Hydrogen and Fuel Cell Technologies

FY 2014 Budget Request Rollout to Stakeholders

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

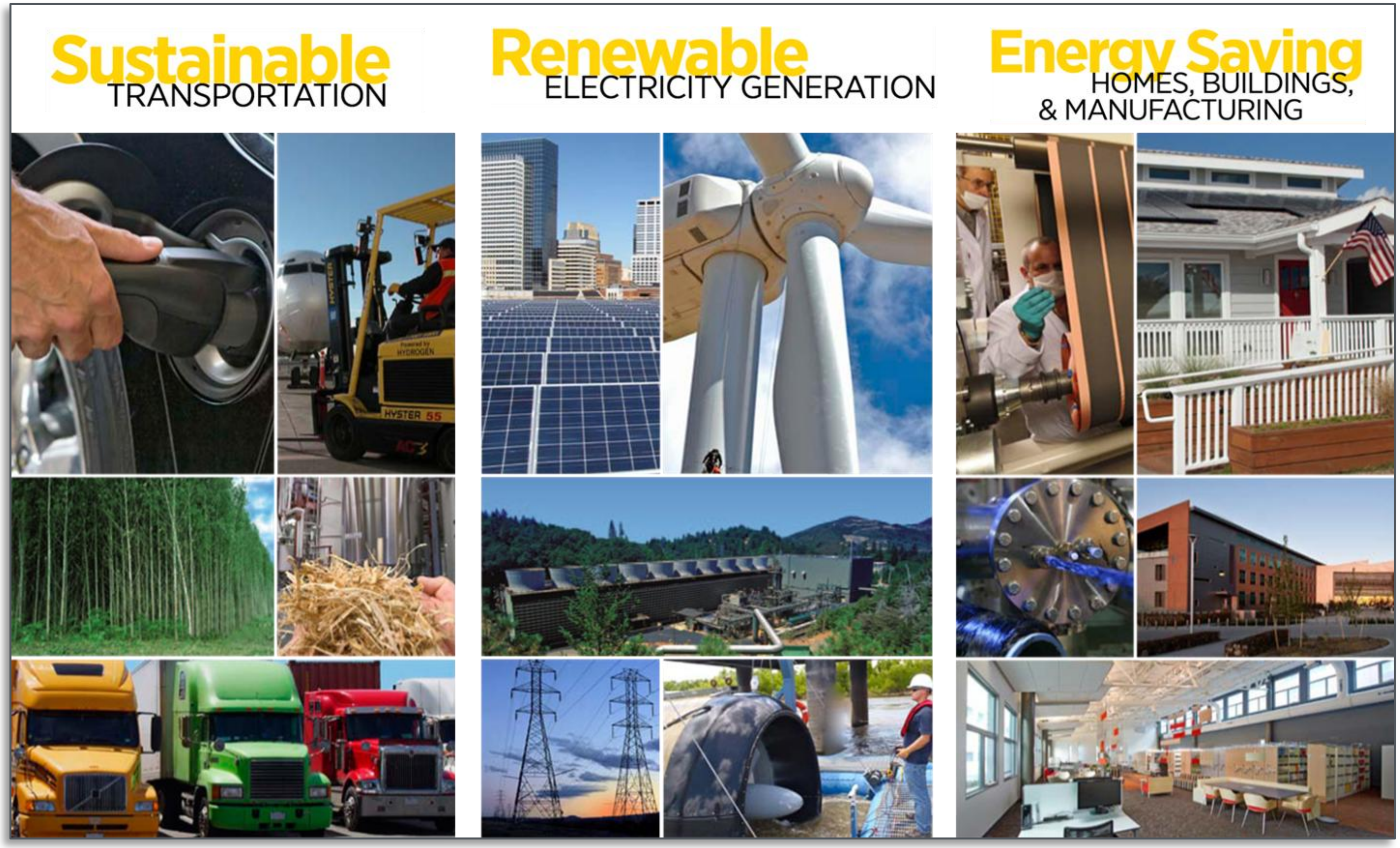
Hydrogen and Fuel Cell Technologies
FY 2014 Budget Request Rollout

Washington, DC
April 12, 2013

Dr. Sunita Satyapal

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

EERE Overview



EERE's National Mission

To create American leadership in the global transition to a clean energy economy through:

1) **High-impact research, development, and demonstration to make clean energy as affordable and convenient as traditional forms of energy**
2) **Breaking down barriers to market entry**

Source: US DOE 4/18/2013

High-Impact in Everything We Do

The 5 EERE Core Questions

1. **HIGH IMPACT:** Is this a high impact problem?
2. **ADDITIONALITY:** Will the EERE funding make a large difference relative to what the private sector (or other funding entities) is already doing?
3. **OPENNESS:** Have we made sure to focus on the broad problem we are trying to solve and be open to new ideas, new approaches, and new performers?
4. **ENDURING U.S. ECONOMIC BENEFIT:** How will this EERE funding result in enduring economic benefit to the United States?
5. **PROPER ROLE OF GOVERNMENT:** Why is what we are doing a proper high impact role of government versus something best left to the private sector to address on its own?

Applying Impact Assessments to All of Our Activities

Source: US DOE 4/18/2013

Impact of DOE Funding for Hydrogen and Fuel Cells

Spurring Innovation & Accelerating Commercialization:

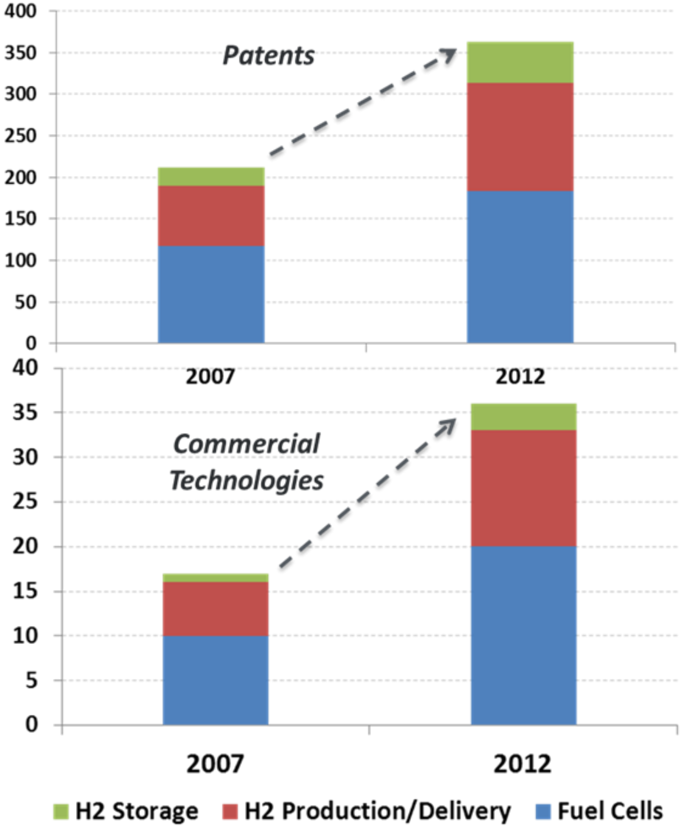
>360 patents, >35 commercial technologies and **65 emerging technologies**

Return on Investment:

Example: ~$70M in funding for specific projects was tracked—**led to nearly $200M** in industry investment & revenues.

Accelerating Commercialization

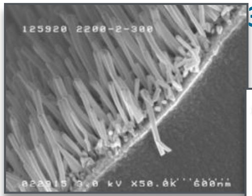
- Commercial technologies and patents resulting from EERE-funded hydrogen and fuel cells projects -



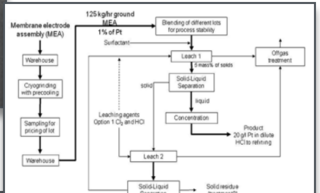
Source: PNNL, www1.eere.energy.gov/hydrogenandfuelcells/pdfs/pathways_success_hfcit.pdf

Examples

3M



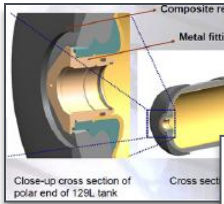
BASF Catalysts LLC



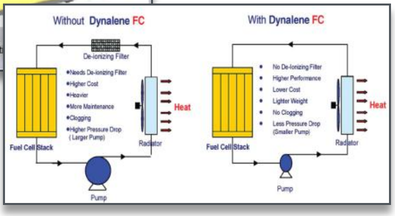
Proton Energy Systems

DuPont

Quantum Technologies



Dynalene,

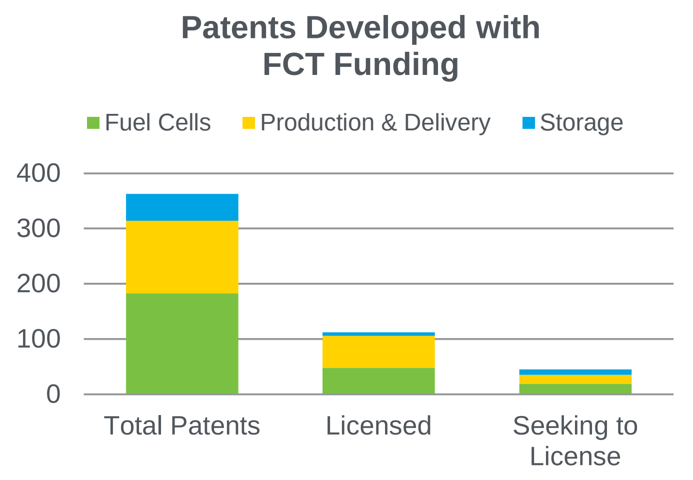


Summary: Program Impact

DOE FCT funding has led to 363 patents, 35 commercial technologies and 65 emerging technologies.
Example of Impact: ~$70M in funding for specific projects was tracked – and found to have led to nearly $200M in industry investment and revenues.

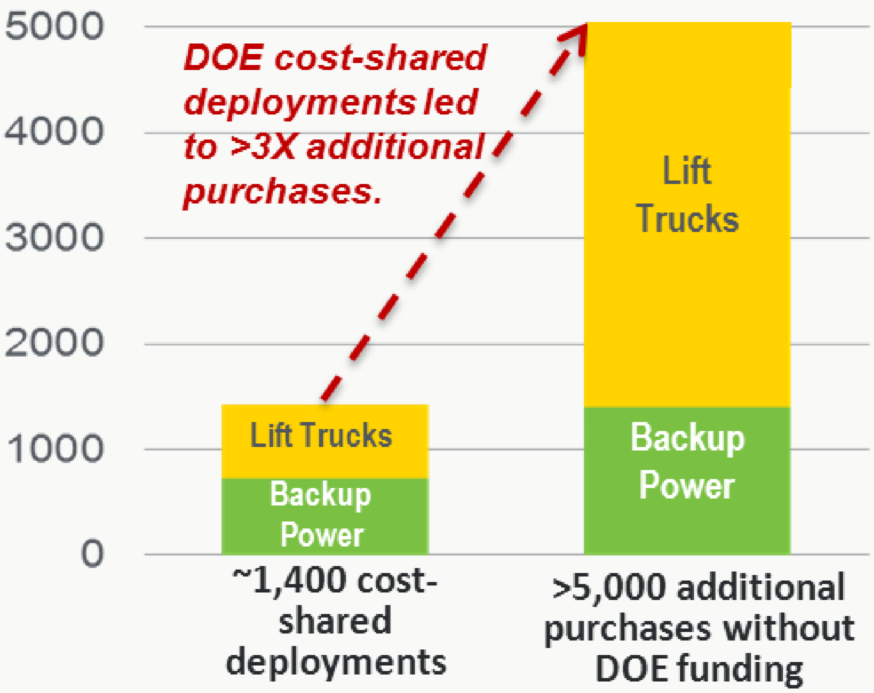
DOE FCT funding has enabled:

- > 80% cost reduction in PEM fuel cells since 2002, > 35% since 2008
- Reduction in Pt by a factor of 5 since 2005
- > Double the durability since 2006
- > 80% cost reduction in electrolyzer stacks in the last decade


Patents Developed with FCT Funding

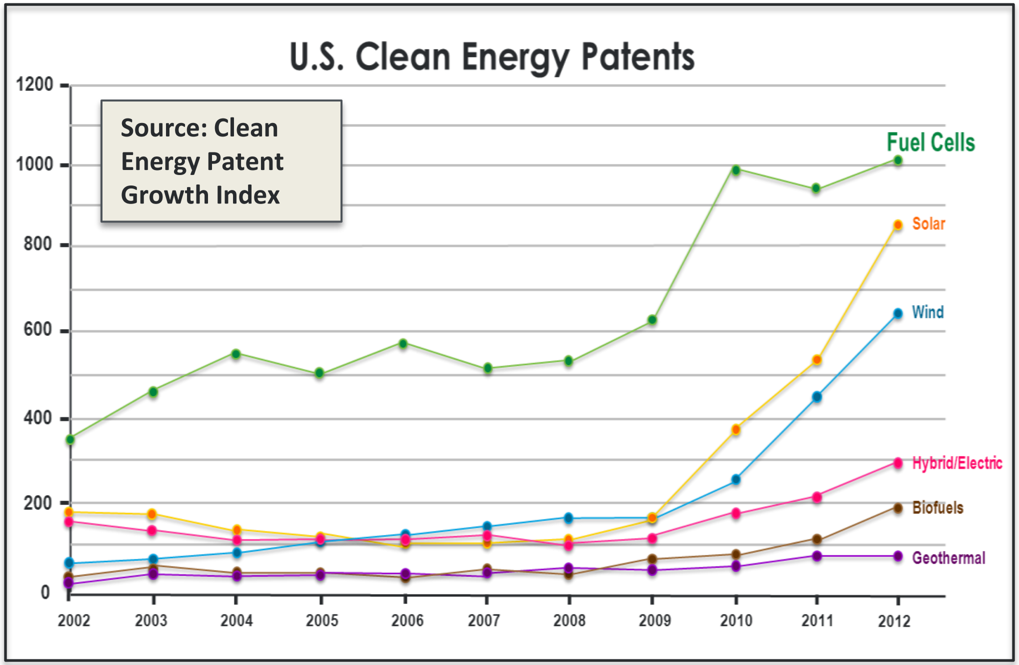
Leveraging DOE Funds:

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

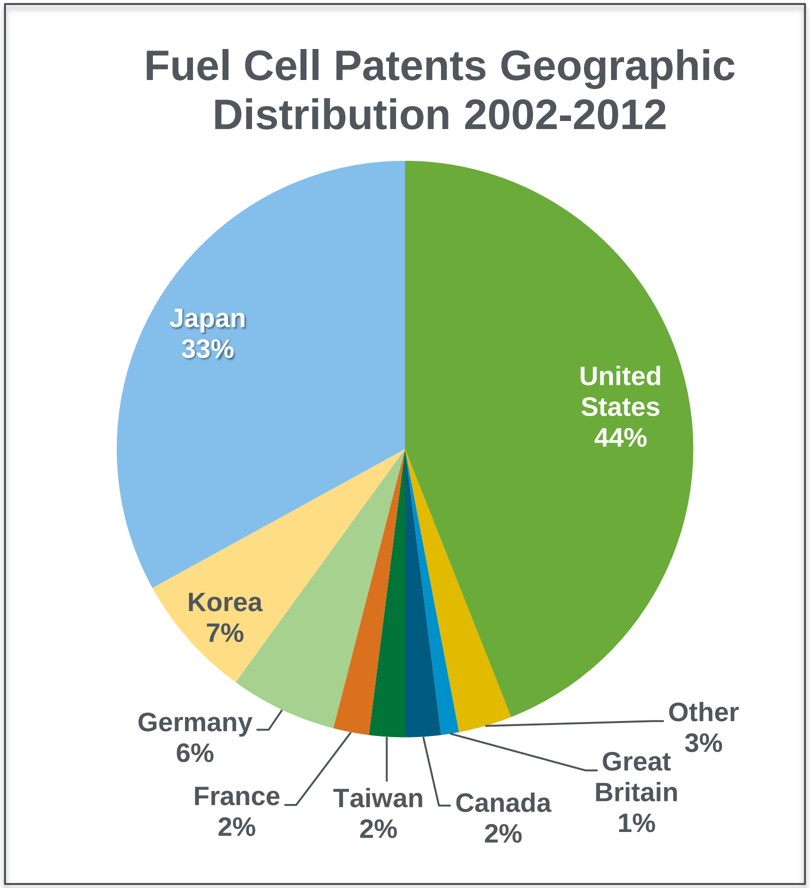

DOE cost-shared deployments led to >3X additional purchases.

Source: US DOE 4/18/2013

Fuel Cells – An Emerging Global Industry



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



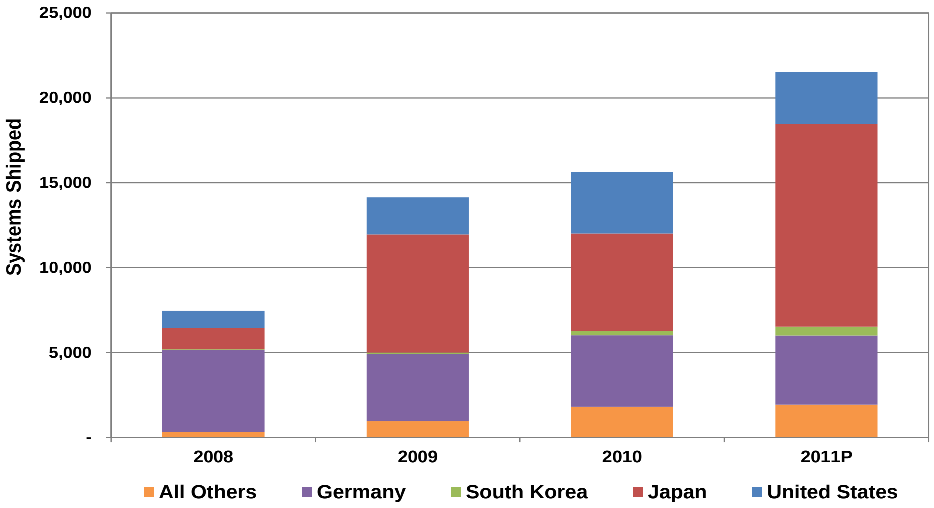
Clean Energy Patent Growth Index shows growth in fuel cell patents along with other clean energy technologies.

(http://cepgi.typepad.com/files/cepgi-4th-quarter-2012.pdf)

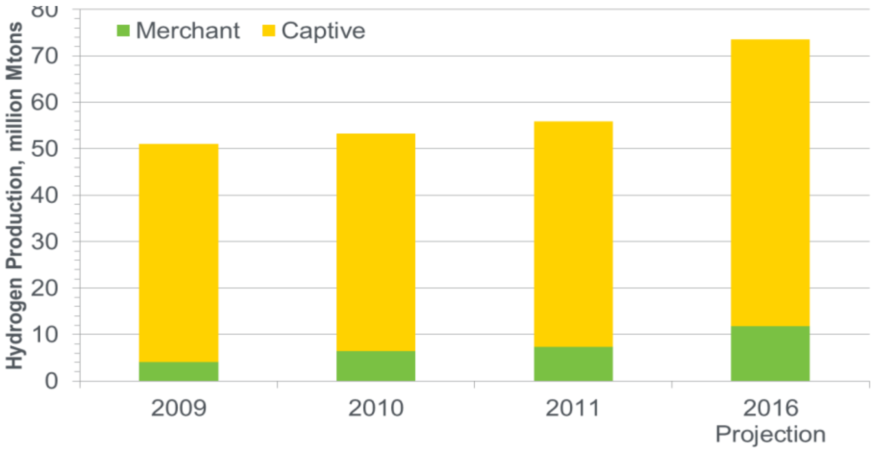
Source: US DOE 4/18/2013

Fuel Cell Market Overview

System Shipments by Key Countries: 2008-2011



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



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

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

The Market Potential

Independent analyses show global markets could mature over the next 10–20 years, producing revenues of:

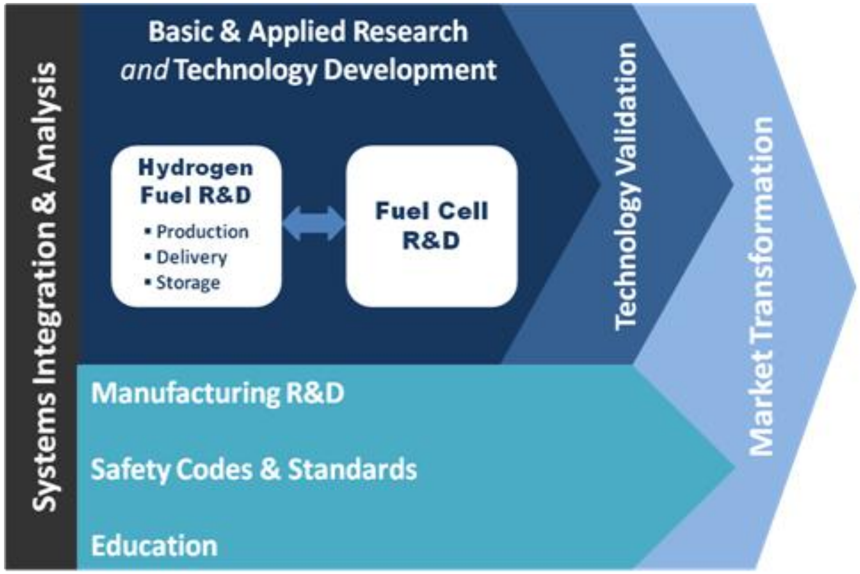
- $14 – $31 billion/year for stationary power
- $11 billion/year for portable power
- $18 – $97 billion/year for transportation

Sources: FuelCells2000, Pike Research, Markets & Markets, ***DOE Hydrogen and Fuel Cells Program Plan,*** **http://www.hydrogen.energy.gov/pdfs/program_plan2011.pdf; "Effects of a Transition to a Hydrogen Economy on Employment in the United States," http://hydrogen.energy.gov/pdfs/epact1820_employment_study.pdf**

DOE Hydrogen & Fuel Cells Program

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).

