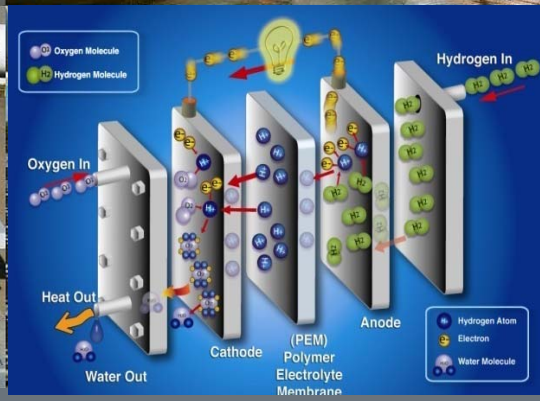
Fuel Cell Technologies Office

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



Fuel Cell Technologies Office Overview

Leveraging ARFVTP Funding

4/23/2014

Dr. Sunita Satyapal

Director
Fuel Cell Technologies Office
U.S. Department of Energy

"All of the Above" for Sustainable Transportation

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

Sustainable TRANSPORTATION - **EERE Technology Offices**

Hydrogen and Fuel Cells

Including stationary power

- **Efficiency Improvement**
- **Fuel Diversification**
- **Domestic & Renewable Sources**
- **Reduced GHG**

Vehicles

Bioenergy

National Energy Goals & Climate Action Plan

Reduce net oil imports by 50% by 2020, compared to 2008

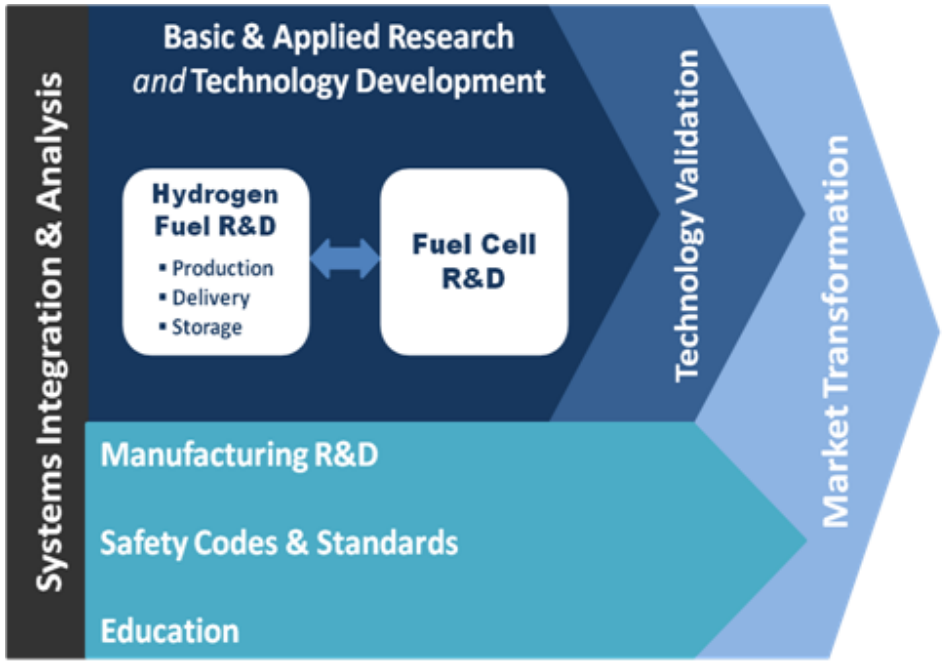
Reduce GHG emissions >80% below 2005 levels by 2050

Fuel Cell Technologies Office Overview

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

Mission: Enable widespread commercialization of a portfolio of hydrogen and fuel cell technologies through applied research, technology development and demonstration, and diverse efforts to overcome institutional and market challenges.

Key Goals : Develop hydrogen and fuel cell technologies for early markets (stationary power, lift trucks, portable power), mid-term markets (CHP, APUs, fleets and buses), and long-term markets (light duty vehicles).



WIDESPREAD COMMERCIALIZATION ACROSS ALL SECTORS

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

More than 200 projects currently funded at companies, national labs, and universities/institutes

Key Targets for Automotive Applications

- **$40/kW by 2020 (ultimate target: $30/kW)**
- **5000 hour durability (150,000 miles)**
- **60% efficiency**
- **> 300 mile driving range**

DOE R&D, Demonstration, & Deployment Successes

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

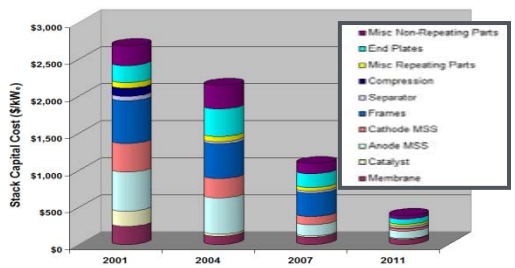
DOE R&D (>$2B)

Fuel Cell System Cost

Transportation projected to (500,000 units per year)

50% reduction vs. 2006 ($55/kW)
68% targeted by 2020 ($40/kW)
76% ultimate target ($30/kW)

Electrolyzer Stack Costs



60% reduction since 2007

DOE Demonstrations Technology Validation

- **Validate technologies**
- **Real-world conditions**
- **Feedback guides R&D**

