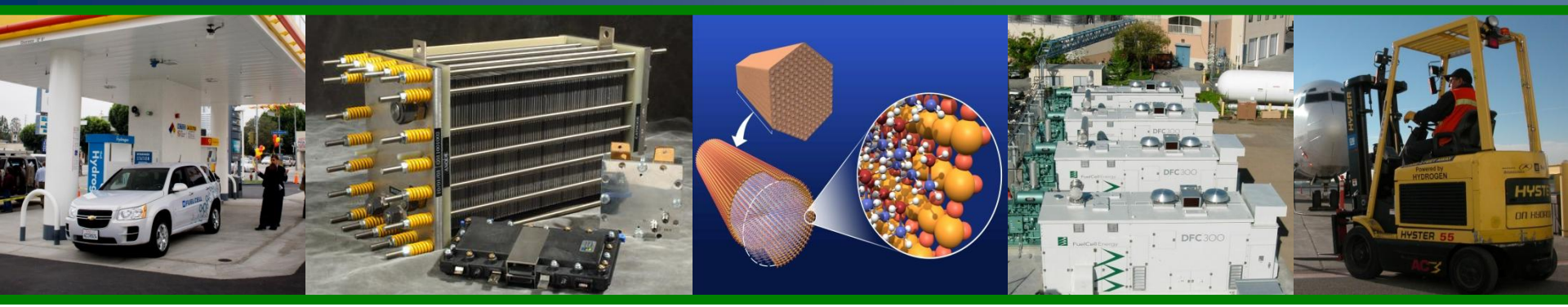
U.S. DEPARTMENT OF ENERGY




# Hydrogen & Fuel Cells
# - Program Overview -

***Sunita Satyapal***

***Program Manager***

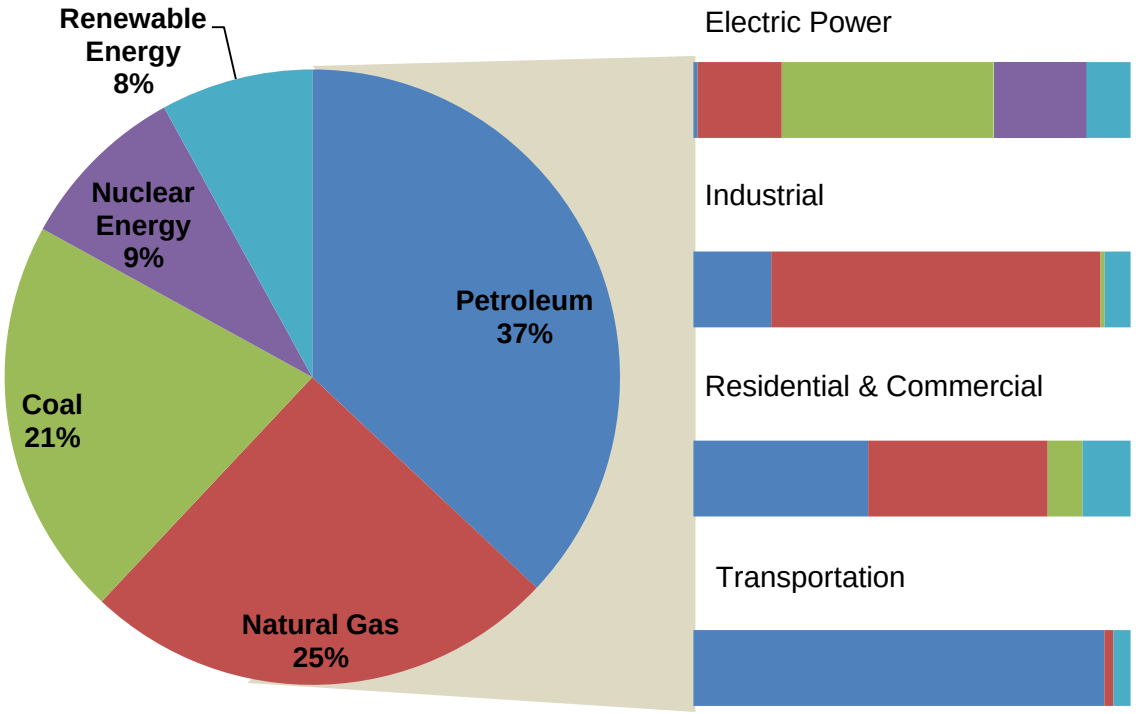
***2012 Annual Merit Review and Peer Evaluation Meeting***

***May 14, 2012***

# U.S. Energy Consumption

U.S. DEPARTMENT OF ENERGY

## U.S. Primary Energy Consumption by Source and Sector

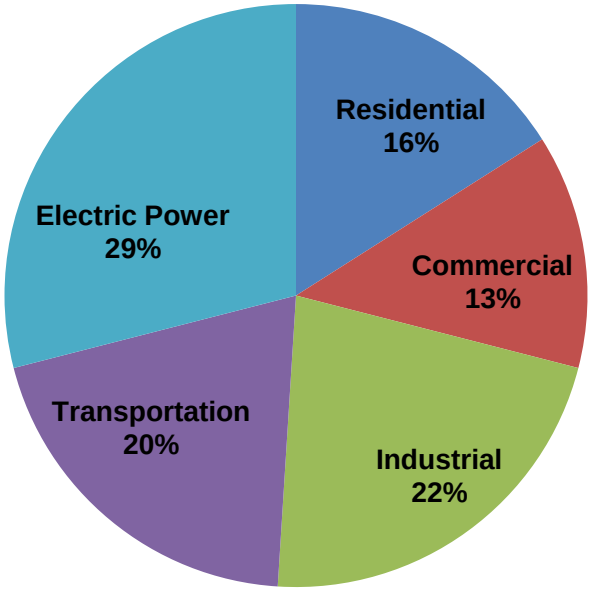



**Total U.S. Energy = 98 Quadrillion Btu/yr**

Source: Energy Information Administration, *Annual Energy Review 2010,* Table 1.3

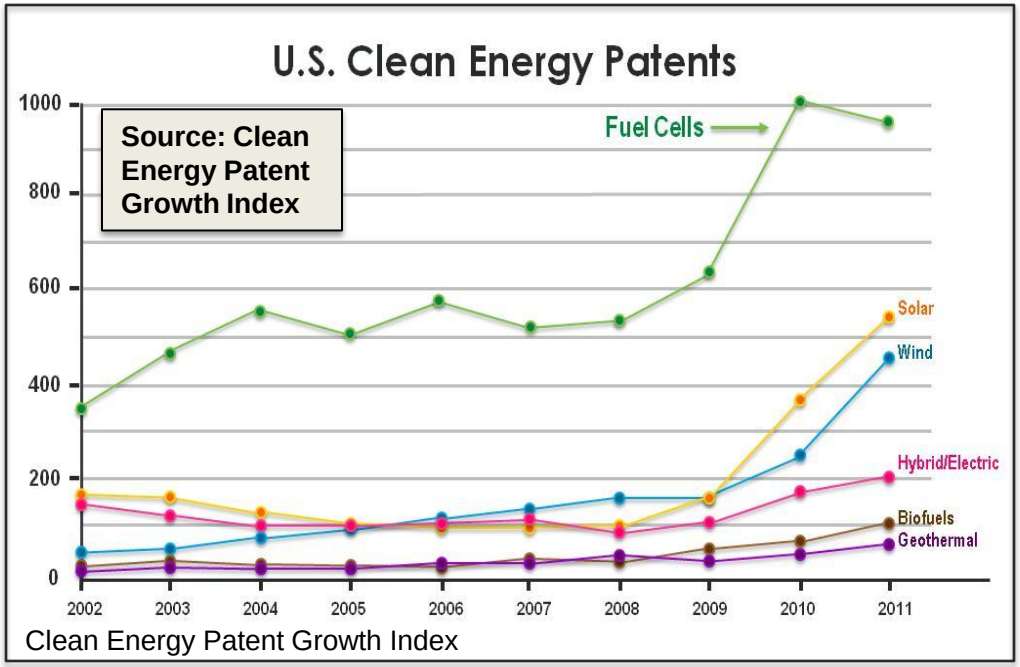
**Fuel Cells can apply to diverse sectors**

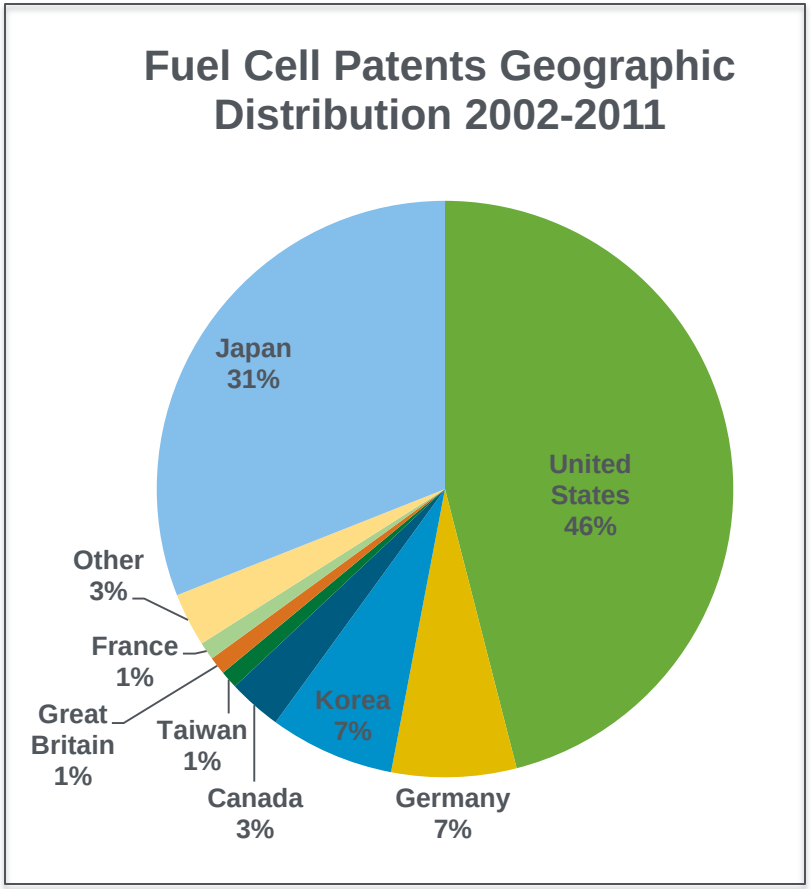
**Share of Energy Consumed by Major Sectors of the Economy, 2010**



# Fuel Cells – An Emerging Global Industry

U.S. DEPARTMENT OF ENERGY




**Top 10 companies: GM, Honda, Samsung, Toyota, UTC Power, Nissan, Ballard, Plug Power, Panasonic, Delphi Technologies**

**Clean Energy Patent Growth Index[1] shows that fuel cell patents lead in the clean energy field with over 950 fuel cell patents issued in 2011.**

