FUEL CELL TECHNOLOGIES PROGRAM

FY 2013 Budget Request Rollout to Stakeholders

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

FY 2013 Budget Request Rollout

Washington, DC

February 14, 2012

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U.S. Department of Energy

Fuel Cell Technologies Program

Program Manager

Fuel Cell Market Overview

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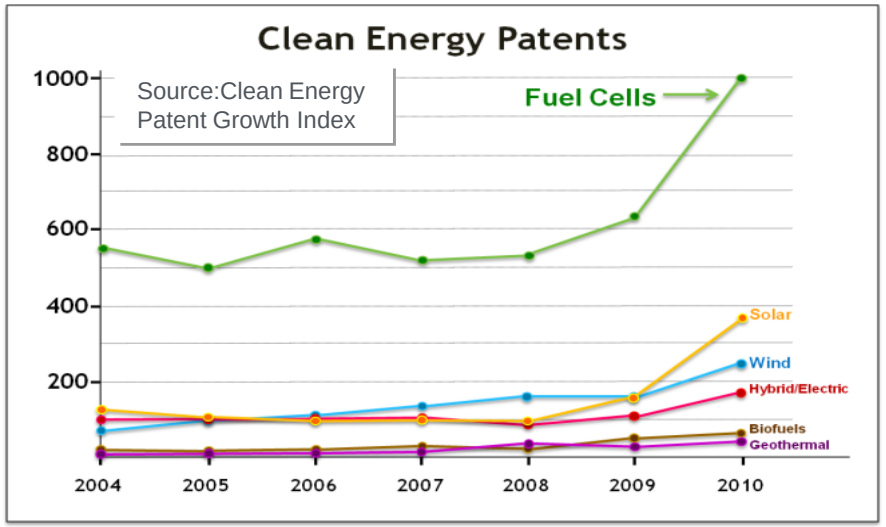
Fuel cell patent growth reflects level of investment in emerging, promising industry

→ **DOE's efforts in fuel cells and hydrogen are spurring innovation throughout the industry.**

Clean Energy Patent Growth Index shows there were nearly 1,000 fuel cell patents worldwide in 2010.



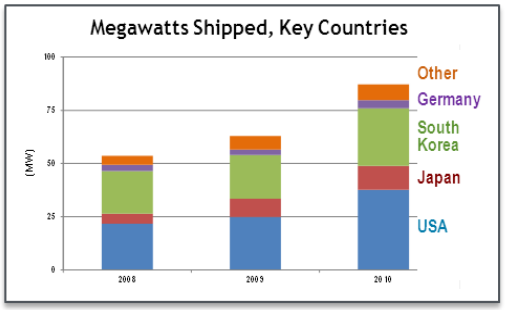
- Number of fuel cell patents grew > 57% in 2010.

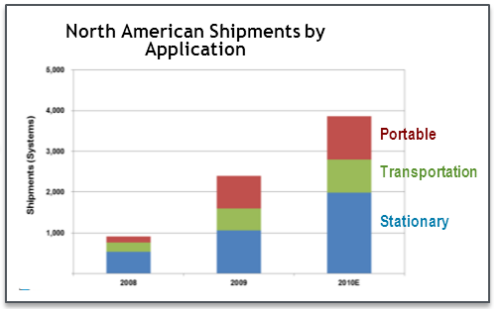
Steady growth in the market but global competition is increasing

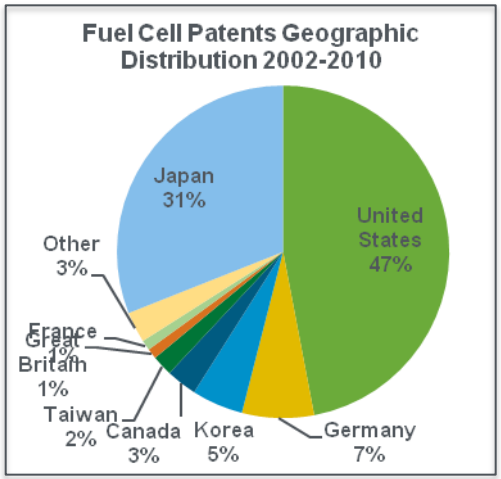
→ Fuel cell markets continue to grow

~ 36% increase in global MWs shipped in 1 year

~ 50% increase in MWs shipped from North America







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

Sources: FuelCells2000, Pike Research, Fuel Cell Today, ANL, www.fuelcells.org/BusinessCaseforFuelCells.pdf, www.fuelcells.org/StateoftheStates.pdf
http://cepgi.typepad.com/heslin_rothenberg_farley_/2011/03/clean-energy-patent-growth-index-2010-year-in-review.html
[1] 2010 Year in Review from http://cepgi.typepad.com/heslin_rothenberg_farley_/

DOE Program Plan Released

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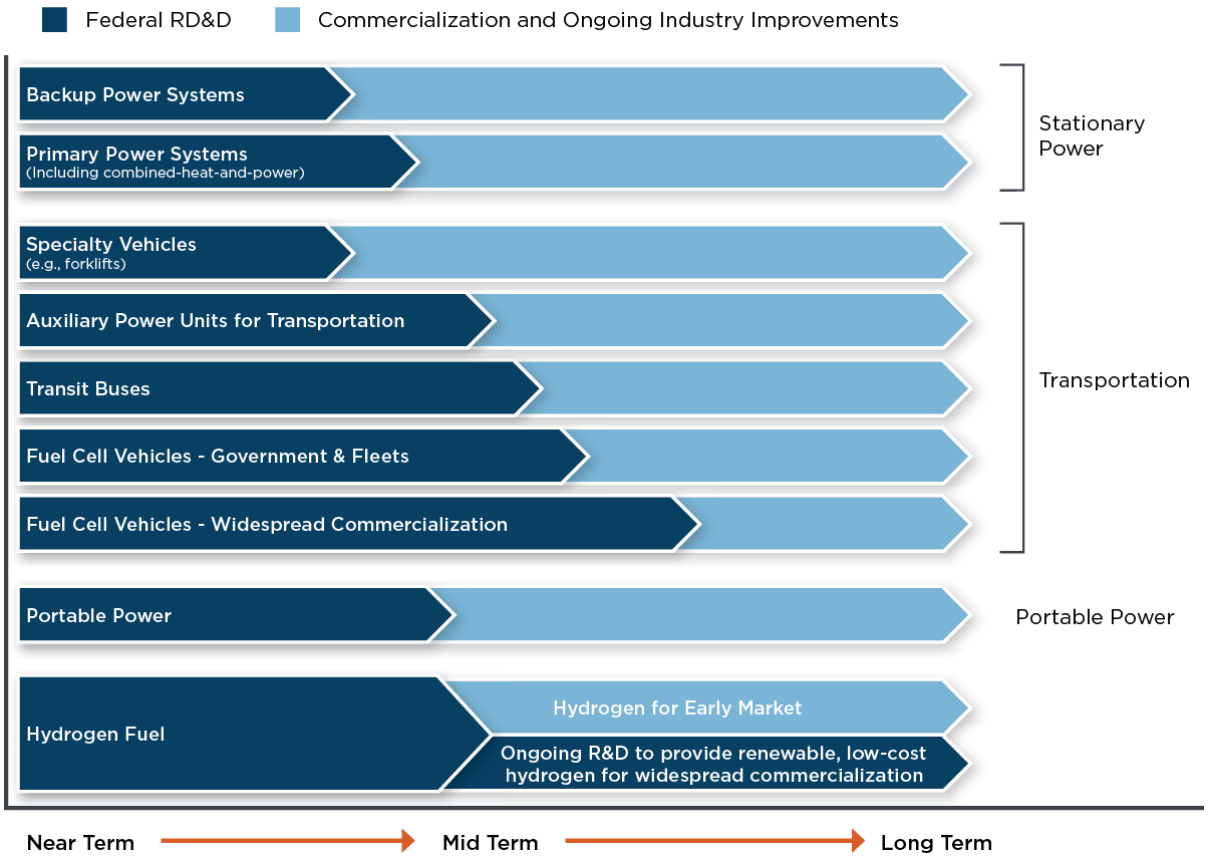
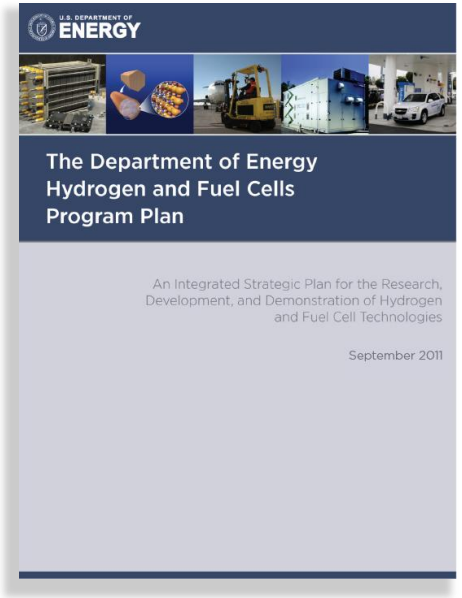
An integrated strategic plan for the research, development, and demonstration activities of DOE's Hydrogen and Fuel Cells Program: Includes Stationary, Portable and Transportation Fuel Cells





Update to the Hydrogen Posture Plan (2006)

Program efforts are planned to transition to industry as technologies reach commercial-readiness.

Released September 2011

http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/program_plan2011.pdf

DOE Program Structure

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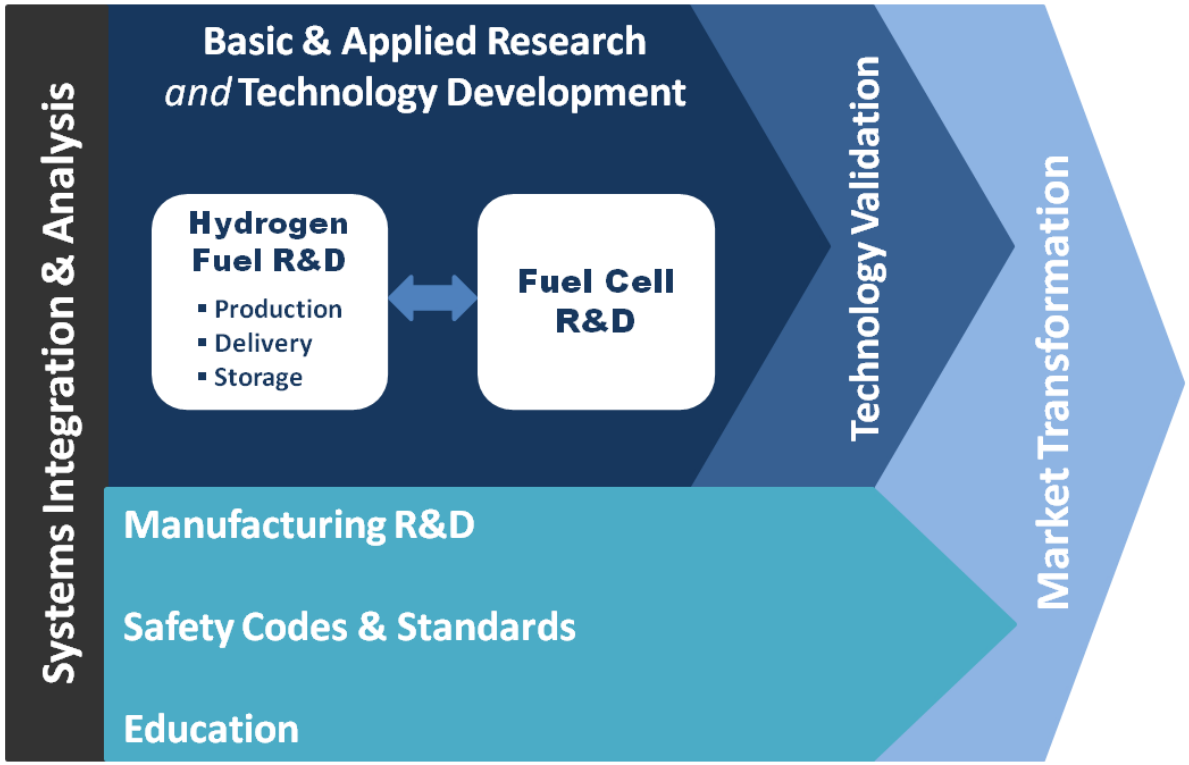
The Program is an integrated effort, structured to address all the key challenges and obstacles facing widespread commercialization.



