IEA HIA Hydrogen Safety Stakeholder Workshop
Bethesda, Maryland
10/2/2012

- Nearly double the second place holder, solar, which has ~540 patents.

Worldwide Investment & Interest Are Strong and Growing

Interest in fuel cells and hydrogen is global, with more than $1 billion in public investment in RD&D annually, and 17 members of the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE).

Activity by Key Global Players

**Germany:** >$1.2 Billion in funding (’07 – ’16); projected demand for 1,000 hydrogen stations; >22,000 small fuel cells shipped.

**Japan:** ~$1.0 Billion in funding (’08 – ’12); plans for 2 million FCEVs and 1000 H₂ stations by 2025; 100 stations by 2015; 15,000 residential fuel cells deployed

**European Union:** >$1.2 Billion in funding (’08–’13)

**South Korea:** ~$590 M (’04–’11); plans to produce 20% of world shipments and create 560,000 jobs in Korea

**China:** Thousands of small units deployed; 70 FCEVs, buses, 100 FC shuttles at World Expo and Olympics

Fuel cell and hydrogen markets continue to grow

- >20,000 systems shipped in 2011 (>35% increase from 2010)
- >55 Mtons produced in 2011 and >70Mtons projected for 2016

Widespread market penetration could create:

- 180,000 new jobs in the US by 2020
- 675,000 jobs by 2035

Projected Global Market Revenues over the next 10-20 Years

<table>
<thead>
<tr>
<th>Stationary Power</th>
<th>Portable Power</th>
<th>Transportation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$14-$31B/yr</td>
<td>$11B/yr</td>
<td>$18-$97B/yr</td>
</tr>
</tbody>
</table>

Many of the world’s major automakers are planning commercialization of FCEVs in the 2012 – 2015 timeframe, including Toyota, Honda, GM, Daimler, Hyundai-Kia.
**Worldwide Commitment to FCEVs**

The world’s leading automakers have committed to develop FCEVs. Germany and Japan have announced plans to expand the hydrogen infrastructure.

### Major Auto Manufacturers’ Activities and Plans for FCEVs

<table>
<thead>
<tr>
<th>Company</th>
<th>Activities and Plans</th>
</tr>
</thead>
</table>
| **Toyota**    | • 2010-2013: U.S. demo fleet of 100 vehicles  
• 2015: Target for large-scale commercialization  
• “FCHV-adv” can achieve 431-mile range and 68 mpgge |
| **Honda**     | • Clarity FCX named “World Green Car of the Year”; EPA certified 72mpgge; leasing up to 200 vehicles  
• 2015: Target for large-scale commercialization |
| **Daimler**   | • Small-series production of FCEVs began in 2009  
• Plans for tens of thousands of FCEVs per year in 2015 – 2017 and hundreds of thousands a few years after  
• In partnership with Linde to develop fueling stations.  
• Recently moved up commercialization plans to 2014 |
| **General Motors** | • 115 vehicles in demonstration fleet  
• 2012: Technology readiness goal for FC powertrain  
• 2015: Target for commercialization |
| **Hyundai-Kia** | • 2012-2013: 2000 FCEVs/year  
• 2015: 10,000 FCEVs/year  
• “Borrego” FCEV has achieved >340-mile range. |
| **Volkswagen** | • Expanded demo fleet to 24 FCEVs in CA  
• Recently reconﬁrmed commitment to FCEVs |
| **SAIC (China)** | • Partnering with GM to build 10 fuel cell vehicles in 2010 |
| **Ford**      | • Alan Mulally, CEO, sees 2015 as the date that fuel cell cars will go on sale.                                 |
| **BMW**       | • BMW and GM plan to collaborate on the development of fuel cell technology                                    |

H₂Mobility - evaluate the commercialization of H₂ infrastructure and FCEVs
- Public-private partnership between NOW and 9 industry stakeholders including:
  - Daimler, Linde, OMV, Shell, Total, Vattenfall, EnBW, Air Liquide, Air Products
  - FCEV commercialization by 2015.
  - $40€ investment to ensure 50 hydrogen station by 2015.

UKH₂Mobility will evaluate anticipated FCEV roll-out in 2014/2015
- 13 industry partners including:
  - Air Liquide, Air Products, Daimler, Hyundai, ITM Power, Johnson Matthew, Nissan, Scottish & Southern Energy, Tata Motors, The BOC Group, Toyota, Vauxhall Motors
  - Government investment of £400 million to support development, demonstration, and deployment.

