of hydrogen and fuel cell technologies.
Challenges

- To synchronize codes and standards development and adoption with technology commercialization needs
- To coordinate enabling R&D with the codes and standards development cycle
- To promote domestic and international consistency
- To make approved codes and standards readily available
- To streamline and standardize the permitting process for hydrogen facilities
- To minimize knowledge gaps by disseminating safety information
- To generate hydrogen safety information due to lack of available data

Source: US DOE 09/2010
## Timeline of Hydrogen Codes and Standards

<table>
<thead>
<tr>
<th>FY03</th>
<th>FY05</th>
<th>FY06</th>
<th>FY07</th>
<th>FY08</th>
<th>FY09</th>
<th>FY10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Building and Fire Codes</td>
<td>ICC Chapter 22 Hydrogen Code Adopted</td>
<td>CSTT formed RD&amp;D Roadmap National Templates</td>
<td>RD&amp;D Roadmap Revised</td>
<td>Changes submitted to IFC to coordinate IFC and NFPA requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NFPA 52 2006 edition Dispensing Hydrogen Specific Codes and Standards</td>
<td>NFPA 2 Hydrogen Technologies Code</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>UL 2267 published</td>
<td>CSA HGV4 Series</td>
<td>SAE 2579</td>
<td>SAE 2601</td>
<td>SAE 2719</td>
<td>ASME B31.12 published</td>
<td>ISO DIS 14687-2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CSA H series draft documents published</td>
<td></td>
</tr>
</tbody>
</table>

Component standards and design codes that are referenced in the NFPA codes and standards such as:
- CSA FC 1 Stationary Fuel Cell Power Systems
- CGA P1 Safe Handling of Compressed Gases in Containers
- ASME B31.3 and ASME BPVC

Source: US DOE 09/2010
Separation Distances

- Provided technical data and incorporated risk-informed approach that enabled NFPA2 to update bulk gas storage separation distances in the 2010 edition of NFPA55
- Quantified how barrier walls can reduce hazards leading to fifty percent distance reduction credit
- Technical data and methodology are published in archival documents

<table>
<thead>
<tr>
<th>Exposure</th>
<th>NFPA 2005 Separation Distance</th>
<th>NFPA 2010 Separation Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lot Lines</td>
<td>5 ft</td>
<td>10 ft</td>
</tr>
<tr>
<td>Air intakes (HVAC, compressors, other)</td>
<td>50 ft</td>
<td>10 ft</td>
</tr>
<tr>
<td>Ignition sources such as open flames or welding</td>
<td>25 ft</td>
<td>10 ft</td>
</tr>
<tr>
<td>Flammable Gas storage systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- non-bulk</td>
<td>10 ft</td>
<td>5 ft</td>
</tr>
<tr>
<td>- bulk</td>
<td>10 ft or 25 ft</td>
<td>15 ft</td>
</tr>
<tr>
<td>Ordinary combustibles</td>
<td>50 ft</td>
<td>5 ft</td>
</tr>
</tbody>
</table>

Source: US DOE 09/2010
2010 Progress & Accomplishments

Materials and Components Compatibility

- Completed report of fracture threshold measurement of tank steels to enable revision of same kd-10
- Completed testing to enable deployment of 100 MPa stationary storage tanks
- Performed testing of forklift tank materials to enable design qualification
- Added two additional Nickel alloy chapters to the Technical Reference
- Forklift tank lifecycle testing program underway to support the development of CSA HPIT1

Online Technical Reference

<table>
<thead>
<tr>
<th>Table of Contents</th>
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</thead>
<tbody>
<tr>
<td>Material Category</td>
</tr>
<tr>
<td>Introduction</td>
</tr>
<tr>
<td>Pure Carbon Ferritic Steels</td>
</tr>
<tr>
<td>Low-Alloy Ferritic Steels</td>
</tr>
<tr>
<td>High-Alloy Ferritic Steels</td>
</tr>
<tr>
<td>High-Strength Steels</td>
</tr>
<tr>
<td>Austenitic Stainless Steels</td>
</tr>
<tr>
<td>Martensitic Stainless Steels</td>
</tr>
<tr>
<td>Precipitation-Strengthened</td>
</tr>
<tr>
<td>Heat Treatable</td>
</tr>
</tbody>
</table>