Demonstrated

- ***>180 FCEVs***
- ***25 stations***
- ***3.6 million miles traveled***
- ***World's first tri-gen station*** *(250 kW on biogas, 100 kg/d)*

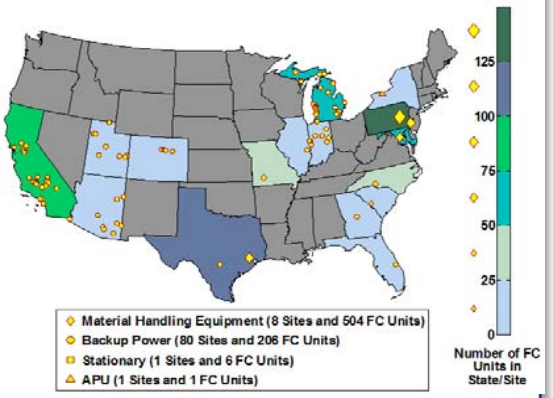
Validated

- ***59% efficiency***
- ***254 mile range***
- ***75,000-mi durability***

Deployments

- ***DOE Recovery Act***
- ***Market Transformation Projects***
- ***Government Early Adoption (DoD, FAA, California, etc.)***
- ***Tax Credits: 1603, 48C***

Recovery Act & Market Transformation Deployments



Nearly 1,600 fuel cells deployed

Fuel Cell Technologies – FY 2015 Budget Request & Priorities

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

(Dollars in Thousands)	FY 2013 Current	FY 2014 Enacted	FY 2015 Request
Fuel Cell R&D	41,266	33,383	33,000
Hydrogen Fuel R&D	31,681	36,545	36,283
Manufacturing R&D	1,899	3,000	3,000
Systems Analysis	2,838	3,000	3,000
Technology Validation	8,514	6,000	6,000
Safety, Codes and Standards	6,808	7,000	7,000
Market Transformation	2,838	3,000	3,000
NREL Site Wide Facility Support	0	1,000	1,700
Total, Fuel Cell Technologies	**95,844**	**92,928**	**92,983**

Fiscal Year 2015 Priorities:

Fuel Cell R&D ($33M): Develop and demonstrate innovative technologies to reduce cost and improve durability – e.g., by increasing PEM fuel cell power output per gram of platinum-group metal catalyst to 6.5kW/g in 2015 and 8.0kW/g by 2020 (from 2.8kW/g in 2008).

Hydrogen Fuel R&D ($36.3M): Advance pioneering technologies in materials, components, and processes that will reduce the cost of hydrogen from renewable resources to $6.80/gge (dispensed and untaxed) from $8.00/gge in 2011; and the cost of hydrogen storage systems by 15% compared to the 2013 baseline of $17/kWh.

Manufacturing R&D ($3M): Demonstrate a ground-breaking 3X increase of continuous in-line measurement processes to achieve 100 ft./min for MEA and MEA component roll-to-roll processing.

Technology Validation (S6M): Demonstrate an electrolyzer capable of producing hydrogen for a refueling station with an output pressure of greater than 50 bar, a hydrogen storage and refueling system for a roof-top backup power system capable of providing power for telecommunications equipment, the potential for doubling hydrogen capacity at refueling stations, and integrating water electrolyzers and/or fuel cells with the grid.

2014 Solicitations

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

Topics
Hydrogen Production R&D
• Integrated or hybrid systems for central, semi-central, or distributed production of low-cost, low carbon hydrogen from natural gas
• Thermochemical conversion of bio-derived liquids for distributed or semi-central production of low-cost hydrogen
• Hydrogen production through direct solar watersplitting technologies: Advanced materials-based systems for direct solar water splitting for central or semi-central production of low-cost renewable hydrogen
Hydrogen Delivery R&D
• Forecourt compressors for 700 bar gaseous hydrogen dispensing
• Integrated Intelligent Hydrogen Dispensers for 700 bar Gaseous Refueling of Fuel Cell Electric Vehicles
Hydrogen Storage R&D
• Reducing the cost of compressed hydrogen storage systems
• Improved materials for fiber composites and balance of plant components
• New hydrogen storage materials discovery
• Forecourt hydrogen storage at 875 bar of greater
Technology Validation & Market Transformation
• Demonstration and deployment of fuel cell hybrid-electric medium-duty trucks
• Validation of advanced hydrogen refueling components
• Demonstration and case study for roof-top installations of hydrogen fuel cell back-up power systems
• Hydrogen meter R&D
Total Funding >$25M (pending selections)

*May include alternates and subject to appropriations.

New Awards

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

Demonstration and Deployment of Fuel Cell Hybrid Electric Medium-Duty Trucks

GREEN SOLUTION TO DRIVING RANGE

FedEx Express

OBJECTIVE:
Develop fuel cell hybrid electric walk-in delivery vans, to extend battery-electric vehicle range from 56 to up to 150 miles. Validate through real-world operation.

IMPACT:
FedEx Express uses approximately 40,000 vehicles in its fleet, which could potentially be replaced with fuel cell hybrid vehicles. The 20 deployed vans could save 97,880 gallons diesel per year and 248 metric tons of CO_2 emissions per year.

PARTNERS:

- **Smith Electric Vehicles** (Kansas City, MO)—*Truck OEM and Electrical Integrator*
- **Plug Power** (Latham, NY)—*Fuel Cell System OEM*

TOTAL FUNDING PLANNED: $6M

- **DOE:** ~$3M
- **Non-Federal:** ~$3M

"FUEL CELL HYBRID ELECTRIC WALK-IN VAN DEPLOYMENT"

Center for Transportation and the Environment

OBJECTIVE:
Develop fuel cell hybrid electric walk-in delivery vans, to extend battery-electric vehicle range from 90 to 150 miles (75 to 125 miles usable). Validate through real-world operation.