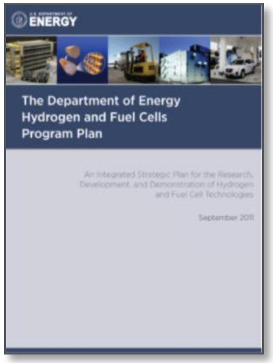


WIDESPREAD COMMERCIALIZATION ACROSS ALL SECTORS

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

Key Targets for FCEVs

- **$30/kW**
- **5000-hr durability** ***(150,000 miles)***
- **60% efficiency**
- **> 300-mile driving range**


U.S. DEPARTMENT OF ENERGY

The Department of Energy Hydrogen and Fuel Cells Program Plan

An Integrated Strategic Plan for the Research, Development, and Demonstration of Hydrogen and Fuel Cell Technologies

September 2011

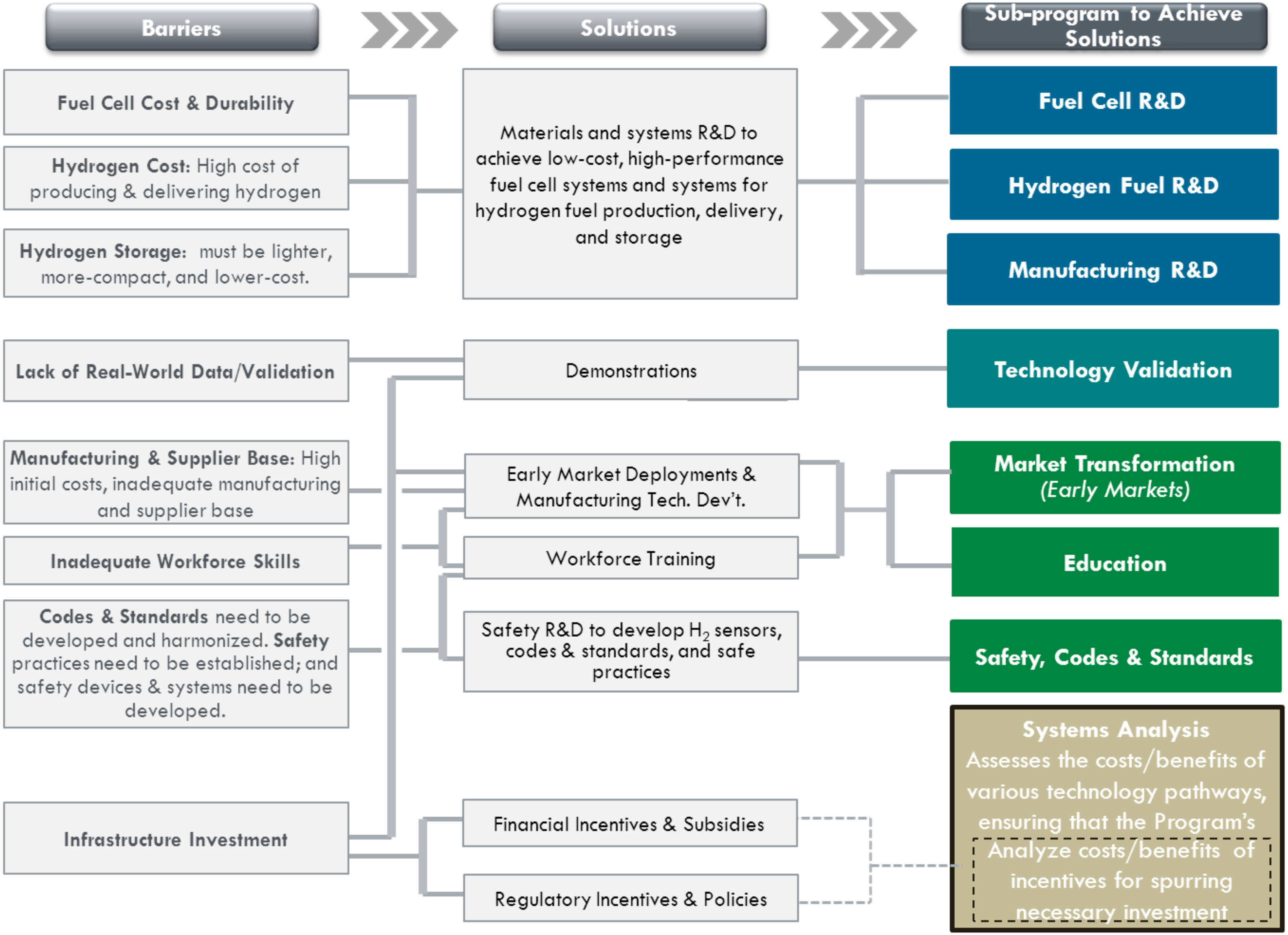
Hydrogen & Fuel Cells Program Plan
Update to the *Hydrogen Posture Plan* (2006).
Includes Four DOE Offices: EERE, FE, NE, and Science.

DOE has a long-standing and substantial commitment to hydrogen and fuel cells:

- **Nearly 300 projects currently funded by DOE at companies, national labs, and universities/institutes**
- **More than $1.3 billion invested from FY 2007 to FY 2012 across four DOE offices**

Source: US DOE 4/18/2013

DOE Program Strategy



Barriers

Solutions

Sub-program to Achieve Solutions

Fuel Cell Cost & Durability

Hydrogen Cost: High cost of producing & delivering hydrogen

Hydrogen Storage: must be lighter, more-compact, and lower-cost.

Materials and systems R&D to achieve low-cost, high-performance fuel cell systems and systems for hydrogen fuel production, delivery, and storage

Fuel Cell R&D

Hydrogen Fuel R&D

Manufacturing R&D

Lack of Real-World Data/Validation

Demonstrations

Technology Validation

Manufacturing & Supplier Base: High initial costs, inadequate manufacturing and supplier base

Inadequate Workforce Skills

Codes & Standards need to be developed and harmonized. **Safety** practices need to be established; and safety devices & systems need to be developed.

Early Market Deployments & Manufacturing Tech. Dev't.

Workforce Training

Safety R&D to develop H_2 sensors, codes & standards, and safe practices

Market Transformation
(Early Markets)

Education

Safety, Codes & Standards

Infrastructure Investment

Financial Incentives & Subsidies

Regulatory Incentives & Policies

Systems Analysis
Assesses the costs/benefits of various technology pathways, ensuring that the Program's
Analyze costs/benefits of incentives for spurring necessary investment

Source: US DOE 4/18/2013

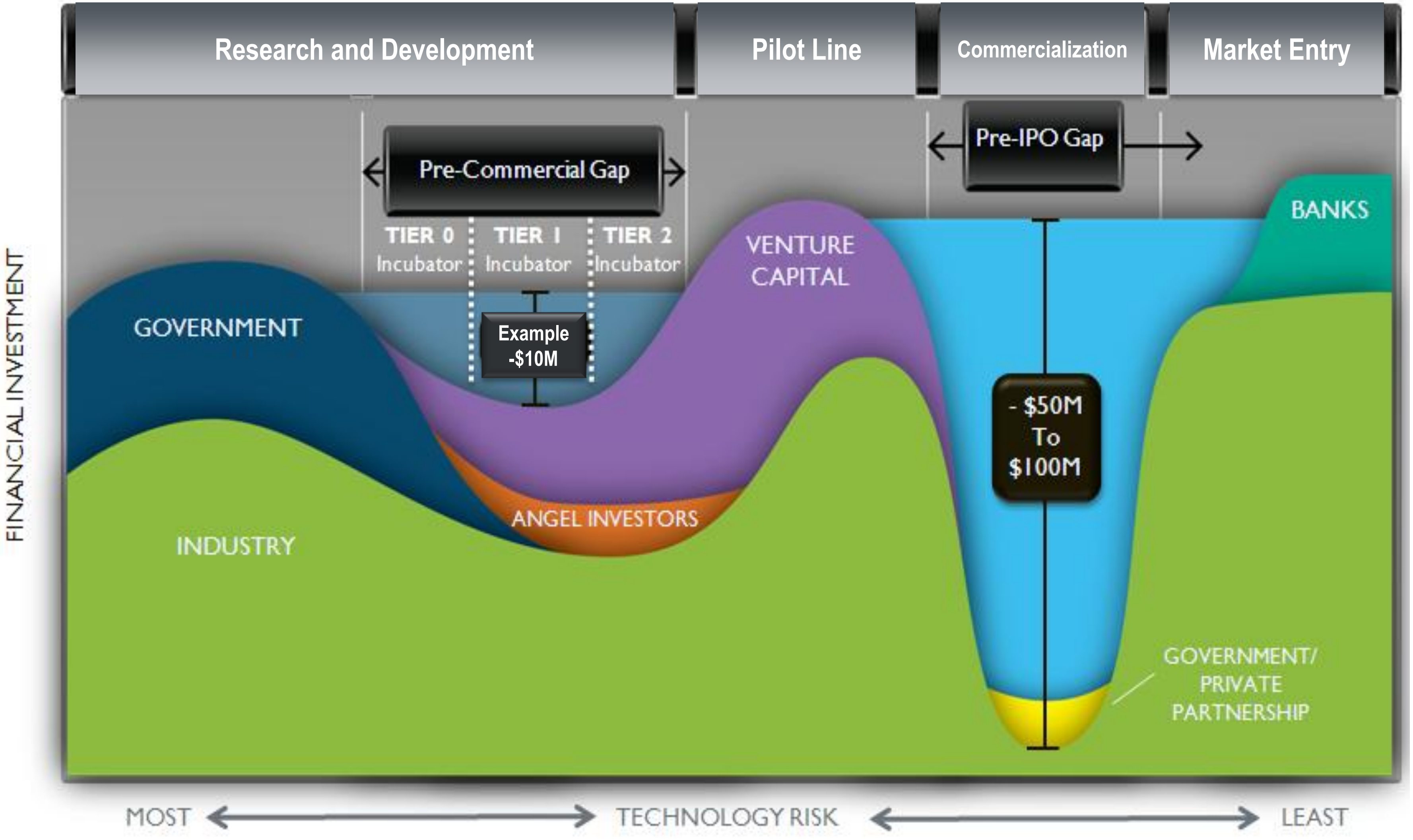
EERE Incubators – High Impact "Off-Roadmap" Technologies

FY 2014 Budget Request will include "Incubator" activities:

- Pilot expansion of successful "Sunshot Incubator Program" in Solar Energy Technology Office to other EERE Technology Offices
- Enables ongoing on-ramp for "off-road-map" emerging technology approaches
- Small fraction of annual R&D budget

Source: US DOE 4/18/2013

Government vs. Private Sector Roles

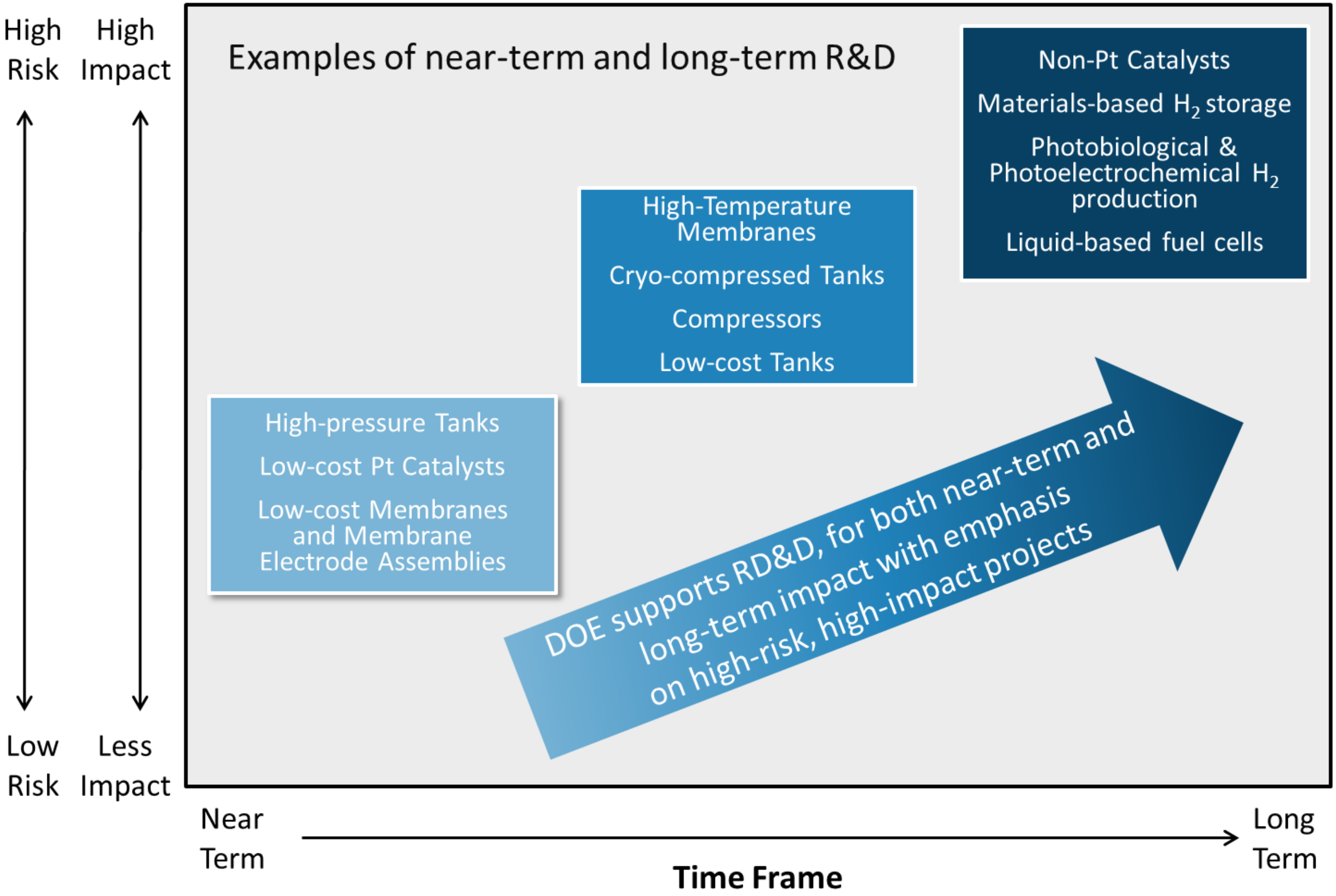


Adapted from SunShot Incubator briefing

Program R&D – Federal Role

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

R&D efforts are focused on pre-competitive, high-risk technologies



Examples of near-term and long-term R&D

High Risk ↔ Low Risk

High Impact ↔ Less Impact

High-pressure Tanks

Low-cost Pt Catalysts

Low-cost Membranes and Membrane Electrode Assemblies

High-Temperature Membranes

Cryo-compressed Tanks

Compressors

Low-cost Tanks

Non-Pt Catalysts

Materials-based H_2 storage

Photobiological & Photoelectrochemical H_2 production

Liquid-based fuel cells

DOE supports RD&D, for both near-term and long-term impact with emphasis on high-risk, high-impact projects

Near Term → Long Term

Time Frame

Budget: FCT Program Key Activities

Funding *($ in thousands)*		
Key Activity	**FY 2013 Request**	**FY 2014 Request**
Fuel Cell R&D	**38,000**	**37,500**
Hydrogen Fuel R&D	**27,000**	**38,500**
Manufacturing R&D	**2,000**	**4,000**
Technology Validation	**5,000**	**6,000**
Safety, Codes and Standards	**5,000**	**7,000**
Market Transformation	**0**	**3,000**
Education	**0**	**0**
Systems Analysis	**3,000**	**3,000**
SBIR/STTR	**- ***	**- ***
NREL Site-Wide Facilities Support	**0**	**1,000**
Total	**$80,000**	**100,000**

*Funds for the SBIR/STTR programs for FY 2013 and FY 2014 will be subtracted at later date.

Note: The FY 2012 and FY 2013 numbers shown on page 384 of the White House's FY 2014 Budget Request (www.whitehouse.gov/sites/default/files/omb/budget/fy2014/assets/doe.pdf) reflect $9.7 million that was carried over from FY 2012 to FY 2013 for obligation in FY 2013.

In FY 2014, the Program will coordinate with other EERE Programs (e.g., Advanced Manufacturing and Vehicle Technologies) in key areas.

FY 2014 Budget Background

- **The FY 2014 Budget Request is 25% higher than the FY 2013 request.** The FY 2014 request provides stable funding to enable continued progress in developing hydrogen and fuel cell technologies for stationary, portable, and transportation applications.
- **Hydrogen and fuel cells are an integral part of the Administration's "all-of-the above" energy strategy**—and the Department is committed to sustaining technical progress to support fuel cell electric vehicle (FCEV) commercialization in the 2015 timeframe and beyond—as announced by several major automakers.
- **Increased funding for Hydrogen Fuel R&D** to focus on improving renewable hydrogen production technologies (e.g., improving electrolyzer stack efficiency and lowering the cost of longer-term technologies using solar resources, including wide bandgap semiconductors) and lowering the carbon fiber composite cost for hydrogen storage vessels
- **Increased funding for Manufacturing R&D** to improve domestic capabilities in hydrogen and fuel cell manufacturing
- **Increased funding for Market Transformation** to spur the growth of key early markets, support the development of a domestic industry, and provide feedback to testing programs, manufacturers, and potential end users
- **FY 2014 activities will focus on technology advancements in key areas**—including ongoing reductions in the cost and improvement in the durability of fuel cells, reductions in the cost of renewably produced hydrogen, and improvements in systems for storing hydrogen.

DOE has made substantial progress in fuel cell technologies

✓ *reduced cost by > 80% since 2002 and > 30% since 2008 (projected to high volume)*

✓ *doubled fuel cell durability*

✓ *reduced platinum content by > 80%*

Source: US DOE 4/18/2013

FY 2014 Budget in Brief: Examples of Key Objectives

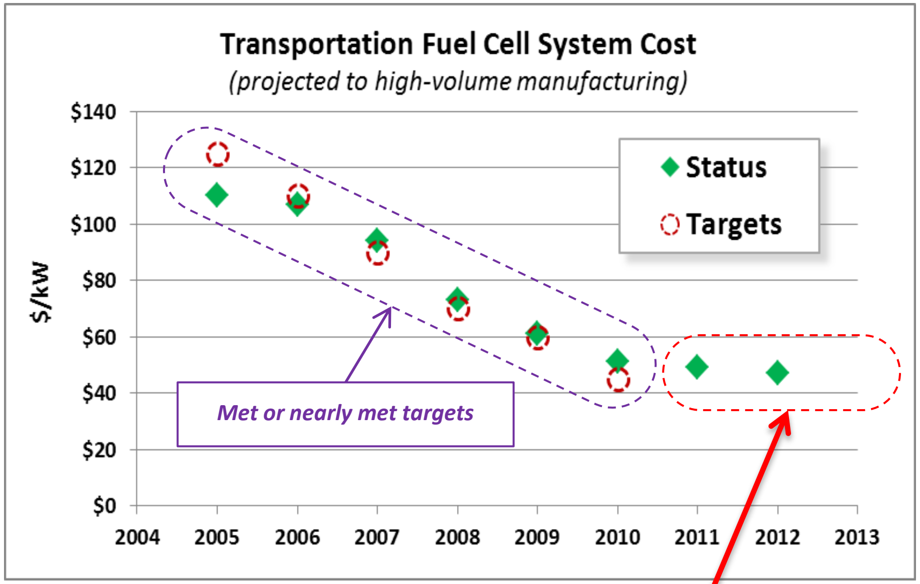
Develop technologies to enable fuel cells to be cost-competitive in diverse applications, including light-duty vehicles (at $30/kW) and stationary power (at less than $1,500/kW), and to enable renewable hydrogen (from diverse resources) to be cost-competitive with gasoline ($2 – 4/gge, delivered and dispensed).

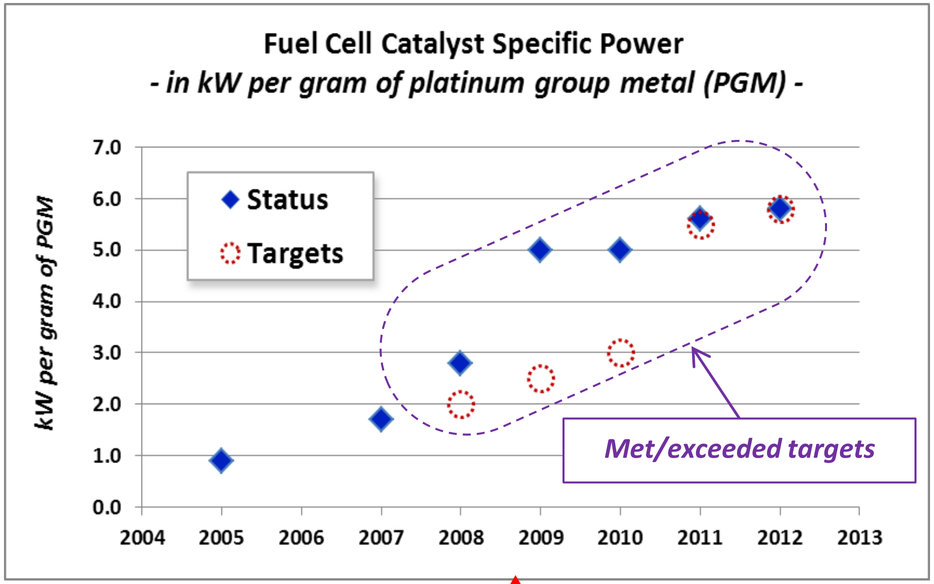
- **Fuel Cell R&D** will improve durability, reduce cost, and improve performance. Key goals include increasing PEM fuel cell power output per gram of PGM catalyst to 6.0 kW/g in 2014 and 8.0 kW/g by 2017 (from 2.8 kW/g in 2008).
- **Hydrogen Fuel R&D,** will focus on production from renewable resources, delivery, and storage R&D—to reduce the delivered, untaxed hydrogen cost to $7.20/gge from the 2011 baseline of $8/gge, and develop hydrogen storage technologies to reduce costs by >10 percent to $15/kWh.
- **Manufacturing R&D** will continue to develop fabrication processes and technologies for fuel cell components to enable an automotive fuel cell cost of $30/kW in 2017.
- **Technology Validation** will gather and analyze data from fuel cell electric vehicles and hydrogen fueling stations—providing critical feedback to R&D efforts.
- **Safety, Codes and Standards** will quantify the impact of fuel contaminants (for the revision of fuel quality standards) and the impact of fast fueling (e.g., SAE J2601).
- **Systems Analysis** will analyze near- and mid-term market impacts and the benefits of integrating stationary fuel cells into the electricity supply system.
- **Market Transformation** will collect and analyze data for early market applications such as backup power, forklifts, CHP, and aircraft ground support equipment, and coordinate efforts to reduce costs associated with hydrogen fuel cell system siting and installation.

Source: US DOE 4/18/2013

Progress – Fuel Cells (status & targets)

Fuel Cell R&D has consistently reduced fuel cell system cost and fuel cell platinum group metal catalyst content *(increasing the power per gram of platinum-group-metal [PGM] catalyst).*





No annual targets for ***fuel cell system cost*** after 2010—next target is $30/kW in 2017 (*cost status varies with platinum price volatility*).

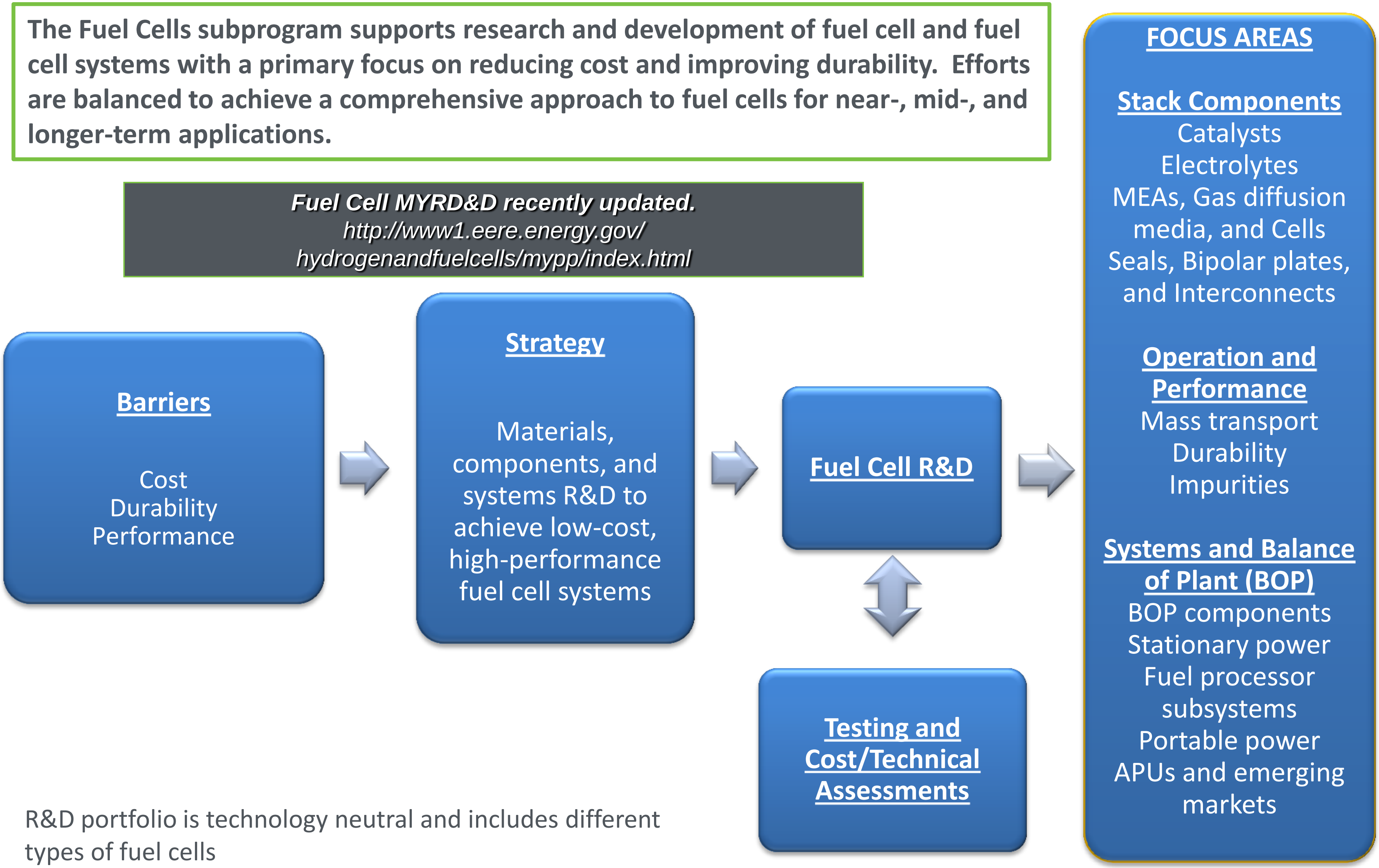
In 2011, ***increasing catalyst specific power*** (reducing platinum-group-metal content) replaced *fuel cell system cost* as the primary fuel cell R&D performance metric.