WIDESPREAD COMMERCIALIZATION ACROSS ALL SECTORS

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

Nearly 300 projects currently funded
at companies, national labs, and universities/institutes
More than $1B DOE funds spent from FY 2007 to FY 2011

Assessing the Impact of DOE Funding

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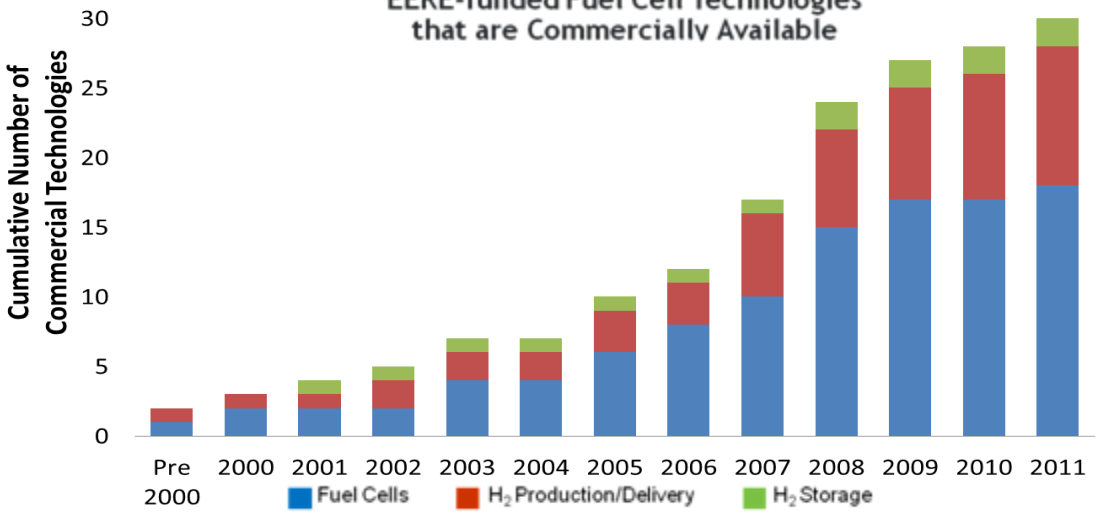
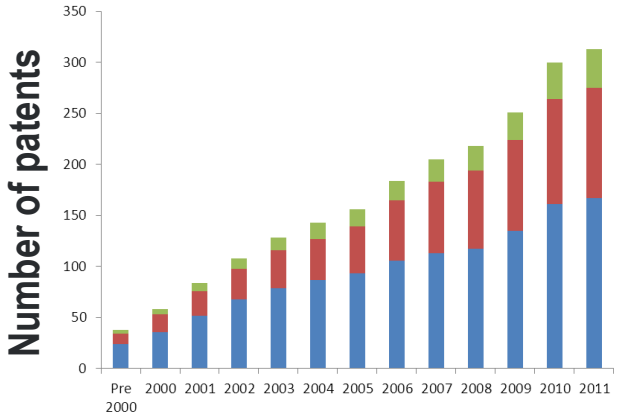
DOE funding has led led to 313 patents, ~30 commercial technologies and >60 emerging technologies.

DOE's Impact: ~$70M in funding for specific projects was tracked – and found to have led to nearly $200M in industry investment and revenues.

Accelerating Commercialization



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



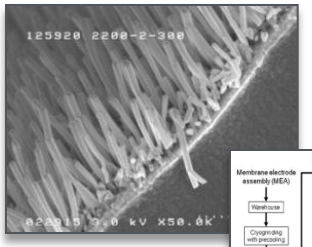
>310 PATENTS resulting from EERE-funded R&D:

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

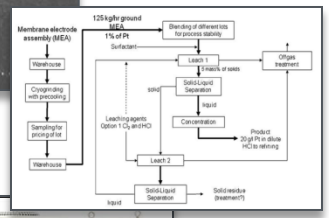
http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/pathways_2011.pdf

Examples

3M



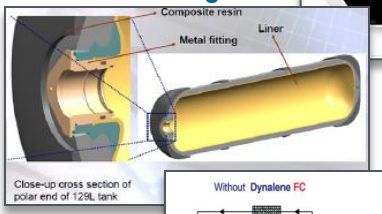
BASF Catalysts LLC



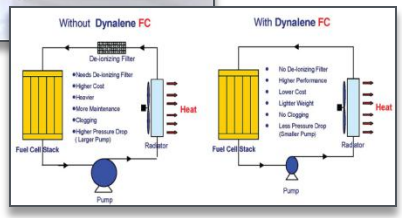
Proton Energy Systems

DuPont

Quantum Technologies



Dynalene, Inc.



FY 2012 Senate Mark Language and Impact

DOE FCT Program adjusted FY 2012 budget based on Senate Mark language.

Excerpts from Senate Mark Language in the FY 2012 Appropriation

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

" Within the available funds, the Committee recommends funding is provided for Technology Validation focused on passenger vehicle and hydrogen infrastructure applications, hydrogen fuels R&D, and for Market Transformation in early markets."

IMPACT

FY 2012 Request: $100.5 M **FY 2012 Appropriation: $104 M**

Following guidance from the Senate mark language:

- **$1 M was added to the original request for Technology Validation (total $9M)**
- **$3 M was added for Market Transformation (total $3M)**

($33.8 M already planned for Hydrogen Fuels R&D)

FY 2013 Budget Background

- The FY 2013 budget request allows the Department to sustain a balanced R&D portfolio, and hydrogen and fuel cells remain an integral part of that portfolio.

  The Department continues to support development of hydrogen and fuel cell technologies for stationary, portable, and transportation applications, ***including fuel cell electric vehicles.***

- The Department has made substantial progress in fuel cell technologies

  - ✓ *reduced cost by more than 80% since 2002 and 30% since 2008*
  - ✓ *doubled fuel cell durability*
  - ✓ *reduced platinum content by a factor of five*

- FY 2013 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.
- Funding has been reduced (or deferred) for aspects of the program with less impact on R&D progress, such as technology validation, codes and standards, market transformation, and education.

Budget: FCT Program Key Activities

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Funding *($ in thousands)*				
Key Activity	**FY 2010 Appropriation**	**FY 2011 Allocation**	**FY 2012 Appropriation**	**FY 2013 Request**
Fuel Cell R&D[1]	75,609	41,916	43,556	36,899
Hydrogen Fuel R&D[2]	45,750	32,122	33,785	26,177
Technology Validation	13,005	8,988	8,987	4,992
Safety, Codes and Standards	8,653	6,901	6,893	4,921
Systems Analysis	5,408	3,000	2,925	2,922
Manufacturing R&D	4,867	2,920	1,941	1,939
Market Transformation	15,005	0	3,000	0
Education	2,000	0	0	0
SBIR/STTR	3,703	2,153	2,537	2,150
Total	$174,000	$98,000	$103,624	$80,000

[1]Fuel Cells Systems R&D includes Fuel Cell Stack Component R&D, Transportation Systems R&D, Distributed Energy Systems R&D, and Fuel Processor R&D

[2]Hydrogen Fuel R&D includes Hydrogen Production & Delivery R&D and Hydrogen Storage R&D

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

Hydrogen and Fuel Cell Technologies

Program Description: The **Hydrogen and Fuel Cell Technologies Program** develops 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 hydrogen (from diverse resources) to be cost-competitive with gasoline *($2 – 4/gge, delivered and dispensed)*.

EERE FCT Funding *($ in thousands)*

Key Activity	FY 2012 Appropriation	FY 2013 Request
Fuel Cell Systems R&D	44,812	38,000
Hydrogen Fuel R&D	34,812	27,000
Technology Validation	9,000	5,000
Market Transformation	3,000	0
Safety, Codes & Standards	7,000	5,000
Education	0	0
Systems Analysis	3,000	3,000
Manufacturing R&D	2,000	2,000
Total	$103,624	$80,000

Key FY 2013 Activities

- **Fuel Cell R&D ($38 M)** will improve the durability, reduce cost, and improve the performance of fuel cell systems, through advances in fuel cell stack materials and components, and in balance of plant components and subsystems. Key goals include:
  - Reduce costs by increasing PEM fuel cell power output per gram of platinum-group catalyst from 2.8 kW/g (in 2008) to 5.9 kW/g in 2013 and 8.0 kW/g by 2017.
- **Hydrogen Fuel R&D ($27 M)** will focus on production, delivery, and storage R&D to achieve a 5% reduction in the dispensed, untaxed hydrogen cost from the baseline of $8/gge (2011), and develop hydrogen storage technologies to reduce costs by 10% from $17/kWh.
- **Safety, Codes and Standards ($5 M)** will develop and validate fast-fill models to optimize fueling protocols for SAE J2601.
- **Manufacturing R&D ($2 M)** will develop and demonstrate advanced manufacturing technologies and processes that will reduce the cost of fuel cell systems and hydrogen technologies. Key goals include:
  - Reduce cost of manufacturing MEAs by 25%, relative to 2008 baseline of $126/kW @ 1000 units/year by 2013.
- **Recovery Act:** will complete the ***Hydrogen Fuel Cells: Enabling Market Transformation and Manufacturing*** project by September 30, 2013 with ≥ 1200 fuel cell deployments, exceeding the original target deployment goal by over 20%.