IMPACT:
Fuel cell hybrid vehicles could potentially take place of ~46,000 diesel walk-in vans in UPS' fleet alone. The 17 deployed vans could save 44,200 gallons of diesel per year and 445 metric tons of CO_2 emissions per year.

PARTNERS:

- **University of Texas – Center for Electromechanics** (Austin, TX)—*Research Center*
- **Electric Vehicles International (EVI)** (Stockton, CA)—*Manufacturer of Alternative Energy Vehicles*
- **Hydrogenics USA** (San Diego and Torrance, CA)—*Hydrogen Supplier*
- **Valence Technology** (Austin, TX)—*Battery Manufacturer*
- **United Parcel Service** (Atlanta, GA)—*Logistics (will supply vans)*

TOTAL FUNDING PLANNED: $10.1M

- **DOE:** ~$3M
- **Non-Federal:** ~$7.1M

DOE SBIR Funding Opportunity Announcements (FOAs)

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

Two FOA Releases for both SBIR Phase I and II:

Phase I: $150-225K/project

- Release 1 from the following DOE offices, topics out in July, FOA out in August, proposal due in October with award notice in January including:
  - Basic Energy Sciences and other Offices
- Release 2 from the following DOE offices, topics out in Oct, FOA out in Nov, proposal due in February with award notice in April:
  - Electricity Delivery and Energy Reliability
  - Energy Efficiency and Renewable Energy

Phase II: $1-1.5M/project, only Phase I awardees eligible to apply

- Release 1:
  - FOA out in October, proposal due in December with award notice in February
- Release 2:
  - FOA out in February, proposal due in April with award notice in June

- Both Phase I and II requires submission of letter of intent and commercialization plan
- http://science.energy.gov/sbir/funding-opportunities/

FCTO Phase I SBIR projects include 58 projects and $6.5M in funding
FCTO Phase II SBIR projects include 24 projects and $20M in funding

Notice of Intent: Fuel Cell Technologies Incubator

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

The EERE Incubator Program is intended to identify potentially impactful technologies that are not already addressed in EERE Technology Offices' strategic plans or project portfolios. The FOA will be 'open' to any and all impactful ideas; however, some anticipated specific areas of interest include:

- Platinum Group Metal (PGM)-free catalysts and membrane electrode assemblies
- Fuel cell–based electrochemical conversion devices for stationary energy storage
- Completely innovative hydrogen production and delivery technologies (including hoses, meters, compressors, etc.)
- Breakthrough, low pressure hydrogen storage materials
- Hydrogen infrastructure: Manufacturing solutions for low-cost, standardized skid-mounted hydrogen fueling stations; and game-changing business models/financial approaches to address infrastructure costs.

FOA Planned Release:
May 2014

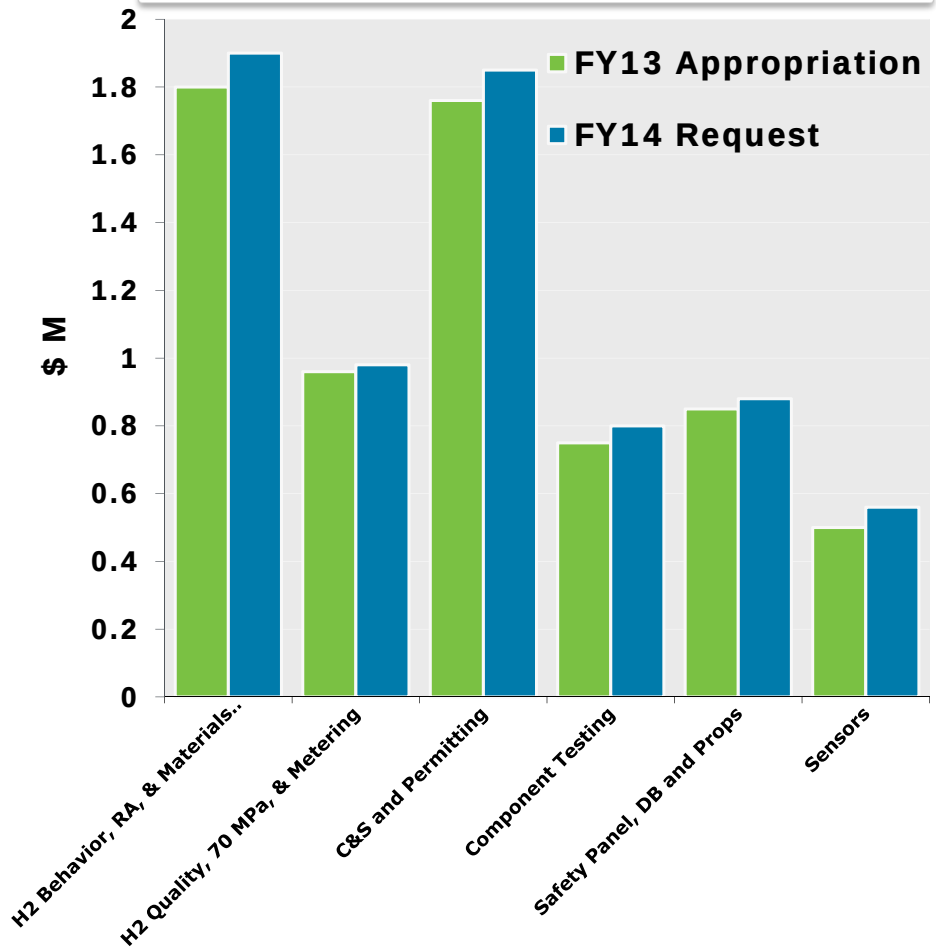
Example: Safety, Codes and Standards

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

FY 2014 Budget Allows for Continued Emphasis on Critical RCS and RD&D

FY 2014 Request = $7M

FY 2013 Appropriation = $6.62M



Emphasis:

- Develop technical information and performance data to enhance codes and standards
- Facilitate the permitting of hydrogen fueling stations and early market applications
- Test, measure and verify hydrogen fuel specification
- Assess risks and establish protocols to identify and mitigate risk
- Harmonize test protocols for qualification and certification
- Harmonize hydrogen fuel quality and other key international standards
- Disseminate hydrogen “best practices” and safety information

Hydrogen Safety, Codes and Standards

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

Codes and Standards - Conduct critical R&D needed for the development of technically sound codes and standards and facilitate harmonization of domestic and international regulations, codes, and standards

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

- Foundational hydrogen behavior
- Quantitative Risk Assessments
- Compatible materials and components
- Test protocols
- Fuel Quality
- Sensors

Impact Codes and Standards

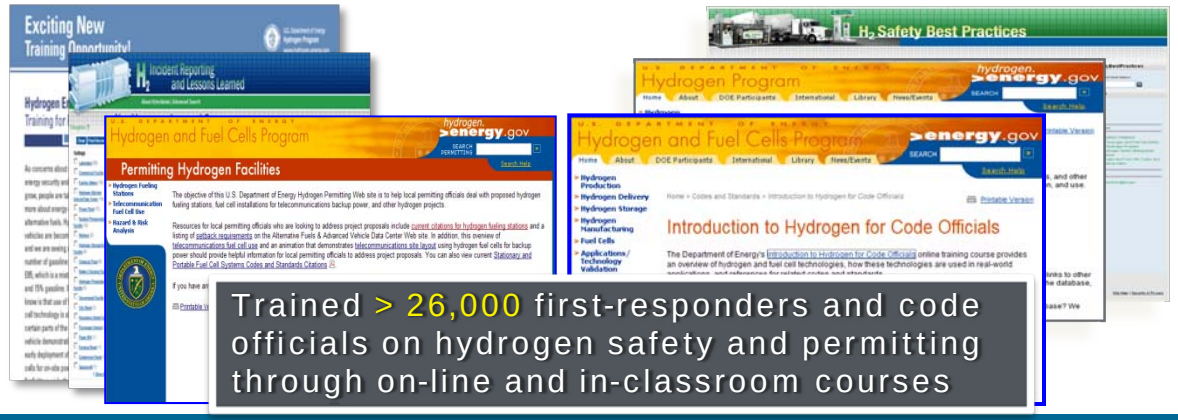
- Participate in and lead technical committees to develop requirements
- Harmonize critical regulations, codes, and standards domestically and internationally (i.e. SAE 2719 and ISO 14687-2)
- Publish R&D results

Critical areas for FY14 for Acceleration of hydrogen infrastructure:

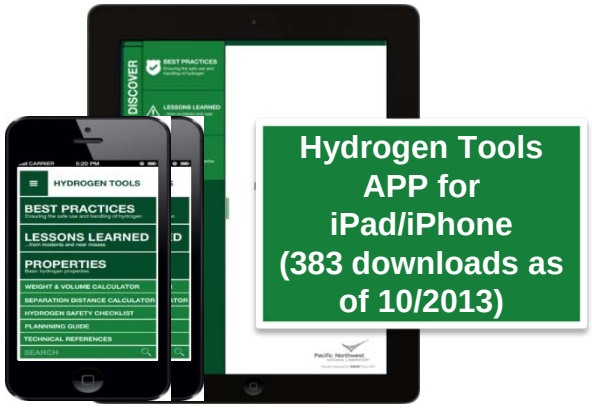
1. NFPA 2 Chapter 5 Validation for Performance Based Approach
2. Initiating LH2 Release Behavior to decrease separation distances in conjunction with NFPA 55
3. Development of Quantitative Risk Assessment Toolkit (HyRAM)
4. Development of a National Permitting Template in conjunction with H2USA and FCHEA

Station Footprint (Cost) Reduction - Critical Separation Distances were reduced by **~50% for GH2 due to supported SCS R&D efforts** and direct participation in code development of NFPA 2 Hydrogen Technologies Code.

Safety - Develop and implement safety practices and procedures to ensure the safe operation, handling, and use of hydrogen and fuel cell technology



Trained > 26,000 first-responders and code officials on hydrogen safety and permitting through on-line and in-classroom courses



Hydrogen Tools APP for iPad/iPhone (383 downloads as of 10/2013)

Launched National Fuel Cell Technology Evaluation Center (NFCTEC)

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

The Secretary of Energy, Ernest Moniz, announced the unveiling of a national secure data center for the independent analysis of hydrogen and fuel cell technologies at the Energy Systems Integration Facility (ESIF) at NREL.

NFCTEC: NREL's independent, third-party analysis of hydrogen fuel cell technologies in real-world operation.