Source: US DOE 4/18/2013

Challenges & Strategy

The Fuel Cells subprogram supports research and development of fuel cell and fuel cell systems with a primary focus on reducing cost and improving durability. Efforts are balanced to achieve a comprehensive approach to fuel cells for near-, mid-, and longer-term applications.

Fuel Cell MYRD&D recently updated.
http://www1.eere.energy.gov/hydrogenandfuelcells/mypp/index.html



Barriers

Cost
Durability
Performance

Strategy

Materials, components, and systems R&D to achieve low-cost, high-performance fuel cell systems

Fuel Cell R&D

Testing and Cost/Technical Assessments

FOCUS AREAS

Stack Components
Catalysts
Electrolytes
MEAs, Gas diffusion media, and Cells
Seals, Bipolar plates, and Interconnects

Operation and Performance
Mass transport
Durability
Impurities

Systems and Balance of Plant (BOP)
BOP components
Stationary power
Fuel processor subsystems
Portable power
APUs and emerging markets

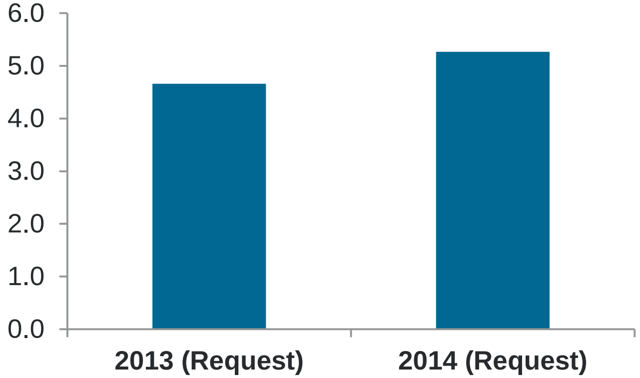
R&D portfolio is technology neutral and includes different types of fuel cells

Key Challenge: Fuel Cell Durability

Durability is a major barrier to fuel cell commercialization. The Program emphasizes the identification of degradation mechanisms and approaches for mitigating the effects.

Market-driven targets set for a range of applications:
For automotive applications, fuel cells will need to have a durability of 5,000 hours. Stationary fuel cell systems will require about 60,000- to 80,000-hour durability depending on size and application.

Planned Budget for Durability Projects



Fuel cell stack and BOP component durability is also addressed through respective component R&D.

FY 2014 Request addresses recommendations from external reviews:

- ✓ *" "FCEV propulsion technology development has progressed significantly over the past several decades, but two remaining challenges are fuel cell durability and cost. Demonstrated on-road durability is less than 100,000 miles and needs to increase by a factor of two to meet vehicle lifetime expectations." (National Petroleum Study, August 2012)*

System/stack durability assessment
NREL is analyzing and aggregating durability results by application, providing a benchmark of state-of-the-art fuel cell durability (time to 10% voltage degradation). Results to date include 82 data sets from 10 fuel cell developers.

Application	Avg Projected Time to 10% Voltage Drop	Avg Operation Hours
Backup power	2,400	1,100
Automotive	4,000	2,700
Forklift	14,600	4,400
Prime	11,200	7,000

FCT Durability Working Group
Meets twice a year to exchange information, create synergies, and collaboratively develop both an understanding of and tools for studying fuel cell degradation. Its members include PIs and supporting personnel from DOE-funded durability projects.

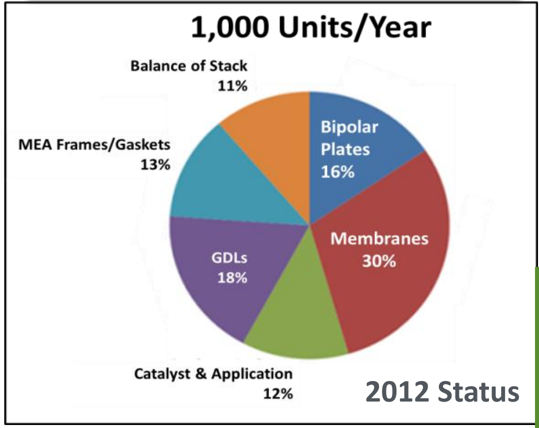
Impurities
The effects of air impurities and system contaminants, on durability are also investigated and quantified, with efforts leading to the development of mitigation strategies

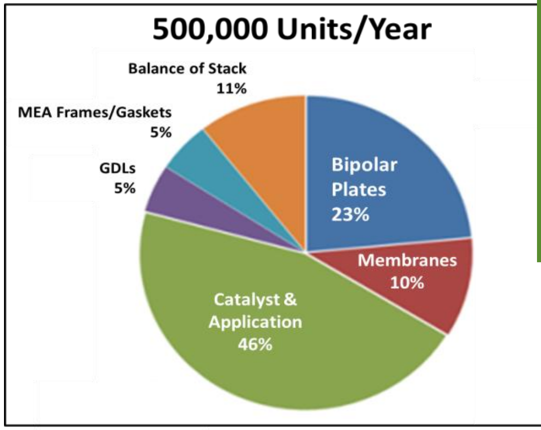
Source: US DOE 4/18/2013

Strategy to Address High-Impact Areas – PEM Example

- **Strategic technical analysis guides focus areas for R&D and priorities for budget**
- **Need to reduce cost, but also increase durability**
- **Advances in PEMFC materials and components could benefit a range of applications**

PEMFC Stack Cost Breakdown

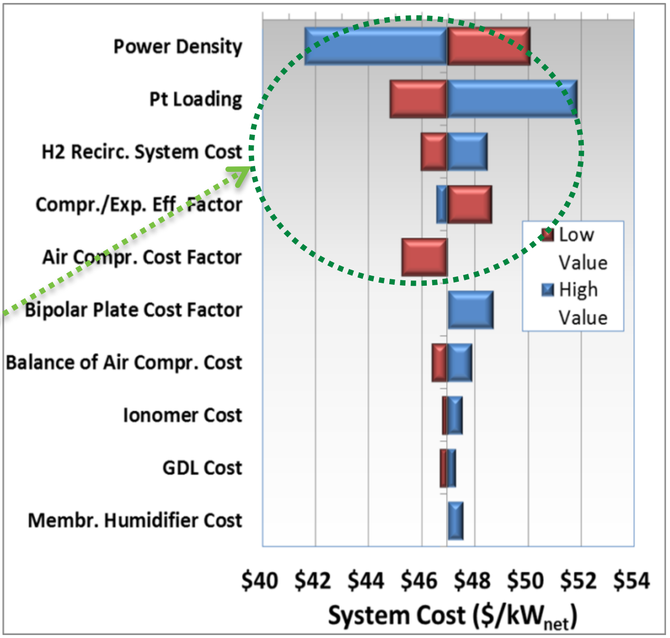




Key Focus Areas for R&D

- **Membrane cost is projected to be the largest single component of a PEMFC stack cost, manufactured at low volume.**
- **Catalyst cost is the largest component at high volume.**

Automotive Fuel Cell System



Sensitivity Analysis helps guide R&D

Strategies to Address Challenges –
Catalyst Examples

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

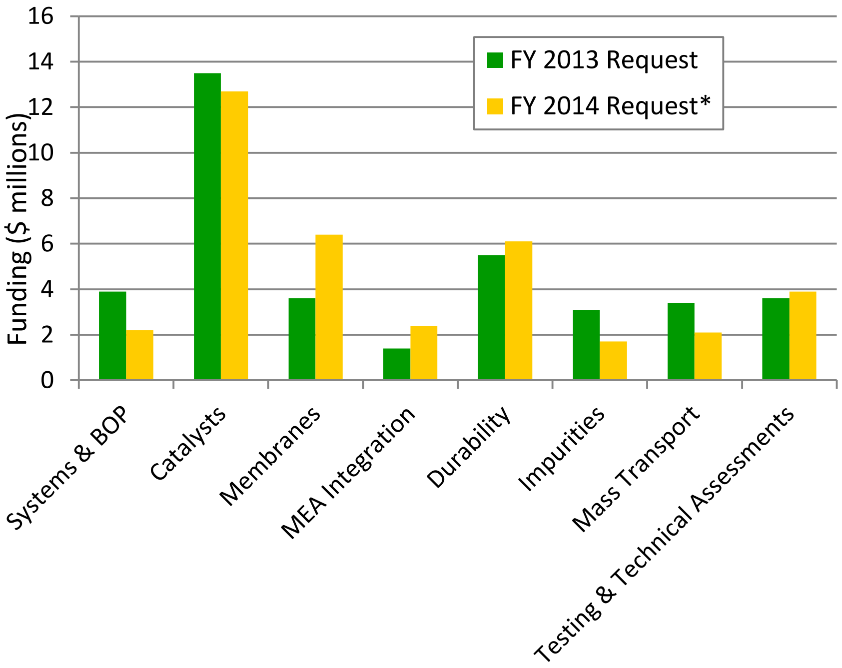
Source: US DOE 4/18/2013

Fuel Cell R&D - Plans

Maintains critical fuel cell R&D to improve the durability, reduce cost, and improve the performance of fuel cell systems for stationary, transportation, and portable power. Key goals: Increase PEM fuel cell power output per gram of PGM catalyst from 2.8 kW/g (in 2008) to 6.0 kW/g in 2014 and 8.0 kW/g by 2017.

FY 2014 Request = $37.5M

FY 2013 Request= $38.0M



*Subject to appropriations, project go/no go decisions and competitive selections. Exact amounts will be determined based on R&D progress in each area and the relative merit and applicability of projects competitively selected through planned funding opportunity announcements (FOAs).

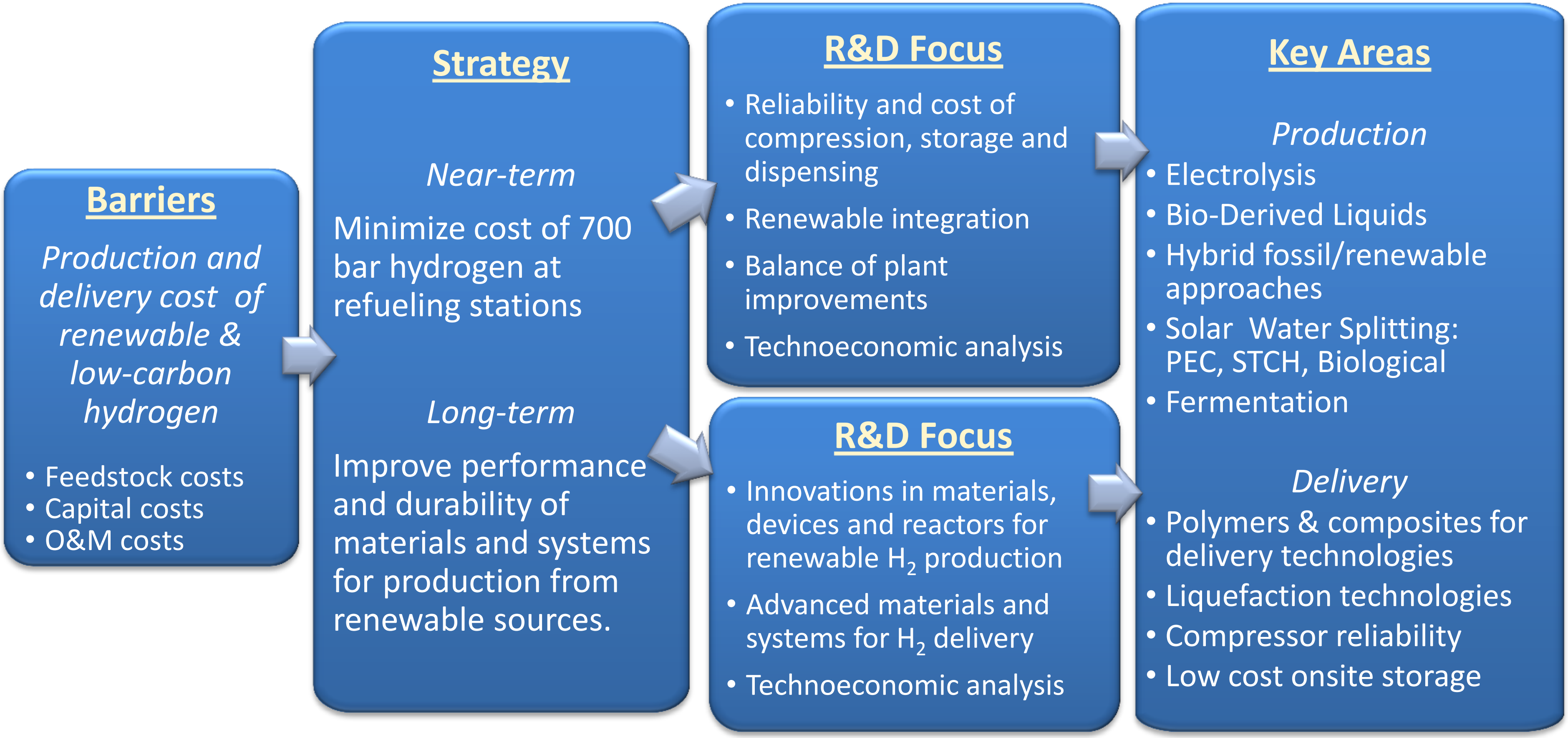
EMPHASIS

- Focus on approaches that will increase activity and utilization of current PGM and PGM-alloy catalysts, as well as non-PGM catalyst approaches for long-term applications.
- Improve PEM-MEAs through integration of state-of-the-art MEA components.
- Develop transport models and in-situ and ex-situ experiments to provide data for model validation.
- Identify degradation mechanisms and develop approaches to mitigate their effects.
- Maintain core activities on components, sub-systems and systems specifically tailored for stationary and portable power applications (e.g. SOFC)

Source: US DOE 4/18/2013

H_2 Production and Delivery Challenges & Strategy

The Hydrogen Production and Delivery subprogram supports research and development of technologies for low-cost, carbon-free hydrogen production from diverse renewable pathways, and low-cost, delivery of hydrogen to achieve a produced, delivered and dispensed (untaxed) cost of \$2-\$4/kg of hydrogen by 2020.



Barriers

Production and delivery cost of renewable & low-carbon hydrogen

- Feedstock costs
- Capital costs
- O&M costs

Strategy

Near-term

Minimize cost of 700 bar hydrogen at refueling stations

Long-term

Improve performance and durability of materials and systems for production from renewable sources.

R&D Focus

- Reliability and cost of compression, storage and dispensing
- Renewable integration
- Balance of plant improvements
- Technoeconomic analysis

R&D Focus

- Innovations in materials, devices and reactors for renewable H_2 production
- Advanced materials and systems for H_2 delivery
- Technoeconomic analysis

Key Areas

Production

- Electrolysis
- Bio-Derived Liquids
- Hybrid fossil/renewable approaches
- Solar Water Splitting: PEC, STCH, Biological
- Fermentation

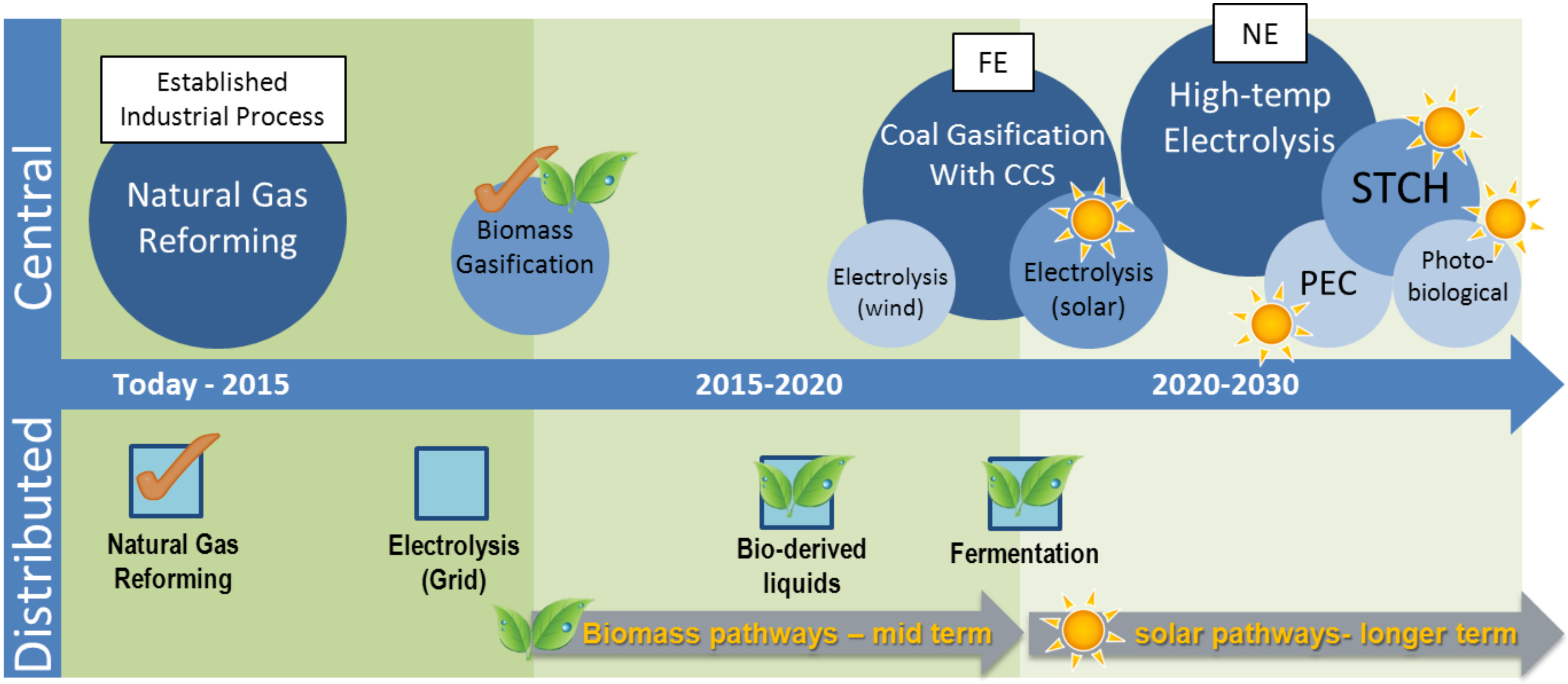
Delivery

- Polymers & composites for delivery technologies
- Liquefaction technologies
- Compressor reliability
- Low cost onsite storage

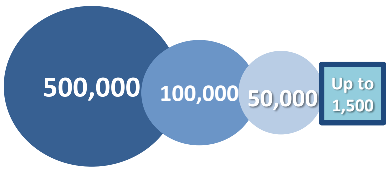
H_2 Production and Delivery MYRD&D chapters available at: *http://www1.eere.energy.gov/hydrogenandfuelcells/mypp/index.html*

Hydrogen Production from Multiple Pathways

Technology Readiness of DOE Funded Production Pathways



Estimated Plant Capacity (kg/day)



✓ **P&D Subprogram R&D efforts successfully concluded**

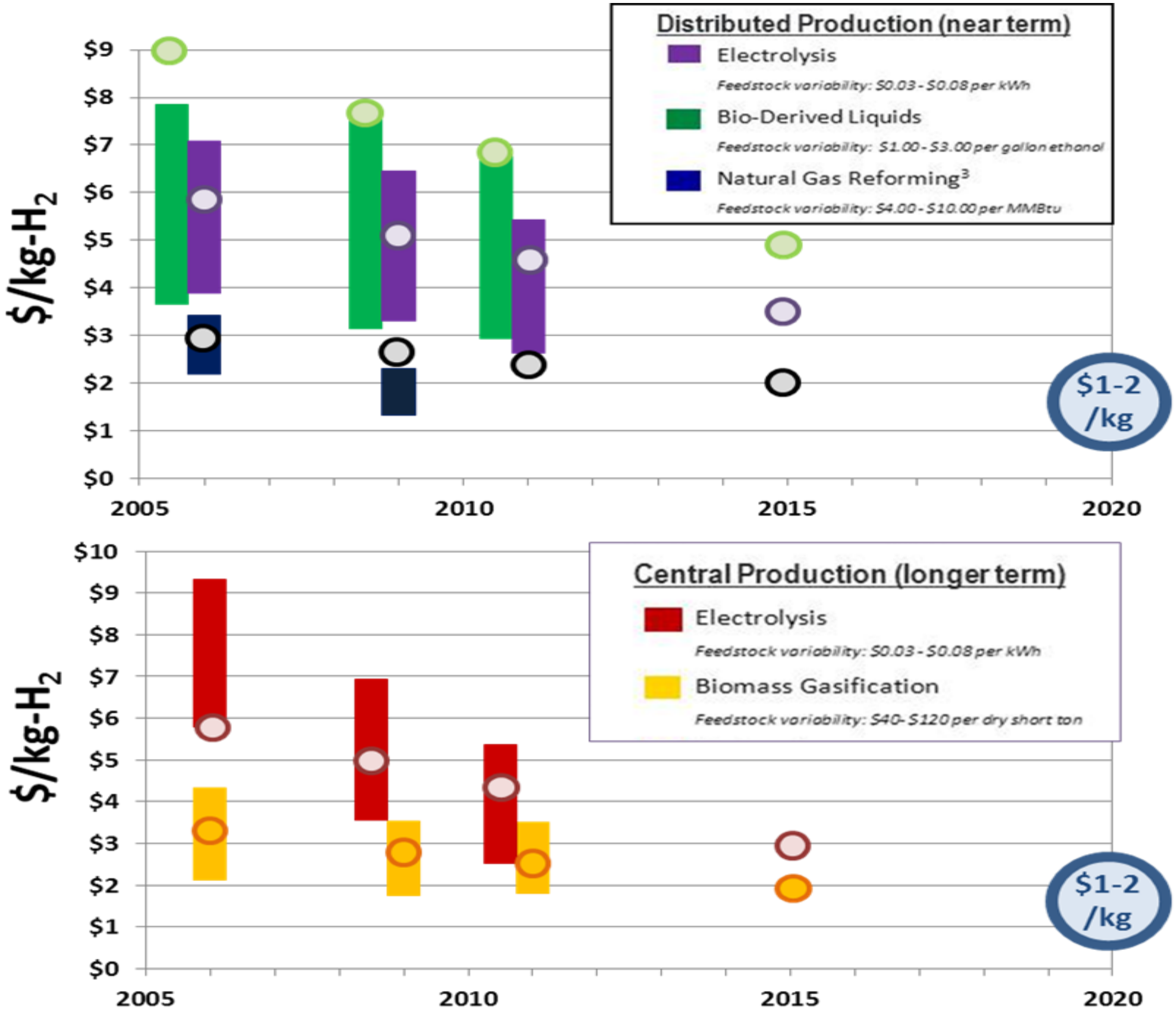
FE *= R&D efforts in DOE Office of Fossil Energy*