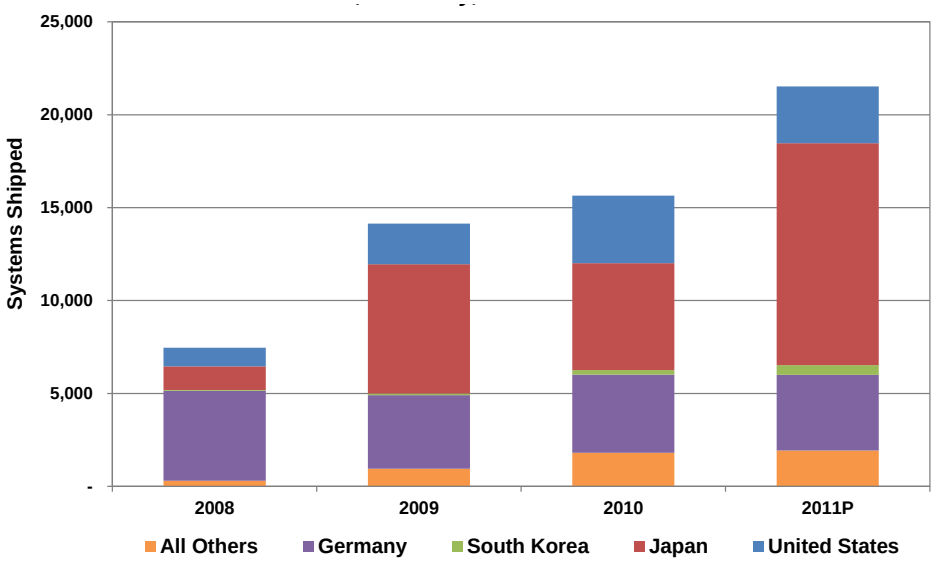
- **Nearly double the second place holder, solar, which has ~540 patents.**

[1] http://cepgi.typepad.com/files/cepgi-4th-quarter-2011-1.pdf

# Fuel Cell Market Overview

U.S. DEPARTMENT OF ENERGY

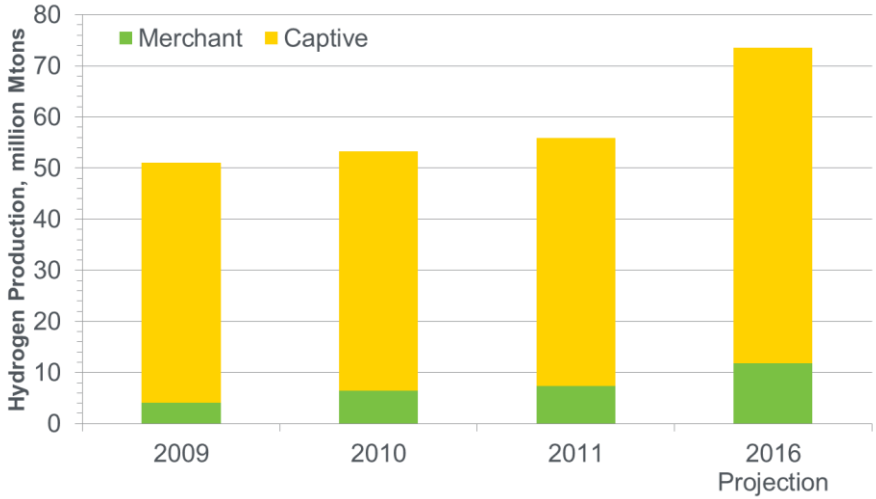
**System Shipments by Key Countries: 2008-2011**




**The fuel cell market remains strong with over 20,000 systems shipped in 2011, a > 35% increase over 2010[1]**

**~3X increase in VC/private equity fuel cell funding in just one year ($113M).***

**Global Hydrogen Production Market 2009 – 2016 (million metric tons)**




**The global hydrogen market is also robust with over 55 Mtons produced in 2011 and over 70 Mtons projected in 2016, a > 30% increase.**

**Sources: FuelCells2000, Pike Research, Markets & Markets**

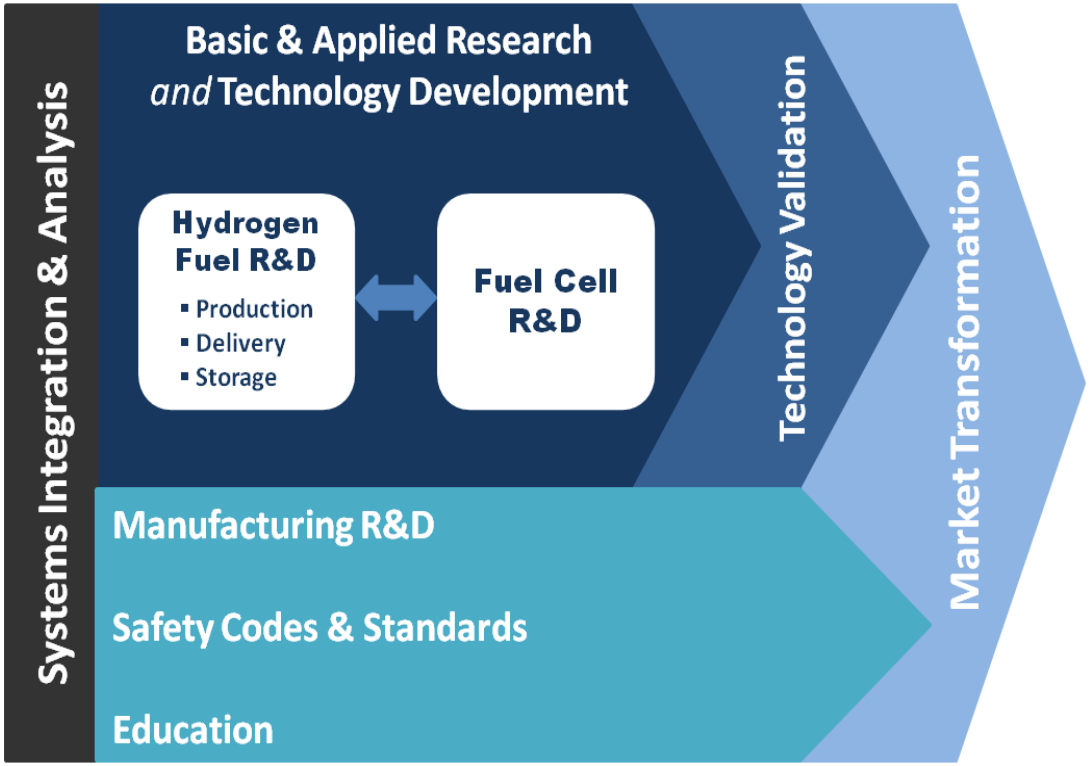
[1]FCT Market Report to be published in June 2012.

*by Top 10 Investors

# DOE Program Structure

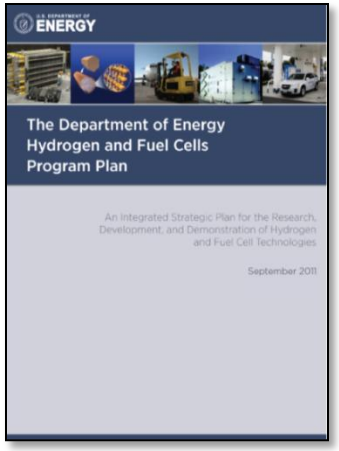
U.S. DEPARTMENT OF ENERGY

***The Program is an integrated effort, structured to address all the key challenges and obstacles facing widespread commercialization.***




**WIDESPREAD COMMERCIALIZATION ACROSS ALL SECTORS**

- Transportation
- Stationary Power
- Auxiliary Power
- Backup Power
- Portable Power




**Released September 2011**
**Update to the Hydrogen Posture Plan (2006)**
**Includes Four DOE Offices**
**EERE, FE, NE and Science**

***Nearly 300 projects currently funded***

***at companies, national labs, and universities/institutes***

***More than $1B DOE funds spent from FY 2007 to FY 2011***

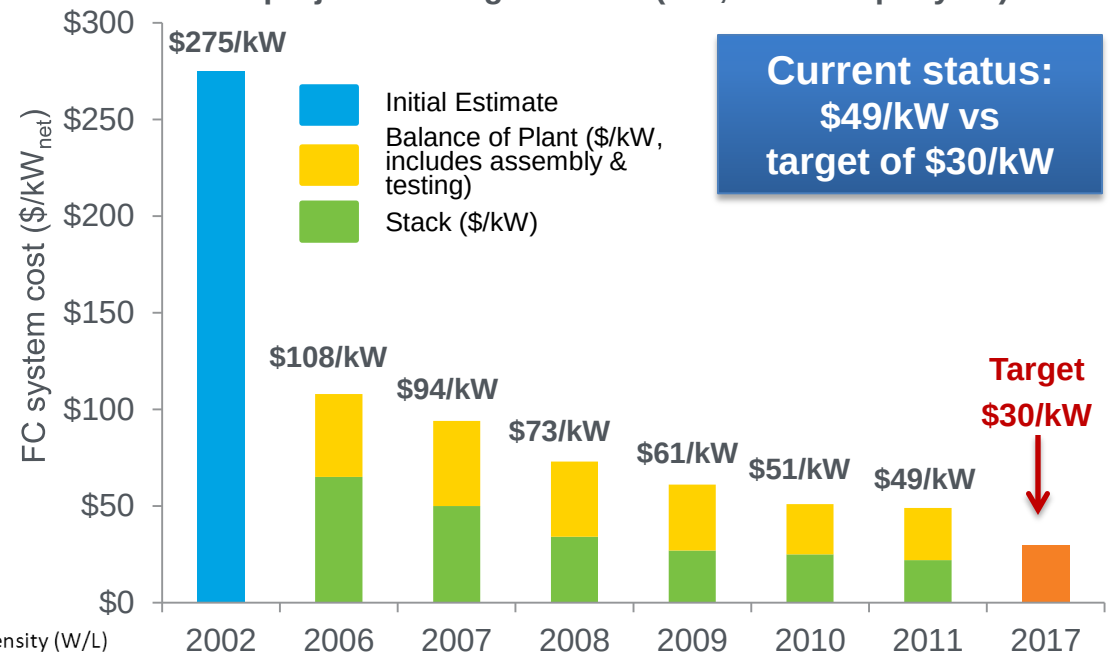
# Fuel Cell R&D

U.S. DEPARTMENT OF ENERGY

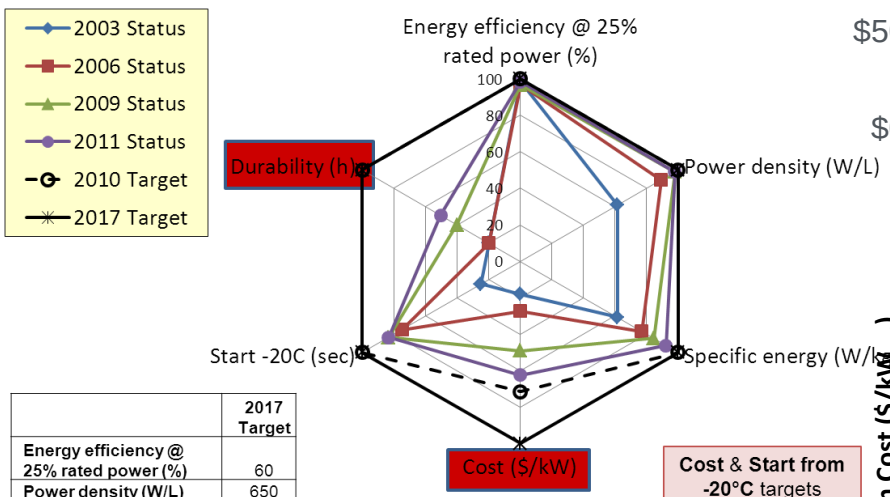
## Reduced projected high-volume cost of fuel cells to $49/kW (2011)*

- ***Reduced Pt by a factor of 5 since 2002***
- ***More than 30% reduction since 2008. More than 80% reduction since 2002***