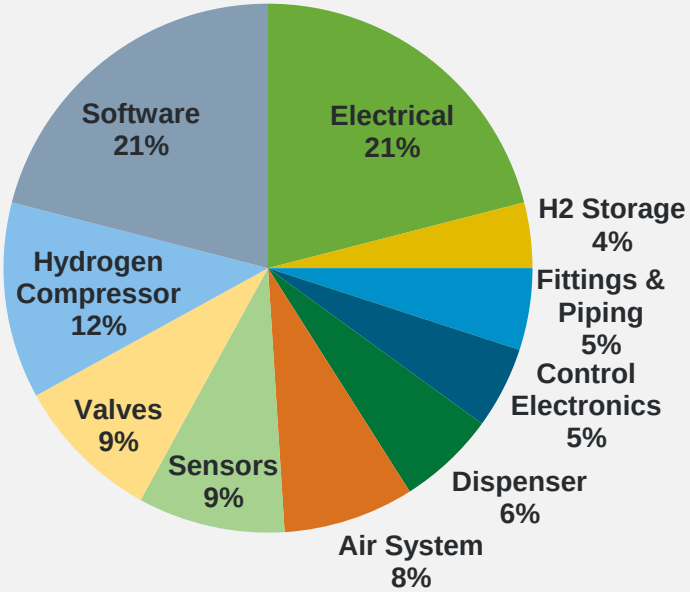
- Securely manages, stores, and processes proprietary data from industry.
- Analyzes detailed data and reports on fuel cell technology status, progress, and technical challenges.
- Provides detailed data products to partners, composite data products (CDP) available online **http://www.nrel.gov/hydrogen/facilities_nfctec.html**

Partner

Partner with NFCTEC to take advantage of state-of-the-art facilities. http://www.nrel.gov/docs/fy13osti/58500.pdf

Contact Us

Interested in working with NFCTEC? Contact techval@nrel.gov



Example CDP - Infrastructure Maintenance by Equipment Type

Over 50% of maintenance is associated with the compressor, electrical, and software systems.

Source: NREL
http://www.nrel.gov/hydrogen/docs/cdp/cdp_94.jpg

Plans: Partnership & Facilities (SNL and NREL as leads) to accelerate H_2 infrastructure technologies

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

NREL and SNL provide:

- Technical expertise – Hydrogen specific materials and systems expertise to develop technical solutions
- Facilities - Physical venues for technical collaboration among diverse stakeholders
- Objectivity – Trustworthy and objective assessment of options to achieve broader goals

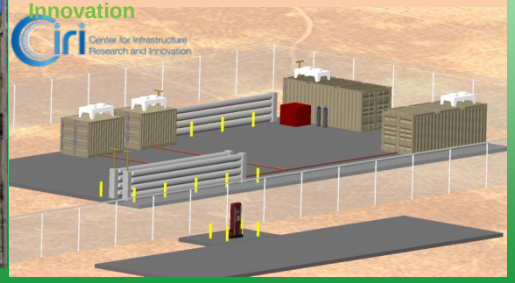
Leverage DOE National Lab Network

Multiple Global Stakeholders involved

Action: Solicit Additional Stakeholders

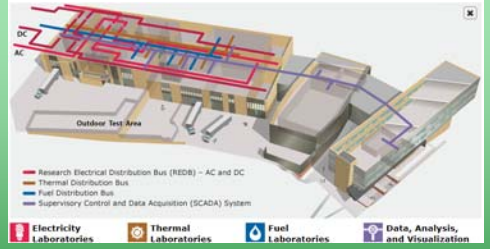
Sandia National Laboratories

Center for Infrastructure Research & Innovation



NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Energy Systems Integration Facility



Distributed Energy Resources Test Facility

Co-Launched Public-Private Partnership

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

H2USA

Mission: To promote the commercial introduction and widespread adoption of FCEVs across America through creation of a public-private partnership to overcome the hurdle of establishing hydrogen infrastructure.

Current partners include (additional in process):

U.S. DEPARTMENT OF ENERGY
DAIMLER
Fuel Cell & Hydrogen Energy Association
GlobalAutomakers
GM
HYDROGENICS Advanced Hydrogen Solutions
HONDA The Power of Dreams
EDTA Electric Drive Transportation Association
NISSAN
HYUNDAI
ITM POWER Energy Storage | Clean Fuel
Mercedes-Benz
OAK RIDGE National Laboratory
AGA American Gas Association
California Fuel Cell Partnership
DRIVING FOR THE FUTURE
SCRA
Sandia National Laboratories
PROTON THE LEADER IN ON SITE GAS GENERATION.
Pacific Northwest NATIONAL LABORATORY
NREL NATIONAL RENEWABLE ENERGY LABORATORY
AIR LIQUIDE
arc:HYDROGEN
plug power
NUVERA Making hydrogen make sense.
Massachusetts Hydrogen Coalition
TOYOTA
Argonne NATIONAL LABORATORY

Communication & Outreach

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

Published more than 80 news articles in 2013 (including blogs, progress alerts, DOE news alerts)

- ***Monthly Webinar Series***
  - Register at - http://www1.eere.energy.gov/hydrogenandfuelcells/webinars.html
- ***Announcements***
  - Fuel Cells kick of Google+ Energy 101 series
  - Secretary of Energy attends DC Auto Show
  - Launched NFCTEC (secure data center)
  - Launched Hydrogen Safety Tools App for iPhone and iPad
  - Launched Alternative Fueling Station Locator App
- ***Training and Workforce Development***
  - Trained more than 10,000 teachers and more than 26,000 code officials and first responders in person and online
- ***Monthly Newsletter***
  - Visit the web site to register or to see archives - (http://www1.eere.energy.gov/hydrogenandfuelcells/newsletter.html)
- ***Caucus on H_2 and Fuel Cells*** *(Senate & House)*
- ***Clean Energy Technology Showcase for investors (NYC and CA)***

President Obama inspects a fuel cartridge while at the Swedish Royal Institute of Technology.