13 companies and Ministry of Transport announce plan to commercialize FCEVs by 2015
- 100 refueling stations in 4 metropolitan areas and connecting highways planned, 1,000 station in 2020, and 5,000 stations in 2030.

Based on publicly available information during 2011
The Program is an integrated effort, structured to address all the key challenges and obstacles facing widespread commercialization.

Nearly 300 projects currently funded at companies, national labs, and universities/institutes

More than $1B DOE funds spent from FY 2007 to FY 2011
Projected high-volume cost of fuel cells has been reduced to $47/kW (2012)*

- More than 35% reduction since 2008
- More than 80% reduction since 2002

*Based on projection to high-volume manufacturing (500,000 units/year). The projected cost status is based on an analysis of state-of-the-art components that have been developed and demonstrated through the DOE Program at the laboratory scale. Additional efforts would be needed for integration of components into a complete automotive system that meets durability requirements in real-world conditions.
The revised hydrogen threshold cost is a key driver in the assessment of Hydrogen Production and Delivery R&D priorities.

Projected High-Volume Cost of Hydrogen Production\(^1\) (Delivered\(^2\))—Status

**Distributed Production (near term)**
- Electrolysis
  - Feedstock variability: $0.03 - $0.08 per kWh
- Bio-Derived Liquids
  - Feedstock variability: $1.00 - $3.00 per gallon ethanol
- Natural Gas Reforming\(^3\)
  - Feedstock variability: $4.00 - $10.00 per MMBtu

**Central Production (longer term)**
- Electrolysis
  - Feedstock variability: $0.03 - $0.08 per kWh
- Biomass Gasification
  - Feedstock variability: $40 - $120 per dry short ton

Notes:
1. Cost ranges for each pathway are shown in 2007$ based on high-volume projections from H2A analyses, reflecting variability in major feedstock pricing and a bounded range for capital cost estimates.
2. Costs include total cost of production and delivery (dispensed, untaxed). Forecourt compression, storage and dispensing added an additional $1.82 for distributed technologies, $2.61 was added as the price of delivery to central technologies. All delivery costs were based on the Hydrogen Pathways Technical Report (NREL, 2009).
3. Analysis of projected costs for natural gas reforming indicated that the threshold cost can be achieved with current technologies or with incremental improvements made by industry. FCTP funding of natural gas reforming projects was completed in 2008.
Hydrogen: Sources & Applications

Diverse Energy Sources
- Natural Gas
- Renewable Resources (wind, solar, biomass)
- Nuclear
- Coal (with carbon sequestration)

Diverse Applications
- Fuel
  - Fuel Cells
  - Engines/Turbines
  - Energy Storage
- Chemical
  - Petroleum Recovery & Refining
  - Methanol Production
  - Electronics
  - Ammonia Production
  - Metal Production & Fabrication
  - Food Processing
  - Cosmetics

Hydrogen Clean Energy Carrier

Central
- Natural Gas Reforming
- Biomass Gasification
- Coal Gasification With CCS
- Electrolysis (wind)
- Electrolysis (solar)

Distributed
- Hydrogen Production
  - Natural Gas Reforming
  - Electrolysis (Grid)
  - Bio-Derived Liquids

Estimated Plant Capacity (kg/day)
- Up to 1,500
- 50,000
- 100,000
- ≥500,000

FE, NE R&D efforts in DOE Offices of Fossil and Nuclear Energy, resp.

HTAC Subcommittee: H₂ Production Expert Panel
Review underway to provide recommendations to DOE
Two Main Options for Low-cost Early Infrastructure

1. Hydrogen delivered from central site
   - Low-volume stations (~200-300 kg/day) would cost <$1M and provide hydrogen for $7/gge (e.g., high-pressure tube trailers, with pathway to $5/gge at 400–500 kg/day- comparable to ~$2.10/gallon gasoline untaxed)

2. Distributed production (e.g. natural gas, electrolysis)

Other options

1. Co-produce H₂, heat and power (tri-gen) with natural gas or biogas
2. Hydrogen from waste (industrial, wastewater, landfills)
**Technology Validation**

**Completed world’s largest single FCEV & H₂ Demonstration to date (50-50 DOE-Industry cost share)**

- >180 fuel cell vehicles and 25 hydrogen stations
- 3.6 million miles traveled; 500,000 trips
  - ~152,000 kg of hydrogen produced or dispensed; >33,000 refuelings