FY 2013 Budget in Brief: Examples of Key Quantitative 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 from 2.8 kW/g (in 2008) to 5.9 kW/g in 2013 and 8.0 kW/g by 2017.
- **Hydrogen Fuel R&D,** will focus on production from renewable resources, delivery R&D to achieve a 10% reduction in the delivered, untaxed hydrogen cost from the baseline of $8/gge, and hydrogen storage R&D to achieve a 10% reduction from current projected costs of $17/kWh.
- **Safety, Codes and Standards** will develop and validate fast-fill models to optimize fueling protocols for SAE J2601.
- **Manufacturing R&D** will develop and demonstrate advanced manufacturing technologies and processes. Key goals include reducing the cost of manufacturing MEAs by 25%, relative to 2008 baseline of $63/kW (@ 1000 units/year).
- **Systems Analysis** will determine technology gaps, economic/jobs potential, infrastructure cost reduction opportunities for early market penetration of fuel cells, and quantify technology advancements in 2013

Funding for Education and Market Transformation is deferred to focus efforts on key R&D challenges. In addition, Market Transformation funding is deferred while Recovery Act deployments, data collection, and analyses continue and FY 2012 projects commence.

Fuel Cell R&D — *Progress: Cost*

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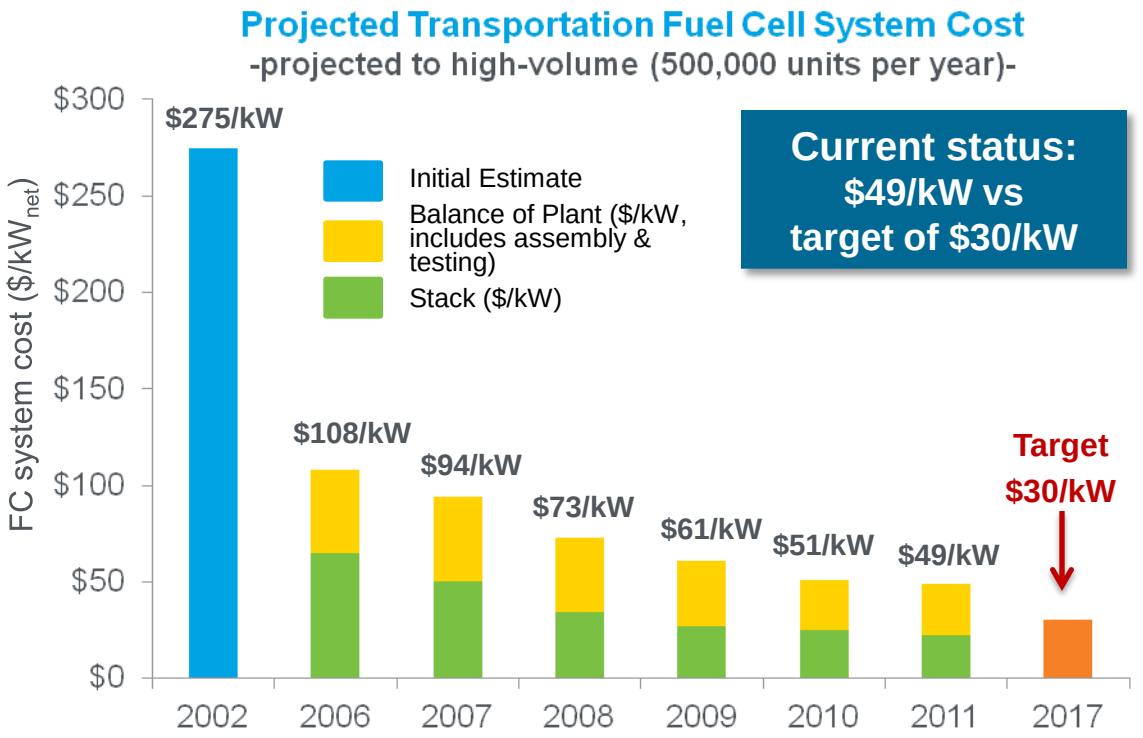
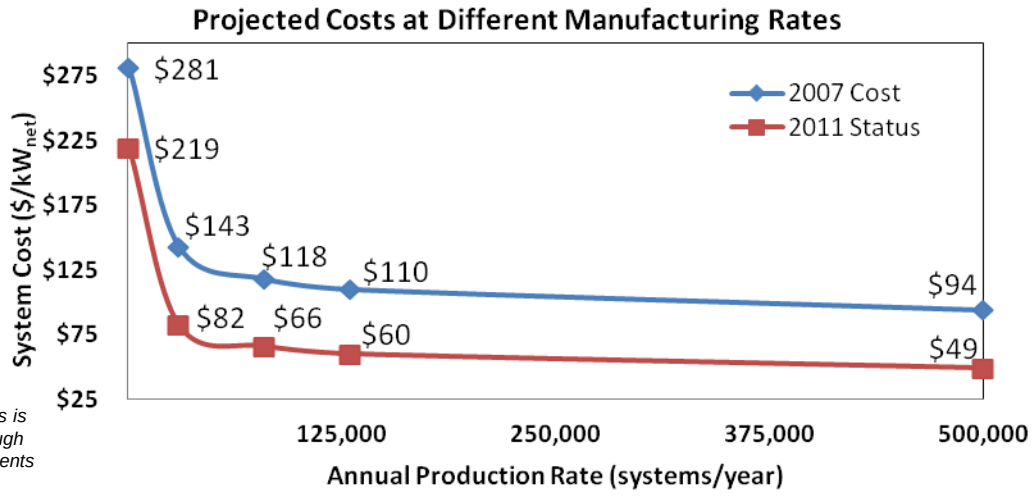
Reduced the projected high-volume cost of fuel cells to $49/kW (2011)*

- *More than 30% reduction since 2008*
- *More than 80% reduction since 2002*

Key Accomplishments:

- **Reduced platinum group metal (PGM) content from**
  - **>1 g/kW to <0.2 g/kW** *(target: 0.125 g/kW)*
- **Novel catalyst structure has shown the potential to meet—and exceed—targets for durability (5,000 hours).**

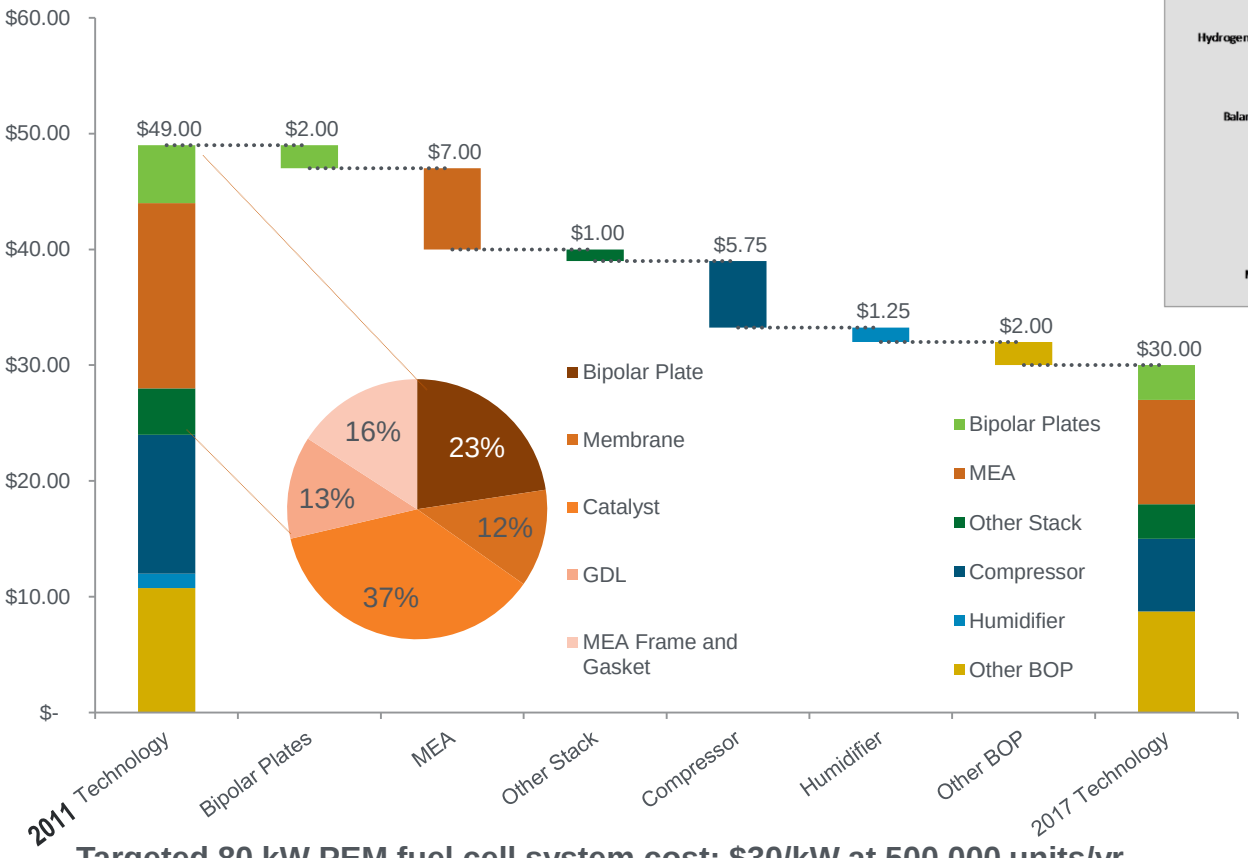




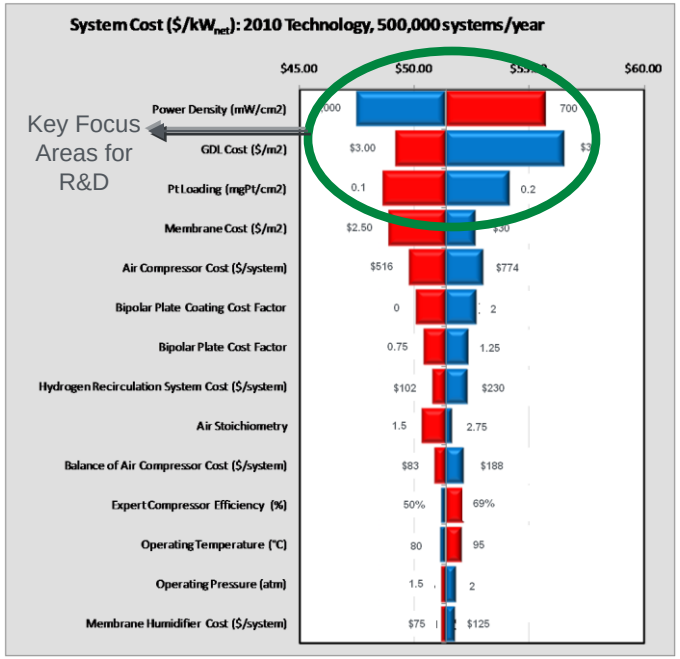
Based on projection to high-volume manufacturing (500,000 units/year). *The projected cost status is based on an analysis of state-of-the-art components that have been developed and demonstrated through the DOE Program at the laboratory scale. Additional efforts would be needed for integration of components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

Current Portfolio Addresses High-Impact Areas

Strategic technical analysis guides focus areas and priorities for budget.
Need to reduce cost from $49/kW to $30/kW and increase durability from 2,500-hr to 5,000-hr.