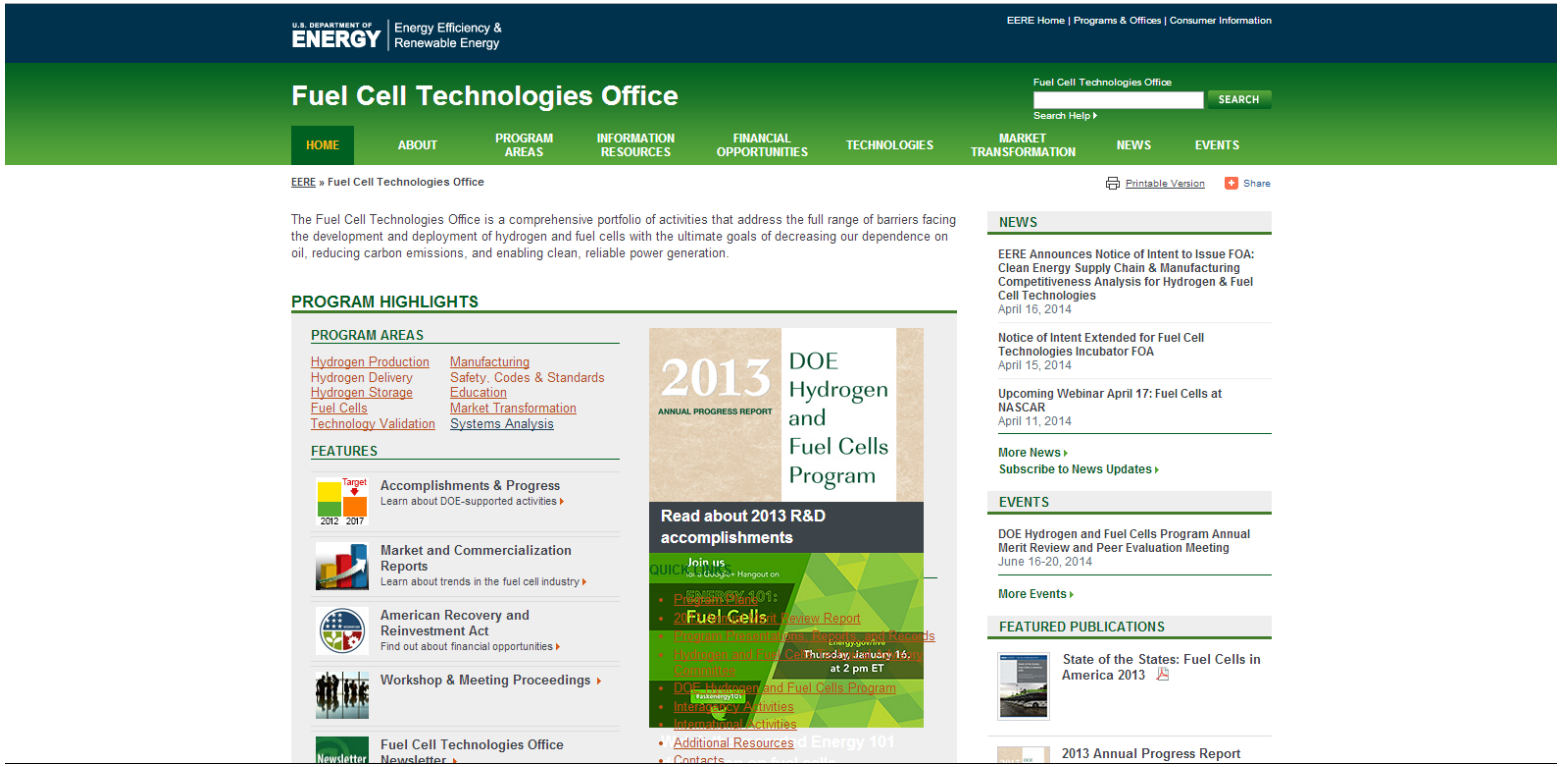
Hydrogen fuel cell powers lights at entertainment industry events.