Source: US DOE 09/2010

www.sandia.gov/hydrogen/research/safetyCodesStandards
2010 Progress & Accomplishments

Hydrogen Safety Knowledge Tools

Expanded and Improved Safety Databases

H2 Lessons Learned Corner

Source: US DOE 09/2010
2010 Progress & Accomplishments

Hydrogen Safety Training for First Responders

First Responder Education

- Completed upgrade of web-based Introduction to Hydrogen Safety for First Responders – averaging 300-500 unique visits/month for a total of 17,000 visits since January 2007

- Held two pilot courses for the advanced-level, prop-based course at the Hazardous Materials Management and Emergency Response (HAMMER) training center

- Held three official deployments of the advanced-level, prop-based reaching 90 students from 18 states.

www.hydrogen.energy.gov/firstresponders.html

Source: US DOE 09/2010
Compressed Natural Gas (CNG), Hydrogen and Hydrogen Blend Workshop

Washington, D.C. December 10-11, 2009

Workshop Objectives:

1. Share safety requirements and regulatory framework in each country to harmonize domestic and international codes and standards
2. Collect data and information from demonstration activities and real-world applications in Canada, Brazil, China, India and the U.S.
3. Discuss safety and testing of storage tanks and identify research, regulations, codes and standards needed to ensure their safe use
4. Compare properties, behavior and R&D efforts for CNG, hydrogen and hydrogen blend (HCNG) fuels
5. Conduct follow-up workshops, conduct collaborative R&D & testing, share hydrogen roadmaps and education and training plans

Workshop Outcomes:  
**Brazil, Canada, China, India and the U.S. will identify projects and activities to collaborate in the following areas:**

1. R&D and Testing: Conduct life cycle tests and analysis of high-pressure CNG and hydrogen tanks
2. Codes and Standards: Harmonize regulations, codes and standards for CNG, hydrogen and HCNG vehicles & fueling facilities
3. Education and Training: Conduct programs to train labor force & increase education and outreach
4. Regulations: Encourage participation in international forums and the development of Global Technical Regulations (GTR) for hydrogen fueled vehicle

www.hydrogenandfuelcells.energy.gov/wkshp_cng_and_h2.html

Source: US DOE 09/2010
**Onboard Storage Tank Workshop**

To coordinate R&D, regulations and codes and standards to qualify and enable the deployment of hydrogen storage tanks.

Sandia National Laboratories, Livermore, CA April 29, 2010

**Workshop Objectives:**
1. Provide initial follow up to the DOE-DOT Workshop on Lessons Learned for Use of CNG, Hydrogen and HCNG Fuels in Vehicles
2. Address specific technical topics from the DOE-DOT Workshop in more detail – including pressure relief device (PRD) testing; tank service life cycle testing, monitoring, and enforcement of inspection requirements
3. Discuss harmonization of key international regulations and codes and standards for on-board hydrogen tanks, including SAE J2579, ISO and Global Technical Regulations (GTR) for hydrogen fueled vehicles

**Workshop Outcomes:**
1. Potential refinements to tank testing protocols to better address service life and possible failure modes
2. Proposals to monitor, inspect and enforce service life requirements of high-pressure gaseous tanks
3. Identification of priorities for hydrogen component certification
4. Discussion of Non Destructive Evaluation (NDE) methods to monitor safety of tanks during service and for recertification of tanks
5. Confirmation of industry interest in validating 70MPa fast-fill model

Source: US DOE 09/2010

**Other Presenters:** California Dept. of Agriculture, Division of Measurement Standards; Smart Chemistry; Powertech; & Sloane Solutions
U.S. PARTNERSHIPS

- **FreedomCAR & Fuel Partnership:** Ford, GM, Chrysler, BP, Chevron, ConocoPhillips, ExxonMobil, Shell, Southern California Edison, DTE Energy


- **State/Local Governments:** California Fuel Cell Partnership, California Stationary Fuel Cell Collaborative, co-coordinators of Bi-Monthly Informational Call Series for State and Regional Initiatives with the National Hydrogen Association and the Clean Energy Alliance