<table>
<thead>
<tr>
<th>Technology Validation Status</th>
<th>Project Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Durability</strong></td>
<td>~2,500</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>196 – 254*</td>
</tr>
<tr>
<td><strong>Efficiency</strong></td>
<td>53 – 59%</td>
</tr>
<tr>
<td><strong>Refueling Rate</strong></td>
<td>0.77 kg/min</td>
</tr>
</tbody>
</table>

**Demonstrated world’s first Tri-generation station**

- Anaerobic digestion of municipal wastewater (Orange County Sanitation District)
- Produces 100 kg/day H₂; generates ~ 250 kW; 54% efficiency co-producing H₂ and electricity
- Nearly 1 million kWh of operation
- >4,000 kg H₂ produced (Air Products, FuelCell Energy)

**Demonstrated H₂ for Energy Storage (NREL)**

- Showed PEM and alkaline electrolysers provide grid frequency regulation, 4X faster than ‘control’ with no electrolysers
- Achieved 5,500 hrs of variable electrolyzer stack operation to determine effects of wind AC power on stack degradation

Air Products UTC Power Daimler
Hyundai GM BP
Chevron Ford KIA

*Independently validated a vehicle that can achieve a 430 mile range.*
Market Transformation: Addressing Market Barriers

Deployments help ensure continued technology utilization growth and catalyze market penetration while providing data and lessons learned.

ARRA Deployment Status

<table>
<thead>
<tr>
<th>Fuel Cell Application</th>
<th>Operational Fuel Cells</th>
<th>Total Fuel Cells Planned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backup Power</td>
<td>668</td>
<td>539</td>
</tr>
<tr>
<td>Material Handling</td>
<td>504</td>
<td>504</td>
</tr>
<tr>
<td>Stationary</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>APU</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,172</strong></td>
<td><strong>&gt;1,000</strong></td>
</tr>
</tbody>
</table>

DOE: $42 M  
Cost-share: $54 M  
Total: $96 M

ARRA Material Handling Equipment Data  
As of 12/31/2011

- Hydrogen Dispensed: 99,650 kg
- Hydrogen Fills: >148,250
- Hours Accumulated: >959,880 hrs

MORE THAN 3,500 ADDITIONAL FUEL CELL LIFT TRUCKS PLANNED OR INSTALLED with NO DOE funding

Deployment Locations

Number of FC Units in State/Site

NREL ARRA Data Collection Snapshot

- Coca-Cola
- Whole Foods
- Sprint
- FedEx
- AT&T
- Genco
- Sysco
- Wegmans
**Market Transformation - Early Market Deployment Summary**

Early market deployments of approximately 1,400 fuel cells have led to more than 5,000 additional purchases by industry—with no further DOE funding.

**Backup Power Units**
- ~730 total DOE cost-shared deployments
- >1,300 purchases without DOE investment*

**Lift Truck Deployments**
- >3,500 purchases without DOE investment*
- ~700 total DOE cost-shared deployments

**Leveraging DOE funds:**

- **Backup Power Units**: DOE deployments led to almost 2X additional purchases by industry.
- **Lift Truck Deployments**: DOE deployments led to >5X additional purchases by industry.

**Recovery Act and Market Transformation Activities – Government as “Catalyst” for market success of emerging technologies**

*Indicates purchases include units on order.
**Goals:** Support the widespread commercialization of hydrogen and fuel cells by facilitating development of regulations, codes, and standards (C&S), and by developing and implementing practices to ensure the safe use of hydrogen and fuel cell technologies.

**Approach**

- **Identify R&D needs**
  - Lead stakeholder workshops, develop R&D roadmaps
  - Analyze existing codes and standards, safety knowledge
  - Participate in technical working groups

- **Perform High-Priority R&D**
  - Understand foundational hydrogen behavior
  - Quantitative Risk Assessments
  - Compatible materials and components
  - Develop and harmonize test protocols

- **Impact Codes and Standards**
  - Participate in and lead technical committees to develop requirements
  - Publish R&D results

**Harmonize Internationally**

- Global Technical Regulations (GTR Phase 1-SAE J2578, SAE J2579)
- International Standards Development Organizations (e.g., ISO, IEC)
- International Partnerships and Agreements (IPHE, IEA)

**Key challenges include:**

- Need to synchronize codes and standards development with technology deployment needs
- Need to standardize the permitting process for H₂ infrastructure
- Lack of sufficient hydrogen safety information (e.g., best practices and frequency data)
Examples of Accomplishments:

- Provided technical data and incorporated a risk-informed approach that enabled NFPA2 to update bulk gas storage separation distances.
- Implemented a science-based approach to develop an ISO standard for hydrogen fuel quality (standard approved).
- Demonstrated >50,000 cycles of metals tanks for forklift applications.
- Launched international round robin testing of Type IV tanks.