**Projected Transportation Fuel Cell System Cost**
**-projected to high-volume (500,000 units per year)-**



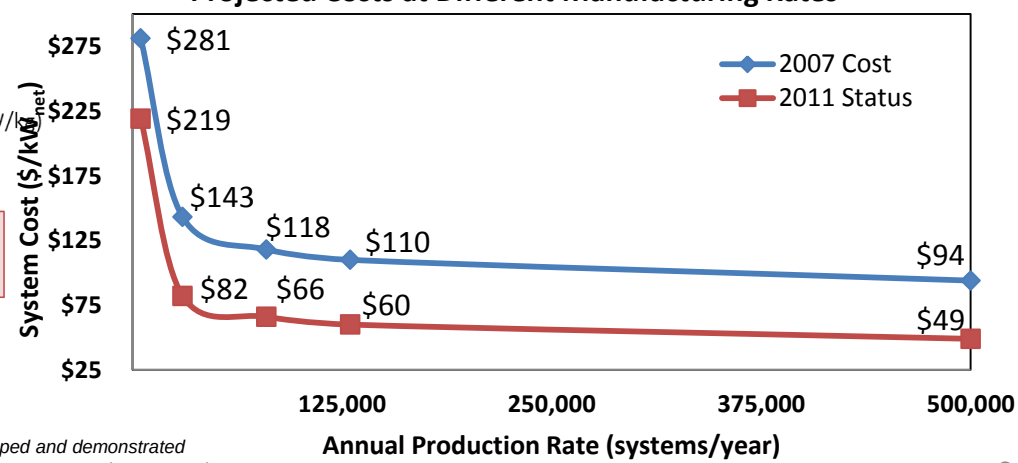

**Current status: $49/kW vs target of $30/kW**




| | 2017 Target |
|---|---|
| Energy efficiency @ 25% rated power (%) | 60 |
| Power density (W/L) | 650 |
| Specific energy (W/kg) | 650 |
| Cost ($/kW) | 30 |
| Start from -20°C (sec) | 15 |
| Durability (h) | 5000 |

**Cost & Start from -20°C** targets plotted as 1/target

**Projected Costs at Different Manufacturing Rates**

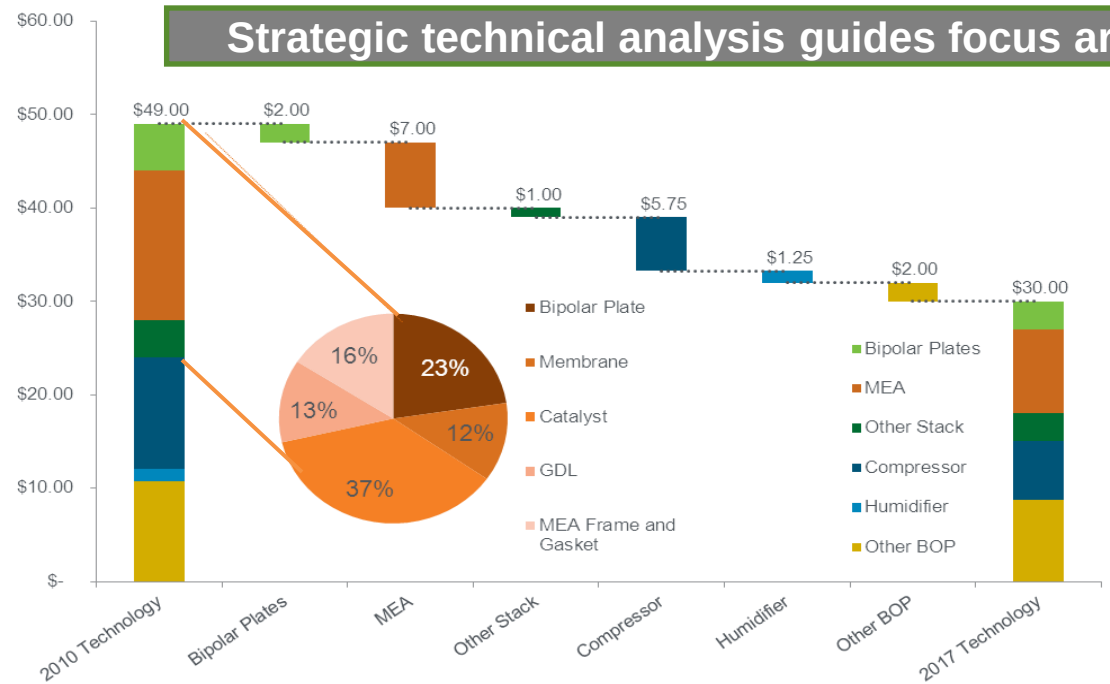



***Based on projection to high-volume manufacturing (500,000 units/year).***
*The projected cost status is based on an analysis of state-of-the-art components that have been developed and demonstrated through the DOE Program at the laboratory scale. Additional efforts would be needed for integration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

# Portfolio Focuses on High Impact Areas

U.S. DEPARTMENT OF ENERGY

## Strategic technical analysis guides focus areas

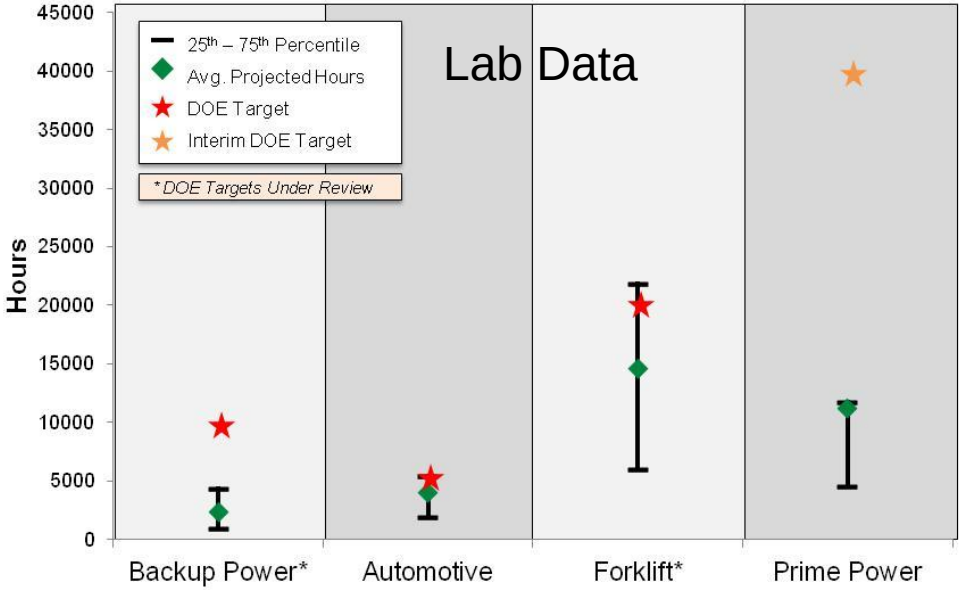



### Strategies to Address Challenges Catalyst Examples

- Lower PGM Content
- Pt Alloys
- Novel Support Structures
- Non-PGM catalysts

**Accomplishment Highlights:**

- **Catalysts meet durability milestones of 5,000 start up/shut down cycles and 200 cell reversals with total PGM loading < 0.135 mg/cm² (3M)**
- **Successfully completed 8,000 hrs desulfurizer testing and 1,000 hrs CPOX reformer testing as part of 1 MW SOFC powerplant concept running on pipeline natural gas (Rolls Royce Fuel Cell Systems)**
- **Launched cost studies for non-automotive applications, developed new fuel cell targets**




Source: DOE/NREL

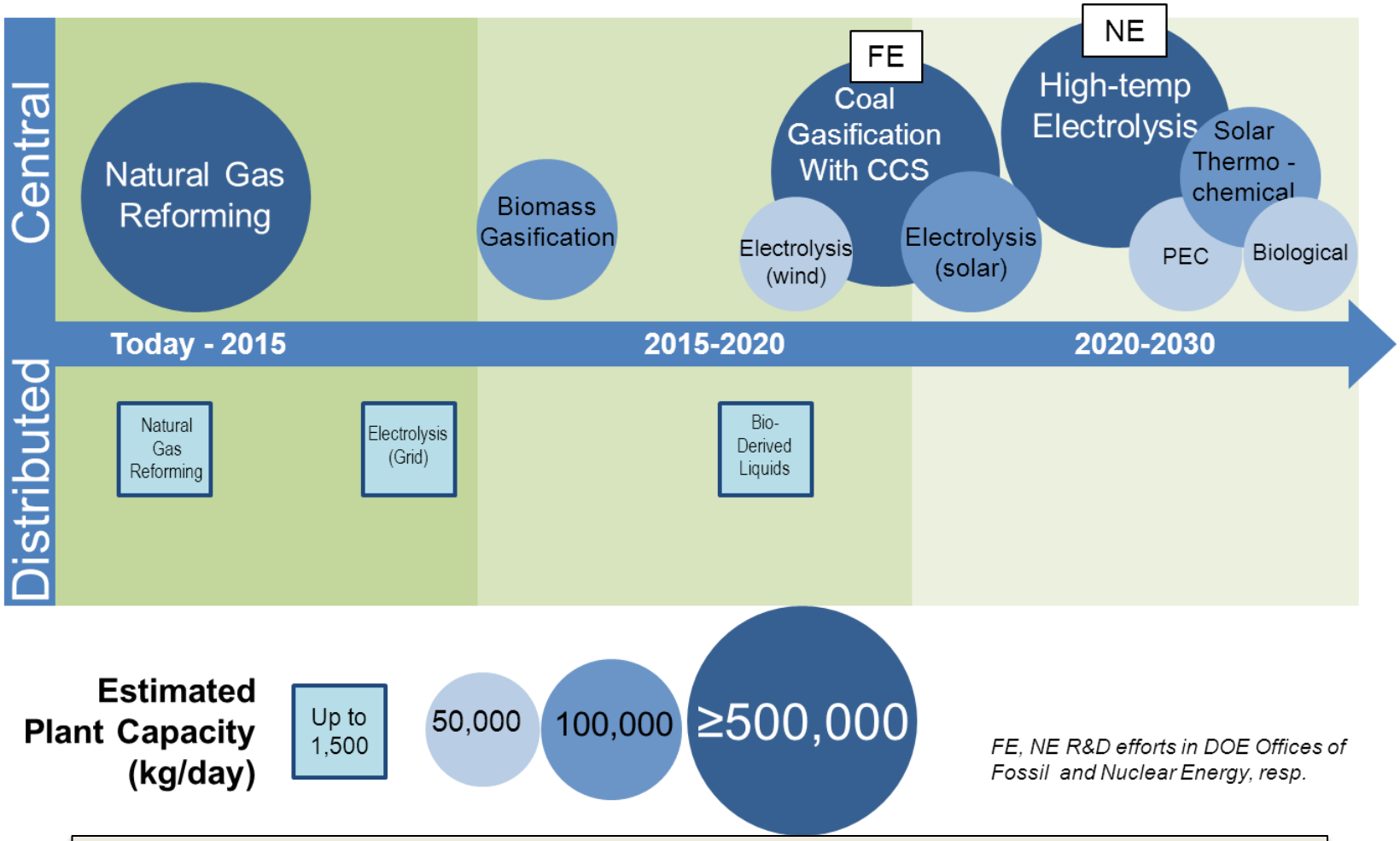
**Aggregated results provide a benchmark in time of state-of-the-art fuel cell durability** (time to 10% voltage degradation). Results include > 80 data sets from 10 fuel cell developers.