Hydrogen fuel cell powered light tower at Space Shuttle launch

FCTO Newsletter

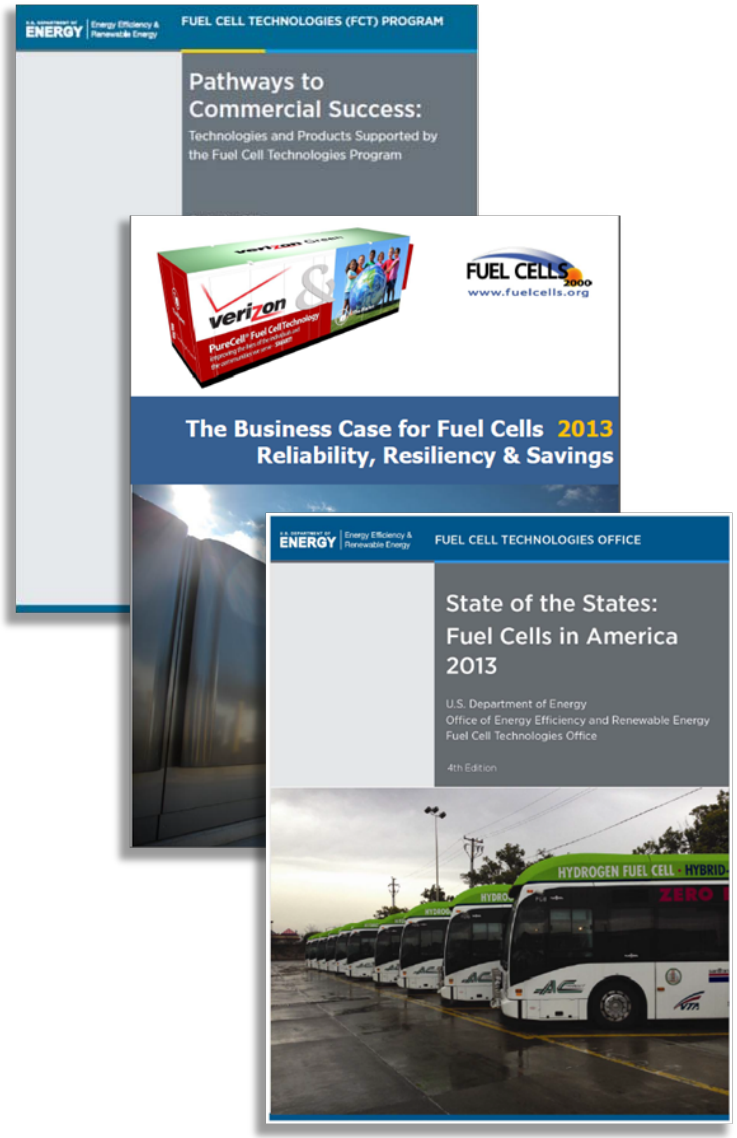
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Visit FCTO's website at
https://www1.eere.energy.gov/hydrogenandfuelcells/



Sign up for the monthly newsletter at
http://www1.eere.energy.gov/hydrogenandfuelcells/newsletter.html

Key Reports



Pathways to Commercial Success: Technologies and Products Supported by the Fuel Cell Technologies Program
By PNNL, http://www.pnl.gov/
http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/pathways_2013.pdf

The Business Case for Fuel Cells 2013: Reliability, Resiliency & Savings
By FuelCells2000, http://www.fuelcells.org
See report: http://www.fuelcells.org/pdfs/2013BusinessCaseforFuelCells.pdf

State of the States 2013: Fuel Cells in America
By FuelCells2000, http://www.fuelcells.org
See report:
http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/state_of_the_states_2013.pdf

Annual Merit Review - Upcoming Dates

June 16-20, 2014 - Washington, D.C.

June 8-12, 2015 - Arlington, VA

June 6-10, 2016 - Washington, D.C.

June 5-9, 2017 - Washington, D.C.

http://annualmeritreview.energy.gov/

Thank You

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hydrogenandfuelcells.energy.gov

H-Prize ($1M)

- Criteria open for public comment
- Home/Community-Scale Refueler
- On-site generation of hydrogen using electricity or natural gas
- Hydrogen fuel for vehicles, homes, community centers, retail sites or similar locations

H-Prize: H2 Refuel Competition Summary

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

The Goal:

Make a system that does on-site generation of hydrogen, using electricity or natural gas, to fuel hydrogen vehicles, that can be used in homes, community centers, retail sites or similar locations. The best entry, based on technical and cost criteria, will win $1 million!

Criteria open for public comment

The Challenge:

Month	
1-12	When the competition opens, teams will have one year to find partners, design a system, test components, find a place to install the system, and register for the prize.
12-14	After one year, the teams will submit data and designs, and the top five will be selected by a team of independent judges to go to the testing phase.
14-21	Finalist teams will have seven months to build, install, and prepare their systems for testing.
22-24	Remote and on-site testing will be used to collect data for the technical criteria, and independent financial experts will evaluate the cost criteria. An open house will let the public get a peek at the entries!
27	Once the data is analyzed, the H-Prize winner will be announced.

FCTO: Workshops

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

Recent and Upcoming Workshops

- Hydrogen Transmission and Distribution Workshop (February 25-26th, 2014)
- Electrolytic Hydrogen Production (February 27-28th, 2014)
- Infrastructure Financing Workshop (April 2014)
- Hydrogen Safety Resource Tools (April 2014)
- 2nd International Workshop on Hydrogen Infrastructure (May 8-9th, 2014)
- Energy Storage Workshop (May 2014)
- Contaminant Detection at the Forecourt (June 12th, 2014)
- Applied Energy Materials Genome (TBD)