- **Industry Associations:** US Fuel Cell Council, National Hydrogen Association


INTERNATIONAL PARTNERSHIPS

- **International Partnership for Hydrogen and Fuel Cells in the Economy** — A partnership among 16 countries and the European Commission

- **International Energy Agency — Implementing Agreements**
  - Hydrogen Implementing Agreement — 21 countries and the European Commission
  - Advanced Fuel Cells Implementing Agreement — 19 countries

Source: US DOE 09/2010
Collaborations

Federal Agencies
- DOC
- DOD
- DOE
- DOT
- EPA
- GSA
- DOI
- NIST
- NASA
- NSF
- USDA
- USPS

Industry Partnerships & Stakeholder Assn’s.
- FreedomCAR and Fuel Partnership
- National Hydrogen Association
- U. S. Fuel Cell Council
- Hydrogen Utility Group
- ~ 65 projects with 50 companies

Universities
~ 50 projects with 40 universities

State & Regional Partnerships
- California Fuel Cell Partnership
- California Stationary Fuel Cell Collaborative
- SC H₂ & Fuel Cell Alliance
- Upper Midwest Hydrogen Initiative
- Ohio Fuel Coalition
- Connecticut Center for Advanced Technology

International
- IEA implementing agreements – 25 countries
- International Partnership for the Hydrogen Economy – 16 countries, 30 projects

National Laboratories
National Renewable Energy Laboratory
P&D, S, FC, A, SC&S, TV
Argonne
A, FC, P&D
Los Alamos
S, FC, SC&S

Sandia
P&D, S, SC&S
Pacific Northwest
P&D, S, FC, A
Oak Ridge
P&D, S, FC, A
Lawrence Berkeley
FC, A

Lawrence Livermore
P&D, S
Savannah River
S, P&D
Brookhaven
S, FC

Other Federal Labs: Jet Propulsion Lab, National Institute of Standards & Technology, National Energy Technology Lab, Idaho National Lab

P&D = Production & Delivery; S = Storage; FC = Fuel Cells; A = Analysis; SC&S = Safety, Codes & Standards; TV = Technology Validation

Source: US DOE 09/2010

* Office of Energy Efficiency and Renewable Energy
For More Information …

Fuel Cell Program Plan
Outlines a plan for fuel cell activities in the Department of Energy
→ Replacement for current Hydrogen Posture Plan
→ To be released in 2010

Annual Merit Review Proceedings
Includes downloadable versions of all presentations at the Annual Merit Review
→ Latest edition released June 2009
  www.hydrogen.energy.gov/annual_review09_proceedings.html

Annual Merit Review & Peer Evaluation Report
Summarizes the comments of the Peer Review Panel at the
Annual Merit Review and Peer Evaluation Meeting
→ Latest edition released October 2009
  www.hydrogen.energy.gov/annual_review08_report.html

Annual Progress Report
Summarizes activities & accomplishments within the Program
over the preceding year, with reports on individual projects
→ Latest edition published November 2009
  www.hydrogen.energy.gov/annual_progress.html

Next Annual Review: May 9 – 13, 2011
Washington, D.C.
http://annualmeritreview.energy.gov/

Source: US DOE 09/2010
Thank you

sunita.satyapal@ee.doe.gov

hydrogenandfuelcells.energy.gov
Additional Slides
Objectives – to determine:
• Business cases
• Number and size of stations needed by 2018-2020
• Factors that will motivate, hinder, or prevent investments
• Possible financing scenarios
• Policies, regulations, etc.
• Opportunities for international programs to leverage their efforts

Fuel Retailers’ Business Environment
• Non-traditional fuel retailers (“big box stores,” etc.) gaining market dominance
• Fuel retailers make profits from their convenience stores, rather than fuel sales
• Station owners must achieve 3-5 year return on investment to justify investment
• Consumer demand and gasoline price most important factors in determining investment in alternative fuels

KEY OUTCOMES
• Develop low-cost, 100 kg/day starter station model
• Policies: including tax incentives, subsidies, gas/carbon tax, low-cost financing, and regulations
• Information and education campaigns: for legislators and public
• Risk Reducing Strategies: Public/private partnerships, insurance pool, cost-share, OEM commitments
• Innovative ways to boost H₂ demand: target fleets and other fuel cell applications, leverage natural gas industry, increase competition
• Novel Business Models: seek new methods of financing, leverage existing H₂ industry