**Please email Fuelcelldatacenter@ee.doe.gov**

# Hydrogen Production - Strategies

U.S. DEPARTMENT OF ENERGY

***Develop technologies to produce hydrogen from clean, domestic resources at a delivered and dispensed cost of $2-$4/gge $H_2$ by 2020***




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

**HTAC Subcommittee: $H_2$ Production Expert Panel Review underway to provide recommendations to DOE**

# $H_2$ Production & Delivery

U.S. DEPARTMENT OF ENERGY

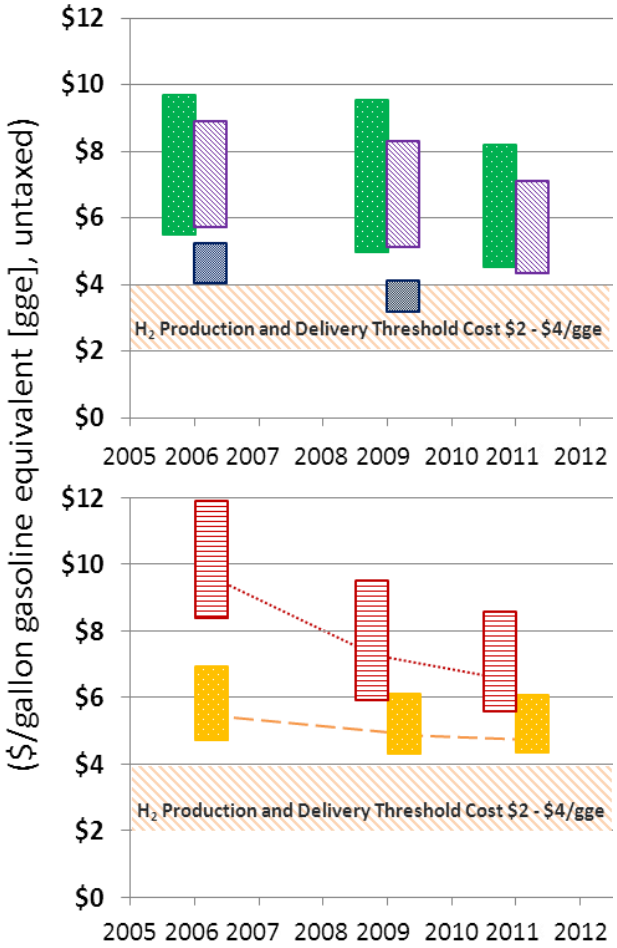
## Projected High-Volume Cost of Hydrogen Production[1] (Delivered[2])—Status

**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
  *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] 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).

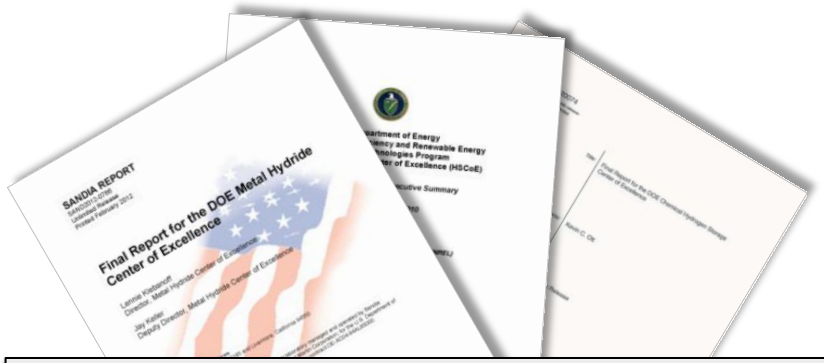
## Accomplishment Highlights:

- **Updated H2A cost analysis tool. (NREL)**
- **Demonstrated high pressure electrolysis (>2,000 psig). (Proton OnSite, Giner)**
- **2-fold increase for fermentative $H_2$ production. (NREL)**
- **18% increase in H2 payload capacity compared to FY11, exceeding 2015 DOE target (700 kg of $H_2$). (Lincoln Composites)**
- **> 40% reduction in the projected tube trailer transport cost relative to the incumbent steel vessels. (Lincoln Composites)**

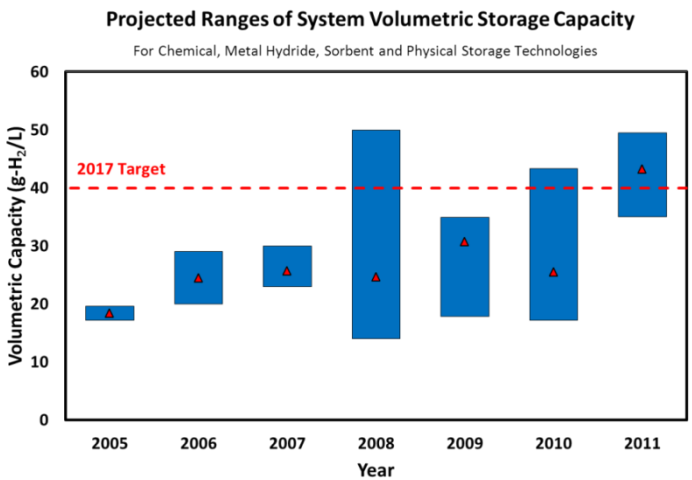
| Delivery Element | 2011 Status* | Goal (2015 Targets)** |
|---|---|---|
| Tube trailers | • Capital cost: $930/kg of $H_2$ transported<br>• Capacity: 616 kg $H_2$ at 250 bar | • Capital cost: < $730/kg of $H_2$ transported<br>• Capacity: 700kg |
| Forecourt storage*** | • Storage tank cost: $1000 - $1450/kg $H_2$ for low to high pressure storage. | • Storage tank cost: $850 - $1200/kg $H_2$ for low to high pressure storage respectively. |

* High volume projections based on the latest data employed in HDSAM (v. 2.3)
** Based on the new DOE-FCTP MYRD&D technical targets for Delivery.
***1,000 kg/day station

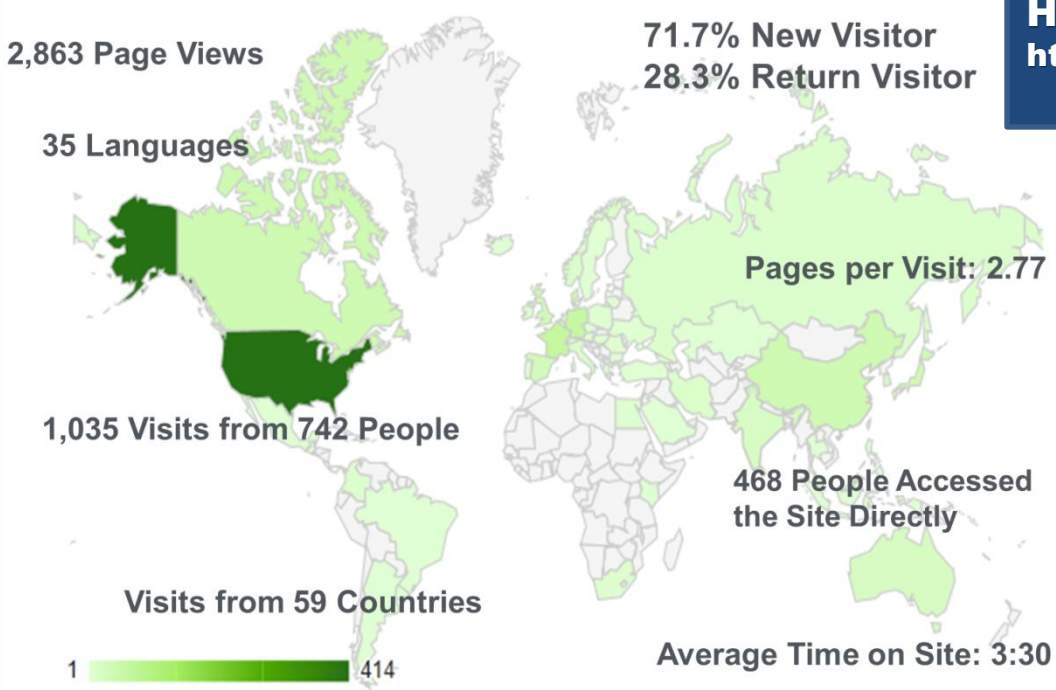
# Hydrogen Storage



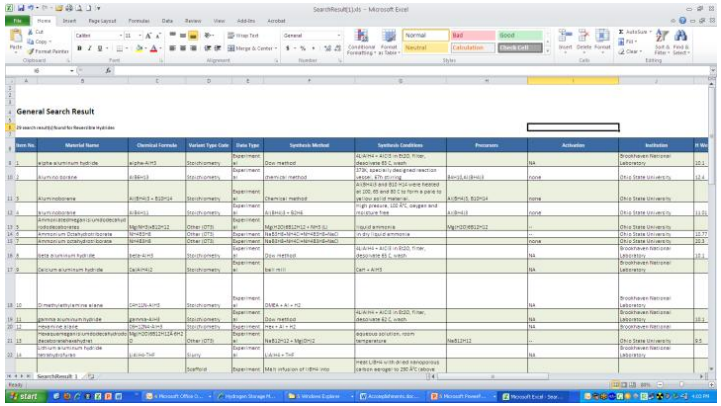

Final Reports and Executive Summaries from the 3 Hydrogen Storage Materials Centers of Excellence available online.
**http://www1.eere.energy.gov/hydrogenandfuelcells/hydrogen_publications.html#h2_storage**




**Launched open source database* on Hydrogen Storage Materials Properties:**
**http://hydrogenmaterialssearch.govtools.us/**




*Still looking to populate it with more data!*




* Presented to President's Materials Genome Initiative Interagency Working Group

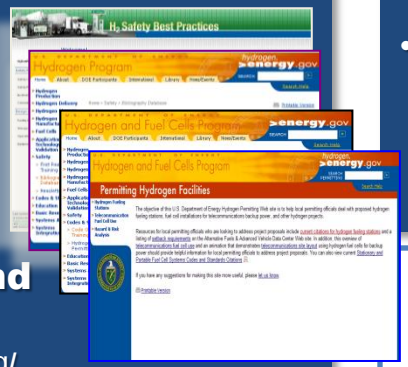
# Safety, Codes & Standards & Manufacturing R&D

U.S. DEPARTMENT OF ENERGY

## Safety, Codes & Standards R&D

**Accomplishment Highlights:**

- **Submitted Global Technical Regulation to the U.N. for Dec 2012 approval**
- **Demonstrated up to 50,000 refuelings of metal tanks for forklift applications**
- **Launched international round robin to harmonize test measurement protocols for high pressure vessels**
- **Published Online Permitting Compendium and Safety Information Tools**
  http://www.hydrogen.energy.gov/permitting/



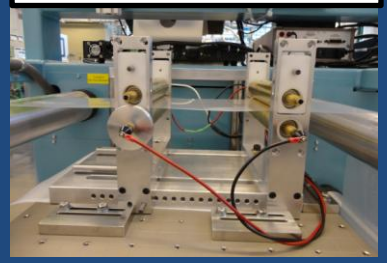

Hydrogen Safety Bibliographic Database
Permitting Hydrogen Facilities
Introduction to Hydrogen for Code Officials
Hydrogen Safety Best Practices Manual
Incidents Database and Lessons Learned

- **Trained > 23,000 first-responders and code officials on hydrogen safety and permitting through on-line and in-classroom courses**

## Manufacturing R&D

- **Scaled up in-line diagnostics for MEA component quality control to 10 - 30 ft/min (NREL)**

IR/Direct Current



- **Used ultrasonic sealing of MEAs to provide rapid bonding and the potential for cost savings of >90% compared to thermal sealing (RPI)**

**NREL Hydrogen & Fuel Cells Manufacturing R&D Workshop**

*Reps from industry, academia, lab, and government identified and prioritized needs and barriers to manufacturing. Output from the workshop was used to update the MYRD&D plan and will inform a future funding opportunity* in FY13.*

**Element One, Inc. named Runner-up in DOE's America's Next Top Energy Innovator Challenge**

*Element One has created revolutionary "smart" coatings for the detection of hydrogen that change color (reversible or non-reversible) to provide information about hydrogen leaks.*

*Subject to appropriations

# Technology Validation

U.S. DEPARTMENT OF ENERGY

## Completed world's largest single FCEV & $H_2$ 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

| | Status | Project Target |
|---|---|---|
| Durability | ~2,500 | 2,000 |
| Range | 196 – 254* | 250* |
| Efficiency | 53 – 59% | 60% |
| Refueling Rate | 0.77 kg/min | 1 kg/min |

| | Status (NG Reforming) | Status (Electroylsis) | Ultimate Target |
|---|---|---|---|
| $H_2$ Cost at Station | \$7.70 - \$10.30/kg | \$10.00 - \$12.90/kg | \$2.00 - \$4.00/kg |

## Demonstrated world's first Tri-generation station

Anaerobic digestion of municipal wastewater (Orange County Sanitation District)

- Produces 100 kg/day $H_2$; generates ~ 250 kW; 54% efficiency co-producing $H_2$ and electricity
- Nearly 1 million kWh of operation
- >4,000 kg $H_2$ produced

(Air Products, FuelCell Energy)

## Demonstrated $H_2$ for Energy Storage (NREL)

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

*Independently validated a vehicle that can achieve a 430 mile range.