NE *= R&D efforts in DOE Office of Nuclear Energy*

Source: US DOE 4/18/2013

Hydrogen Production — Status & Pathways

Projected High-Volume Cost of Hydrogen Production for Different Pathways



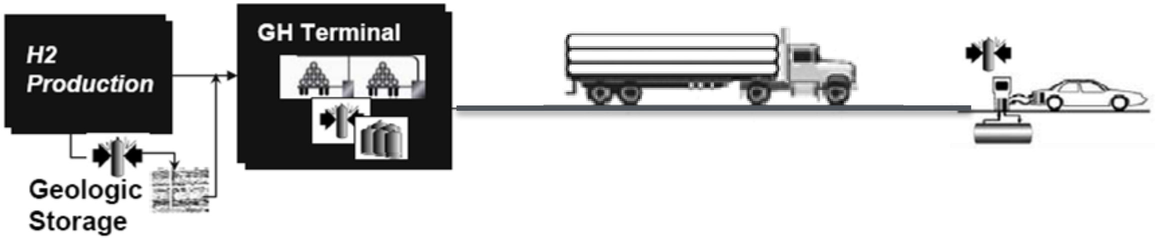
- ***Status of hydrogen cost is shown in vertical bars, reflecting values based on a range of assumptions (feedstock/capital costs).***
- ***Targets for hydrogen cost are shown in circles.***
- ***Targets shown are normalized for consistency in feedstock assumptions and year-cost basis (2007 dollars)***
- ***Targets prior to 2015 extrapolated based on 2015 and 2020 targets in the FCT Office's Multi-year RD&D Plan.***
- **Cost ranges are shown in 2007 dollars, based on projections from H2A analyses, and reflect variability in major feedstock pricing and a bounded range for capital cost estimates.**
- **Projections of costs assume Nth-plant construction, distributed station capacities of 1,500 kg/day, and centralized station capacities of ≥50,000 kg/day.**

Source: US DOE 4/18/2013

Primary Hydrogen Delivery Pathways

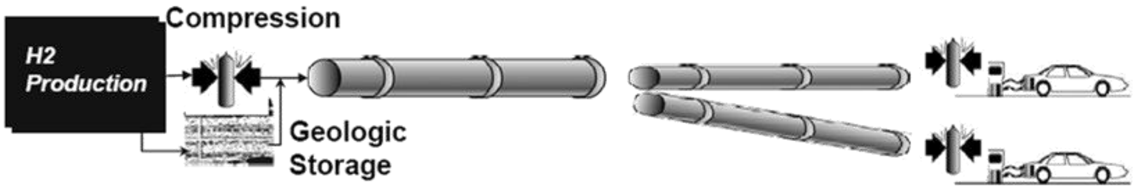
Key challenge: reduce the cost of hydrogen delivery to enable overall cost that is competitive with other energy carriers and fuels

Gaseous H_2 – via tube trailer



Refueling

Gaseous H_2 –via pipeline



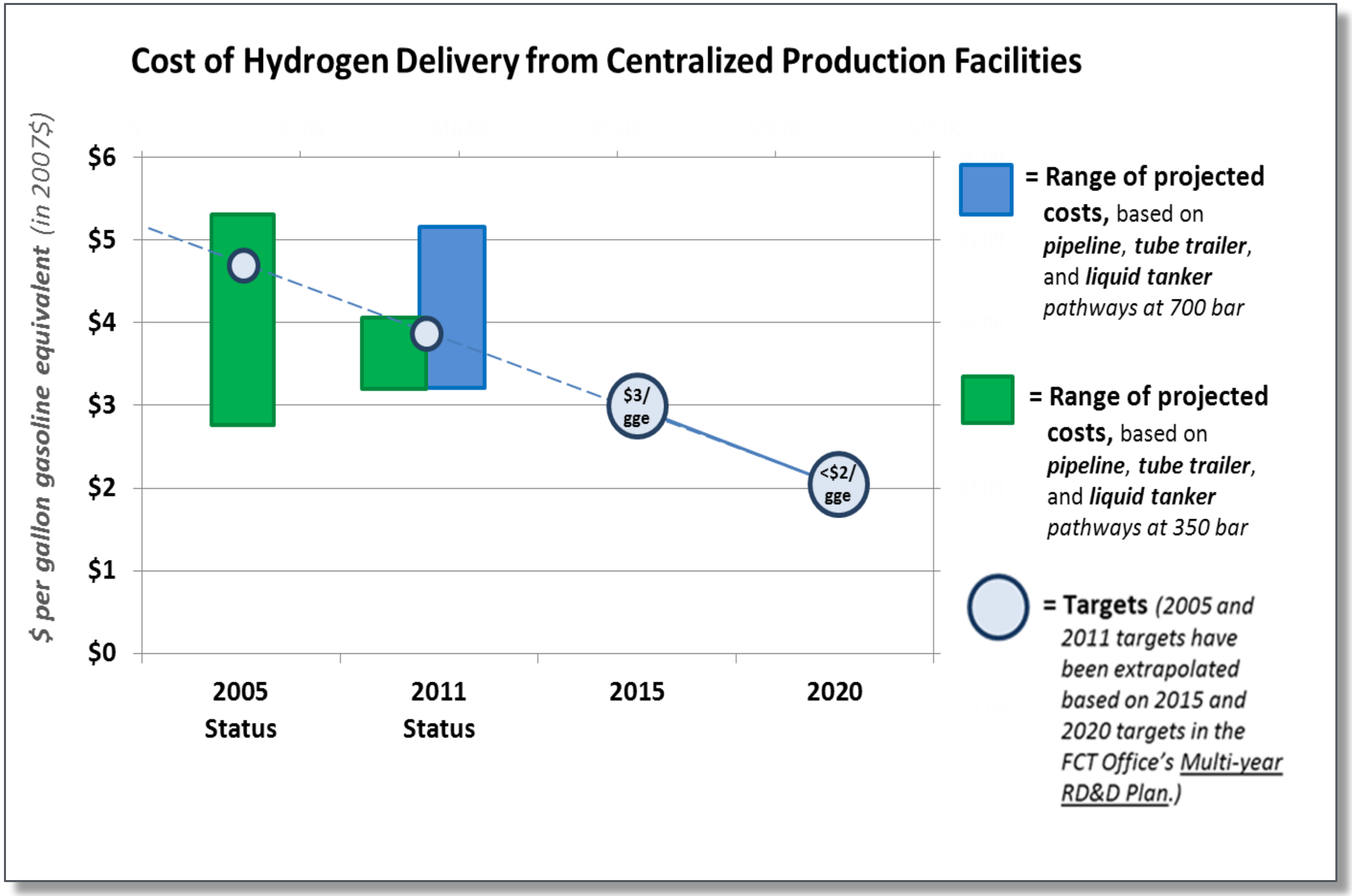
Refueling

Liquid H_2 –via tanker truck

Refueling

Source: US DOE 4/18/2013

Hydrogen Delivery Status & Targets



Cost of Hydrogen Delivery from Centralized Production Facilities

🟦 = **Range of projected costs,** based on ***pipeline***, ***tube trailer***, and ***liquid tanker*** *pathways at 700 bar*

🟩 = **Range of projected costs,** based on ***pipeline***, ***tube trailer***, and ***liquid tanker*** *pathways at 350 bar*

○ = **Targets** *(2005 and 2011 targets have been extrapolated based on 2015 and 2020 targets in the FCT Office's Multi-year RD&D Plan.)*

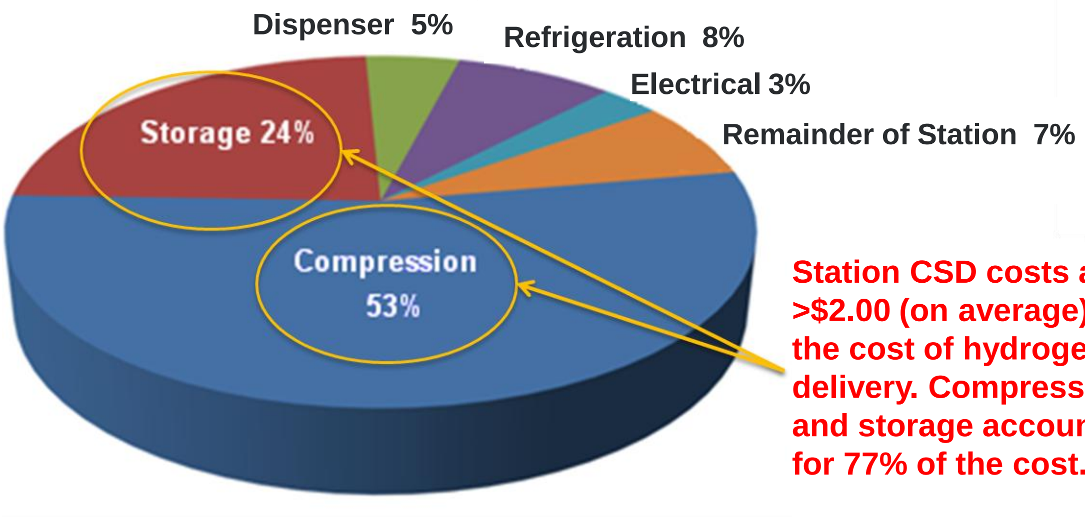
Hydrogen Delivery R&D Focus

- ✓ Identify cost drivers for H_2 delivery in early market applications
- ✓ Evaluate options to improve station compressor reliability
- ✓ Investigate the role of high-pressure tube trailers in reducing station costs

Source: US DOE 4/18/2013

Reducing Station Costs – Pathways

Station costs dominate delivery costs—key focus area.



Station CSD costs add >$2.00 (on average) to the cost of hydrogen delivery. Compression and storage account for 77% of the cost.[1]

Fueling Station (CSD) Costs

	2011 Projected Cost*	2020 Projected Cost*
Centralized Production	$1.70-$2.20/kg	<$0.70/kg
Distributed Production	$2.50/kg	<$1.70/kg

Recent SBIR Topic on Dispensers

Workshop March 20–21, 2013 to identify key RD&D areas for CSD

RFI to collect public feedback on workshop report

FOA on RD&D topics to address cost reduction at the forecourt.

---

[1] **Hydrogen & Fuel Cells Program Record 12021,** Cost Projections for Delivery Operations at a Distributed H_2 Production/Refueling Site, may 2012, **http://www.hydrogen.energy.gov/program_records.html**

Hydrogen Production & Delivery - Plans

Key goals include: Achieve a 10% reduction in the delivered, untaxed hydrogen cost from the baseline of $8/gge. Construct and test a hydrogen storage vessel that reduces refueling station vessel costs by 25%. Demonstrate 750 hour operational lifetime in a high efficiency (≥10%) photoelectrochemical device.

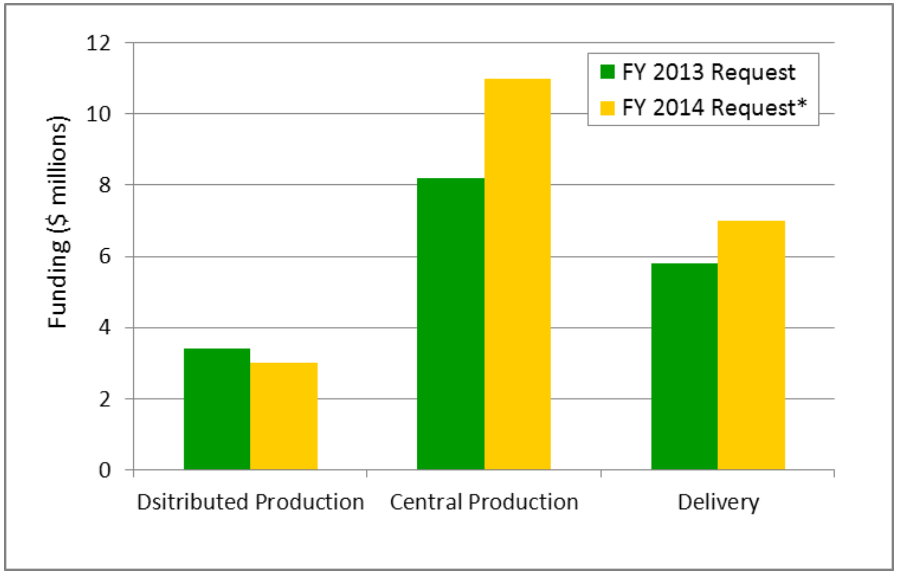
Hydrogen Fuel R&D

(for Production, Delivery & Storage)

FY 2014 Request = $38.5M

FY 2013 Request= $27.0 M

Production & Delivery Portion of Hydrogen Fuel R&D



* Subject to appropriations, project go/no go decisions and competitive selections. Exact amounts will be determined based on R&D progress in each area and the relative merit and applicability of projects competitively selected through planned funding opportunity announcements (FOAs).

EMPHASIS

- Maintain core efforts in key pathways
- Improve performance and durability of materials and systems for production from renewable sources: photoelectrochemical, biological, and solar thermochemical.
- Implement optimized delivery technologies and strategies to minimize cost of 700 bar hydrogen at refueling stations.

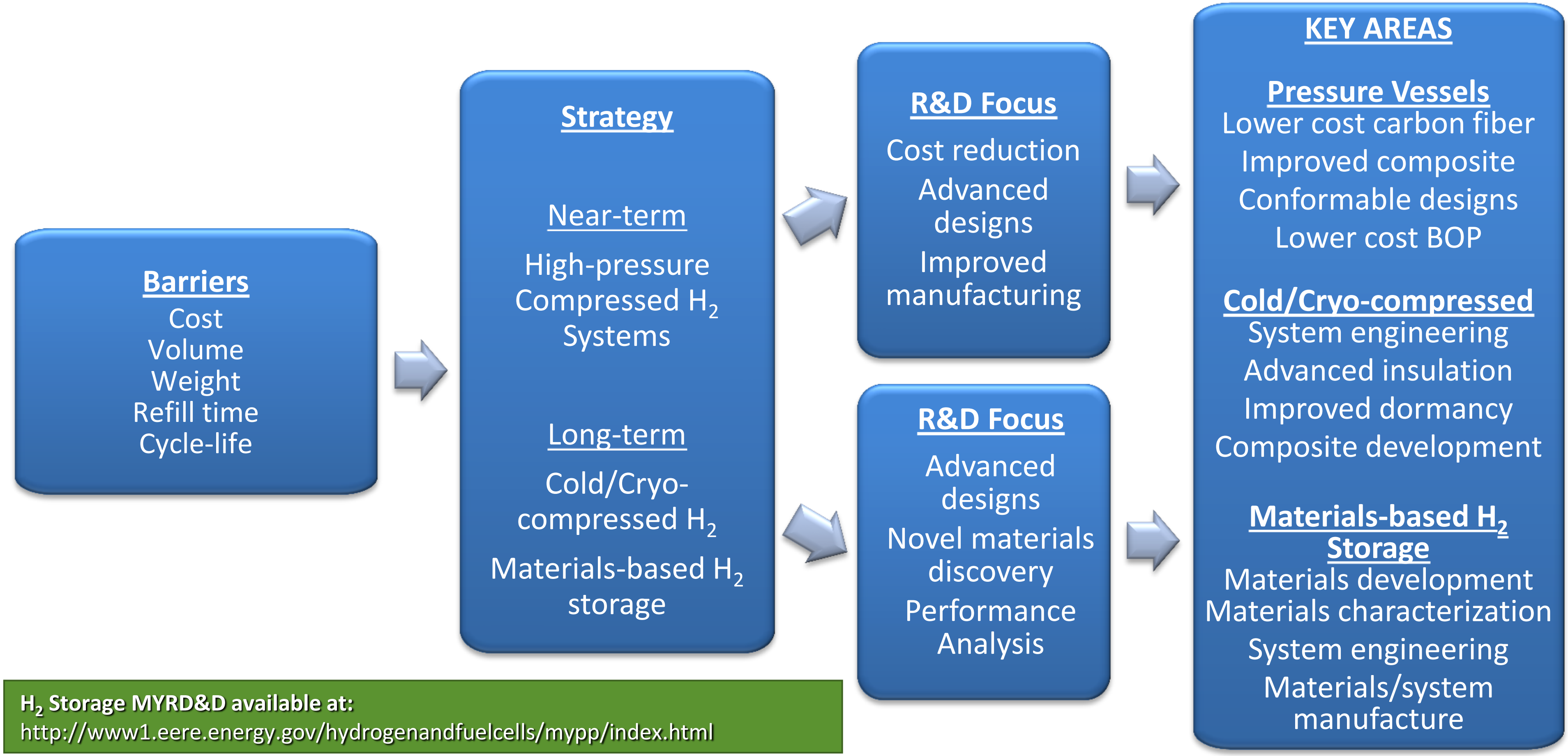
Production & Delivery FOAs in FY 2013 for FY 2014 funds

Notices of Intent will be posted soon

Source: US DOE 4/18/2013

H_2 Storage Challenges & Strategy

- **H_2 Storage supports R&D of advanced hydrogen storage technologies, with a primary focus on reducing system cost, weight, and volume.**
- **Near-term focus** = lowering costs; **long-term focus** = achieving all performance targets
- **R&D portfolio is technology neutral** and includes a broad spectrum of storage technologies.
- DOE has **validated a vehicle capable of up to 430-mile driving range**, but cost is a key challenge.



Barriers
Cost
Volume
Weight
Refill time
Cycle-life

Strategy

Near-term
High-pressure Compressed H_2 Systems

Long-term
Cold/Cryo-compressed H_2
Materials-based H_2 storage

R&D Focus
Cost reduction
Advanced designs
Improved manufacturing

R&D Focus
Advanced designs
Novel materials discovery
Performance Analysis

KEY AREAS

Pressure Vessels
Lower cost carbon fiber
Improved composite
Conformable designs
Lower cost BOP

Cold/Cryo-compressed
System engineering
Advanced insulation
Improved dormancy
Composite development

Materials-based H_2 Storage
Materials development
Materials characterization
System engineering
Materials/system manufacture

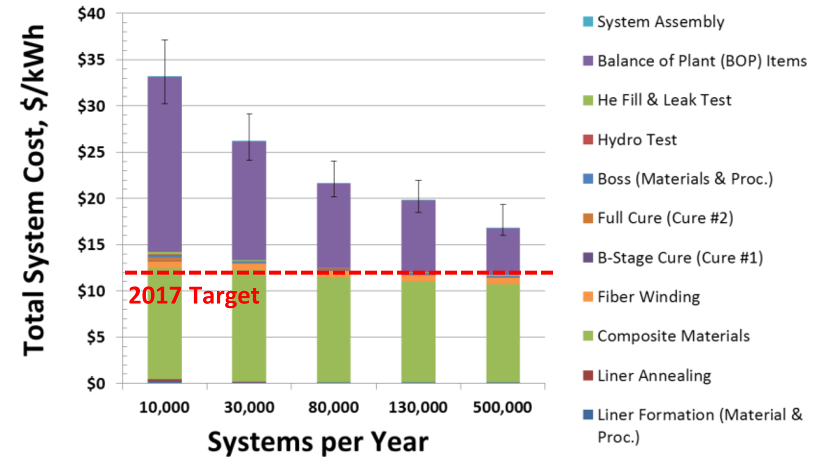
H_2 Storage MYRD&D available at:
http://www1.eere.energy.gov/hydrogenandfuelcells/mypp/index.html

Source: US DOE 4/18/2013

Hydrogen Storage

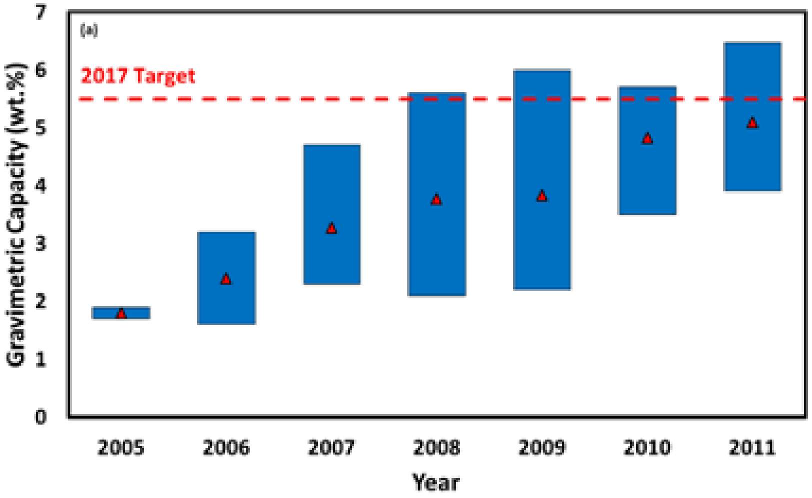
Compressed Gas Storage System Cost (70 Mpa)

5.6 kg H2 capacity, cost in 2007$



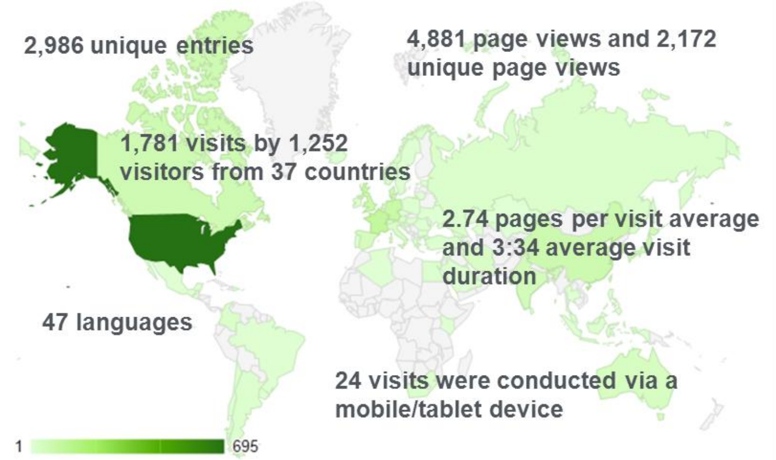
Hydrogen Storage: Gravimetric Capacity

-bars represent ranges of capacities for systems evaluated each year-



Launched open source database* on Hydrogen Storage Materials Properties

(http://hydrogenmaterialssearch.govtools.us/)



2,986 unique entries

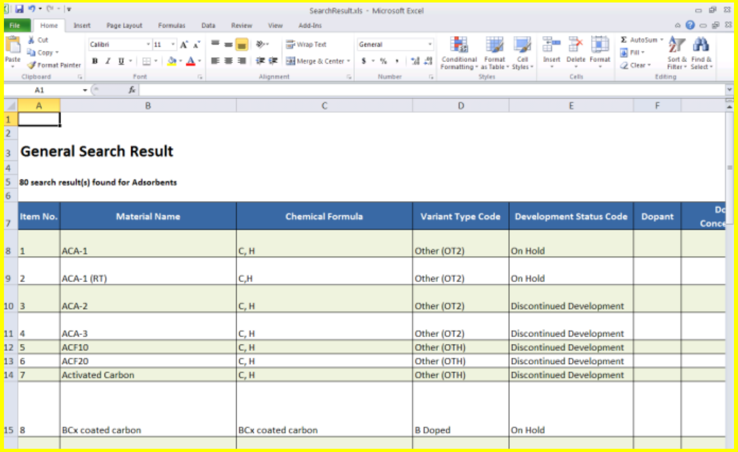
4,881 page views and 2,172 unique page views