National template developed to delineate and coordinate critical roles of standards and model code development organizations

www1.eere.energy.gov/hydrogenandfuelcells/codes/standards_organization.html
Example Project Areas

Fast-Fill Model Validation (SNL, China):

**Motivation**
- A variety fill models exist, some proprietary
- A generalized, validated model provides a comparative standard
- Current data may be inadequate to fully validate a model

**Experimental Approach**
- Current Standards (SAE 2579, GTR, EIHP)
  - Perform hydrogen filling experiments at specified and relevant pressure ramp rate while the following measurements are made:
    - The transient gas pressure in the tank
    - The total enthalpy of hydrogen entering the tank
    - The transient mass flow rate of hydrogen entering the tank
    - The final uniform temperature and pressure in the tank after fill
    - The transient mass-averaged gas temperature in the tank

Fuel Quality (LANL):

ISO TC 197 Working Group 12
- FDIS Draft Submitted in Nov 2011

SAE J2719
- Hydrogen Quality Guidelines for Fuel Cell Vehicles
  (Published Sept 2011)

ASTM (D7653-10)
- Determination of Trace Gaseous Contaminants in Hydrogen Fuel by Fourier Transform Infrared (FTIR) Spectroscopy

Materials Compatibility (SNL, Japan):

- Completion of standards through committee leadership and data evaluation
  - CSA HPIT1 completed Sept. 2011
  - CSA CHMC1 (Part 1) published early 2012
  - SAE J2579 progress reported at ICHS conference Sept. 2011
  - ASME KD-10

\[ \begin{align*}
\text{Crack growth rate, } \frac{da}{dN} & \text{ (mm/cycle)} \\
\sigma & \text{ (MPa) } \\
K & \text{ (MPa m}^{1/2}\text{)} \\
\end{align*} \]

\[ \begin{align*}
5 & \times 10^{-3} \\
10 & \times 10^{-3} \\
20 & \times 10^{-3} \\
50 & \times 10^{-3} \\
\end{align*} \]

\[ \begin{align*}
34CrMo4 & \text{ 45 MPa } H_2 f=1 Hz R=0.1 \\
34CrMo4 & \text{ 45 MPa } H_2 f=10 Hz R=0.1 \\
\end{align*} \]

Sensors (NREL, LANL, LLNL, & EC):

- Working group participation on national and international sensor test standards
  - ISO
  - UL
  - FM

- International Collaboration (NREL/JRC-IET) MOU
  - Oxygen dependence
  - Assess improvements/degradations MEMs sensor
    - Team expanded to include Univ. of Quebec
  - Hydrogen detection via oxygen displacement
Full-scale pressure vessel testing support CSA HPIT1 standard development

- Engineered defects used to evaluate defect tolerance
- Vessels cycled to failure or up to 50,000 cycles
- Cycle-life compared to ASME design calculations for hydrogen pressure vessels
- Materials testing in gaseous hydrogen also performed
- All observed failures were leak-before-break
- Cycle-life calculations (with engineered defects) are conservative by factor of 4 or more
- Results used to justify design requirements in CSA HPIT1 standard

Proposed design requirements
- Quench and tempered Cr-Mo steels
- $S_{\text{ult}}$ (ultimate strength) ≤ 890 MPa
- hoop stress ≤ 0.4 $S_{\text{ult}}$
Progress: Safety Knowledge Tools

- 206 Lessons Learned events in "H2Incidents.org"
- Approximately 750 entries in the Hydrogen Safety Bibliographic Database

www.eere.energy.gov/hydrogenandfuelcells/codes/

Developed training material for first responders, code officials. Educated > 23,000 to-date (online & in-person)
Roadmap Milestones - Examples

**FY 2011**
- NFPA 2 (Hydrogen Technologies Code) published
  *(Separation Distances for bulk storage updated)*
- 4th International Conference on Hydrogen Safety (ICHS), US