# Market Transformation and ARRA – Catalyst for Deployments

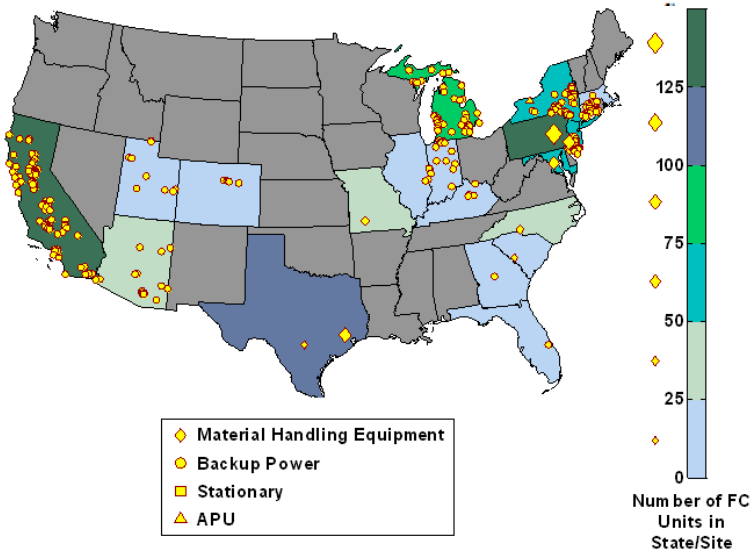
U.S. DEPARTMENT OF ENERGY

***ARRA and MT deployments of fuel cells for lift trucks led to industry purchases* of an estimated 3,000 additional fuel cell lift trucks with NO DOE funding***

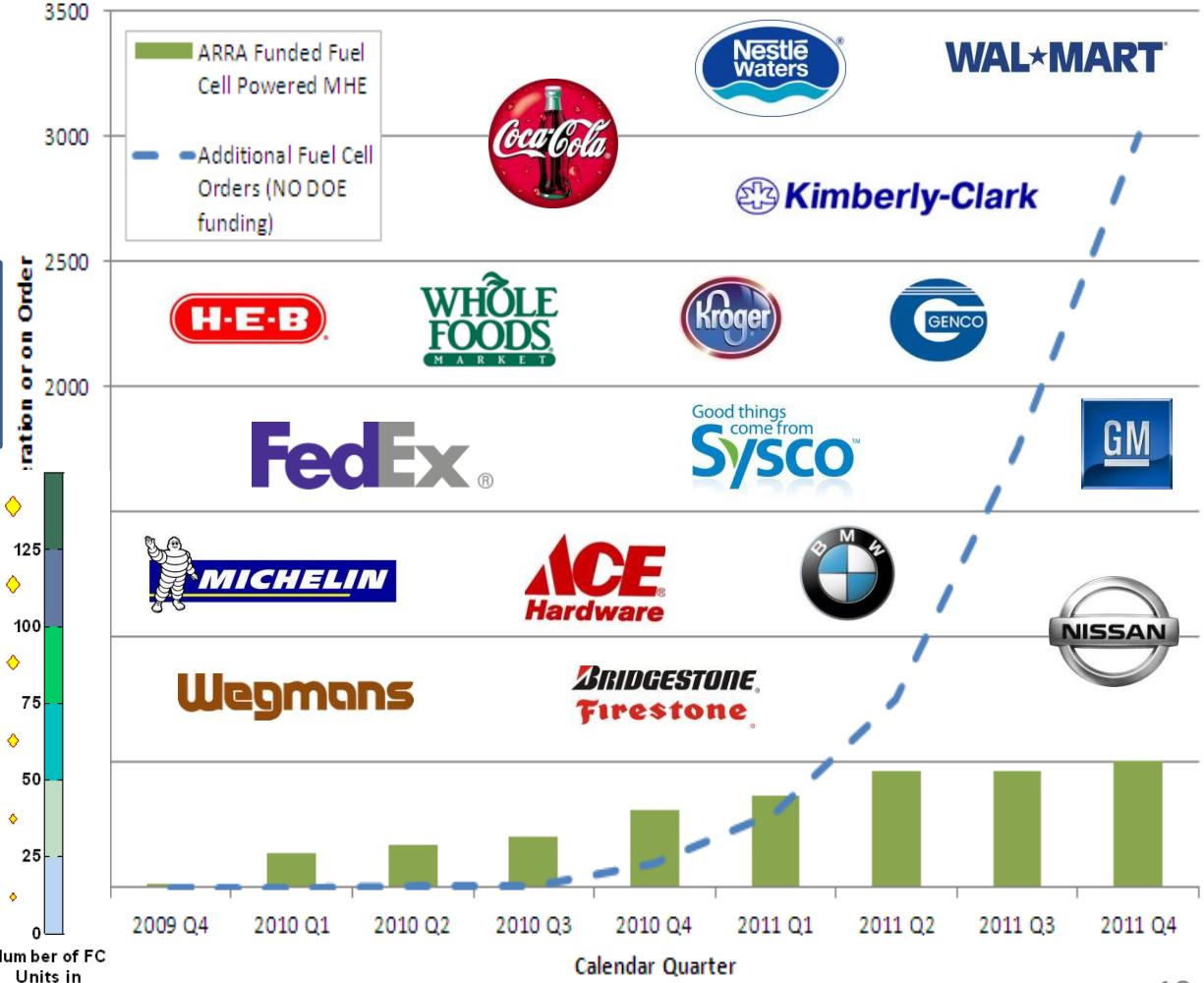
## Fuel Cell Deployments

| Application | Currently Operational (#) |
|---|---|
| Backup Power | 668 |
| Material Handling | 504 |
| **Total** | **1,172** |

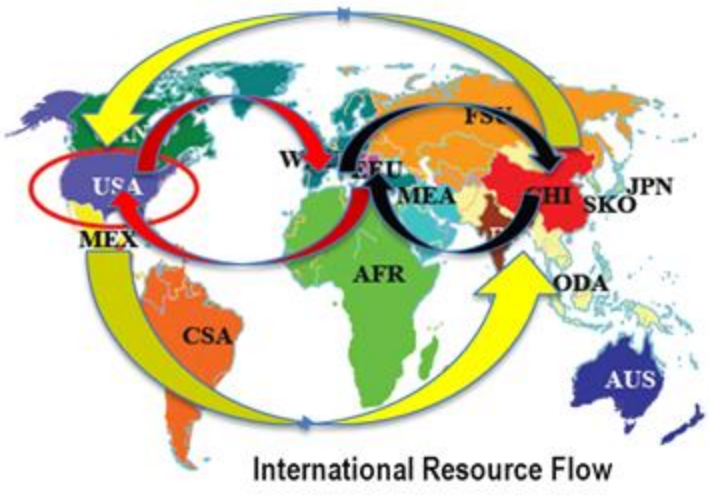
- **Exceeded ARRA target of up to 1,000 fuel cell deployments**
- **Demonstrated 1 million hours of operation to date**

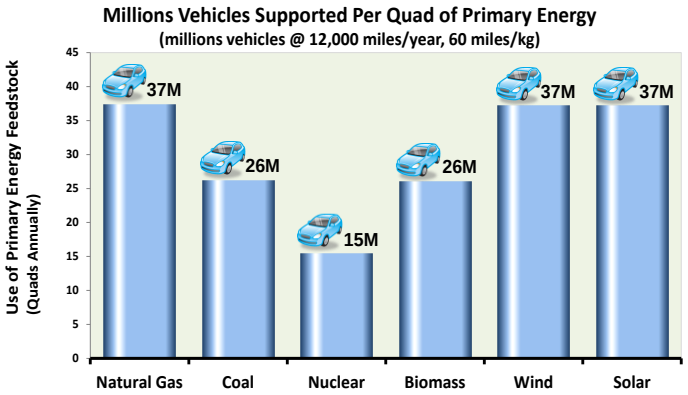


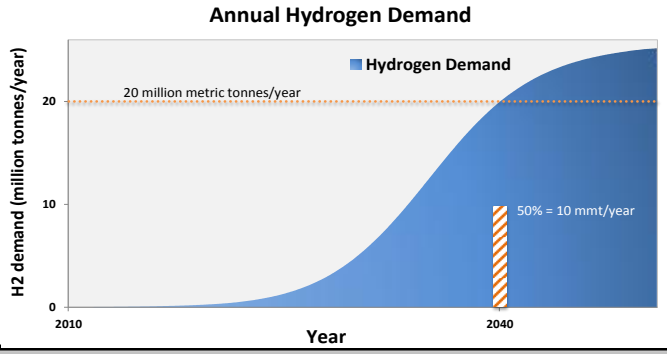

## Fuel Cell Lift Truck Purchases



# Systems Analysis

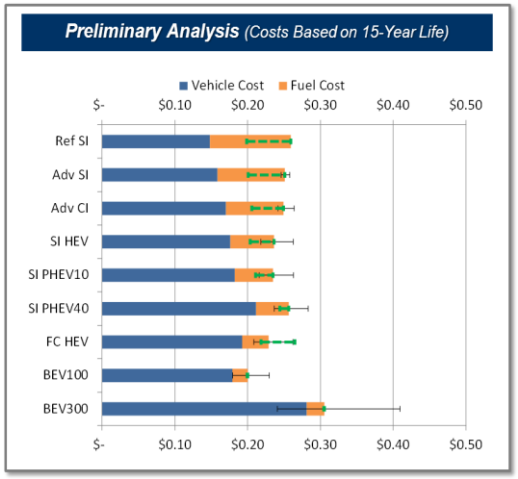


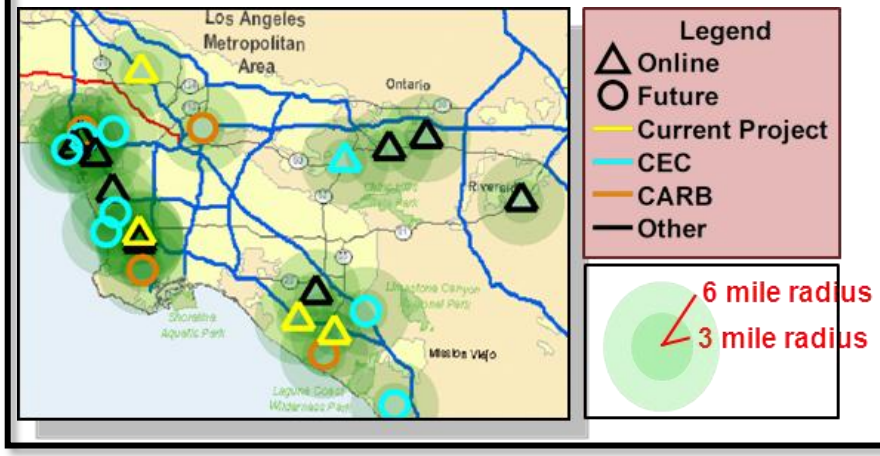




**Accomplishments:**

- **Conducted life cycle cost and emissions analysis**
- **Developed station cost tool (NREL)**
- **Launched global study on H2 resource availability (IEA HIA, SNL, NREL)**
- **Workshop identified opportunities for natural gas-$H_2$ synergies (ANL)**
- **Completed $H_2$ in natural gas pipelines study (NREL)**