Targeted 80 kW PEM fuel cell system cost: $30/kW at 500,000 units/yr



Sensitivity Analysis helps guide R&D

Strategies to Address Challenges –

Catalyst Examples

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

Fuel Cell R&D- Plans

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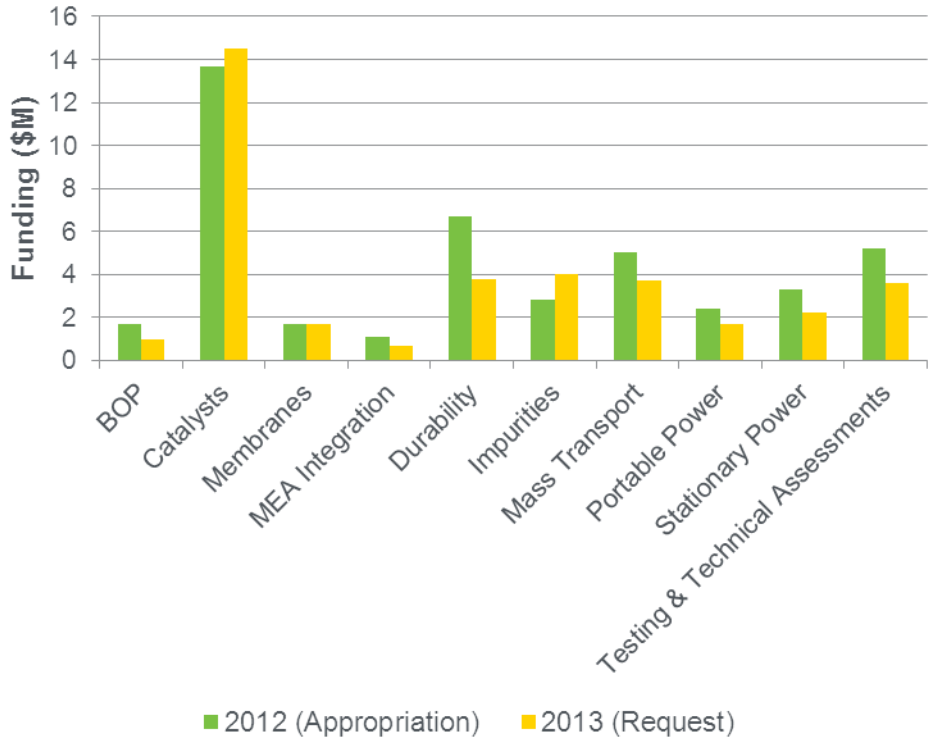
Maintains critical fuel cell R&D to improve the durability, reduce cost, and improve the performance of fuel cell systems for stationary, transportation and portable power. Key goals: Increase PEM fuel cell power output per gram of PGM catalyst from 2.8 kW/g (in 2008) to 5.9 kW/g in 2013 and 8.0 kW/g by 2017.

FY 2013 Request = $36.9M*

FY 2012 Appropriation = $43.6M



* Excludes SBIR/STTR

Subject to appropriations, project go/no go decisions and competitive selections

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.
- Develop high-temperature membranes that will reduce the negative effects of impurities and decrease the size of the cooling system.
- 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, subsystems and systems specifically tailored for stationary and portable power applications (e.g. SOFC)

Hydrogen Production - Strategies

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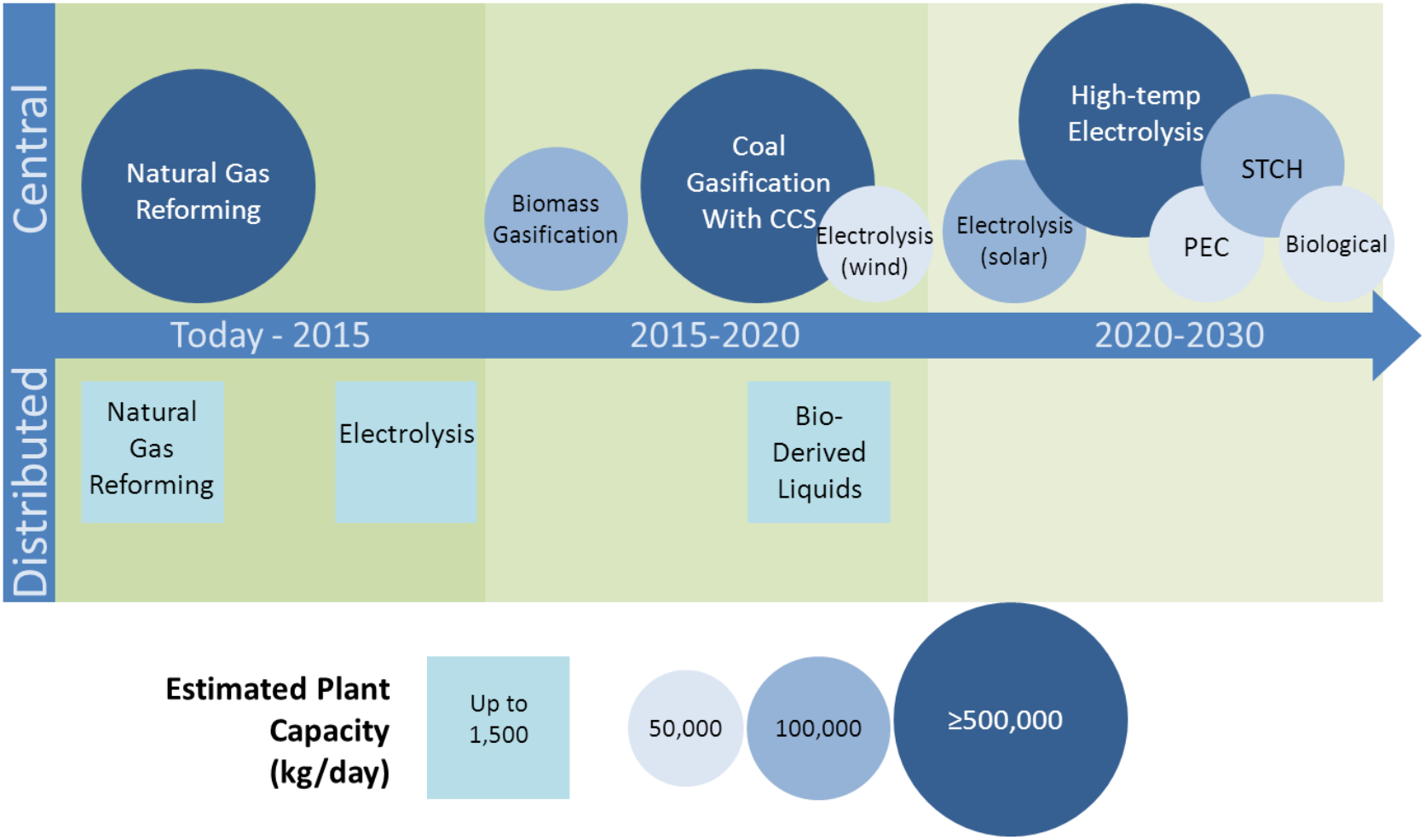
Hydrogen Production Technology Portfolio
Potential Capacity and Readiness Date



Progress: *Hydrogen Production R&D*

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The revised hydrogen threshold cost is a key driver in the assessment of Hydrogen Production and Delivery R&D priorities.

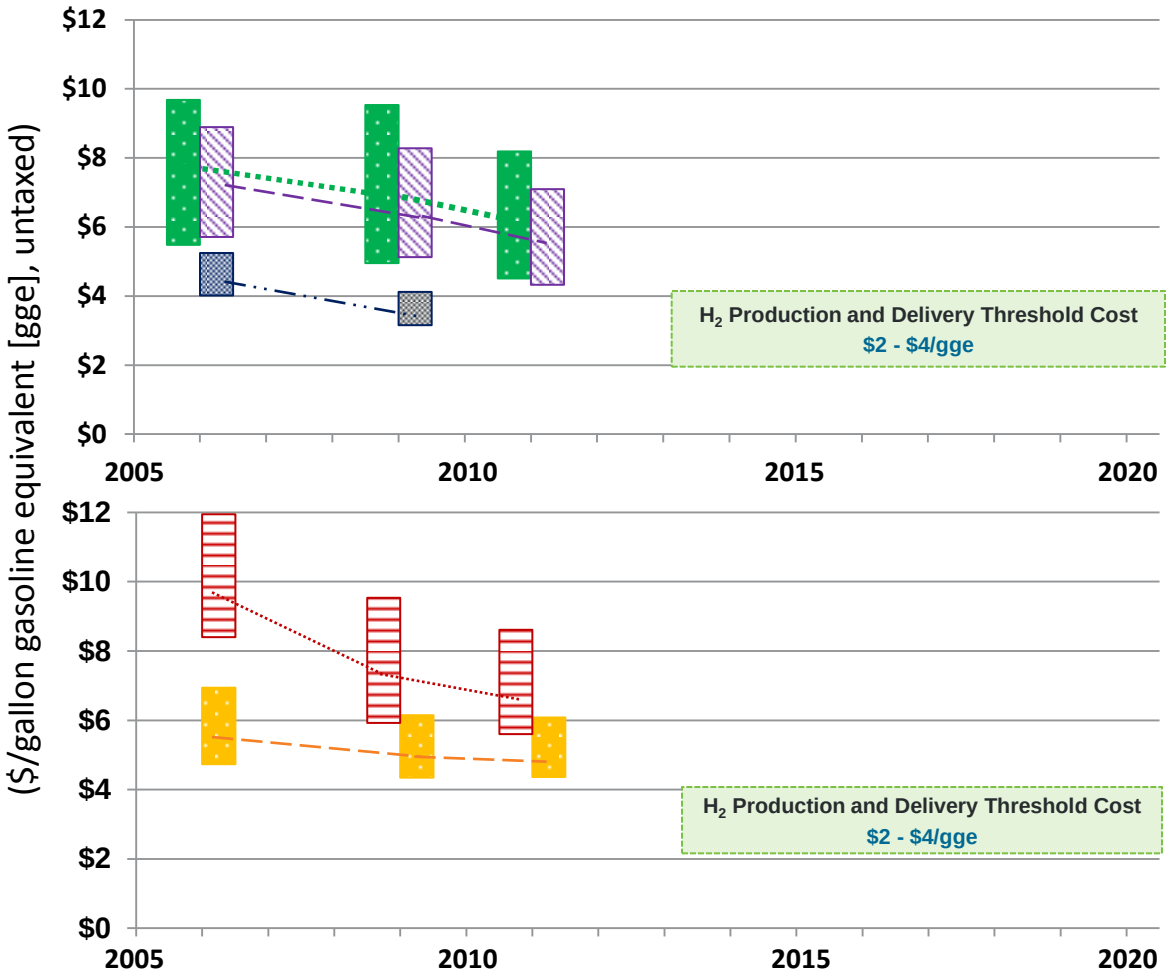
Projected High-Volume Cost of Hydrogen Production[1] (Delivered[2])—Status