1,781 visits by 1,252 visitors from 37 countries

2.74 pages per visit average and 3:34 average visit duration

47 languages

24 visits were conducted via a mobile/tablet device



General Search Result

80 search result(s) found for Adsorbents

Item No.	Material Name	Chemical Formula	Variant Type Code	Development Status Code	Dopant	Dc Conce
1	ACA-1	C, H	Other (OT2)	On Hold		
2	ACA-1 (RT)	C,H	Other (OT2)	On Hold		
3	ACA-2	C, H	Other (OT2)	Discontinued Development		
4	ACA-3	C, H	Other (OT2)	Discontinued Development		
5	ACF10	C, H	Other (OTH)	Discontinued Development		
6	ACF20	C, H	Other (OTH)	Discontinued Development		
7	Activated Carbon	C, H	Other (OTH)	Discontinued Development		
8	BCx coated carbon	BCx coated carbon	B Doped	On Hold		

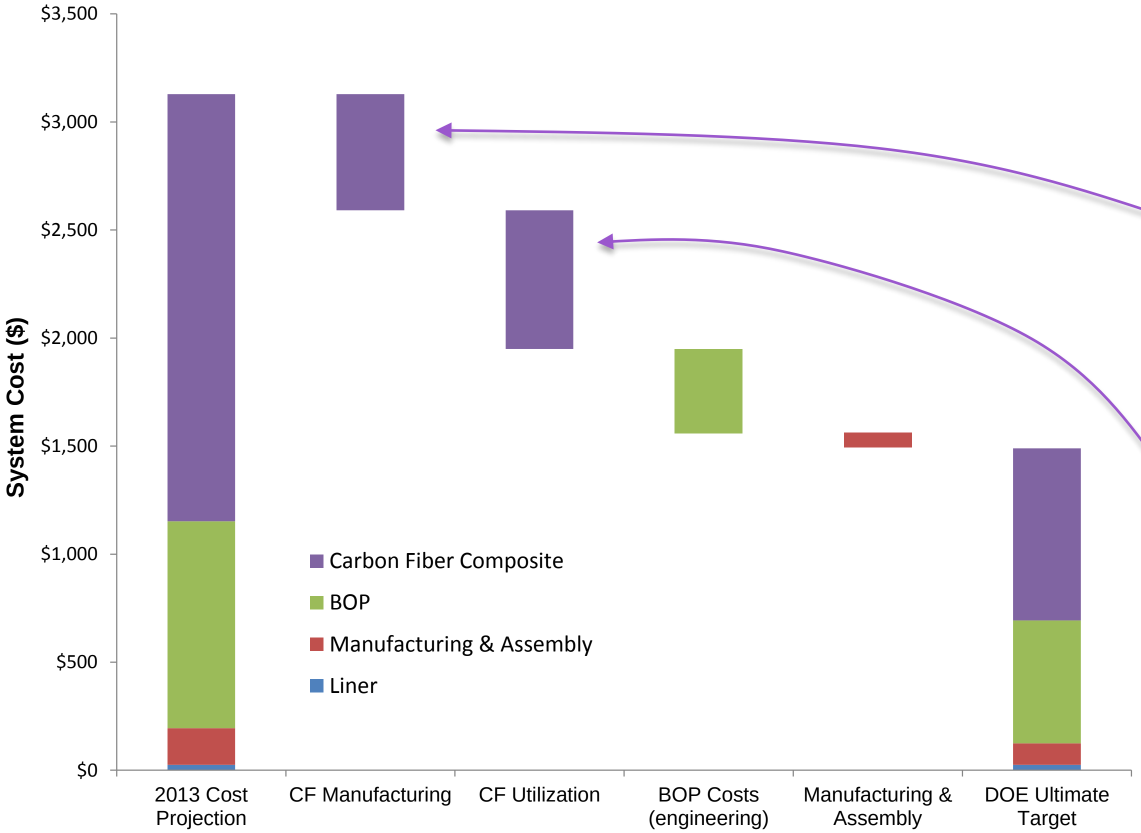
* Included in President's Materials Genome Initiative (MGI), http://www.whitehouse.gov/mgi

Source: US DOE 4/18/2013

Lowering the Cost of Compressed Gas Vessels is Key to Adoption

Strategy is to reduce cost through strategic investments and leveraging Vehicle Technologies & Advanced Manufacturing Offices

- Preliminary Analysis -



Research to Address R&D Gaps:

Analyses to identify cost reduction potentials

- Performance analyses to identify R&D needs
- Cost analyses to identify savings potential and trade-offs

Lowering cost of carbon fiber

- Lower cost precursors – 25% reduction in carbon fiber cost (17% vessel cost savings)
- Advanced precursor processing – 30% reduction in carbon fiber cost (20% vessel cost savings)
- Leverage investments by VTO & AMO

Lowering cost of composite systems

- Advanced resins to increase composite strength (20% vessel cost savings)
- Graded fiber approach to increase fiber usage efficiency (20% vessel cost savings)
- Leverage investments by VTO & AMO

Source: US DOE 4/18/2013

Hydrogen Storage R&D – Plans

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

Focused on advanced tanks for near-term hydrogen storage and materials R&D for long-term hydrogen storage.

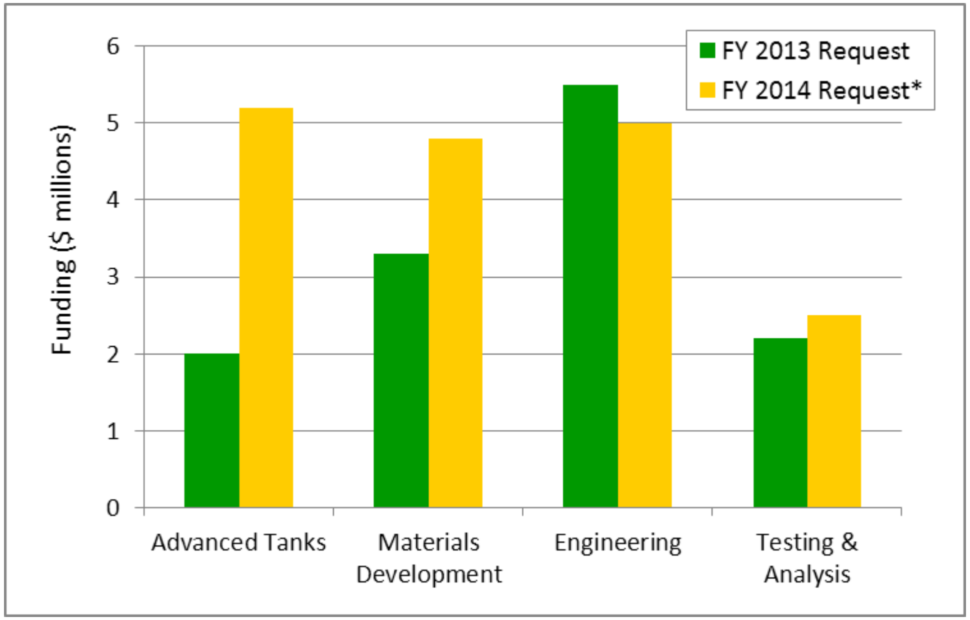
Hydrogen Fuel R&D

(for Production, Delivery & Storage)

FY 2014 Request = $38.5M

FY 2013 Request = $27.0 M

Storage Portion of Hydrogen Fuel R&D



* Subject to appropriations, project go/no go decisions and competitive selections. Exact amounts will be determined based on R&D progress in each area and the relative merit and applicability of projects competitively selected through planned funding opportunity announcements (FOAs).

EMPHASIS

- Reduce projected costs of high pressure composite vessels for hydrogen storage by at least 10% from the 2011 projected costs of $17/kWh through reduced cost carbon fiber materials, improved composite materials and improved vessel design (leverage manufacturing sub-program)
- Continue Engineering Center of Excellence including system engineering design of materials-based technologies to meet key 2017 storage system targets.
- Maintain core efforts on new materials development to increase the capacity and temperature of operation of adsorbent materials from cryogenic conditions (e.g. liquid nitrogen) to near room temperature by increasing the surface area and tailoring heats of adsorption.

Source: US DOE 4/18/2013

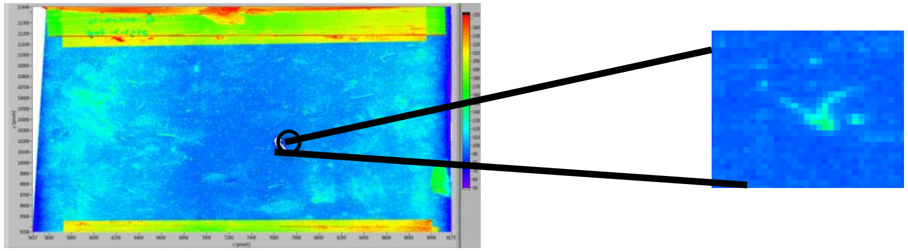
Manufacturing R&D

Developing and demonstrating technologies and processes to reduce cost of fuel cell components and systems and grow domestic supplier base

Manufacturing R&D Subprogram Key Accomplishments

- Reduced manufacturing labor cost of gas diffusion electrodes (GDEs) by 75% through development of a higher throughput coating process
- Demonstrated off-line and in-line diagnostics for measurement of variability and defects in fuel cell membranes, GDLs, electrodes, and full MEAs
- Moving from batch coating and hand-drying cathode electrodes to pilot scale roll-to-roll cathode coating

Development Platform for Diagnostics: Industrial webline



Membrane sample spliced into carrier web, moving at 30 ft/min

Source: US DOE 4/18/2013

Manufacturing Workshop Results

Workshop Held to Inform Potential Focus Areas for Future FOAs/Activities

- Gathered input on barriers to reducing cost of manufacturing hydrogen and fuel cell systems and components
- Identified high-priority needs and R&D activities that government can support to overcome those barriers

Issue	Votes
PEM Fuel Cells/Electrolyzers BOP: Facilitate a manufacturing group for DOE to expand supply chain.	21
Electrodes: How to apply ink directly to membrane; dual direct coating of CCM; *membrane dimensional change with deposition of current inks (overlaps with purview of Fuel Cell R&D subprogram)*	20
PEM Fuel Cells/Electrolyzers BOP: *Develop low cost manufacturing of natural gas reformers (overlaps with purview of Fuel Cell R&D subprogram*	18
Stack Assembly: High volume stack assembly processes: reduced labor, improved automation	15
Quality/Inspection/Process Control: Develop methods of identifying coating defects on a moving web, then rejecting single pieces downstream; defect detection after MEA assembly when defect may no longer be visible; ability to separate materials with defects from rolled goods with minimum production of scrap	15
SOFC: Multi-layer/component sintering	14

Identified high-priority topics for Manufacturing R&D

Workshop organized by the National Renewable Energy Laboratory for the U.S. Department of Energy
Minutes posted at: http://www1.eere.energy.gov/hydrogenandfuelcells/wkshp_h2_fc_manufacturing.html

Source: US DOE 4/18/2013

PEMFC and SOFC Manufacturing Status vs. Needs

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

PEM Fuel Cells

Current MEA

- Large batch mixing
- Roll-to-roll processes for membrane, electrode, and GDL fabrication
- Decal transfer of electrode to membrane
- Manual assembly of MEA with seals
- Hot pressing

Advancements

- Continuous mixing
- Robotic or roll-to-roll assembly of MEAs with seals
- Direct coating of electrode on membrane
- Hot-roll lamination or improved pressing

Current Stack

- Manual assembly
- Manual leak/performance test

Advancements

- Automated assembly
- Automatic leak/performance test

Current BOP

- Lean manufacturing cells and flow
- Unique components

Advancements

- Standardized designs
- Robotic BOP/system assembly line

Solid Oxide Fuel Cells

Current Cell

- Large batch mixing of powders and slurries
- Single layer tape casting with lamination of layers (planar)
- Batch pressing or extrusion of tubes (tubular)
- Semi-automated coating of electrolyte and cathode (tubular)
- Batch heat treatment and sintering
- Manual assembly of cells with seals
- Manual winding of interconnect wire (tubular)

Advancements

- Continuous mixing
- Multi-layer tape casting (planar)
- Continuous pressing or extrusion of tubes (tubular)
- Continuous firing and sintering
- Robotic assembly of cells with seals
- Automated winding of interconnect wire (tubular)

Current Stack

- Manual assembly
- Manual shaping of insulation
- Manual leak/performance test

Advancements

- Automated assembly
- Net-shape or other methods for insulation
- Automatic leak/performance test

Current BOP

- Manual assembly
- Unique components

- Lean manufacturing cells and flow

Advancements

- Standardized designs
- Robotic BOP/system assembly line

Source: US DOE 4/18/2013

Manufacturing Demonstration Facilities and the Clean Energy Manufacturing Initiative

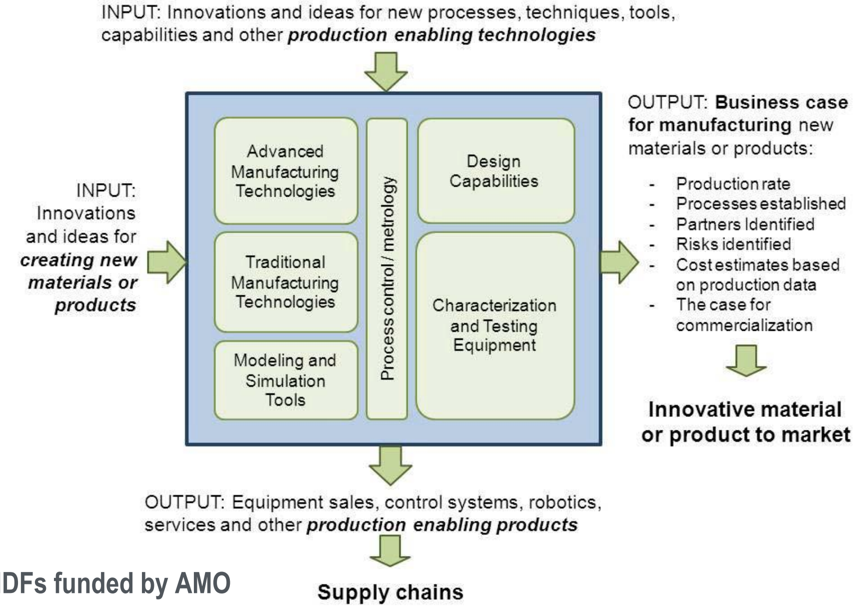
Opportunities for Collaboration with AMO: Manufacturing Demonstration Facilities (MDFs)

Barriers addressed:

- Access to expensive technologies and capabilities
  Sharing overhead costs -more efficient use of capital
- Increases visibility of unknown process options
- Accelerates partnership development and supplier relationships

Effect on U.S. competitiveness:

- Increased pool of domestic competitors, especially SMEs
- Increased rate of new product development
- Positive feedback between production and research/design accelerates both



INPUT: Innovations and ideas for new processes, techniques, tools, capabilities and other ***production enabling technologies***

INPUT: Innovations and ideas for ***creating new materials or products***

OUTPUT: **Business case for manufacturing** new materials or products:

- Production rate
- Processes established
- Partners Identified
- Risks identified
- Cost estimates based on production data
- The case for commercialization

Innovative material or product to market

OUTPUT: Equipment sales, control systems, robotics, services and other ***production enabling products***

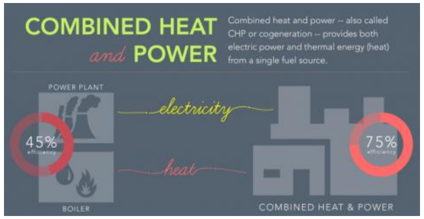
Supply chains

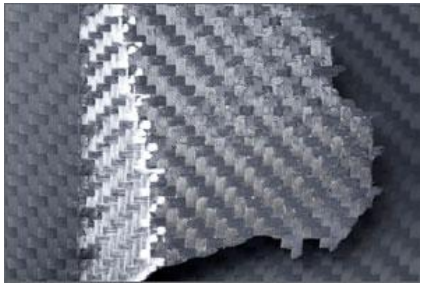
MDFs funded by AMO

http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/webinarslides_fct-amo_mfg_112012.pdf

Clean Energy Manufacturing Initiative

1. **Increase U.S. competiveness in the production of clean energy products**
   - *Invest in competitive advantages, overcome competitive disadvantages*
2. **Increase U.S. manufacturing competitiveness across the board by increasing energy productivity**
   - *Enhancing competitiveness of US companies*





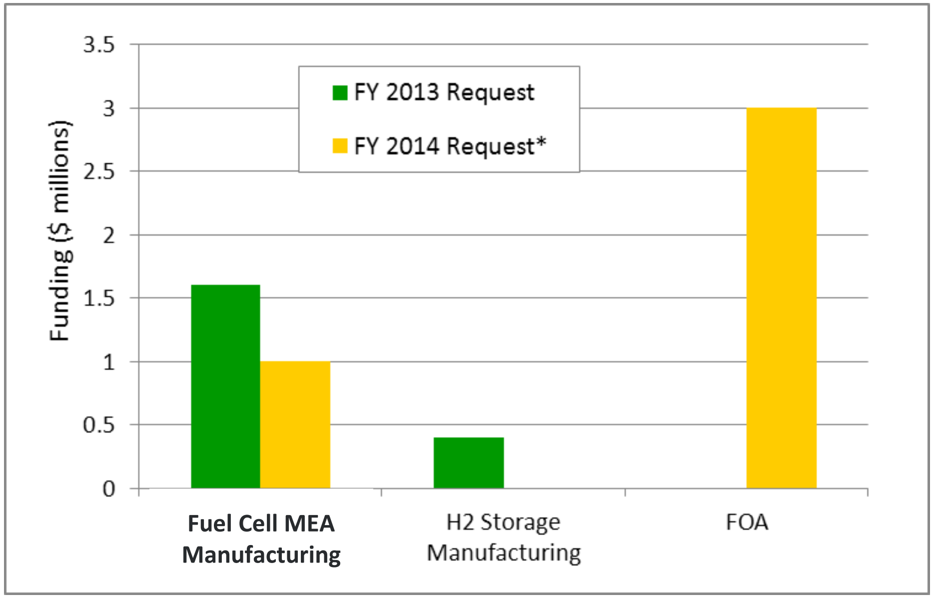
Manufacturing R&D - Plans

Develop fabrication processes and technologies for fuel cell components to enable an automotive fuel cell cost of $30/kW in 2017

FY 2014 Request = $4.0M

FY 2013 Request = $2.0M

Manufacturing R&D Funding



* Subject to appropriations, project go/no go decisions and competitive selections. Exact amounts will be determined based on R&D progress in each area and the relative merit and applicability of projects competitively selected through planned funding opportunity announcements (FOAs).

EMPHASIS

- Continue core efforts on PEM fuel cells
  - Simplify roll-to-roll processing of MEAs by reducing the number of coating passes and direct coating of catalyst onto ionomer

Projects

- **MEA Manufacturing**
- **Detection of defects in catalyst coated membranes, gas diffusion electrodes, and solid oxide tube cells**

- Fund new projects (from FY 2013 funding opportunity announcement) based on results from hydrogen and fuel cell Manufacturing R&D workshop (subject to appropriations)

Source: US DOE 4/18/2013

Technology Validation

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

Completed World's Largest FCEV & Hydrogen Demonstration to Date

- with 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 *(some of this hydrogen used by vehicles not in the learning demonstration)*
- **>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

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

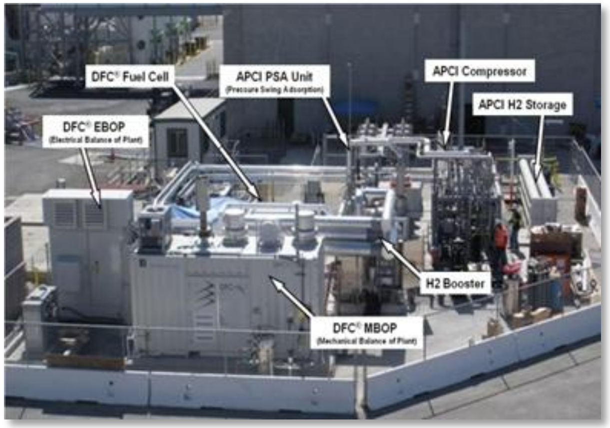
	Status *(NG Reforming)*	Status *(Electroylsis)*	Ultimate Target
H_2 Cost at Station	$7.70–$10.30/kg	$10.00–12.90/kg	$2.00–4.00/kg

Partners: Air Products, BP, Chevron, Daimler, Ford, GM, Hyundai, Kia, UTC Power

Demonstrated World's First "Tri-generation" Station

- Capable of co-producing electricity, hydrogen, and heat -

- Utilizes anaerobic digestion of municipal wastewater (from the 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



Partners: Air Products, California Air Resources Board, FuelCell Energy, South Coast Air Quality Management District, UC Irvine

Funding Opportunity Announcement

RFI Issued: ***"Fuel cell technology validation, commercial acceleration and potential deployment strategies in early market applications"***

http://www1.eere.energy.gov/hydrogenandfuelcells/news_detail.html?news_id=19089.

Closed April 10, 2013.

Potential Technology Validation FOA Topics

- Advanced Refueling Components (H_2 Meters, Dispensers, Compressors, Hydrogen Tank-Trailers).
- Highly-efficient Combined Hydrogen, Electricity and Heat Generation (trigeneration) at fueling stations.
- Building-Integrated Fuel Cell Combined Heat and Power Systems.
- Innovative On-board hydrogen storage systems for FCEVS

Planned for FY 2014

Potential opportunities for leveraging state activities (e.g. CA state funding for fueling stations)
FCT will not be funding infrastructure but can fund technology innovation that could be applicable to/enable infrastructure (e.g. innovative refueling/compression technologies)

Source: US DOE 4/18/2013

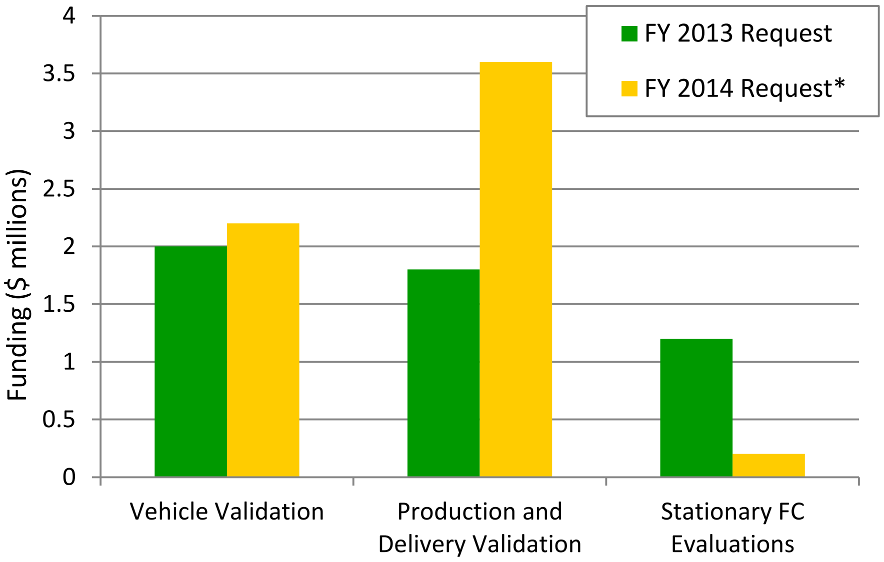
Technology Validation - Plans

Includes real-world data collection from FCEVs and H_2 stations, evaluation of innovative H_2 fueling and delivery components, and production and storage of hydrogen from renewable sources.