**Developed online jobs tool to determine employment potential (ANL)**
**http://jobsfc.es.anl.gov**




CA STREET model – Optimizing station locations (UC Irvine, CaFCP

# Renewable Hydrogen Production by Electrolysis

U.S. DEPARTMENT OF ENERGY

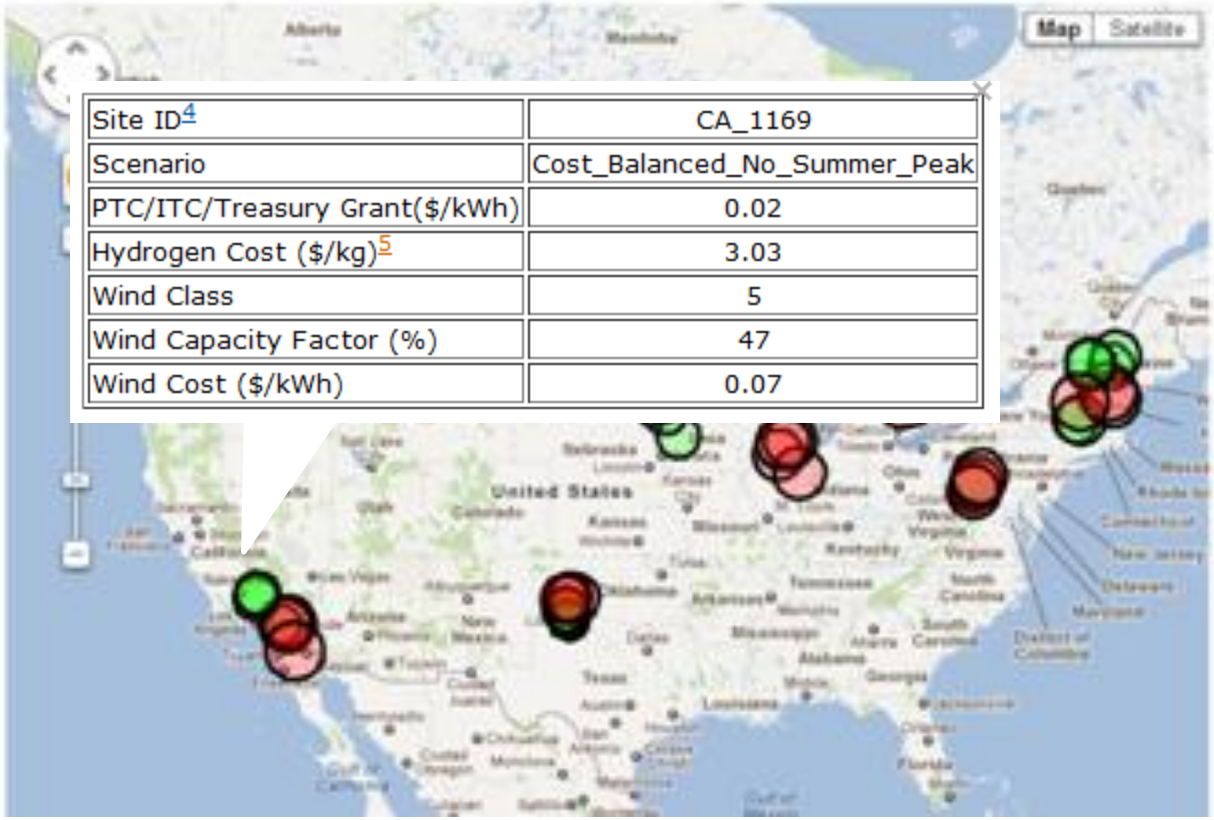
***NREL has analyzed the viability of wind-based electrolysis at 42 sites in 11 states and five electricity markets in the continental US.***

**Summer Peak Purchase**

| | Yes | No |
|---|---|---|
| Power Balanced | ◉ | ○ |
| Cost Balanced | ○ | ○ |

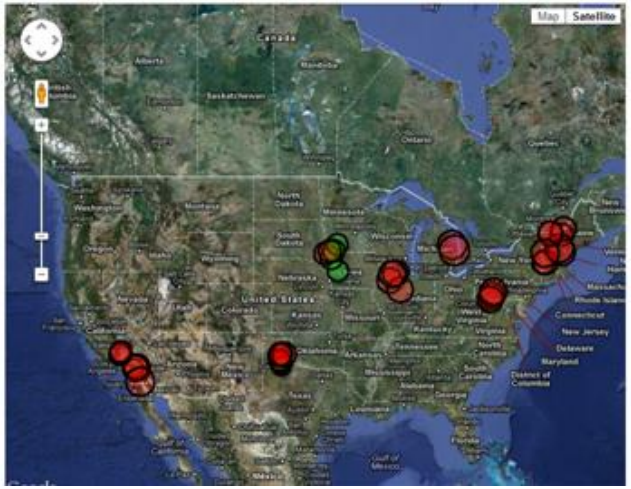
**Other Variables**

| | | |
|---|---|---|
| Enable PTC/ITC/Treasury Grant [1] | ☑ Reduces wind power cost $0.02/kWh | |
| Target Cost[2] | ○ Central $3.10/kg | ◉ Distributed $3.70/kg |
| Compression, Storage, and Dispensing Costs[3] | ☐ $2.00/kg $H_2$ | $ ____ /kg $H_2$ |




| | |
|---|---|
| Site ID[4] | CA_1169 |
| Scenario | Cost_Balanced_No_Summer_Peak |
| PTC/ITC/Treasury Grant($/kWh) | 0.02 |
| Hydrogen Cost ($/kg)[5] | 3.03 |
| Wind Class | 5 |
| Wind Capacity Factor (%) | 47 |
| Wind Cost ($/kWh) | 0.07 |

## Satellite View




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

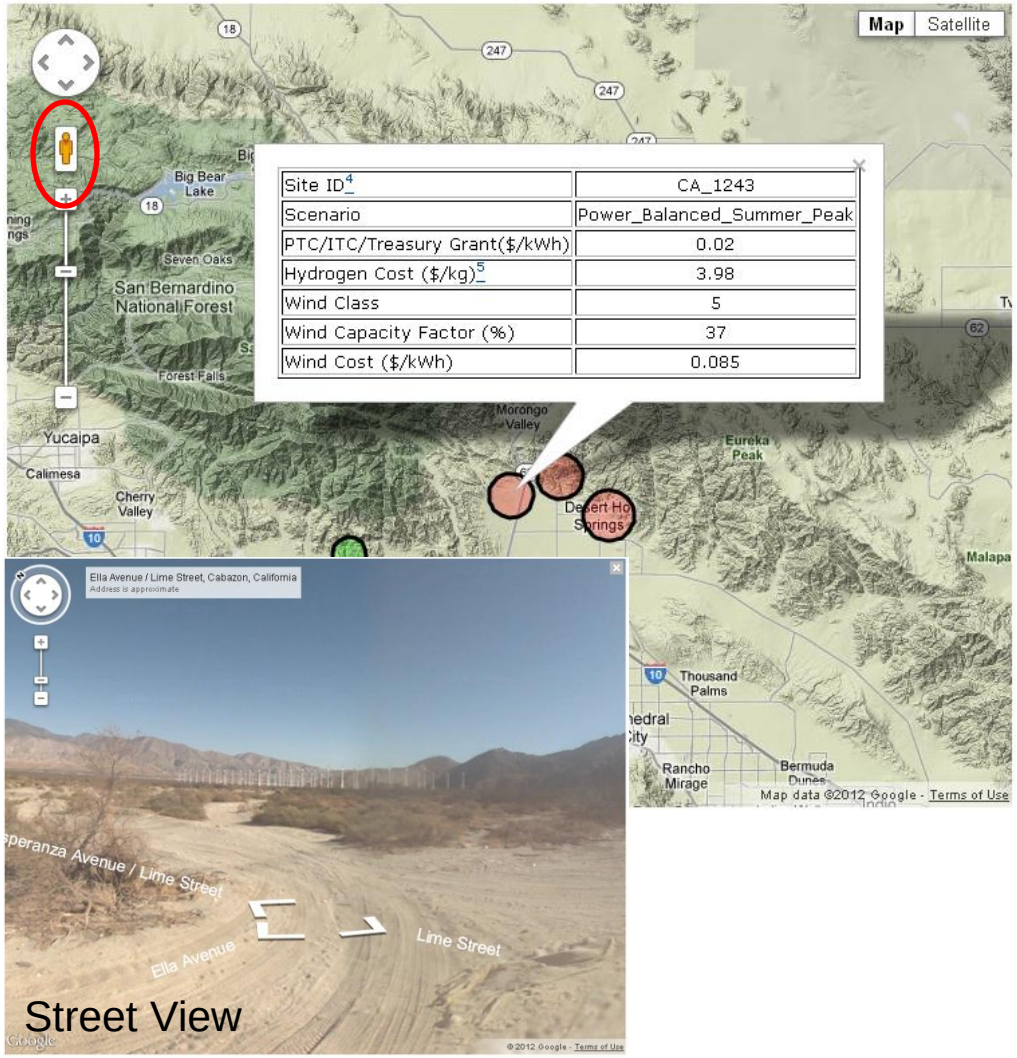


NREL NATIONAL RENEWABLE ENERGY LABORATORY

# Renewable Hydrogen Production by Electrolysis

U.S. DEPARTMENT OF ENERGY

***NREL has analyzed the viability of wind-based electrolysis at 42 sites in 11 states and five electricity markets in the continental US.***




| | |
|---|---|
| Site ID[4] | CA_1243 |
| Scenario | Power_Balanced_Summer_Peak |
| PTC/ITC/Treasury Grant($/kWh) | 0.02 |
| Hydrogen Cost ($/kg)[5] | 3.98 |
| Wind Class | 5 |
| Wind Capacity Factor (%) | 37 |
| Wind Cost ($/kWh) | 0.085 |

## Significance of Results

- Wind incentives amounting to $0.02/kWh result in a $~1/kg $H_2$ cost reduction.
- These incentives allow some sites to meet DOE targets.
- Interactive tool allows users to provide input to the analysis and see updated results immediately.