Distributed Production (near term)

- Electrolysis
  - *Feedstock variability: $0.03 - $0.08 per kWh*
- Bio-Derived Liquids
  - *Feedstock variability: $1.00 - $3.00 per gallon ethanol*
- Natural Gas Reforming[3]
  - *Feedstock variability: $4.00 - $10.00 per MMBtu*

Central Production (longer term)

- Electrolysis
  - *Feedstock variability: $0.03 - $0.08 per kWh*
- Biomass Gasification
  - *Feedstock variability: $40- $120 per dry short ton*



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

Cost Reduction Roadmap for H_2 Production
Example — Photoelectrochemical Production

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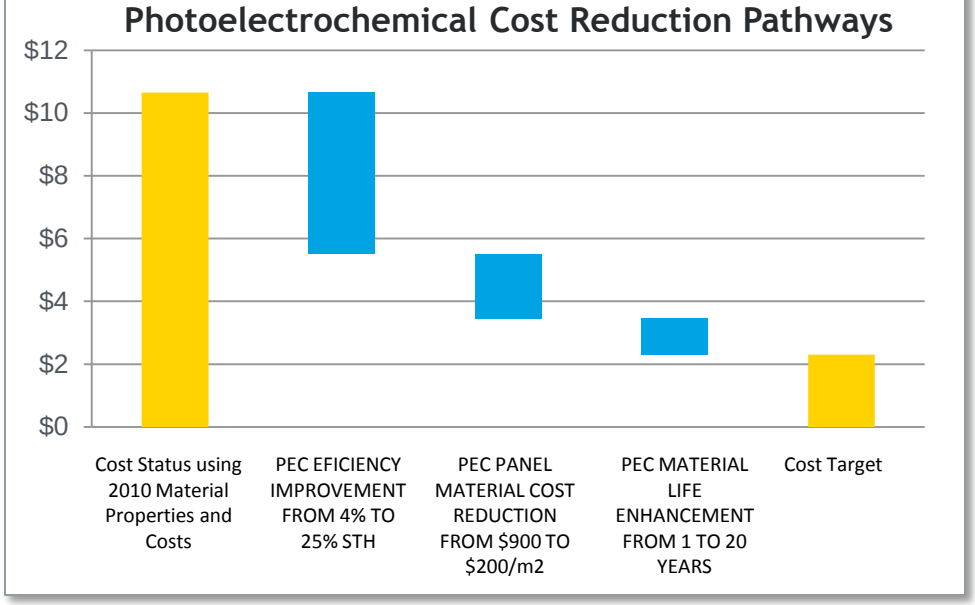
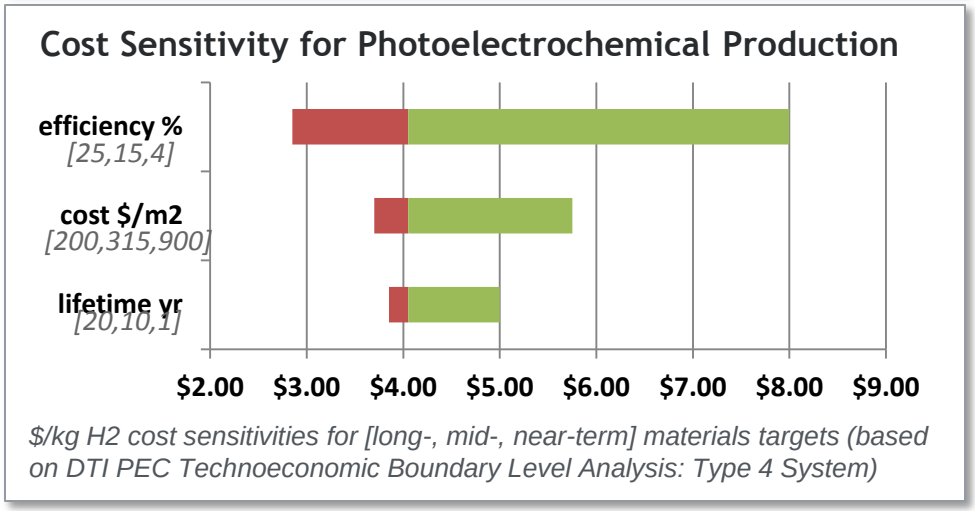
Potential areas for cost reduction guide R&D activities





$/kg H2 cost sensitivities for [long-, mid-, near-term] materials targets (based on DTI PEC Technoeconomic Boundary Level Analysis: Type 4 System)

MATERIAL EFFICIENCY: Increase PEC efficiency from 4% (baseline) to 25%.

Focus on novel integrated thin film device structures (e.g., with metal oxides) with multi-junction absorber layers for 1.8-2.2 V and enhanced surface catalysis for efficiency enhancements toward the 25% target

MATERIAL COST: Decrease PEC panel material cost from $900/m^2 to $200/m^2.

Focus on material and processing/fabrication cost reductions, e.g. breakthrough self-assembling semiconductor synthesis approaches (instead of vapor deposition, etc.)

MATERIAL LIFETIME: Increase life from 1 to 20 yrs.

Focus on advanced surface modification strategies to enhance catalysis and mitigate corrosion of the crystalline material systems currently capable of >18% solar-to-hydrogen conversion

NEW IDEAS: Disruptive technologies incorporating nano-structured semiconductor, catalyst and membrane components with the potential for high efficiency and durability using low-cost synthesis routes (e.g., work with EFRC/Solar Hub on approaches such as nanoparticle MoS_2 in porous scaffold)

Blue Ribbon Panel: H_2 Production

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Provide guidance to DOE FCT Program on coordination with other agencies and offices to optimize effectiveness of the Hydrogen Production Portfolio

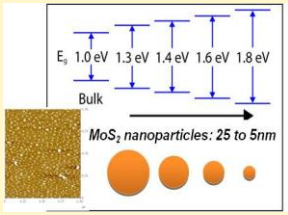
Objectives

1. Evaluate the current status and future prospects for distributed- and central- hydrogen production pathways, including those currently in the DOE R&D portfolio
2. Prioritize research and development needs to advance hydrogen production technologies
3. Recommend how to best coordinate R&D efforts in hydrogen production among DOE Offices and Programs (including EERE-FCT, SC, ARPA-E and the Innovation Hubs), and with other agencies

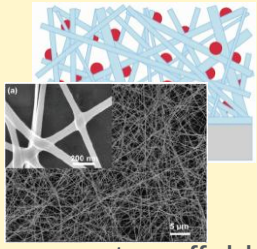
Progress to Date

HTAC & DOE defined purpose and focus of Panel
Development of agenda in process

Current Collaborations

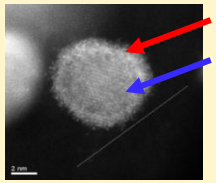


Bandgap tailoring

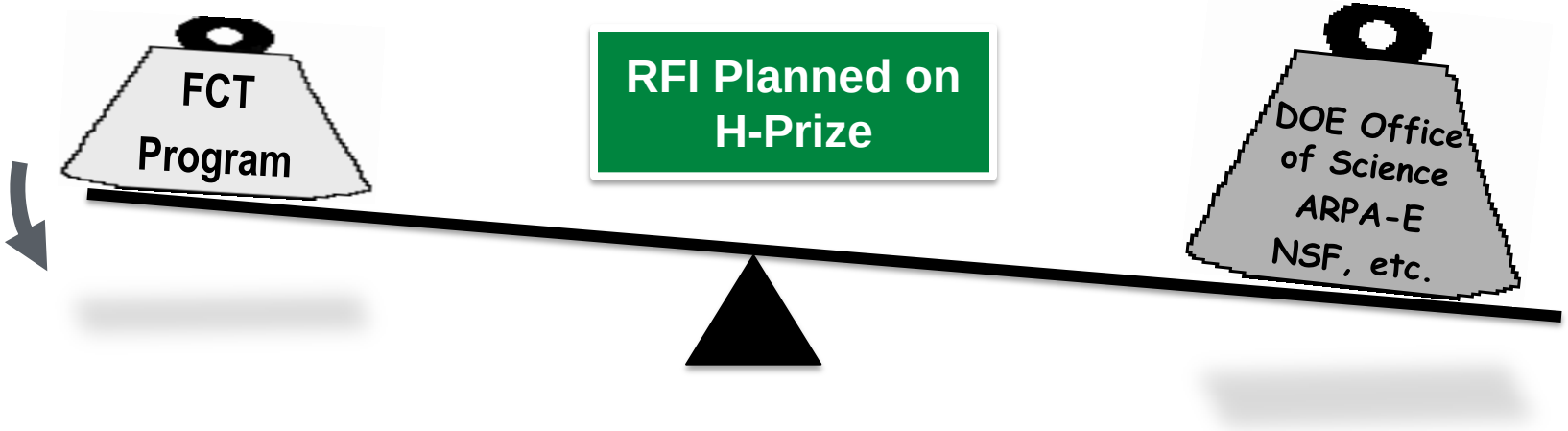


Nano-catalyst support scaffold (Stanford)