Source: US DOE 09/2010
Total DOE Hydrogen and Fuel Cell Technologies
FY11 Budget Request
(in millions of US$)

Fuel Cell Systems R&D: 67
Hydrogen Fuel R&D: 50
Technology Validation: 52
Market Transformation and Safety, Codes & Standards: 5
Systems Analysis: 11
Manufacturing R&D: 12
Fossil Energy (FE): 5
Nuclear Energy (NE)*: 5
Basic Science (SC)**: 9
SECA - MW SOFC (FE): 5

Total FY11 Budget Request $256 Million

*NE request TBD, $5M represents FY10 funding
**SC Includes BES and BER

Source: US DOE 09/2010
Some tax credits affecting fuel cells were expanded. Through new financing mechanisms, these credits can help facilitate federal deployments.

<table>
<thead>
<tr>
<th>Policy</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen Fueling Facility Credit</td>
<td>Increases the hydrogen fueling credit from 30% or $30,000 to 30% or $200,000.</td>
</tr>
<tr>
<td>Grants for Energy Property in Lieu of Tax Credits</td>
<td>Allows facilities with insufficient tax liability to apply for a grant instead of claiming the Investment Tax Credit (ITC) or Production Tax Credit (PTC). Only entities that pay taxes are eligible.</td>
</tr>
<tr>
<td>Manufacturing Credit</td>
<td>Creates 30% credit for investment in property used for manufacturing fuel cells and other technologies</td>
</tr>
<tr>
<td>Residential Energy Efficiency Credit</td>
<td>Raises ITC dollar cap for residential fuel cells in joint occupancy dwellings to $3,334/kW.</td>
</tr>
</tbody>
</table>

Source: US DOE 09/2010
We are participating in a project to demonstrate a combined heat, hydrogen, and power (CHHP) system using biogas.

- System has been designed, fabricated and shop-tested
- Improvements in design have led to higher H\textsubscript{2}-recovery (from 75\% to >85\%)
- On-site operation and data-collection planned for FY10 – FY11

Combined heat, hydrogen, and power systems can:
- Produce clean power and fuel for multiple applications
- Provide a potential approach to establishing an initial fueling infrastructure

Tri-Generation (CHHP) Concept

Baseline System

CHHP System

Public-Sector Partners: South Coast Air Quality Management District, California Air Resources Board

Source: US DOE 09/2010
Hydrogen production costs for a stand-alone steam methane reforming (SMR) station and high-temperature CHHP application were compared. Costs are dependent on natural gas costs. CHHP applications may be more cost-effective at lower production capacities.

In cases where there is a low demand for hydrogen in early years of fuel cell vehicle deployment, CHHP may have cost advantages over on-site SMR production.

Source: Fuel Cell Power Model

Source: US DOE 09/2010
Federal Interagency Coordination

**DOE Hydrogen Program**

- Secretary of Energy
  - Under Secretary

**Program Secretarial Officers**

- Energy Efficiency and Renewable Energy – EERE
- Fossil Energy – FE
- Nuclear Energy – NE
- Science - SC

**DOE Program Manager**

**Program Coordination Group***:

*Coordinates H₂ activities of EERE, FE, NE, SC*

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**Interagency Task Force**

- High-level
- Coordinates Federal Deployments

**Interagency Working Group**

- Staff-level
- Coordinates RD&D

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**Other Federal Agencies Involved in H₂ & FC RD&D and Deployments**

- Dept. of Agriculture
- Dept. of Commerce
- Dept. of Defense
- Dept. of Education
- Dept. of the Interior
- Dept. of Homeland Security
- Dept. of Transportation
- Environmental Protection Agency
- Executive Office of the President
- General Services Administration
- National Aeronautics and Space Administration
- National Science Foundation
- U.S. Postal Service

*Also coordinates activities with Dept. of Transportation*

Source: US DOE 09/2010
International Partnerships

**International Partnership for Hydrogen and Fuel Cells in the Economy**
Partnership among 18 member countries & the European Commission

**International Energy Agency – Hydrogen Implementing Agreements**
21 member countries and the European Commission Advanced Fuel Cells Implementing Agreement – 19 countries