2013 Workshops

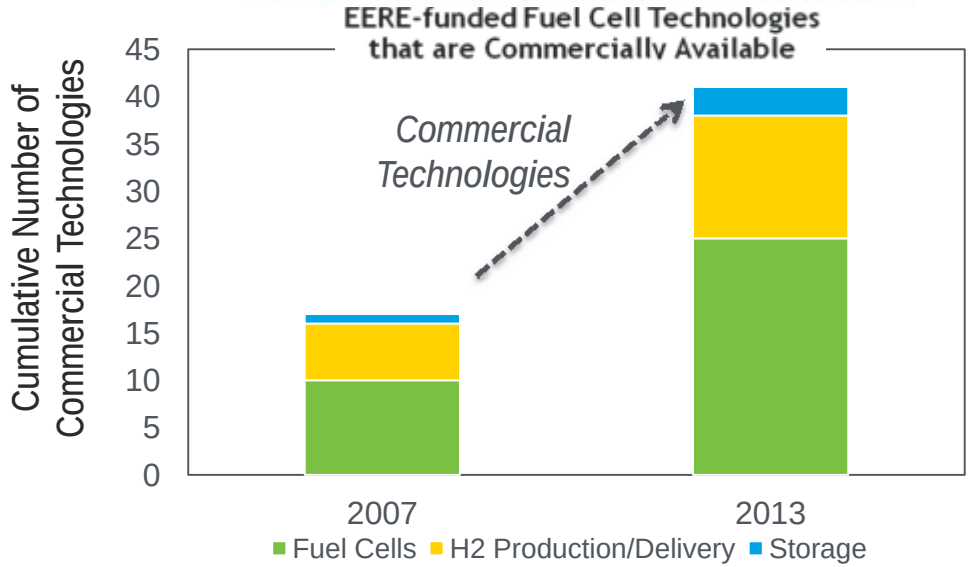
- Hydrogen Compression, Storage, and Dispensing Cost Reduction Workshop (March 2013)
  - https://www1.eere.energy.gov/hydrogenandfuelcells/wkshp_hydrogen_csd.html
- Biological Hydrogen Production Workshop (September 2013)
  - https://www1.eere.energy.gov/hydrogenandfuelcells/wkshp_bio_h2_production.html
- EERE Quality Control Workshop (December 2013)
  - https://www1.eere.energy.gov/hydrogenandfuelcells/wkshp_eere_quality_control.html

Assessing the Impact of DOE Funding

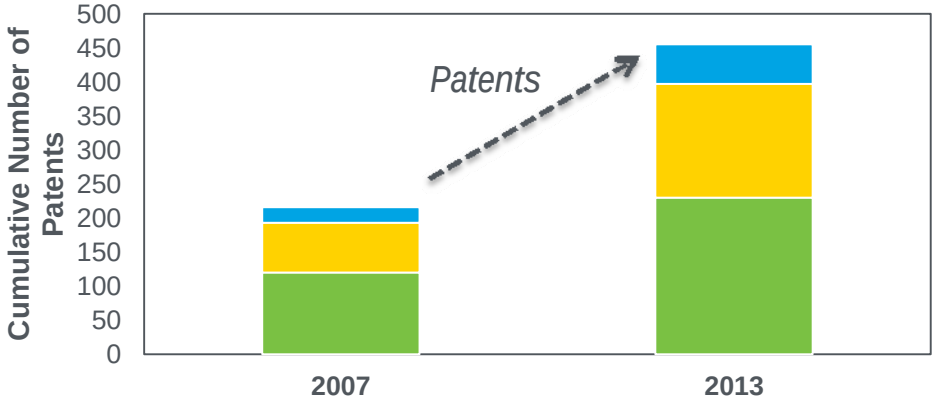
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

DOE funding has led to 40 commercial hydrogen and fuel cell technologies and 65 emerging technologies.

Accelerating Commercialization

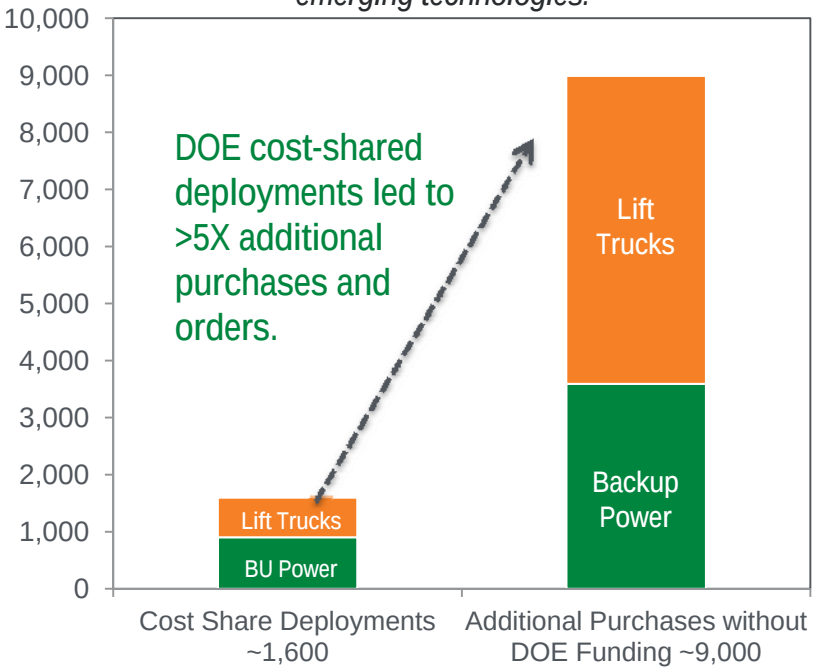


Source: Pacific Northwest National Laboratory
http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/pathways_success_hfcit.pdf



Leveraging DOE Funds:

Government as "catalyst" for market success of emerging technologies.



More than 450 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_2013.pdf