Mechanistic understanding of catalysts



Pt monolayer
Pd core



Progress – Delivery R&D Examples

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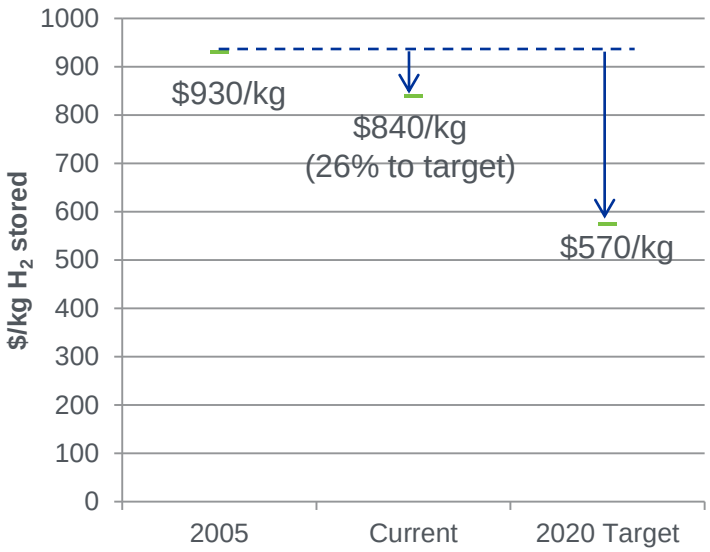
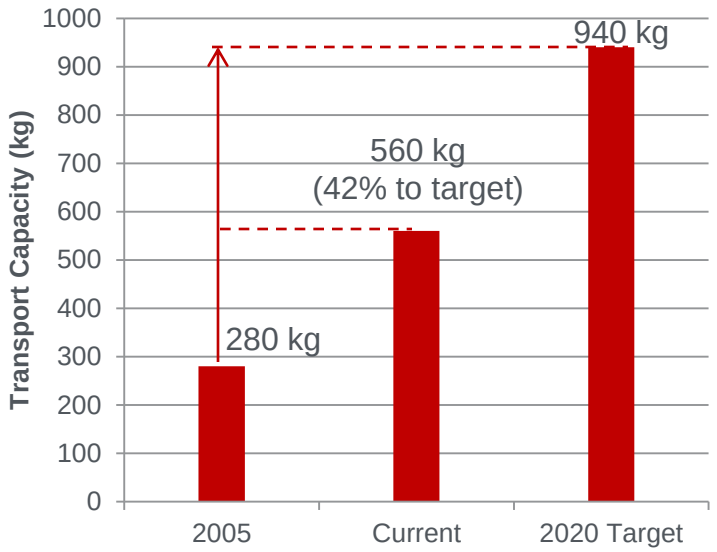
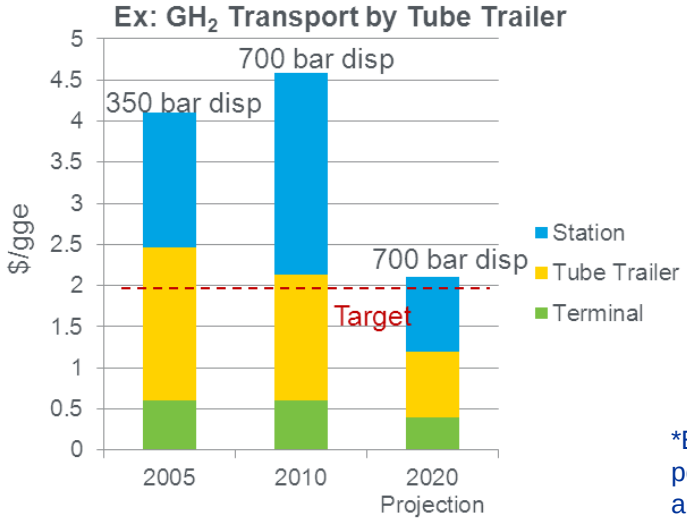
Delivery costs are being reduced but challenges still need to be address – eg., compressor cost at the station is significant.

Tube Trailers

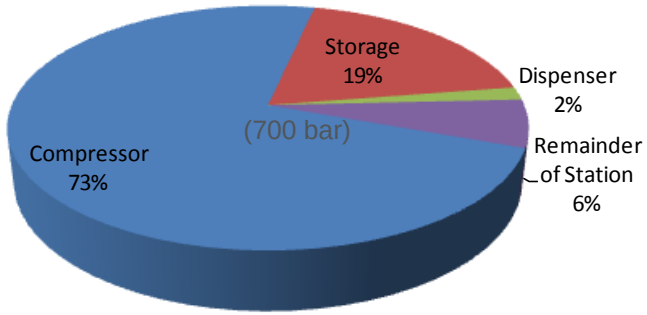




Pathway Cost



Refueling Station (2010 Technology)



1000 kg/day

*Based on **preliminary** HDSAM (v2.3) analysis assuming 15% market penetration in a city with a population of 1.2M ; also assumes 700bar dispensing and a back-up compressor (update in process)

Hydrogen Production & Delivery - Plans

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

Maintains critical hydrogen R&D. Key goals include: Achieve a 10% reduction in the delivered, untaxed hydrogen cost from the baseline of $8/gge. Design a hydrogen storage vessel that reduces refueling station vessel costs by 25%. Demonstrate 100 hour operational lifetime in a high efficiency (≥10%) photoelectrochemical device.

Hydrogen Fuel R&D

FY 2013 Request = $26.2M

(for Production, Delivery & Storage)

FY 2012 Appropriation = $33.8M

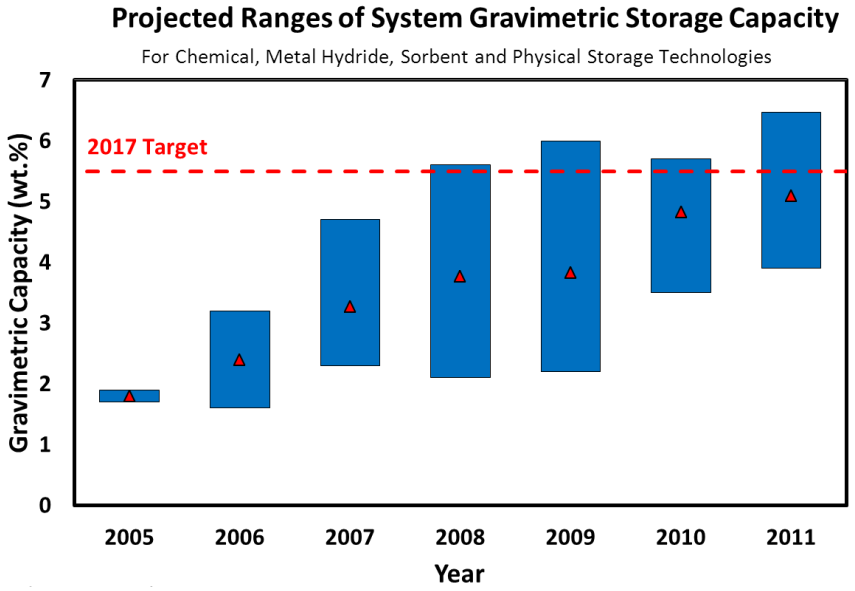
Production & Delivery Portion of Hydrogen Fuel R&D

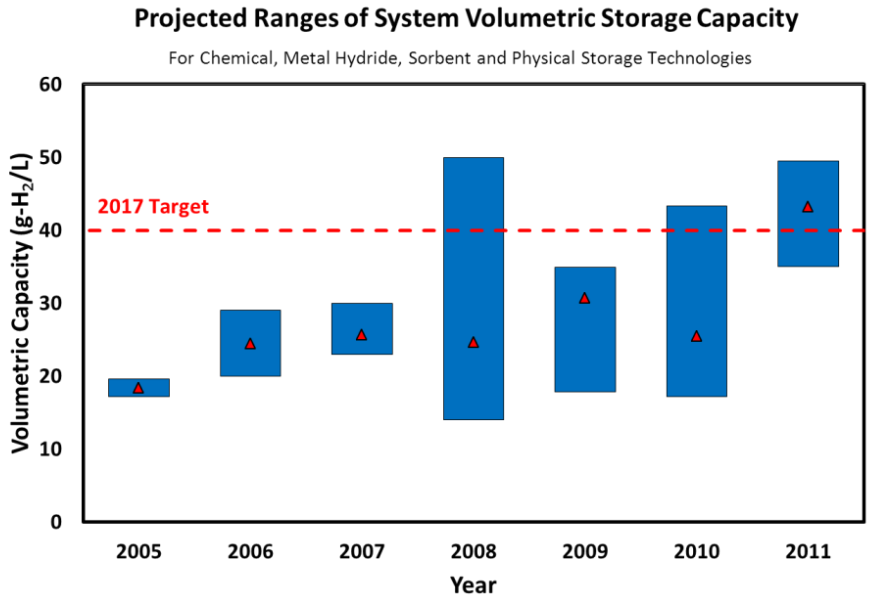
Subject to appropriations, project go/no go decisions and competitive selections

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.

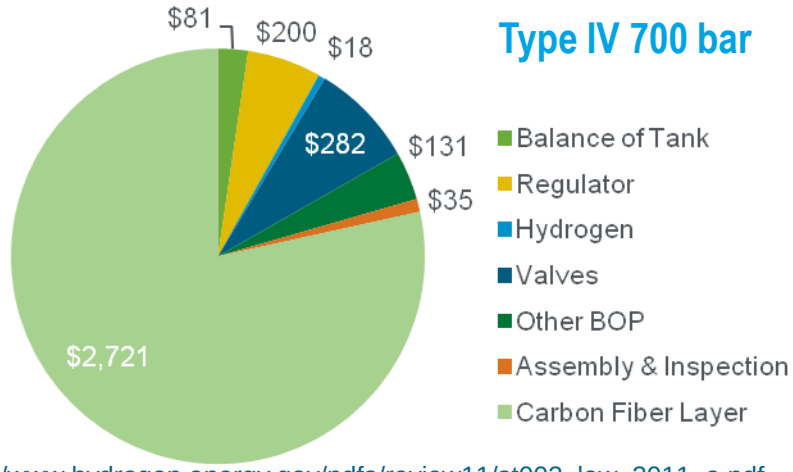
Projected Capacities for Complete 5.6-kg H_2 Storage Systems





- **Compressed H_2 tanks can achieve >250 mile range**
- **Validated a vehicle that can achieve 430 mile range (with 700 bar Type IV tanks)**
- **Developed and evaluated more than 400 material approaches experimentally and millions computationally**

Costs in the Carbon-Fiber Matrix



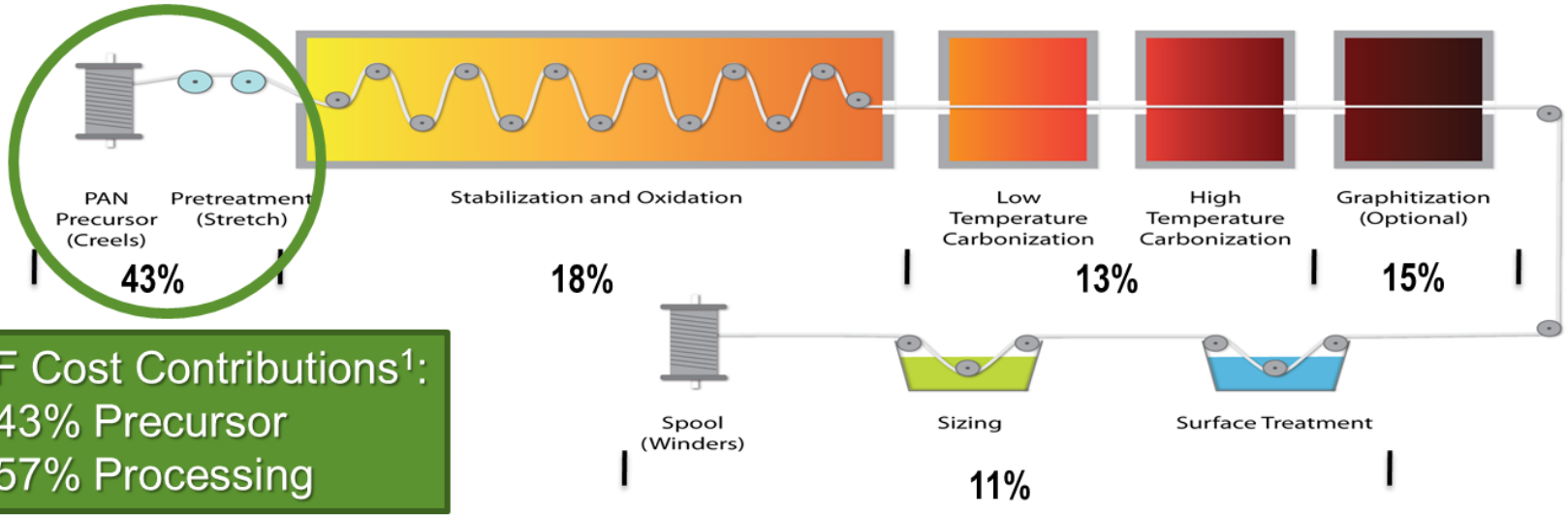
http://www.hydrogen.energy.gov/pdfs/review11/st002_law_2011_o.pdf

Carbon Fiber Cost is Key Focus Area

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

Opportunities to leverage Vehicle Technologies & Advanced Manufacturing Programs

Initiated programs to develop low-cost PAN fibers as precursors to reduce costs of high-strength carbon fibers



CF Cost Contributions[1]:
- 43% Precursor
- 57% Processing

[1]Kline and Company, 2007, in a study commissioned by the Automotive Composites Consortium.