**International Association for Hydrogen Safety (HySafe)**
Facilitate the international coordination, development and dissemination of hydrogen safety knowledge by being the focal point for hydrogen safety research, education and training

**International Conference on Hydrogen Safety**
International safety conference organized by HySafe and the HIA
The fourth international conference will be held in San Francisco September 12 – 14, 2011

Source: US DOE 09/2010
Safety, Codes and Standards Budget

FY 2010 Appropriation: $8.8 M
FY 2011 Request: $9.0 M

FY 2010 EMPHASIS

- Creating technical information and performance data to validate codes and standards
- Developing tools to facilitate permitting of hydrogen fueling stations and stationary fuel cell installations
- Testing, measuring, and verifying hydrogen fuel quality
- Assessing risks and establishing protocols to identify and mitigate risks
- Harmonizing hydrogen fuel quality and other key international standards
- Disseminating hydrogen “best practices” and safety information

Source: US DOE 09/2010
2010 Progress & Accomplishments

Codes and Standards Training and Outreach

Permitting Tools for Code Officials

- Added Permitting Compendium – *online information database*
- Introduction to Hydrogen for Code Officials – *online course*
- Permitting Workshops – *classroom training*

Source: US DOE 09/2010
2010 Progress & Accomplishments

Hydrogen Fuel Quality Specification

• Technical Specification (TS) published and harmonized with SAE J2719, Committee Draft (CD) prepared

• Draft International Standard (DIS) to be submitted to ISO TC197 Dec 2010

• Unified testing underway at LANL, HNEI, USC, Clemson-SRNL, UConn for critical contaminants

• Collaborative testing underway in Japan (JARI) and France (CEA-Liten)

• Developing standardized sampling and analytical methodologies with ASTM

• Applied ANL fuel cell stack and PSA models to support testing and to address fuel quality-fuel cost tradeoffs

• Coordinated overall approach and testing with Fuel Cell, Delivery, and Storage Tech Teams

Fuel Quality - ISO DIS 14687-2
Hydrogen Fuel Product Specification

SPECIFICATION TRADEOFFS

Impact on Fuel Cell

<table>
<thead>
<tr>
<th>High</th>
<th>Low</th>
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<tbody>
<tr>
<td>Sulfur species</td>
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<tr>
<td>Ammonia</td>
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<tr>
<td>Aromatic &amp; Aliphatic HCs</td>
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<tr>
<td>Carbon Monoxide</td>
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<tr>
<td>Oxygen</td>
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<td>Methane</td>
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<tr>
<td>Nitrogen</td>
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<td>Helium</td>
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Difficulty to Attain and Verify Level

Source: Shell Hydrogen

Source: US DOE 09/2010
Coordinate R&D and code development efforts to enable the rapid deployment of early market fuel cell applications.

Workshop Objectives:
1. Early Market Fuel Cells Panel: Industry perspective on barriers to technology deployment
2. Code Development Panel: Coordination of the fire code, the fork lifts and the fuel cell system component
3. Enabling Research Panel: Implementation of R&D in materials, components and risk analysis in the code development process
4. Identification of codes and standards gaps for early market fuel cell technologies

Workshop Outcomes:
1. More than 25 gaps identified in the areas of fire codes, component codes and enabling research
2. Facilitated integration of the DOE Safety, Codes and Standards Program elements with early market fuel cell applications

Source: US DOE 09/2010
On October 5, 2009 President Obama signed Executive Order 13514 – Federal Leadership in Environmental, Energy, and Economic Performance

**Requires Agencies to:**
- Set GHG reduction Targets
- Develop Strategic Sustainability Plans and provide in concert with budget submissions
- Conduct bottom up Scope 1, 2 and 3 baselines
- Track performance

**Examples:**
- **Achieve** 30% reduction in vehicle fleet petroleum use by 2020
- **Requires** 15% of buildings meet the Guiding Principles for High Performance and Sustainable Buildings by 2015
- **Design** all new Federal buildings which begin the planning process by 2020 to achieve zero-net energy by 2030

**Potential opportunities for fuel cells and other clean energy technologies...**

Source: US DOE 09/2010

http://www1.eere.energy.gov/femp/regulations/eo13514.html