**FY 2012**
- Risk analysis: indoor refueling & operation of industrial trucks *(for CSA HPIT1)*
- SAE J2601 submission as a standard
- UN Global Technical Regulation (GTR) for H2 fueled vehicles *(harmonized with SAE J2579)*
- International Standard ISO14687–2: Hydrogen fuel product specification

**FY 2013**
- Validate fast-fill model, SAE J2601 updated
- H2 specific requirements for public parking garages *(NFPA 2 2014 edition)*
- UN Global Technical Regulation approved by UN ECE WP 29 *(anticipated)*

**FY 2014**
- 5th International Conference on Hydrogen Safety (ICHS), EU
Developed Interagency Action Plan with 10 Federal Agencies (Interagency Working Group)

December 2011

Developed Procurement Guide (ORNL)
Provides guidance on CHP technology – its benefits, ideal usage, and financing options.

Published States Report (Joel M. Rinebold, et al, Connecticut Center for Advanced Technology (CCAT))
Identified numerous opportunities for fuel cells for different applications.
>1.8 GW opportunity identified.

California (CaFCP)
Identified infrastructure requirements for commercial FCEV launch (“tipping point” is 68 stations)

Developed Roadmaps for Northeastern States (CCAT)
Hydrogen and Fuel Cell Initiatives at the State Level

Several states—including California, Connecticut, Hawaii, Ohio, New York, and South Carolina—have major hydrogen and fuel cell programs underway.

California

FCEVs and Fuel Cell Buses

- > 450 vehicles in operation since 1999 — ~200 currently operating
- ~ 4.3 million miles driven
- > 1 million passengers on fuel cell buses

Investment in Hydrogen Stations

- 20 stations — including planned/funded
- ~$34M invested (C.A.R.B. and C.E.C.) — with ~$23M industry cost share
- ~$18M planned for future solicitations

Industry’s Plans for FCEV Sales in CA (based on 2010 survey of automakers)

New York

Plans 100 hydrogen stations (70 city, 30 highway) by 2020 to support minimum of 50,000 FCEVs — plan starts in 2015 with 1500 vehicles and 20 stations

- Industry Investment: Six auto companies plan total investment of nearly $3.0 Billion
- State Investment: NY developing plans to provide $50M to support infrastructure rollout while leveraging >$165M in Federal vehicle incentives for initial FCEV commercial deployment

Hawaii

Agreement signed by 12 stakeholders—including GM, utilities, hydrogen providers, DOD, DOE—to establish hydrogen as a major part of the solution to Hawaii’s energy challenges.

- 15 GM FCEVs currently in demonstrations with military

- Renewable hydrogen (from geothermal and wind energy) will be used for buses
- Goals include 20-25 stations on Oahu by 2015 to support annual sales of up to 5,000 FCEVs in early years.
Published more than 40 news articles so far in 2012 (including blogs, progress alerts, and DOE FCT news alerts)

Communication and Outreach Activities include:

• Webinar Series:
  • 2012 Student Design Contest Winners
  • Storage Vessels for Fuel Cell Forklifts
  • Fuel Cells for Portable Power
  • BNL's Low-Platinum Electro catalysts for FCEVs

• News Items:
  • New Energy Department Report Shows Strong Growth in the Fuel Cell Market in 2011
  • DOE Issues "State of the States: Fuel Cells in America 2012"

• Monthly Newsletter

Blogs and Social Media:

• Winners of Hydrogen Student Design Contest Turn Urban Waste into Energy

• Multiple DOE-EERE Facebook and Twitter posts

Progress in low and zero Pt catalysts highlighted in Science

Hydrogen power lights at the 2011 Golden Globes

Hydrogen fuel cells providing critical backup power

"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."
Collaborations

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

- Interagency coordination through staff-level Interagency Working Group (meets monthly)
- Assistant Secretary-level Interagency Task Force mandated by EPACT 2005.

External Input
- Annual Merit Review & Peer Evaluation
- H2 & Fuel Cell Technical Advisory Committee
- National Academies, GAO, etc.