Objective: To produce low-cost PAN-based precursors for high strength CF[2]:

- Textile-grade PAN fibers with methyl acrylate comonomer – a 30-50% reduction in precursor costs
- Develop melt-spun PAN precursor technology - potential to reduce cost of the high strength CF's by ~ 30%.[3]

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FISIPE Virginia Tech

[2]PAN w/ MA precursor: ORNL with FISIPE; Melt-spun PAN precurusors: ORNL w/ VT.
[3][Kline & Company, 2007]

Hydrogen Storage R&D - Plans

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

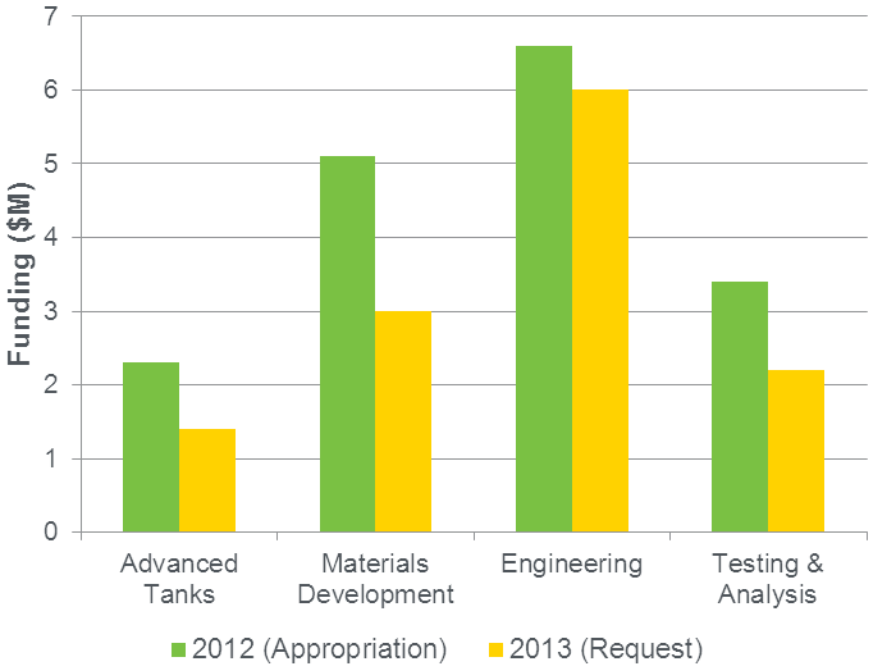
Hydrogen Fuel R&D

FY 2013 Request = $26.2M

(for Production, Delivery & Storage)

FY 2012 Appropriation = $33.8M

Storage Portion of Hydrogen Fuel R&D



Subject to appropriations, project go/no go decisions and competitive selections

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.

Manufacturing Progress

Manufacturing R&D Sub-program Key Accomplishments

1. Reduced cost of GDLs by over 50% (from $36/kW to $16/kW) and increased manufacturing capacity by a factor of 4 since 2008.
2. Reduced manufacturing labor cost of gas diffusion electrodes (GDEs) by 75% through development of a higher throughput coating process
3. Demonstrated off-line and in-line diagnostics for measurement of variability and defects in fuel cell membranes, GDLs, electrodes, and full MEAs.
4. Moved from batch coating and hand-drying cathode electrodes to pilot scale roll-to-roll cathode coating.

Workshop Held to Inform Potential Future Focus Areas

Workshop convened industry and stakeholders with expertise in hydrogen and fuel cell technologies, manufacturing, and automation to solicit input on barriers to the manufacture of hydrogen and fuel cell systems and components, and high-priority needs and R&D activities that government can support to overcome the barriers.

Objectives of Workshop:

- Summarize the status of hydrogen and fuel cell manufacturing capabilities
- Identify needs and barriers for manufacturing R&D
- Identify and prioritize specific actions to address barriers
- Identify opportunities for government and industry in facilitating growth of hydrogen and fuel cell manufacturing

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

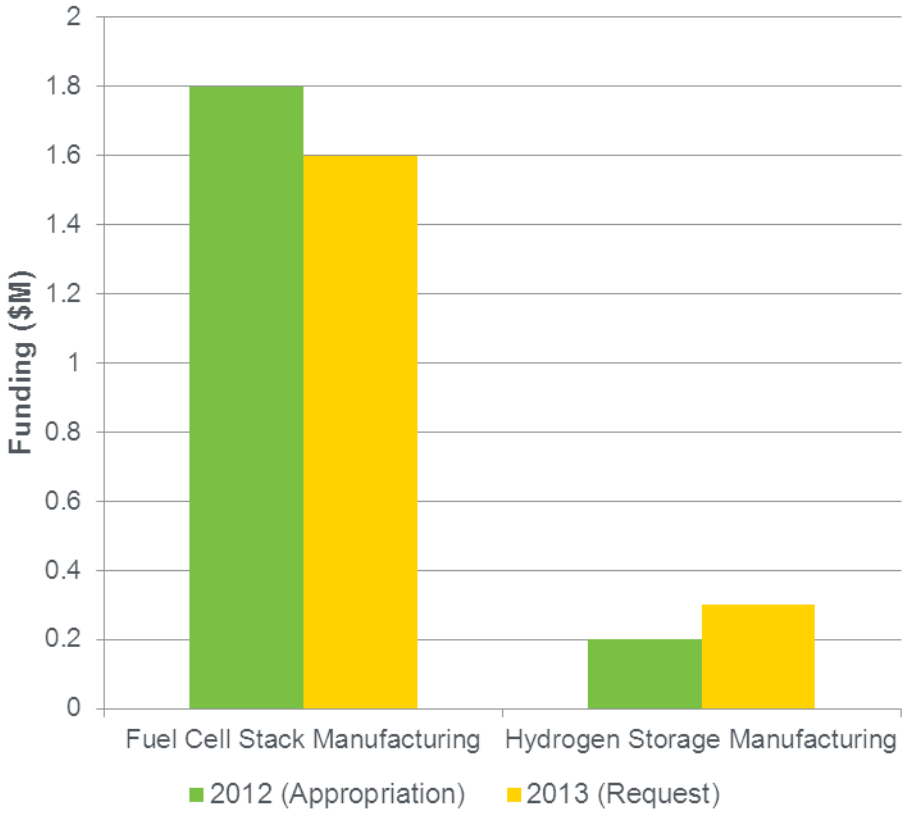
Manufacturing R&D - Plans

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

Reduce the cost of manufacturing membrane electrode assemblies for PEM fuel cells by 25%, relative to 2008 baseline of $63/kW$_e$ (at 1,000 units per year).

FY 2013 Request = $1.9M

FY 2012 Appropriation = $1.9M



Subject to appropriations, project go/no go decisions and competitive selections

EMPHASIS

- Continue core efforts on PEM fuel cells
  - Efficiently optimize electrode and GDL thermal, geometric, & transport properties and interactions for MEA fabrication
  - Dramatically reduce the rejection rate of gas diffusion electrodes caused by surface defects by switching from cloth to paper gas diffusion media
  - Develop and Optimize thickness and variation-in-thickness measurement capability during manufacture of bipolar plates
- Continue efforts on carbon fiber tank manufacturing cost reduction
- Develop potential funding opportunity announcement for FY 2013 release based on results from hydrogen and fuel cell Manufacturing R&D workshop (subject to appropriations)

Progress – Technology Validation

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

Demonstrations are essential for validating technologies in integrated systems.

Real-world Validation

Vehicles & Infrastructure

- >180 fuel cell vehicles and 25 hydrogen fueling stations
- Over 3.6 million miles traveled
- 2,500 hours (nearly 75K miles) durability
- 5 minute refueling time (4 kg of hydrogen)
- Vehicle Range: ~196 – 254 miles
- Independently validated vehicle capable of 430 miles on a single fill

Buses (with DOT)

- H_2 fuel cell buses have 42% to 139% better fuel economy when compared to diesel & CNG buses

Forklifts

- Over 130,742 total refuelings since 2009

CHHP (Combined Heat, Hydrogen and Power)

- Demonstrated the world's first facility using wastewater treatment plant biogas for co-producing hydrogen and power (with 54% efficiency)

Recent DOE webinar on the National Hydrogen Learning Demonstration – 2/6/2012

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

Potential Technology Validation FOA Topics

- Fuel Cell Electric Vehicle Data Collection
- Hydrogen Station Data Collection
- Validation of Innovative Refueling Components
- Validation of Advanced Hydrogen Tank-Trailers

Planned for FY 2012

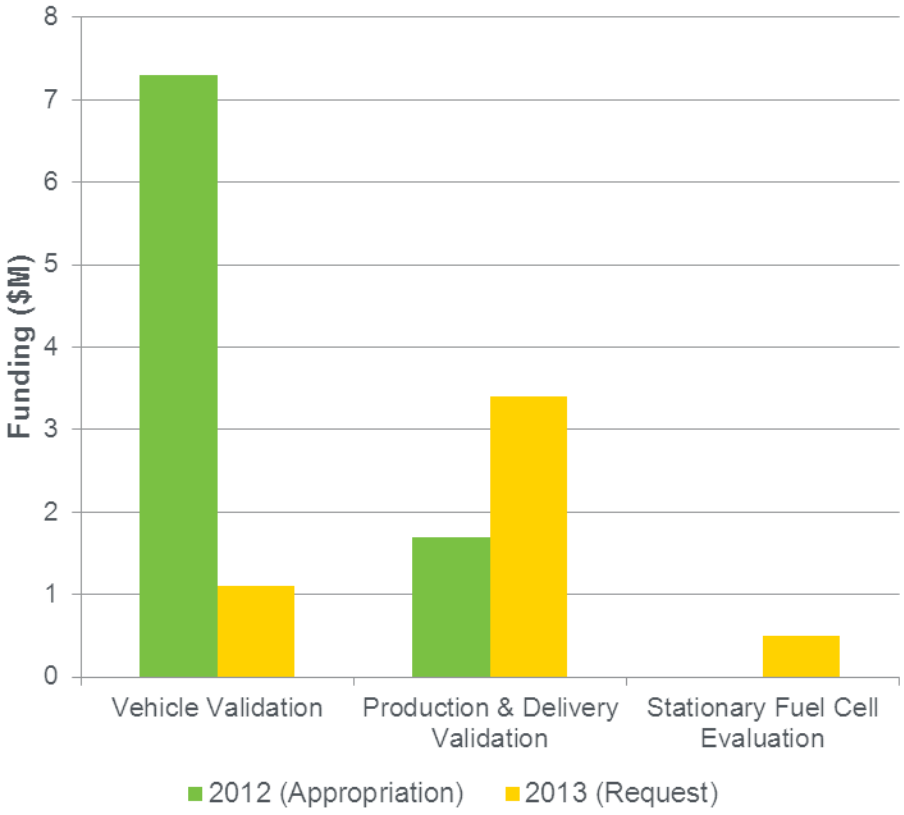
Plans include leveraging state activities (e.g. CA state funding for fueling stations)
FCT will not be funding infrastructure but can fund technology innovation that could be applicable to/enable infrastructure (e.g. innovative refueling/compression technologies)