FY 2014 Request = \$6.0M

FY 2013 Request = \$5.0M

Technology Validation Funding



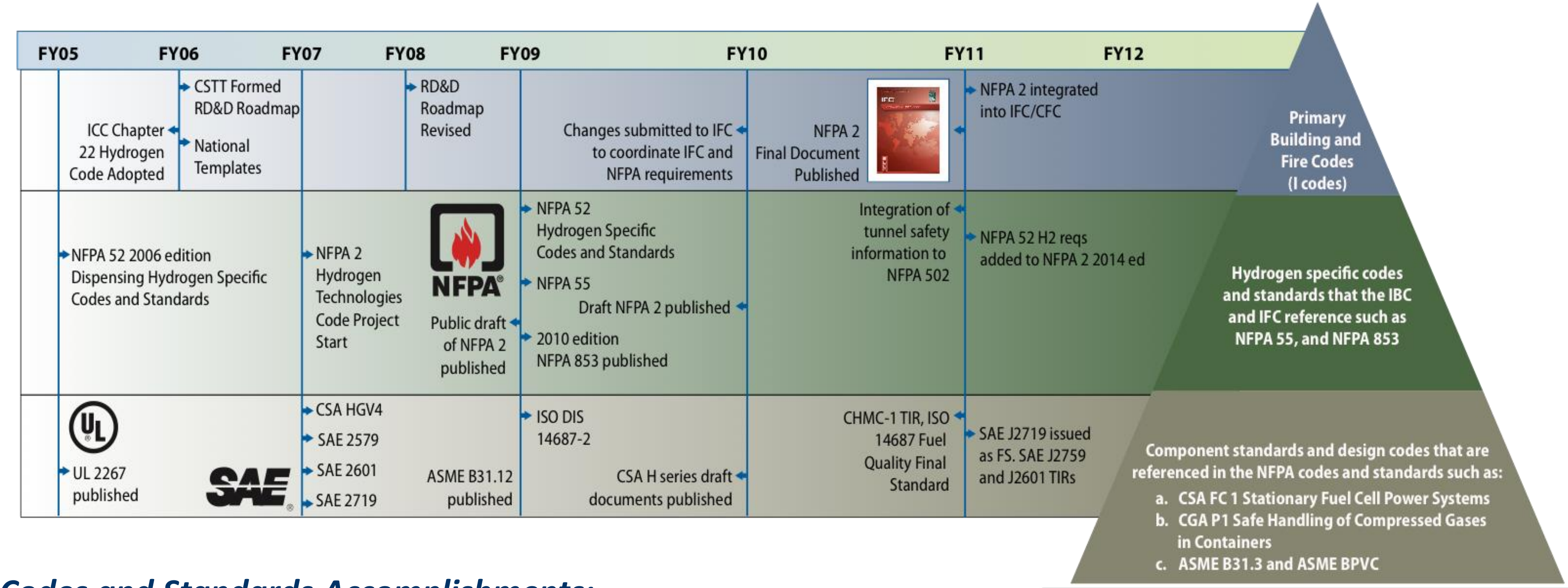
* Subject to appropriations, project go/no go decisions and competitive selections. Exact amounts will be determined based on R&D progress in each area and the relative merit and applicability of projects competitively selected through planned funding opportunity announcements (FOAs).

EMPHASIS

- Data collection, analysis and evaluation. (leverages equipment funded outside the Program) — *FY12–FY13 awards*
  - Light-duty vehicles, buses and hydrogen refueling stations. (Collaboration on buses with DOT)
  - Hydrogen Compressors and Advanced Refueling components
- Real-world demonstration / evaluations (small number of units for validation purposes) — *FY12–FY13 awards*
  - Stationary Hydrogen and Electricity Generation
  - High-Pressure Electrolyzers
  - Electrochemical Hydrogen Pump

Progress: Safety, Codes & Standards

Timeline of Hydrogen Codes and Standards



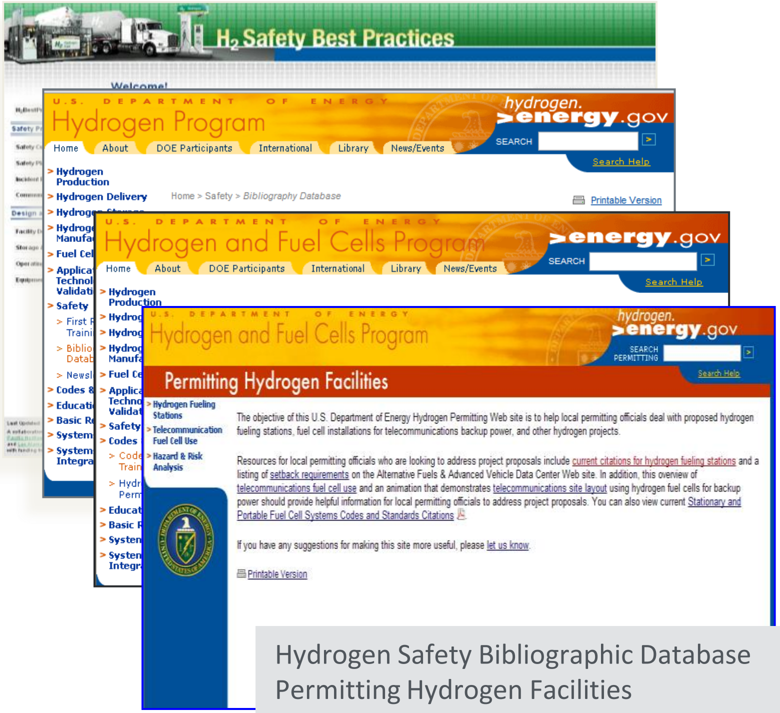
Developed training materials for first responders, code officials.

Codes and Standards Accomplishments:

- Submitted Global Technical Regulation (GTR) to the U.N. ECE WP29 Dec. 2012, Target Acceptance June 2013. The GTR will be the technical underpinning for the development of the U.S. Federal Motor Vehicle Safety Standard (FMVSS)
- A science-based approach to develop an ISO standard for hydrogen fuel quality led to standard approval in Dec 2012
- Launched international round robin on test measurement protocol for Type IV tanks under IPHE RCSWG
- Provided technical data and incorporated a risk-informed approach that enabled NFPA2 to update bulk gas storage separation distances

Source: US DOE 4/18/2013

Safety, Codes and Standards



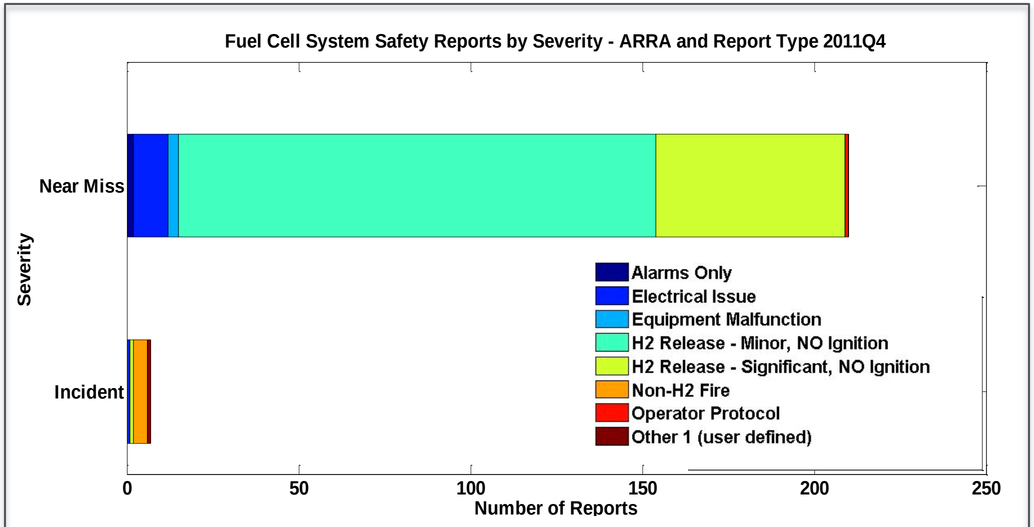
The objective of this U.S. Department of Energy Hydrogen Permitting Web site is to help local permitting officials deal with proposed hydrogen fueling stations, fuel cell installations for telecommunications backup power, and other hydrogen projects.

Resources for local permitting officials who are looking to address project proposals include current citations for hydrogen fueling stations and a listing of setback requirements on the Alternative Fuels & Advanced Vehicle Data Center Web site. In addition, this overview of telecommunications fuel cell use and an animation that demonstrates telecommunications site layout using hydrogen fuel cells for backup power should provide helpful information for local permitting officials to address project proposals. You can also view current Stationary and Portable Fuel Cell Systems Codes and Standards Citations

If you have any suggestions for making this site more useful, please let us know.

Printable Version

Hydrogen Safety Bibliographic Database
Permitting Hydrogen Facilities
Introduction to Hydrogen for Code Officials
Hydrogen Safety Best Practices Manual



Source:
http://www.nrel.gov/hydrogen/cfm/images/cdparra_mhe_27_safetyreportsbyseverity.jpg

Other Supporting Websites

H_2 Safety Snapshot bulletin
Introduction to Hydrogen Safety for First Responders
Hydrogen Incident Reporting Database

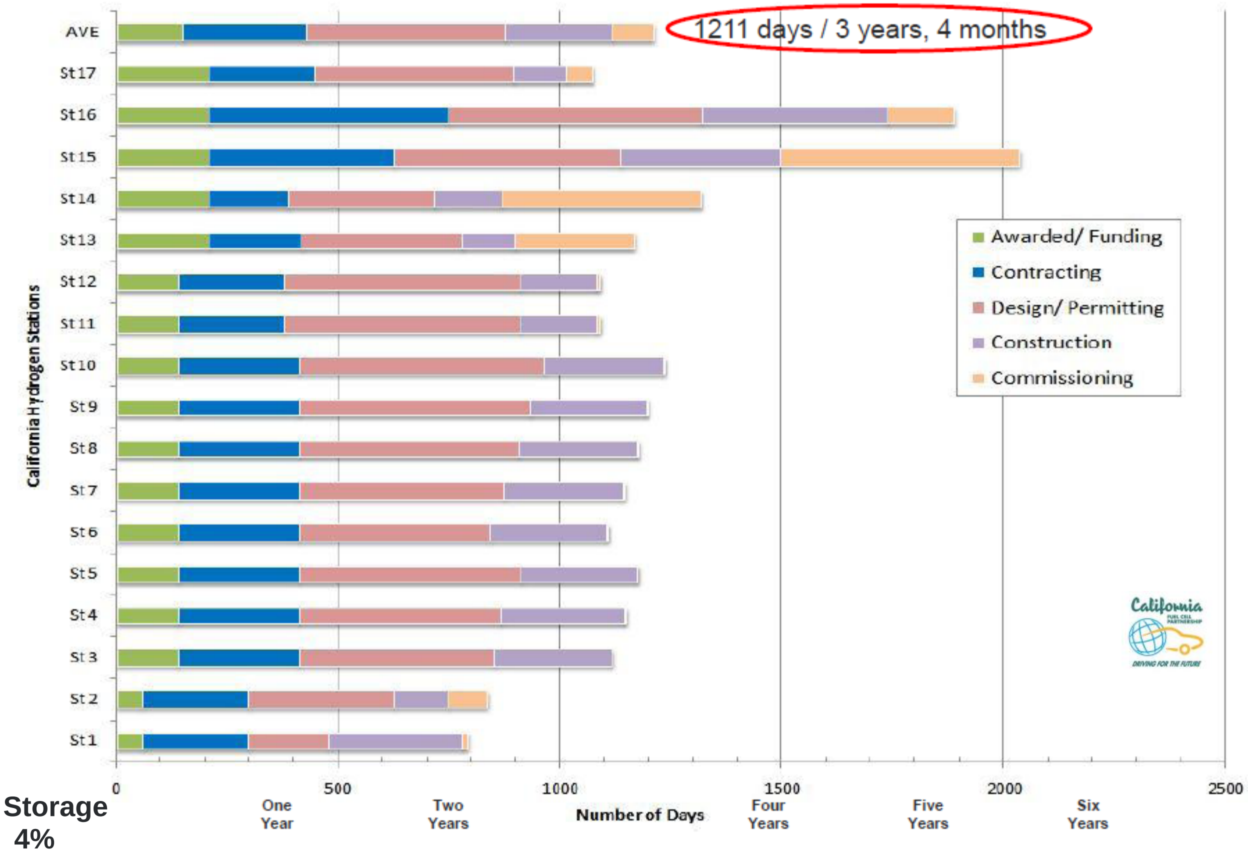
- Trained > 23,000 first-responders and code officials on hydrogen safety and permitting through on-line and in-classroom courses
- 206 Lessons Learned Events in "H2Incidents.org"
- Approximately 750 entries in the Hydrogen Safety Bibliographic Database

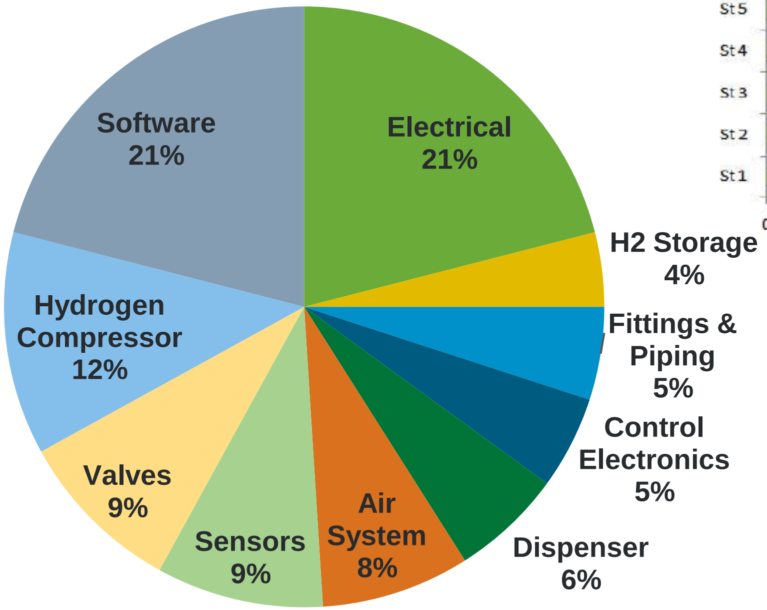
www.eere.energy.gov/hydrogenandfuelcells/codes/

Infrastructure: Current Barriers

Despite progress in infrastructure development, more work is needed to address permitting times, contract issues, and equipment reliability.

Time to Build Stations





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

Safety, Codes & Standards - Plans

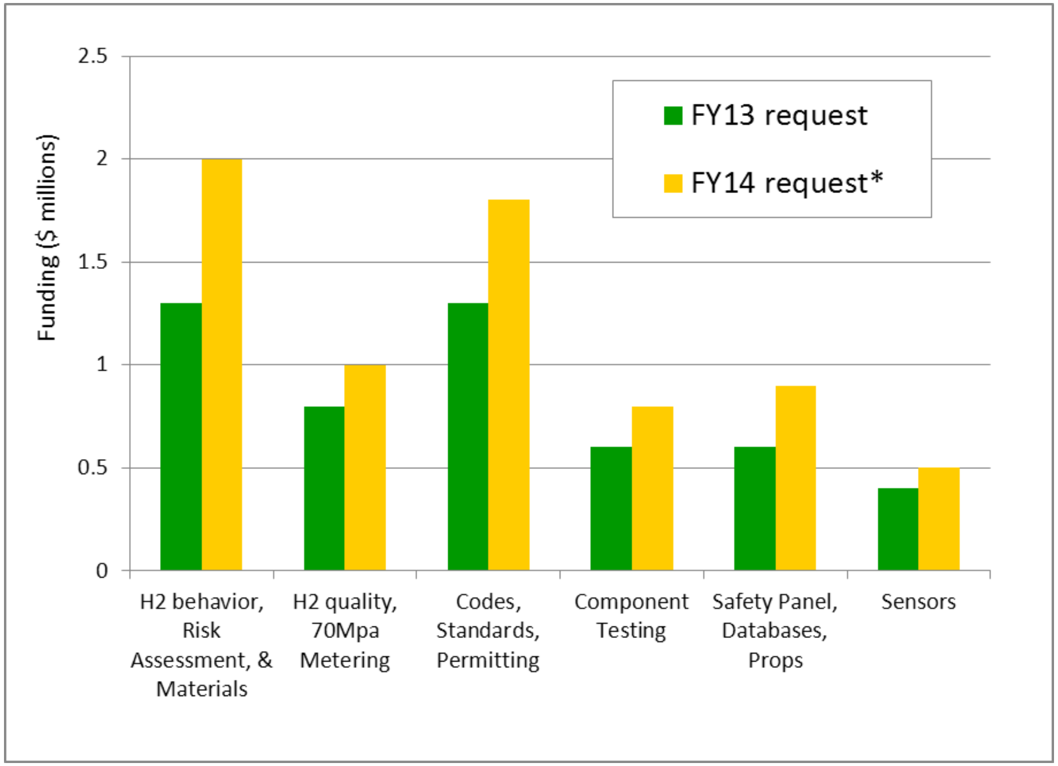
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Maintain critical Safety, Codes and Standards activities and leverage external efforts (states, industry, etc.)

FY 2014 Request = $7.0M

FY 2013 Request = $5.0M

Safety, Codes & Standards Funding



* Subject to appropriations, project go/no go decisions and competitive selections. Exact amounts will be determined based on R&D progress in each area and the relative merit and applicability of projects competitively selected through planned funding opportunity announcements (FOAs).

EMPHASIS

- Maintain core R&D to inform development and revisions of codes and standards
  - Validate performance data
  - Conduct risk assessments and establish protocols to identify and mitigate risk
  - Develop testing protocols for components and systems including high pressure vessels
  - Maintain efforts on materials compatibility, and hydrogen quality, measurement, and metering.
- Continue coordination and harmonization activities through international & domestic technical working groups.
- Continue coordination and dissemination of hydrogen safety information and safety panel activities.

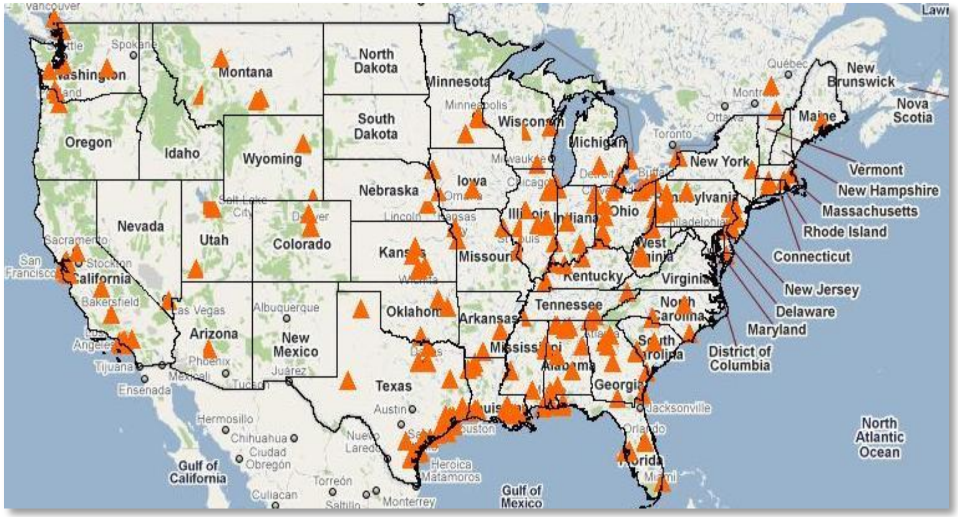
Source: US DOE 4/18/2013

Systems Analysis: Options for Early Hydrogen Infrastructure

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

Current Status

- Over **9MMT** of H_2 produced per year
- Over **1,200 miles** of H_2 pipelines in use (CA, TX, LA, IL, and IN)
- Over **50 fueling stations** in the U.S.



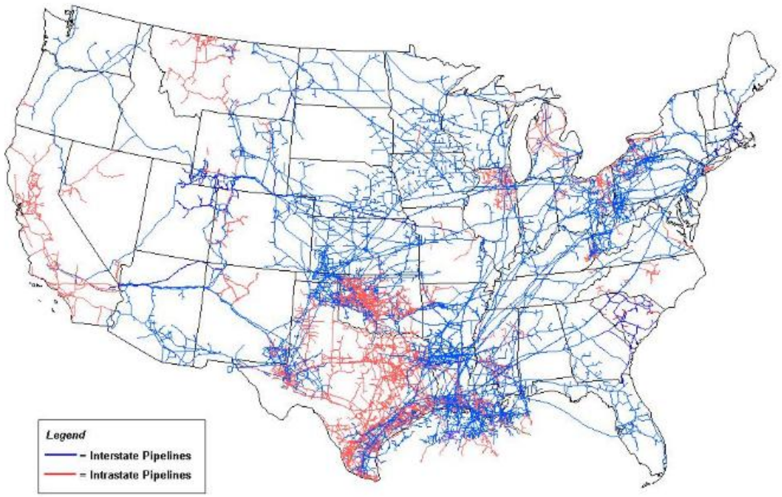
Existing Hydrogen Production Facilities

Two Main Options for Low-cost Early Infrastructure

- **H_2 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)*
- **Distributed production (e.g. natural gas, electrolysis)**

Other options

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



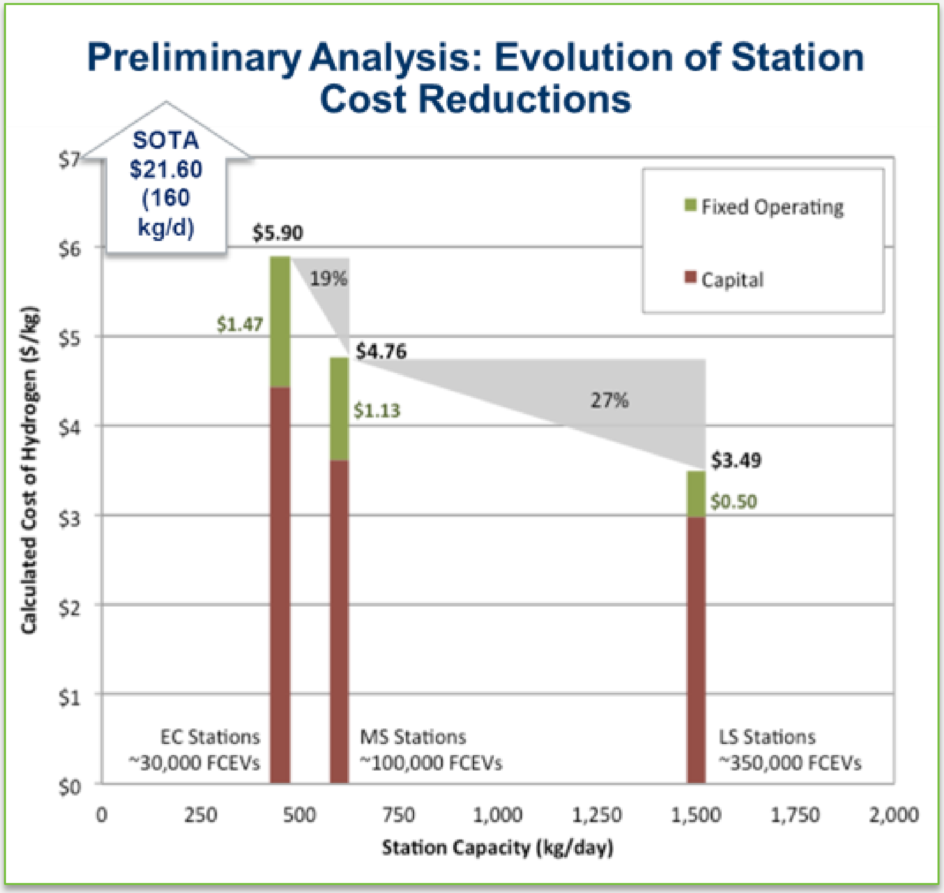
Source: Energy Information Administration, Office of Oil & Gas, Natural Gas Division, Gas Transportation Information System