Industry Partnerships & Stakeholder Assn’s.
- Tech Teams (U.S. DRIVE)
- Fuel Cell and Hydrogen Energy Association (FCHEA)
- Hydrogen Utility Group
- ~ 65 projects with 50 companies

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

University Partnerships
- ~ 50 projects with 40 universities

International
- IEA Implementing agreements – 25 countries
- International Partnership for Hydrogen & Fuel Cells in the Economy – 17 countries & EC

National Laboratories
- National Renewable Energy Laboratory
  P&D, S, FC, A, SC&S, TV, MN
- Argonne
  A, FC, P&D, SC&S
- Los Alamos
  S, FC, SC&S
- Sandia
  P&D, S, SC&S
- Pacific Northwest
  P&D, S, FC, SC&S, A
- Oak Ridge
  P&D, S, FC, A, SC&S
- Lawrence Berkeley
  FC, A
- Lawrence Livermore
  P&D, S, SC&S
- Savannah River
  S, P&D
- Brookhaven
  S, FC
- Idaho National Lab
  P&D

External Input: Jet Propulsion Lab, National Institute of Standards & Technology, National Energy Technology Lab (NETL)

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

International Partnership for Hydrogen and Fuel Cells in the Economy

- Representatives from 17 member countries & the European Commission
- Facilitates international collaboration on RD&D and education
- Provides a forum for advancing policies and common codes and standards
- Guided by four priorities:
  1. Accelerating market penetration and early adoption of hydrogen and fuel cell technologies and their supporting infrastructure
  2. Policy and regulatory actions to support widespread deployment
  3. Raising the profile with policy-makers and public
  4. Monitoring technology developments

Recent Activities:
- Published a brochure on the status of research and commercialization of H₂ and FCs.
- IPHE Infrastructure Workshop (Sacramento, 2010)
- Published Demonstration and Deployment Map
- Published Communiqué on the opportunities associated with using hydrogen and fuel cell technologies
- Fuel Cell Cost Analysis Comparison Published

Website: http://www.iphe.net

International Energy Agency – Implementing Agreements

Advanced Fuel Cells Implementing Agreement: 19 member countries currently implementing six annexes

Hydrogen Implementing Agreement: 21 member countries, plus the European Commission currently implementing nine tasks

Other Collaborations

Joint Technology Initiative (JTI); MOUs (NEDO-AIST-LANL, Hiroshima U-LANL);
Bi-lateral agreements, strong international collaboration on safety
Continue to promote and strengthen R&D activities

– Hydrogen, fuel cells, safety, codes and standards, etc.

Conduct strategic, selective demonstrations of innovative technologies

– Technology validation – solicitation planned

Continue to conduct key analysis to guide RD&D and path forward

– Life cycle cost; economic & environmental analyses, etc.

Leverage activities to maximize impact

– U.S. and global partnerships

Safety, codes & standards is critical across the entire Program.
**World Class Researchers - Examples**

**Professor Thomas Jaramillo (Stanford)** received a 2012 Presidential Early Career Award for Scientists & Engineers (PECASE). PECASE is the highest honor bestowed by the U.S. government on outstanding scientists and engineers who are early in their independent research careers. Jaramillo is the first ever EERE awardee.

**Dr. Adam Weber (LBNL) and Professor Vijay Ramani (IIT)** honored as Energy Technology Division Supramaniam Srinivasan Young Investigator Award from The Electrochemical Society in Seattle.

**Professor Scott Samuelsen (UC Irvine)** named a White House Champion of Change for his work as Director of the Advanced Power and Energy Program and the National Fuel Cell Research Center.

**Dr. Fernando Garzon (LANL)** was elected President of the National Electrochemical Society (ECS).

**Dr. Radoslav Adzic (BNL)** honored as 2012 Inventor of the Year by the NY Intellectual Property Law Association.

**Other Presidential Awardees:**

- **Professor Susan Kauzlarich** – UC Davis, a 2009 recipient of the *Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring*—and a partner of the Chemical Hydrogen Storage Center of Excellence

- **Dr. Jason Graetz** – Brookhaven National Laboratory, a 2009 recipient of the *Presidential Early Career Award for Scientists and Engineers*—and a partner of the Metal Hydride Center of Excellence

- **Dr. Craig Brown** – NIST, a 2009 recipient of the *Presidential Early Career Award for Scientists and Engineers*—and a Partner of the Hydrogen Sorption Center of Excellence
Thank You

Sunita.Satyapal@ee.doe.gov

To add additional information on data and deployments, please email:

fuelcelldatacenter@ee.doe.gov

fuelcelldeployments@ee.doe.gov

hydrogenandfuelcells.energy.gov