**Users can:**

- Explore the effects of the four different balance scenarios; cost or power with & without the purchase of peak summer electricity.
- Compare $H_2$ costs with DOE targets.
- See the effects of wind power incentives on $H_2$ costs.
- Add compression, storage, and dispensing costs.
- See the effects of local topography.
- See what's at the site with Google Street View. ™

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

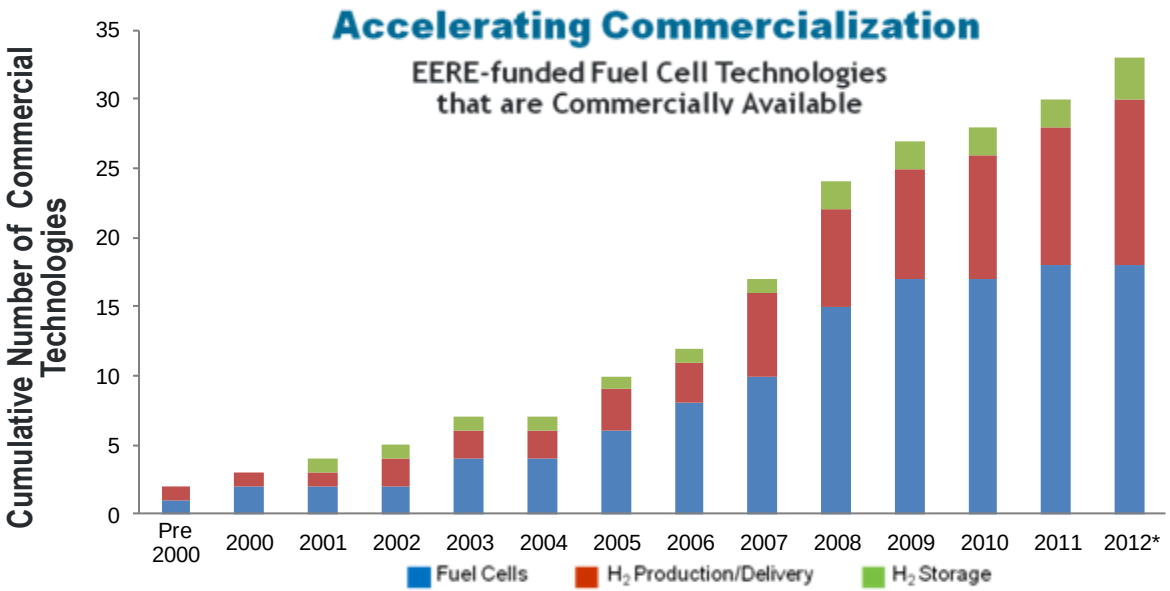


NREL NATIONAL RENEWABLE ENERGY LABORATORY

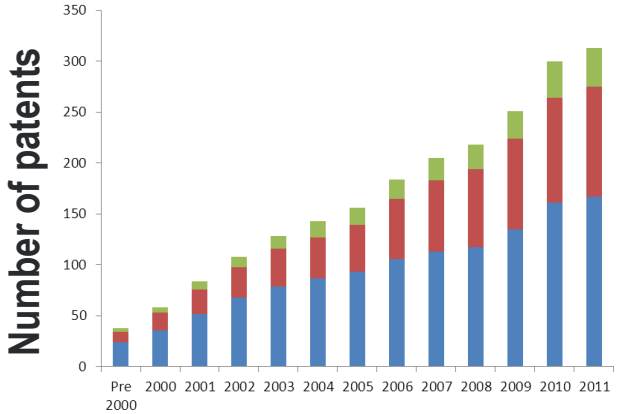
# Assessing the Impact of DOE Funding

U.S. DEPARTMENT OF ENERGY

***DOE funding has led to 313 patents, ~33 commercial technologies and >60 emerging technologies.***
***DOE's Impact: ~$70M in funding for specific projects was tracked – and found to have led to nearly $200M in industry investment and revenues.***




*Source: Pacific Northwest National Laboratory*
http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/pathways_success_hfcit.pdf



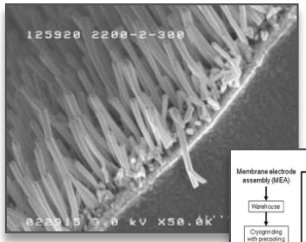

**>310 PATENTS resulting from EERE-funded R&D:**

- *Includes technologies for hydrogen production and delivery, hydrogen storage, and fuel cells*

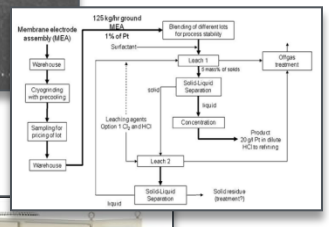
http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/pathways_2011.pdf

**Examples**

**3M**



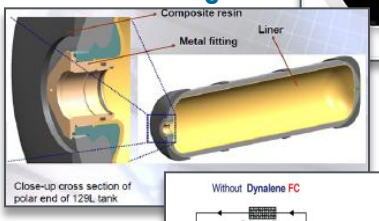
**BASF Catalysts LLC**



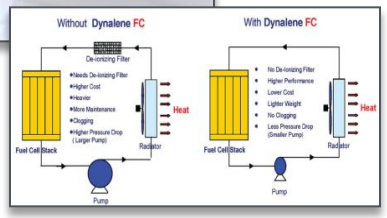
**Proton OnSite**

**DuPont**

**Quantum Technologies**




**Dynalene, Inc.**



# Methodology – Includes competitive review processes, peer reviews & go/no go decisions

U.S. DEPARTMENT OF ENERGY

## Topic Selection

- **Stakeholders**
  - e.g.: RFIs, industry, HTAC, etc.
- **U.S. DRIVE**
- **Peer Reviews**
  - NAS
  - GAO
  - Others

→

- **Targets**
- **"Critical Path" needs**
- **Technology Gaps**

→

- **Risk Analysis**
- **Technology Reviews**

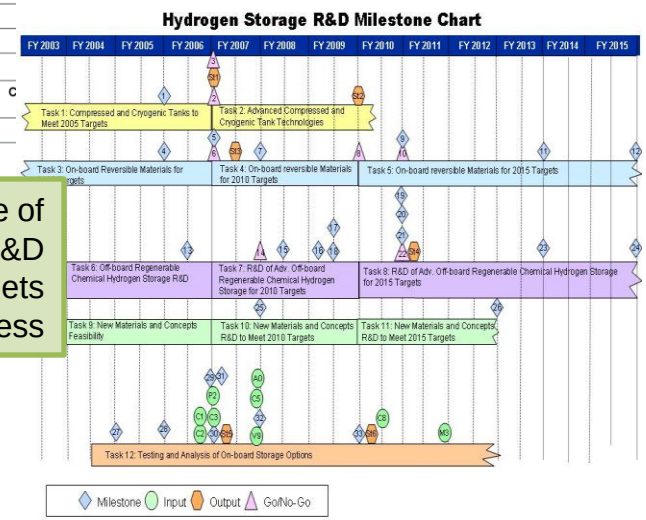
↓

**RD&D Plan and Solicitation Topics**

## Example Fuel Cell Membrane Targets

| Characteristic | Units | 2011 status | 2017 target | Nafion® NRE211 |
|---|---|---|---|---|
| Maximum oxygen crossover | mA/cm² | <1 | 2 | 2.7 |
| Maximum hydrogen crossover | mA/cm² | <1.8 | 2 | 2.2 |
| Area specific resistance at: | | | | |
| Max operating temp and 40 – 80 kPa water partial pressure | ohm cm² | 0.023 (40 kPa) 0.012 (80 kPa) | 0.02 | 0.186 |
| 80°C and water partial pressures from 25 - 45 kPa | ohm cm² | 0.017 (25 kPa) 0.006 (44 kPa) | 0.02 | 0.03-0.12 |
| 30°C and water partial pressures up to 4 kPa | ohm cm² | 0.02 (3.8 kPa) | 0.03 | 0.049 |
| -20°C | ohm cm² | 0.1 | 0.2 | 0.179 |
| Operating temperature | | | | |
| Minimum electrical resistance | | | | |
| Cost | | | | |
| Durability | | | | |
| Mechanical | | | | |
| Chemical | | | | |

Technical targets help guide go/no-go decisions.




Update of Multiyear RD&D Plan and Targets in process

## Project & Program Review Processes

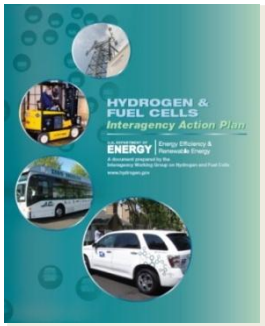
- **Annual Merit Review & Peer Evaluation meetings**
- **Tech Team reviews (monthly)**
- **Other peer reviews- National Academies, GAO, etc.**
- **DOE quarterly reviews and progress reports**

| Project Number | Project Title *PI Name & Organization* | Final Score | Continue | Discontinue | Other | Summary Comment |
|---|---|---|---|---|---|---|
| 123 | New Polymer/ Inorganic Proton Conductive Composite Membranes for PEMFC | 2.1 | | X | | The project was unable to meet conductivity targets or significantly improve upon Nafion®, and the membranes developed have poor chemical stability. The project will not be continued. |

***Over $19M saved in the last 3 years through go/no-go decisions***

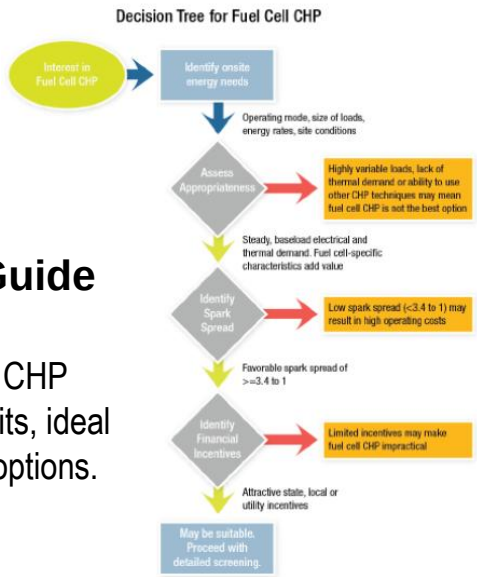
Reviewer comments for projects posted online annually. Projects discontinued/ work scope altered based on performance & likelihood of meeting goals.

# Collaborations – Federal Agencies and States




December 2011

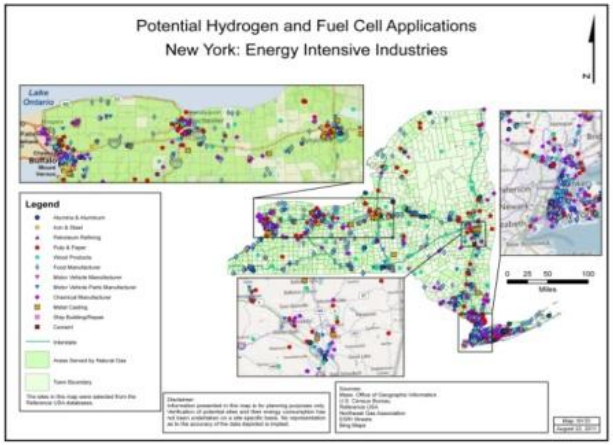
## Developed Interagency Action Plan with 10 Federal Agencies (Interagency Working Group)




## Developed Procurement Guide (ORNL)

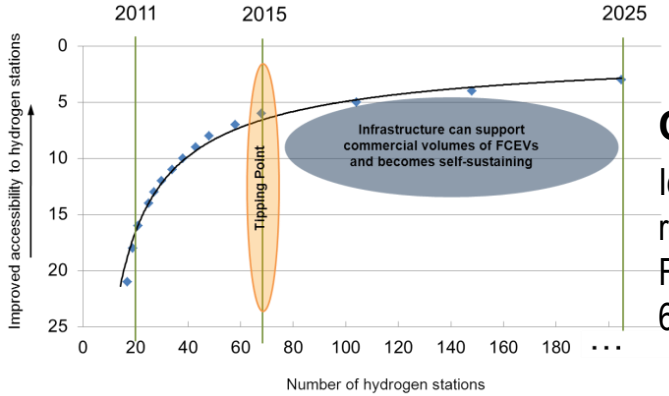
Provides guidance on CHP technology – its benefits, ideal usage, and financing options.

**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.**

**Developed Roadmaps for Northeastern States (CCAT)**




## California (CaFCP)

Identified infrastructure requirements for commercial FCEV launch ("tipping point" is 68 stations)

# Communication & Outreach

U.S. DEPARTMENT OF ENERGY

**Published more than 70 news articles in FY 2011 (including blogs, progress alerts, DOE news alerts)**

- ***Webinar Series***
  - May 22: Jobs Tool
  - June: Recent fuel cell licenses
  - July: Portable power
  - August: Mobile lighting
  - Register at - http://www1.eere.energy.gov/hydrogenandfuelcells/webinars.html

***We are requesting topics for future webinars and value your input!***

- ***News Items***
- Energy Department Announces up to $2.5 Million to Deploy Fuel Cell Powered Baggage Vehicles at Commercial Airports (April 25, 2012)
- Energy Department Awards More than $5 Million to Reduce Cost of Advanced Fuel Cells (March 27)

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

"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."