Natural Gas Pipeline Network, 2009

Systems Analysis – Analysis Examples

Hydrogen Station Cost Tool—Infrastructure analysis on station cost reduction

Stakeholders' input identified >80% reduction in hydrogen fueling station cost


Preliminary Analysis: Evolution of Station Cost Reductions

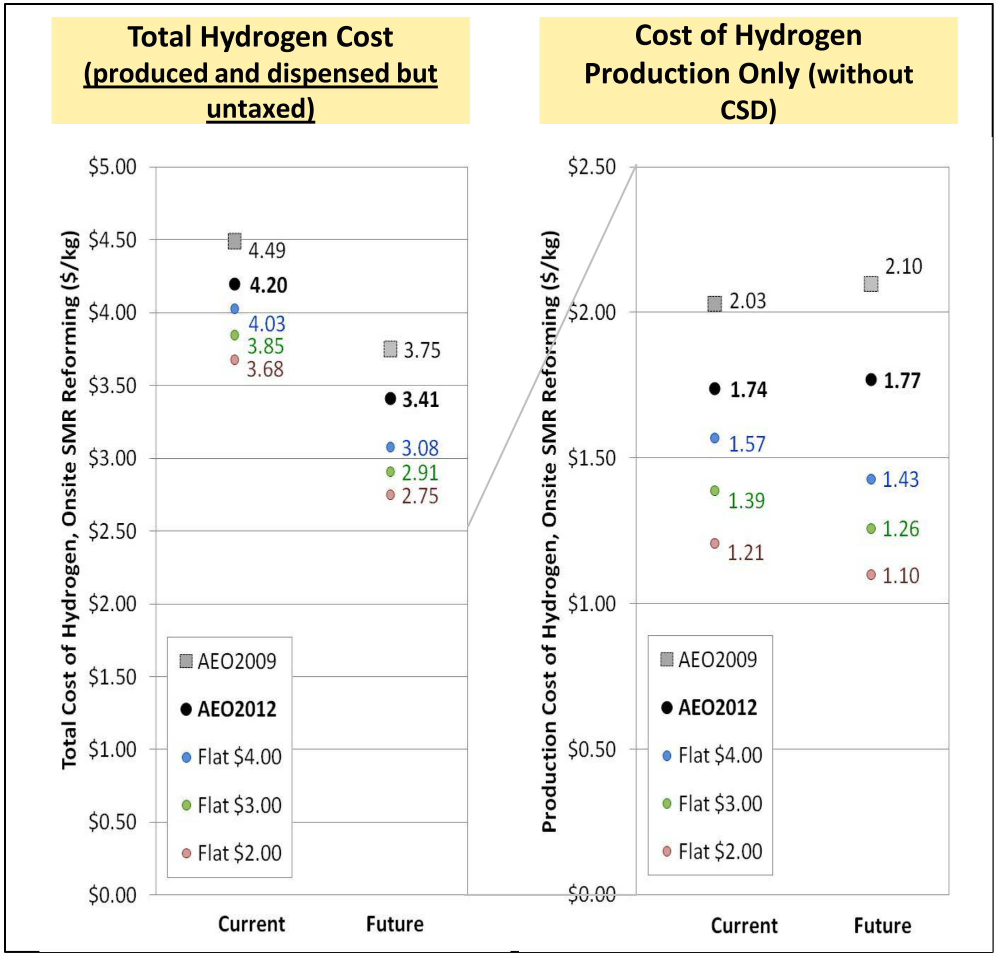
Peer-reviewed employment model for job creation potential for states and regions released for public use

- **ANL-RCF developed an employment and economic impact tool to estimate stationary FC industry impacts:**
  - **Production (PEMFC, PAFC and MCFC) in target applications**
  - **Installation of FCs and required infrastructure**
  - **O&M including fuel**
  - **Construction/expansion of manufacturing capacity**
- **State, regional and national level analyses including supply chain impacts**
- **Applications included forklifts, back-up power, specialty vehicles, etc.**
- **Jobs model will enable analysis of gross and net jobs, and revenues generated from fuel cell installation and investment.**

Next application of model will be to assess employment impact of H_2 infrastructure build-out.

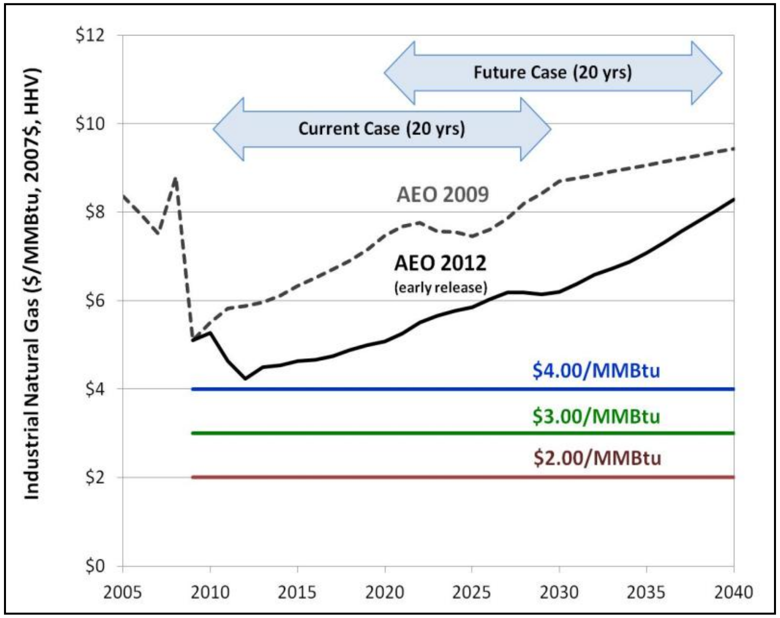
Model available from ANL website: JOBSFC.es.anl.gov

Cost of Hydrogen Produced from Distributed Natural Gas Reforming



Total Hydrogen Cost (produced and dispensed but untaxed)

Cost of Hydrogen Production Only (without CSD)



Notes: The values shown reflect the AEO 2009 and AEO 2012 (early release) prices for industrial natural gas. The flat prices of $4.00, $3.00 and $2.00 per MMBtu were used to conduct sensitivity analyses and are not associated with AEO data. Prices beyond AEO projections are extrapolated using AEO data and the results of the Pacific Northwest National Laboratory's MiniCAM model for 2035 and 2050.

Source: DOE Hydrogen and Fuel Cells Program Record #12024, http://hydrogen.energy.gov/pdfs/12024_h2_production_cost_natural_gas.pdf

Systems Analysis - Plans

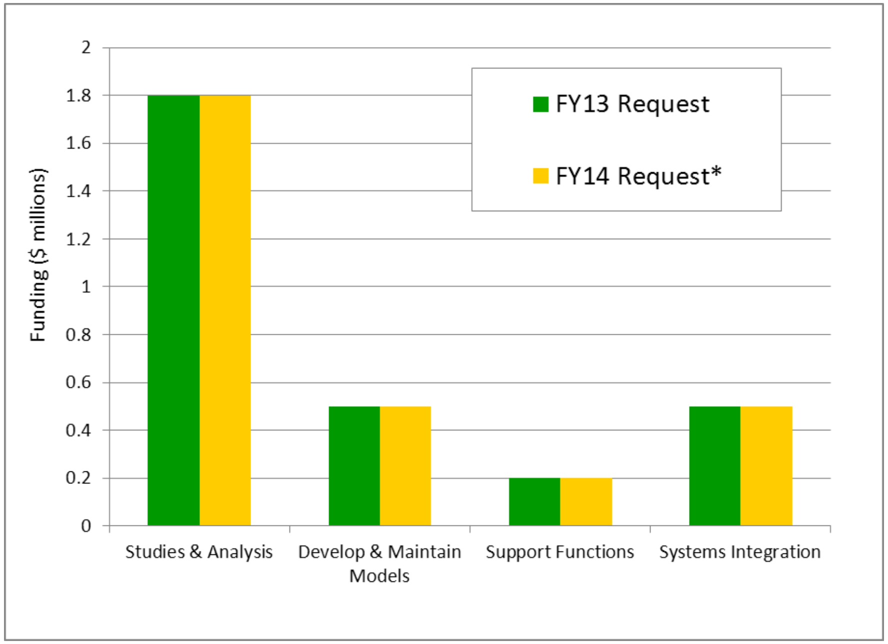
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Focus: Determine technology gaps, economic/jobs potential, and benefits of key technology advances; and quantify 2013 technology advancement.

FY 2014 Request = $3.0 M

FY 2013 Request = $3.0 M

Systems Analysis Funding



* Subject to appropriations, project go/no go decisions and competitive selections. Exact amounts will be determined based on R&D progress in each area and the relative merit and applicability of projects competitively selected through planned funding opportunity announcements (FOAs).

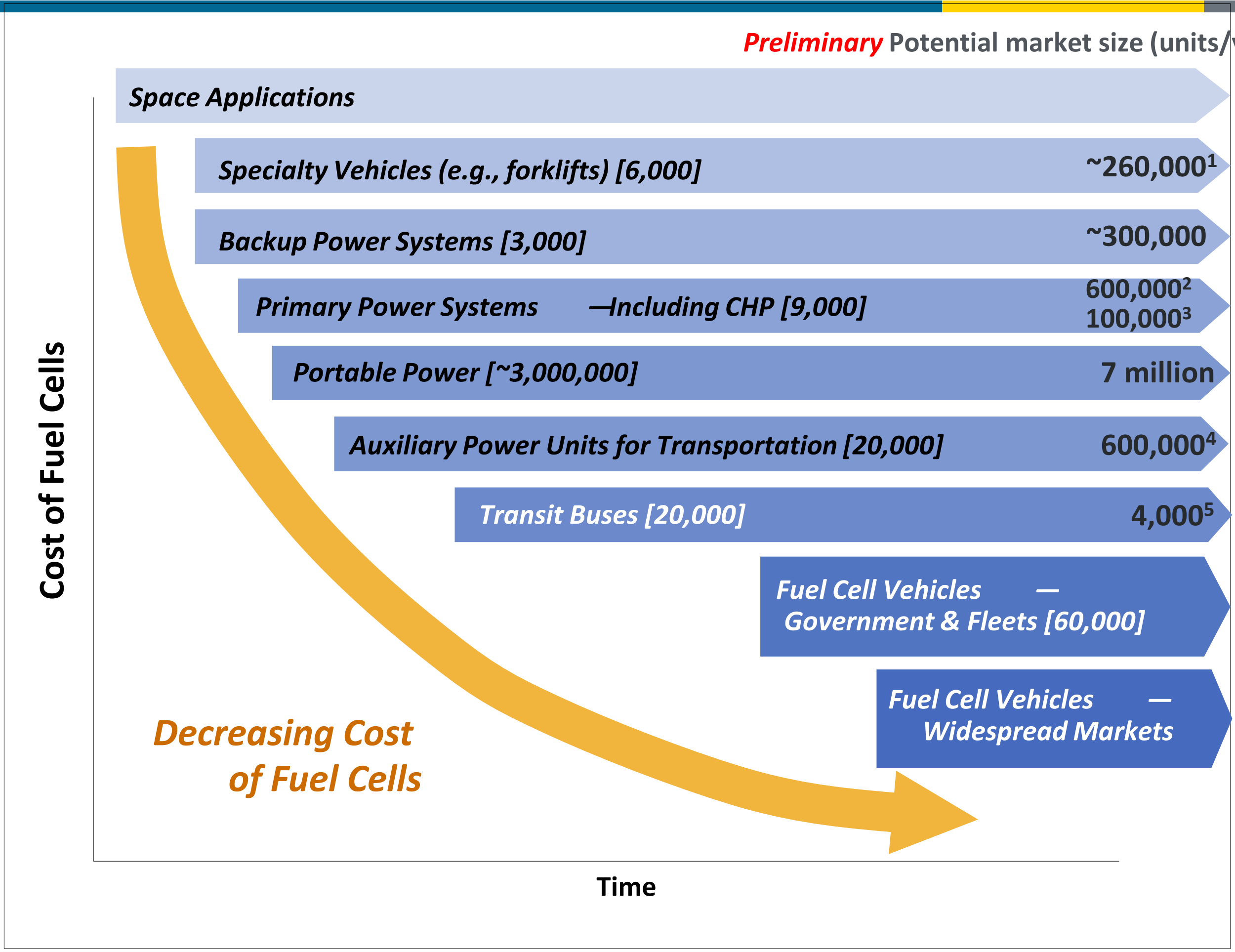
EMPHASIS

- ➢ Update and refine models for program analysis using cost, performance and environmental (emissions, etc.) information.
- ➢ Continue life-cycle analyses of cost, greenhouse gas emissions, petroleum use and criteria emissions, and impacts on water use.
- ➢ Assess gaps and drivers for early market infrastructure cost for transportation and power generation applications
- ➢ Assess programmatic impacts on market penetration, job creation, return on investment, and opportunities for fuel cell applications in the near term.

Source: US DOE 4/18/2013

Potential Early Markets to Reduce Cost

As the cost of fuel cells comes down (through technological improvements and economies of scale), they will become competitive in a growing number of markets.



Preliminary **Potential market size (units/yr)**

Space Applications

Specialty Vehicles (e.g., forklifts) [6,000] **~260,000[1]**

Backup Power Systems [3,000] **~300,000**

Primary Power Systems —Including CHP [9,000] **600,000[2]** **100,000[3]**

Portable Power [~3,000,000] **7 million**

Auxiliary Power Units for Transportation [20,000] **600,000[4]**

Transit Buses [20,000] **4,000[5]**

Fuel Cell Vehicles — Government & Fleets [60,000]

Fuel Cell Vehicles — Widespread Markets

Decreasing Cost of Fuel Cells

Cost of Fuel Cells

Time

Critical Role of Early Markets

DOE aims to achieve advances for a wide variety of fuel cell applications, with varying time frames for commercial success.

Growth of early markets can help to:

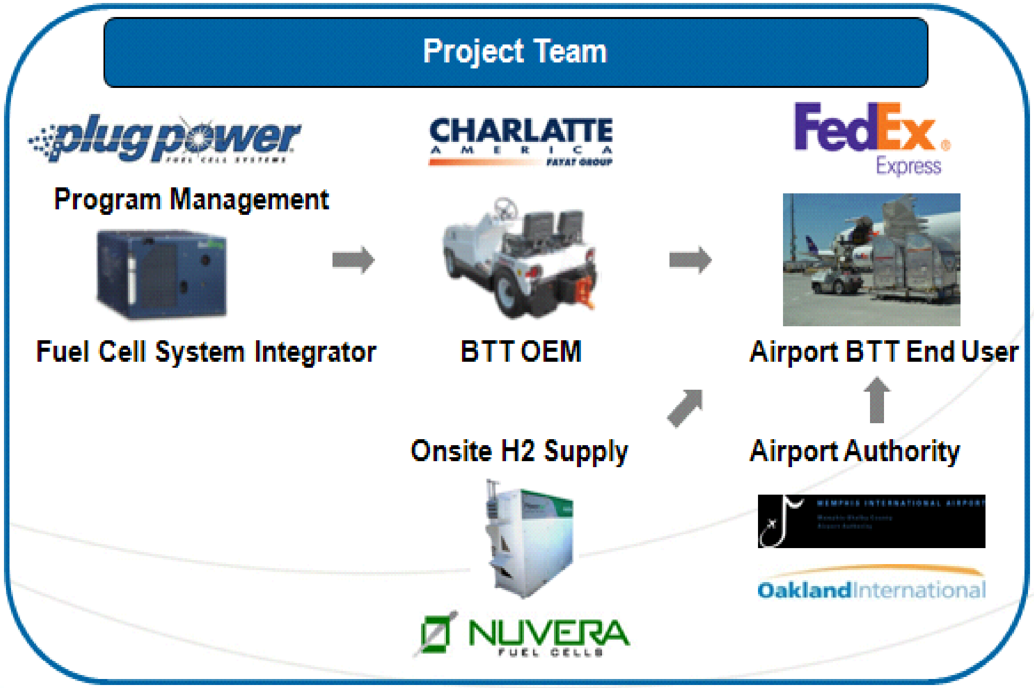
- **Reduce costs industry-wide**
- **Strengthen consumer acceptance**
- **Grow the domestic supplier base**
- **Expand infrastructure**
- **Overcome a variety of logistical challenges**

References: [1]ITA 2010 Outlook, [2]MicroCHP, [3]Large scale CHP, [4]Industry estimate based on refrigerated truck and trailer APUs (total number), [5]http://hydrogen.energy.gov/pdfs/12012_fuel_cell_bus_targets.pdf

Fuel Cell Airport GSE Demonstrations

Background/Status:

- Awarded January 31, 2013
- Fuel Cell Powered Airport Ground Support Equipment (GSE) Deployment
- 3 years, $2.5M DOE share, 50% cost share, two phases:
- Product development and testing
- Demonstrations under "real world" operating environments
- 15 Baggage Tow Tractors with ~20kW fuel cell systems
- 10 units at FedEx in Memphis, TN
- 5 units at FedEx in Oakland, CA



Project Team

plug power FUEL CELL SYSTEMS

Program Management

Fuel Cell System Integrator

CHARLATTE AMERICA FAYAT GROUP

BTT OEM

FedEx Express

Airport BTT End User

Onsite H2 Supply

NUVERA FUEL CELLS

Airport Authority

MEMPHIS INTERNATIONAL AIRPORT

Oakland International

Preliminary Estimate

	Near Term	50 % Total Market
USA Market Potentials	1,400	31,000
Diesel reduction (gal/yr)	8,000,000	~ 177,000,000
NOx, PM, HC,CO reduction (MTs/yr)	2,875	~ 63,250
CO_2 reduction (MTs/yr)	80,000	~ 1,760,000

Source: US DOE 4/18/2013

RFI for Early Market Opportunities and Short Haul fleet Demos

RFI: Opened March 11, 2012 – Closes April 10, 2013

Requesting Stakeholder feedback on the commercial readiness and novel finance methods for hydrogen and fuel cell technologies, including:

- **Fuel Cells for Seaport Operations**
  - **E.g., deployment projects for cargo port medium duty delivery electric truck using fuel cell recharging systems.**
- **Low-Interest Loan Pilot Program**
- **Innovative Hydrogen and Fuel Cell Technologies (e.g. Incubator)**
  - Applications successful in research and proof-of-concept work that need funding to accelerate the transition of pre-commercial prototypes.

And VTP Funded projects in FY 2012 (Vehicle Technologies Program)

- 2 Demo-Deploy projects awarded for on board fuel cell rechargers
  - SCAQMD project in Port of LA for 3 eHDV with rechargers
  - HARC project in Port of Houston for 20 eHDV with rechargers.

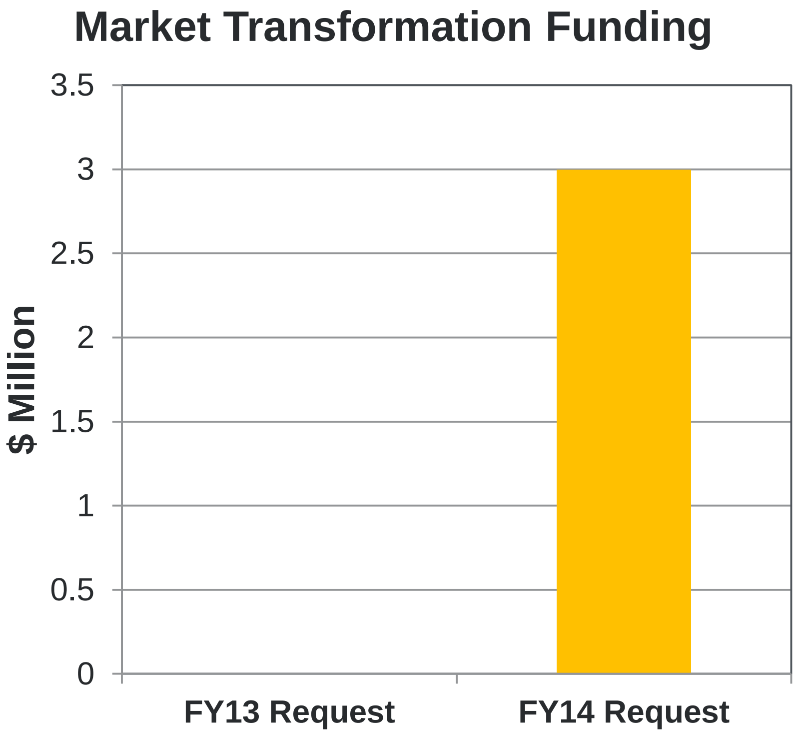
Source: US DOE 4/18/2013

Market Transformation

Market Transformation focuses on supporting early market successes such as emergency backup power and specialty vehicle applications. The goal is to enable emerging markets to achieve economies of scale and reduce fuel cell life-cycle cost to be on a par with conventional technologies by 2020.

FY 2014 Request = $3M

FY 2013 Request = $0M



* Subject to appropriations, project go/no go decisions and competitive selections. Exact amounts will be determined based on R&D progress in each area and the relative merit and applicability of projects competitively selected through planned funding opportunity announcements (FOAs).

EMPHASIS

- Accelerate widespread commercialization of hydrogen and fuel cell technologies (e.g., next example similar to forklifts and telecom success stories)
- Fund cost-shared deployments and provide technical support to deployment efforts
- Complete assessment of early market fuel cell systems and provide feedback to program R&D areas
- Provide technical and financial assistance for government and other technology adopters such as for:
  - Distributed power
  - Auxiliary power for vehicles e.g., heavy duty trucks

*Preliminary estimates

Source: US DOE 4/18/2013

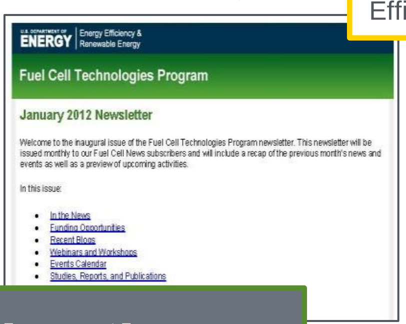
Communication & Outreach

Published more than 70 news articles in FY 2012 (including blogs, progress alerts, DOE news alerts)

- ***Monthly Webinar Series***
  - Hydrogen Refueling Protocols
  - Advanced Electrocatalysts for PEM Fuel Cells
  - Wind-to-Hydrogen Cost Modeling and Project Findings
  - Mobile lighting
  - Register at - http://www1.eere.energy.gov/hydrogenandfuelcells/webinars.html
- ***News Items***
- New Report Analyzes Options for Blending Hydrogen into Natural Gas Pipelines (March 14, 2013)
- Automotive Fuel Cell Cost and Durability Target Request For Information Issued (Feb 4, 2013)
- ***Monthly Newsletter***
- Visit the web site to register or to see archives (http://www1.eere.energy.gov/hydrogenandfuelcells/newsletter.html)

"Fuel cells are an important part of our energy portfolio…deployments in early markets are helping to drive innovations in fuel cell technologies across multiple applications."