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

In the News

Hydrogen fuel cell power lights at the 2011 Golden Globes

**Developed education materials and educated more than 9,600 teachers on $H_2$ and fuel cells to date.**

Hydrogen fuel cell powered light tower at Space Shuttle launch

# EERE $H_2$ & Fuel Cells Budgets

U.S. DEPARTMENT OF ENERGY

***FY12 Appropriations:*** **" The Committee recognizes the progress and achievements of the Fuel Cell Technologies program. The program has met or exceeded all benchmarks, and has made significant progress in decreasing costs and increasing efficiency and durability of fuel cell and hydrogen energy systems."**

| EERE FCT Funding *($ in thousands)* | | | |
|---|---|---|---|
| ***Key Activity*** | **FY 2011 Allocation** | **FY 2012 Appropriation** | **FY 2013 Request** |
| Fuel Cell Systems R&D | 41,916 | 44,812 | 38,000 |
| Hydrogen Fuel R&D | 32,122 | 34,812 | 27,000 |
| Technology Validation | 8,988 | 9,000 | 5,000 |
| Market Transformation | 0 | 3,000 | 0* |
| Safety, Codes & Standards | 6,901 | 7,000 | 5,000 |
| Education | 0 | 0 | 0 |
| Systems Analysis | 3,000 | 3,000 | 3,000 |
| Manufacturing R&D | 2,920 | 2,000 | 2,000 |
| Total | $95,847 | $103,624 | $80,000* |

**FY 2013 House Mark: $82M  Senate Mark: $104 M**

## Future Directions

**Continue critical R&D**

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

**Conduct strategic, selective demonstrations of innovative technologies**

**Continue to conduct key analysis to guide RD&D and path forward, determine infrastructure needs**

**Leverage activities to maximize impact**

***In FY 2013, the Program plans to leverage activities in other EERE Programs (e.g., Advanced Manufacturing and Vehicle Technologies in key areas), *subject to appropriations.***

# Funding Opportunity Announcements & Requests for Information

U.S. DEPARTMENT OF ENERGY

| FY 2012 FOAs | FY 2012 Funding |
|---|---|
| Collect Performance Data on Fuel Cell Electric Vehicles (deadline extended 6/18) | $6.0 million |
| Hydrogen Fueling Stations and Innovations in Hydrogen Infrastructure Technologies (closed 5/11) | $2.0 million |
| Fuel Cell Powered Baggage Vehicles at Commercial Airports | $2.5 million |
| Zero-Emission Cargo Transport Vehicles (Vehicle Technologies, closes 5/15) | $10.0 million |

## Requests for Information

- Fuel Cell RFIs on Targets for Lift Trucks and Backup Power
- Potential Topics for H-Prize—*extended to May 31, 2012* (www.hydrogenandfuelcells.energy.gov/m/news_detail.html?news_id=18182)
- Storage RFI on Early Market Targets
  (Posted on eXCHANGE at https://eere-exchange.energy.gov/Default.aspx#6d785cb1-552e-44bd-98e3-e27a7e3fea0b)

# Acknowledgements

U.S. DEPARTMENT OF ENERGY

## Federal Agencies

- DOC
- DOD
- DOE
- DOT
- EPA
- GSA
- DOI
- DHS
- NASA
- 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

## Universities

~ 50 projects with 40 universities

## DOE Hydrogen & Fuel Cells Program

## State & Regional Partnerships

- California Fuel Cell Partnership
- California Stationary Fuel Cell Collaborative
- SC $H_2$ & Fuel Cell Alliance
- Upper Midwest Hydrogen Initiative
- Ohio Fuel Coalition
- Connecticut Center for Advanced Technology

## 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

Other Federal Labs: 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*

# World Class Researchers - Examples

U.S. DEPARTMENT OF ENERGY

**Adam Weber (LBNL)** honored as Energy Technology Division Supramaniam Srinivasan Young Investigator Award from The Electrochemical Society in Seattle.

**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).

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

**3 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**
**Program Manager**
**Hydrogen and Fuel Cells Program**
**Sunita.Satyapal@ee.doe.gov**
**(202) 586-2336**

## Additional Information

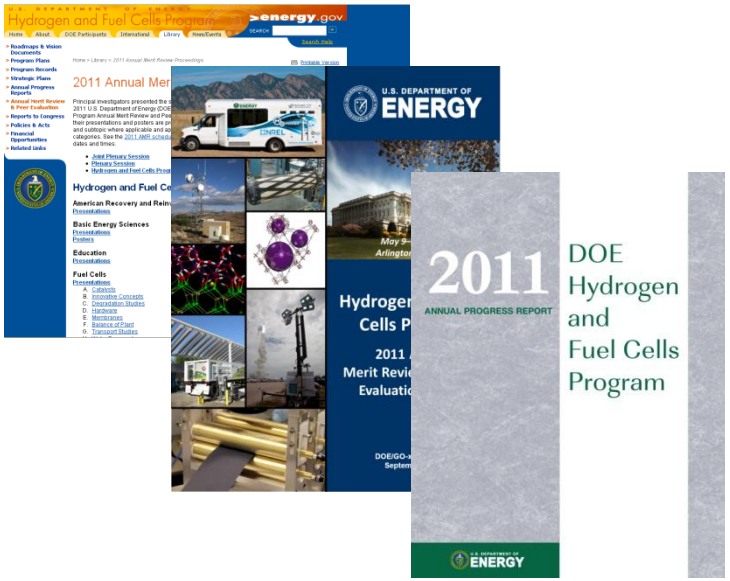
## www.hydrogen.energy.gov

# Key Reports

**Pathways to Commercial Success: Technologies and Products Supported by the Fuel Cell Technologies Program**
By PNNL, http://www.pnl.gov/
**See report: http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/pathways_2011.pdf**

**The Business Case for Fuel Cells 2011: Energizing America's Top Companies**
By FuelCells2000, http://www.fuelcells.org
**See report:**
**http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/business_case_fuel_cells_2011.pdf**

**State of the States 2011: Fuel Cells in America**
By FuelCells2000, http://www.fuelcells.org
**See report:**
**http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/stateofthestates2011.pdf**




**Annual Merit Review & Peer Evaluation Proceedings**

*Includes downloadable versions of all presentations at the Annual Merit Review*

http://www.hydrogen.energy.gov/annual_review11_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*

http://hydrogen.energy.gov/annual_review11_report.html

**Annual Progress Report**

*Summarizes activities and accomplishments within the Program over the preceding year, with reports on individual projects*

www.hydrogen.energy.gov/annual_progress.html

**Next Annual Review: May 13– 17, 2013 Arlington, VA**
***http://annualmeritreview.energy.gov/***

# Examples of DOE-funded Partners and Locations – Fuel Cell Technologies Program

U.S. DEPARTMENT OF ENERGY

# Participation Organizations/Collaborators

U.S. DEPARTMENT OF ENERGY

- **Industry**
  - 3M
  - Acumentrics
  - Air Products & Chemicals, Inc.
  - Altergy
  - Arkema, Inc.
  - AT&T
  - Avalence
  - Ballard
  - BASF
  - BMW
  - Boeing
  - BP
  - Carolina Tractor
  - Chevron
  - Clear Edge
  - Coca Cola
  - Concepts ETI
  - Concepts NREC
  - ConocoPhillips
  - Delphi Automotive
  - Dupont
  - Eaton
  - EnergyWorks
  - ExxonMobil
  - FedEx Freight East
  - Ford Motor Company
  - FuelCell Energy
  - Gas Technology Institute
  - GENCO
  - General Motors
  - Giner
  - H2 Technology Consulting LLC
  - Hawaii Hydrogen Carriers, LLC.
  - H-E-B
  - HRL Laboratories
  - Hydrogen Frontier, Inc.
  - Hydrogenics Corporation
  - Hyundai-Kia
  - Ion Power
  - Innovatek
  - Jadoo Power
  - Kimberly Clark
  - Linde
  - Lincoln Composites
  - Lockheed Martin
  - Media and Process Technologies
  - Mercedes Benz R&D, North America
  - Midwest Optoelectronics
  - MITI
  - Mohawk Innovative
  - MTI Micro Fuel Cells
  - MV Systems
  - Nuvera Fuel Cells
  - Oorja Protonics
  - ORISE
  - PG&E
  - Plug Power
  - Praxair
  - Proton OnSite
  - Quantum Technologies
  - Regulatory Logic
  - ReliOn, Inc.
  - Rolls Royce
  - SAIC
  - Sempra Energy
  - Shell
  - Sprint Nextel
  - Strategic Analysis
  - SunLine
  - Sysco Houston
  - Sysco Philadelphia
  - TDA (SBIR Phase III)
  - TIAX
  - UTC Power
  - UTRC
  - Versa Power
  - Wegmans
  - Whole Foods Market
  - W. L. Gore & Associates

# Participation Organizations/Collaborators

U.S. DEPARTMENT OF ENERGY

- **National Labs**
  - Argonne National Laboratory
  - Brookhaven National Laboratory
  - Jet Propulsion Laboratory
  - Lawrence Berkeley National Laboratory
  - Lawrence Livermore National Laboratory
  - Los Alamos National Laboratory
  - National Renewable Energy Laboratory
  - Oak Ridge National Laboratory
  - Pacific Northwest National Laboratory
  - Sandia National Laboratories
  - Savannah River National Laboratory

- **Government/Non-Profits**
  - AC Transit
  - Army CERL
  - CA Fuel Cell Partnership
  - Clean Energy State Alliance
  - City of Burbank, CA
  - City of Folsom, CA
  - Connecticut Center for Advanced Technology, Inc.
  - CT Transit
  - FAA
  - Fort Irwin
  - Hydrogen Education Foundation
  - NASA
  - National Energy Education Development Project
  - NIST
  - NPS
  - ONR
  - Ohio Fuel Cell Coalition
  - SCRA
  - South Carolina Hydrogen and Fuel Cell Alliance
  - Technology Transition Corporation
  - U.S. DOT
  - U.S. DOC
  - Virginia Clean Cities
  - Warner Robins Air Force Base

- **Universities & Institutes**
  - Battelle
  - California Institute of Technology
  - Cal State – LA
  - Case Western University
  - Colorado School of Mines
  - Farmingdale State College
  - Hawaii Natural Energy Institute
  - Humboldt State University
  - I2CNER
  - Illinois Institute of Technology
  - J. Craig Venture Institute
  - Kettering University
  - Miami University
  - Michigan Technical University
  - National Fuel Cell Research Center, U.C. Irvine
  - Northeastern University
  - Northwestern University
  - Oregon State University
  - Pennsylvania State University
  - Rochester Polytechnic Institute
  - Southwest Research Institute
  - Stanford University
  - Stark State College
  - State University of New York
  - Texas A&M University
  - Univ. of Akron
  - Univ. of California – Berkeley Lawrence Hall of Science
  - Univ. of California – Davis
  - Univ. of California – Irvine
  - Univ. of California – LA
  - Univ. of Central Florida
  - Univ. of Colorado – Boulder
  - Univ. of Hawaii
  - Univ. of Michigan
  - Univ. of Missouri – Columbia
  - Univ. of Nevada – Las Vegas
  - Univ. of NC – Charlotte
  - Univ. of North Dakota
  - Univ. of North Florida
  - Univ. of Oregon
  - Univ. of South Carolina
  - Vanderbilt University
  - Virginia Tech University