- Dr. David Danielson
Assistant Secretary for Energy Efficiency and Renewable Energy



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

Fuel Cell Technologies Program

January 2012 Newsletter

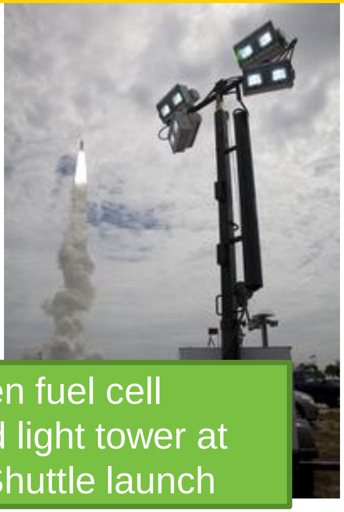
Welcome to the inaugural issue of the Fuel Cell Technologies Program newsletter. This newsletter will be issued monthly to our Fuel Cell News subscribers and will include a recap of the previous month's news and events as well as a preview of upcoming activities.

In this issue:

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

Hydrogen fuel cell powers lights at entertainment industry events.

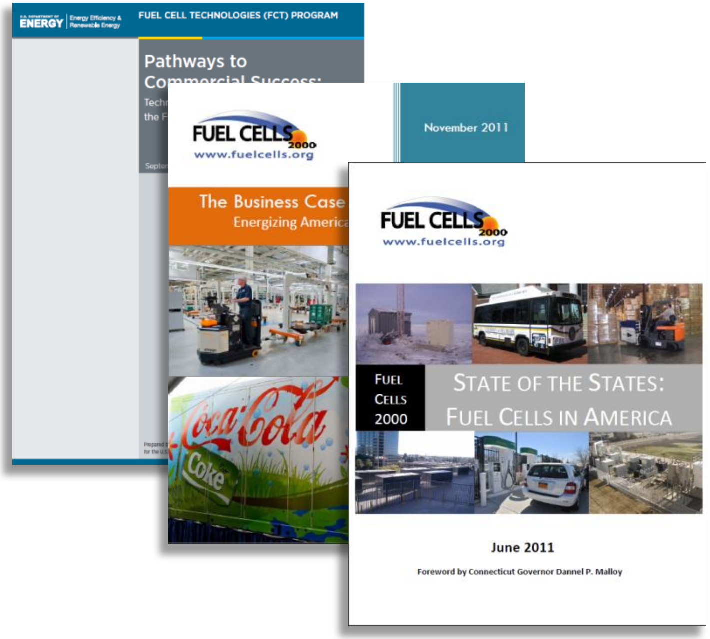
Developed education materials and educated more than 9,600 teachers on H_2 and fuel cells to date.



Hydrogen fuel cell powered light tower at Space Shuttle launch

Source: US DOE 4/18/2013

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

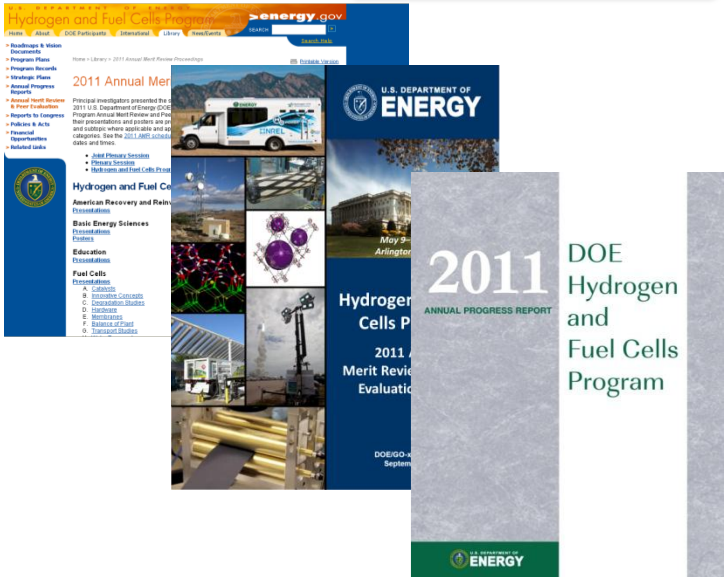
By FuelCells2000, http://www.fuelcells.org

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/

Source: US DOE 4/18/2013

FCT Monthly Newsletter

Fuel Cell Technologies Office Newsletter: March 2013

The March 2013 issue of the Fuel Cell Technologies Office newsletter includes stories in these categories:

- In the News
- Webinars and Workshops
- Studies, Reports, and Publications
- National Laboratory and Principal Investigator Achievements

In the News

Hydrogen and Fuel Cells Part of the Blueprint for a Clean and Secure Energy Future
On March 16 President Obama visited Argonne National Laboratory in Illinois to talk about his *Blueprint for a Clean and Secure Energy Future* and the progress that we are seeing from the "all-of-the-above" energy strategy. While there, he unveiled his plans for an Energy Security Trust that focuses on developing cost-effective transportation alternatives, including hydrogen fuel cell electric vehicles.

Hydrogen and Fuel Cell Technology Readiness Request For Information Issued
The Fuel Cell Technologies Office has issued a Request for Information (RFI) seeking feedback from stakeholders regarding technology validation and deployment activities aimed at ensuring commercial readiness and stimulating commercialization of fuel cell and hydrogen technologies. For details, see the RFI announcement for DE-FOA-0000873. Comments must be provided by April 10.

Clean Energy Manufacturing Initiative
On March 26, the Energy Department launched the Clean Energy Manufacturing Initiative (CEMI), a new Department initiative focused on growing American manufacturing of clean energy products and boosting U.S. competitiveness through major improvements in manufacturing energy productivity. The announcement was made at the ribbon cutting of the Department's Carbon Fiber Technology Facility in Oak Ridge, Tennessee, a new advanced manufacturing facility to reduce the cost of carbon fiber—a critical material for efficient lightweight vehicles, like FCEVs.

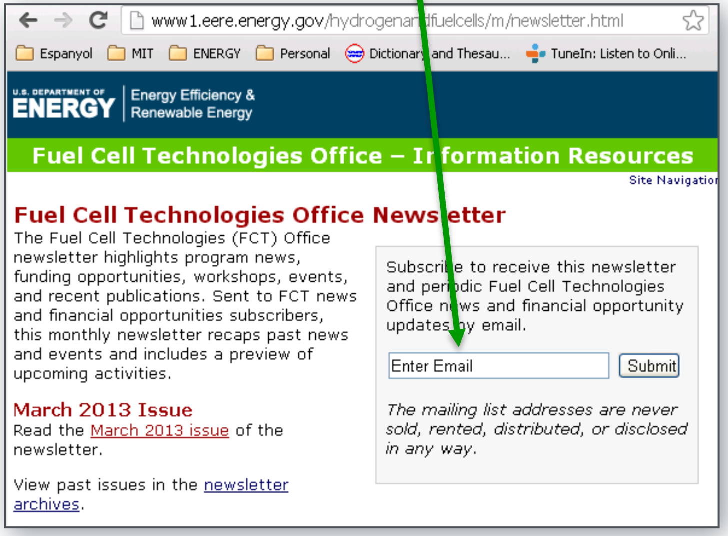
Energy Department, Treasury Announce Availability of $150 Million in Tax Credits for Clean Energy Manufacturers
The DOE and the Department of Treasury recently announced the availability of $150 million in Advanced Energy Manufacturing Tax Credits for clean energy and energy efficiency manufacturing projects across the United States. The program supports manufacturing of a range of clean energy products, from renewable energy equipment to energy efficiency products to advanced energy storage and carbon capture technology. A full list of eligible projects can be found in the 48C Manufacturing Tax Credit fact sheet and includes fuel cell technologies. The application period for certification began on February 7, 2013, and ends on July 23, 2013.

SBIR/STTR Phase I Release 3 Award Winners Announced, Hydrogen Storage and Fuel Cell Manufacturing Projects Included
The FY 2012 Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) Phase I Release 3 award winners include three hydrogen and fuel cell projects. The companies are Composite Technology Development in Colorado, Nextgen Aeronautics in California, and Treadstone Technologies in New Jersey.

Women @ Energy Features
Fuel cell technologies were represented in celebration of Women's History Month, through DOE's recently launched new feature – Women at Energy – showcasing talented and dedicated employees at the Energy Department who work to change the world—ensuring America's security and prosperity through transformative science and technology solutions. Women @ Energy profiles individuals, like Fuel Cell Technologies Office Director Sunita Satyapal, who share insights on what inspired them to work in STEM (Science, Technology, Engineering and

Subscribe here:

http://www1.eere.energy.gov/hydrogenandfuelcells/subscribe.html



Fuel Cell Technologies Office Newsletter

The Fuel Cell Technologies (FCT) Office newsletter highlights program news, funding opportunities, workshops, events, and recent publications. Sent to FCT news and financial opportunities subscribers, this monthly newsletter recaps past news and events and includes a preview of upcoming activities.

March 2013 Issue
Read the March 2013 issue of the newsletter.

View past issues in the newsletter archives.

Subscribe to receive this newsletter and periodic Fuel Cell Technologies Office news and financial opportunity updates by email.

Enter Email | Submit

The mailing list addresses are never sold, rented, distributed, or disclosed in any way.

Source: US DOE 4/18/2013

Summary

and

Additional Opportunities

Potential Collaborations: Vehicle Technologies

Fiscal Year 2014 Priority Activities

- **EV Everywhere Grand Challenge, $303.5M:** Make the U.S. the first country to provide a wide array of plug-in electric vehicle models that are as affordable and convenient as gasoline vehicles by 2022.
- **SuperTruck Initiative:** Develop and demonstrate technologies that improve heavy-duty, class 8 vehicle fuel economy by 50% (relative to a comparable 2009 vehicle) by increasing energy efficiency, reducing aerodynamic drag and weight, and hybridization.
- **Alternative Fuel Vehicle Community Partner Projects, $90M**: Accelerate the adoption of PEV's, natural gas vehicles, and other alternative fuels through highly-leveraged community partnerships to introduce alternative fuel and advanced vehicles at scale.
- **Grid Integration Initiative, $20M:** Coordinate with EERE's Building and Solar Energy Technologies Offices, to develop and advance the platform of technologies necessary to fully integrate PEVs and other clean energy technologies into the distribution system in a safe, reliable, and cost effective manner.
- **Vehicle Technologies Incubator, $30M:** Funding program to introduce potentially high-impact promising "off-road-map" new technologies and learning curves into the Vehicle Technologies portfolio.

(Dollars in Thousands)	FY 2012 Current	FY 2013 Request	FY 2013 Annualized CR*	FY 2014 Request
Batteries and Electric Drive Technology	117,740	210,000	—	240,200
Vehicle and Systems Simulation & Testing	47,198	57,000	—	70,000
Advanced Combustion Engine R&D	58,027	57,000	—	59,500
Materials Technology	40,830	50,000	—	59,500
Fuels and Lubricant Technologies	17,904	12,000	—	17,500
Outreach, Deployment and Analysis	39,267	34,000	—	126,300
NREL User Facility	0	0	—	2,000
Total, Vehicle Technologies	320,966	420,000	330,819	575,000

*FY 2013 amount shown reflect the P.L. 112 175 continuing resolution level annualized to a full year. These amounts are shown only at the "congressional control" level and above; below that level, a dash (-) is shown.

Source: US DOE 4/18/2013

Potential Collaborations: Advanced Manufacturing

Fiscal Year 2014 Priority Activities

- **Next Generation Manufacturing R&D Projects:** Focused on transformational improvements in manufacturing which will strengthen the competitiveness of today's industry, grow the U.S. manufacturing base, and advance foundational technology opportunities for clean energy applications to grow a new clean energy industry.

- **Advanced Manufacturing R&D Facilities:** Clean Energy Manufacturing Innovation Institutes, Critical Materials Hub and the Manufacturing Demonstration Facility on additive manufacturing are all critical parts of accelerating advanced manufacturing.

- **Industrial Technical Assistance:** Provide technical assistance to improve industrial competitiveness and catalyze better energy management using international standards and other best practices, and assist with adoption of CHP.

(Dollars in Thousands)	FY 2012 Current	FY 2013 Request	FY 2013 Annualized CR*	FY 2014 Request
Next Generation Manufacturing R&D Projects	60,334	205,000	—	120,000
Advanced Manufacturing R&D Facilities	34,628	54,000	—	217,500
Industrial Technical Assistance	17,730	31,000	—	27,500
Total, Advanced Manufacturing	112,692	290,000	116,287	365,000
*FY 2013 amount shown reflect the P.L. 112 175 continuing resolution level annualized to a full year. These amounts are shown only at the "congressional control" level and above; below that level, a dash (-) is shown.				

Source: US DOE 4/18/2013

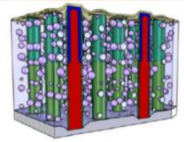
SC-EERE-ARPA-E Collaborations

Examples of Cross-Office Collaborative Successes.

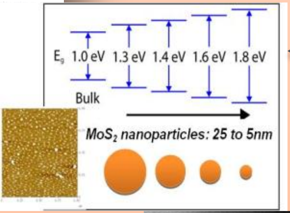
Need to continue to leverage activities across other Programs

Advancing fundamental science knowledge base

Solar to Fuels Hub

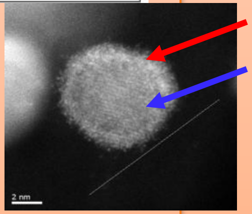


Nanowire based solar fuels generation (CalTech)



andgap tailoring (Stanford)

Mechanistic understanding of catalysts



Pt monolaye r

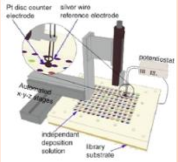
Pd core

Biological H_2 production

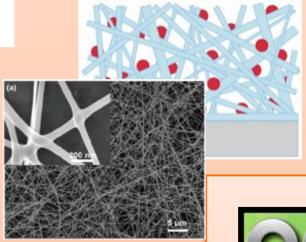
Materials-based H_2 storage

Applied RD&D of innovative technologies

High Throughput Processes (UCSB)



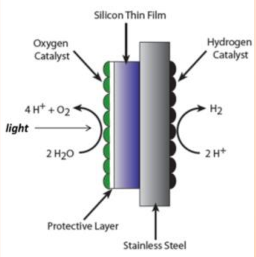
Standard protocols and benchmarking



Nano-catalyst support scaffold (Stanford)

Working Groups PEC, Biological, High T Membranes, Storage Systems

Using ARPA-E developed catalyst in water splitting device



ARPA-E: Focus on creative, high-risk transformational energy research

Alkaline Membranes

Developing novel catalysts (high risk/high impact)

Source: US DOE 4/18/2013

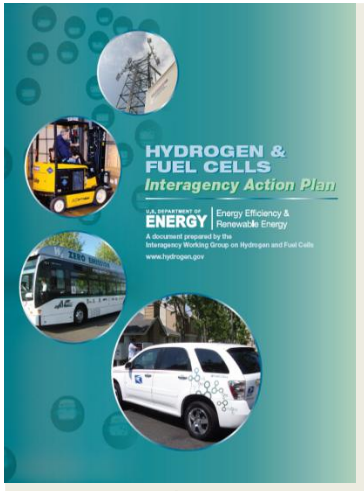
DOE and Interagency Activities

Developed Interagency Action Plan—integrated plan for coordinating U.S. federal agency efforts hydrogen and fuel cells RDD&D

DOE will continue to lead Interagency Task Force and Working Group across 10 Agencies and identify opportunities to leverage funding and activities

Goals

1. **Strengthen and Accelerate Research and Development**
2. **Accelerate Development & Adoption of Codes, Standards & Safe Practices**
3. **Work with Industry to Validate Technologies under Real-World Conditions**
4. **Adopt Technologies in U.S. Government Operations**
5. **Track and Communicate Results**



HYDROGEN & FUEL CELLS
Interagency Action Plan

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

A document prepared by the Interagency Working Group on Hydrogen and Fuel Cells

www.hydrogen.gov

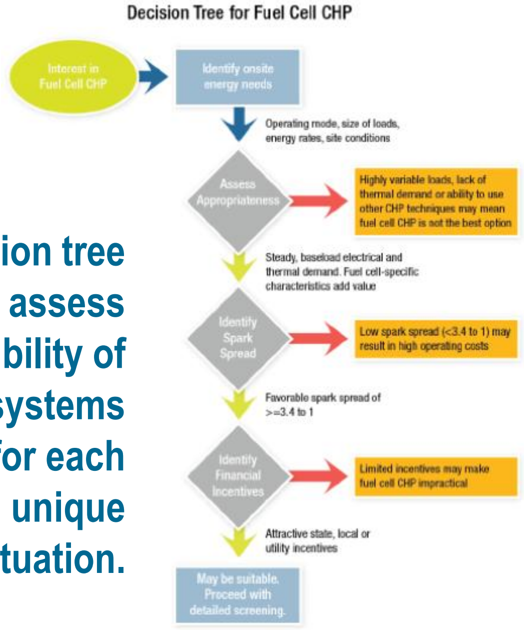
December 2011

Future Focus Area: Increase demand through Federal deployments

Developed Procurement Guide (ORNL)

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

Decision tree to help assess feasibility of CHP systems for each unique situation.



Source: US DOE 4/18/2013

Collaborations

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.*

Universities

~ 50 projects with 40 universities

International

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

External Input

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

DOE Hydrogen & Fuel Cells Program

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 H_2 & Fuel Cell Alliance
- Upper Midwest Hydrogen Initiative
- Ohio Fuel Coalition
- Connecticut Center for Advanced Technology

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

Source: US DOE 4/18/2013

EERE Budget: FY 2011 – FY 2014

Funding *($ in thousands)*				
Activity	**FY 2011 Allocation**	**FY 2012 Appropriation**	**FY 2013 *Request***	***FY 2014 Request***
Biomass and Biorefinery Systems	179,979	199,276	270,000	282,000
Building Technologies	207,310	219,204	310,000	300,000
Federal Energy Management Program	30,402	29,891	32,000	36,000
Geothermal Technology	36,992	37,862	65,000	60,000
Hydrogen and Fuel Cell Technologies	95,847	103,624*	80,000	100,000
Water Power	29,201	58,787	20,000	55,000
Advanced Manufacturing (formerly Industrial Technologies)	105,899	115,580	290,000	365,000
Solar Energy	259,556	288,951	310,000	356,500
Vehicle Technologies	293,151	328,807	420,000	575,000
Weatherization & Intergovernmental Activities	231,300	128,000	195,000	248,000
Wind Energy	78,834	93,254	95,000	144,000
Facilities & Infrastructure	51,000	26,311	26,400	46,000
Strategic Programs	32,000	25,000	58,900	36,000
Program Direction	170,000	165,000	164,700	185,000
Congressionally Directed Activities	228,803	292,135	0	0
RE-ENERGYSE	0	0	0	0
Adjustments	-29,750	-9,909	-69,667	-12,800
Total	1,711,721	1,809,638	2,267,333	**2,775,700**

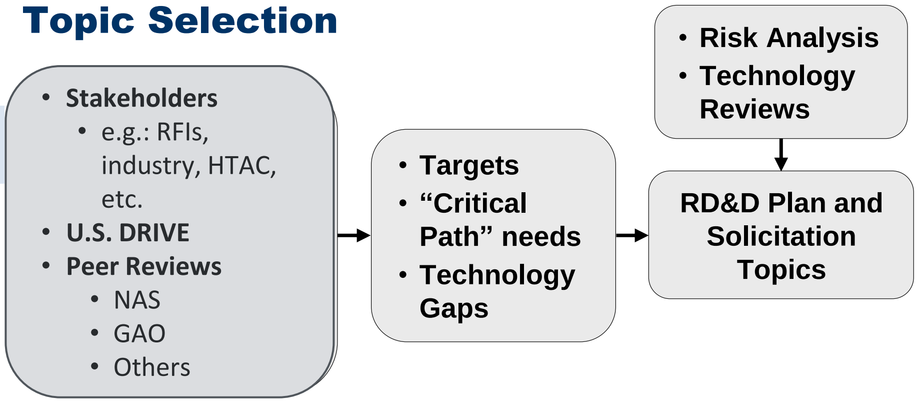
* The FY 2012 and FY 2013 numbers shown on page 384 of the White House's FY 2014 Budget Request (www.whitehouse.gov/sites/default/files/omb/budget/fy2014/assets/doe.pdf) reflect $9.7 million that was carried over from FY 2012 to FY 2013 for obligation in FY 2013

A number of opportunities to leverage activities (e.g. Vehicle Technologies, Advanced Manufacturing)

Source: US DOE 4/18/2013

Competitive review processes, peer reviews, active project management & go/no-go decisions

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

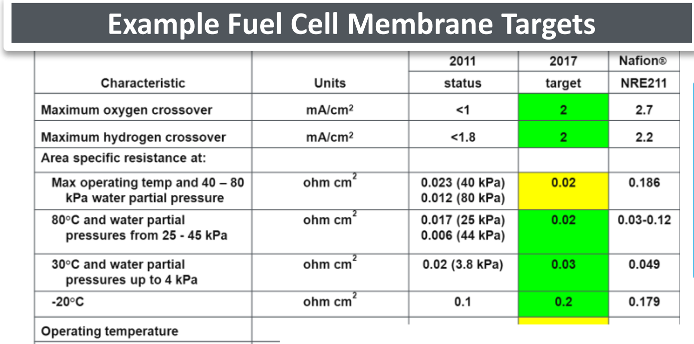
Project & Program Review Processes

- **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.

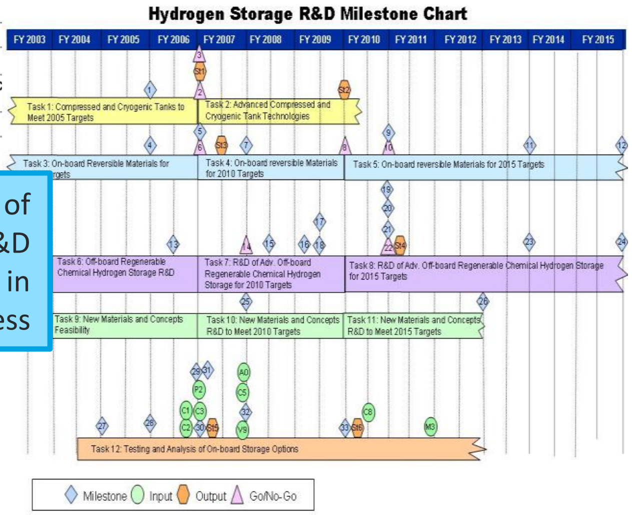
Reviewer comments for projects posted online annually. Projects discontinued/ work scope altered based on performance & likelihood of meeting goals.

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 cm^2	0.023 (40 kPa) 0.012 (80 kPa)	0.02	0.186
80°C and water partial pressures from 25 - 45 kPa	ohm cm^2	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 cm^2	0.02 (3.8 kPa)	0.03	0.049
-20°C	ohm cm^2	0.1	0.2	0.179
Operating temperature				
Minimum electrical resistance				
Cost				
Durability				
Mechanical	C			
Chemical				

Technical targets help guide go/no-go decisions.



Update of Multiyear RD&D Plan and Targets in process

Over $25M saved in the last 4 years through active project management.

Project scope redirected or terminated to increase impact

Source: US DOE 4/18/2013

Reminder: FY 2012 Funding Changes for New Awards

The conference committee appropriation language changes how new R&D awards could be funded.

Excerpts from Language

"The conferees are concerned the Department is over-committing future budgets by announcing multi-year awards subject to future appropriations for a substantial portion of activities within Energy Programs."

"The Department is directed to transition to a model in which it fully funds multi-year awards with appropriated funds, except in the cases of major capital projects, management and operating contracts, and large research centers which require multi-year awards subject to appropriations."

POTENTIAL FUNDING CHANGES

CURRENT SYSTEM	PROPOSED SYSTEM
Fund projects on a fiscal year basis	Fully fund all projects up front
Number of awards based on projected spending pattern	Fewer awards made since all funds must be available in current year
Quantitative Go/No Go milestones	Quantitative Go/No Go milestones

Source: US DOE 4/18/2013

Thank you

Sunita.Satyapal@ee.doe.gov

www.hydrogenandfuelcells.energy.gov

Source: US DOE 4/18/2013