Technology Validation - Plans

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

FY 2013 Request = $5.0M

FY 2012 Appropriation = $9.0M

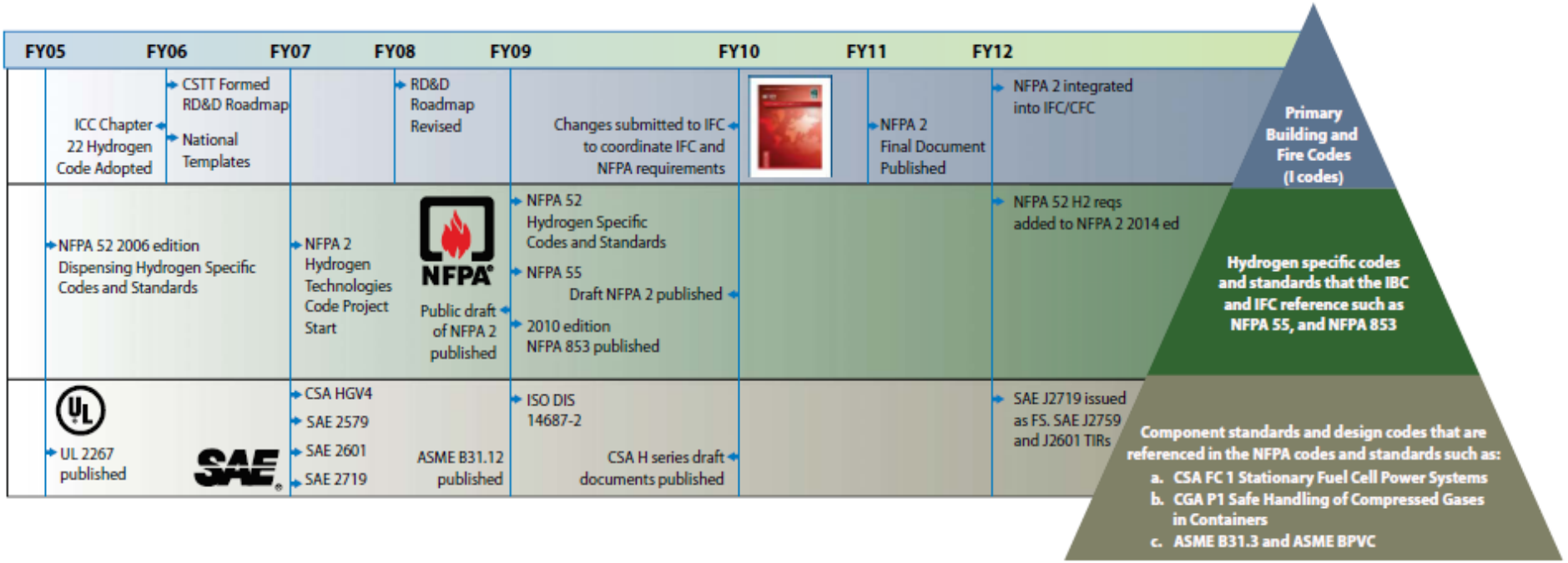


EMPHASIS

- Data collection, analysis and evaluation. (leverages equipment funded outside the Program)
  - Light-duty vehicles, buses and hydrogen refueling stations. (Collaboration on buses with DOT)
  - Wind to Hydrogen
  - Forklifts and Backup Power
  - Stationary Fuel Cells
- Real-world demonstration / evaluations (small number of units for validation purposes)
  - Innovative refueling components
  - Advanced hydrogen delivery

Subject to appropriations, project go/no go decisions and competitive selections

Timeline of Hydrogen Codes and Standards



Examples of Accomplishments:

- Demonstrated cycle-life of >50,000 refuelings of metals tanks for forklift applications
- Provided technical data and incorporated a risk-informed approach that enabled NFPA2 to update bulk gas storage separation distances
- Launched international round robin testing of Type IV tanks
- Implemented a science-based approach to develop an ISO standard for hydrogen fuel quality (standard approved).
- Completed R&D to enable Test Method for Evaluating Materials Compatibility standard.

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

The United States will use the GTR as the technical underpinning for the development of the U.S. Federal Motor Vehicle Safety Standard (FMVSS). Submitted to the U.N. ECE WP29 Dec. 2011, Target Acceptance Dec. 2012

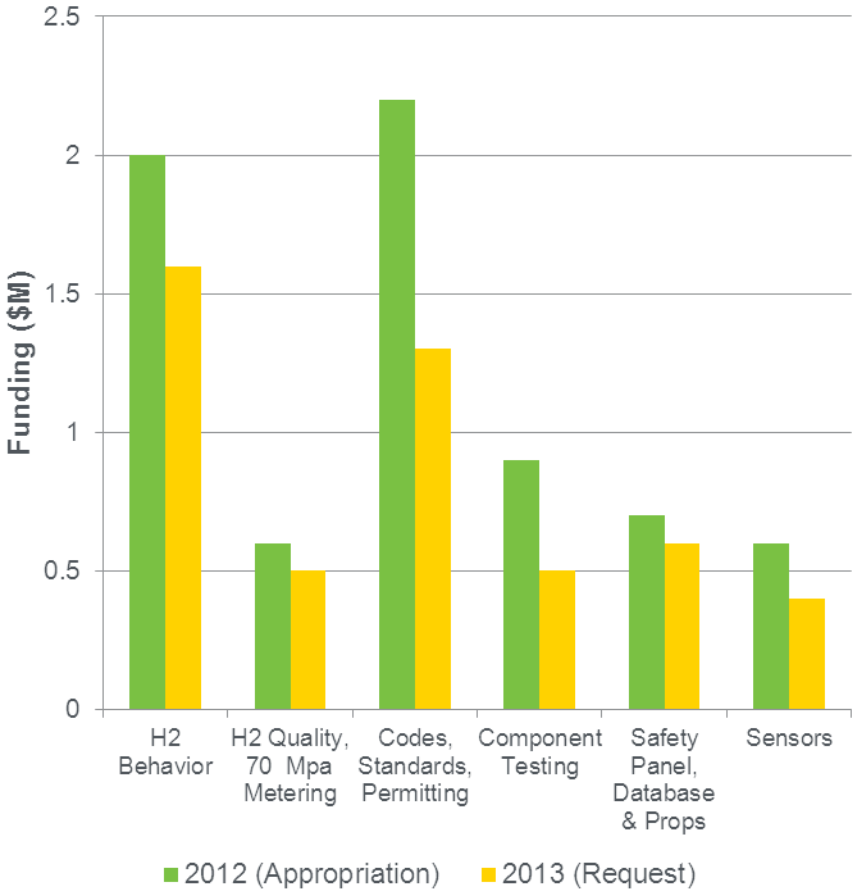
Safety, Codes & Standards - Plans

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

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

FY 2013 Request = $4.9M

FY 2012 Appropriation = $6.9M



Subject to appropriations, project go/no go decisions and competitive selections

EMPHASIS

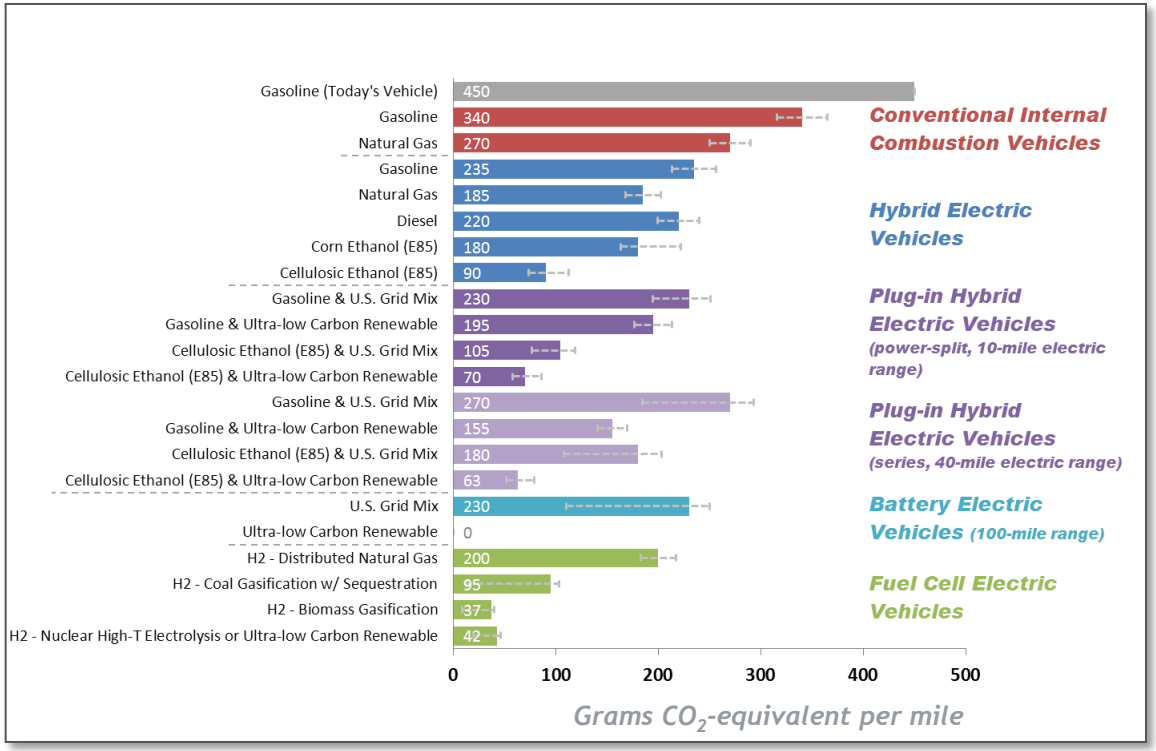
- Maintain core R&D to inform development and revisions of codes and standards
  - Validate performance data
  - Conduct risk assessments and establish protocols to identify and mitigate risk
  - Develop testing protocols for components and systems including high pressure vessels
  - Maintain efforts 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.

Systems Analysis

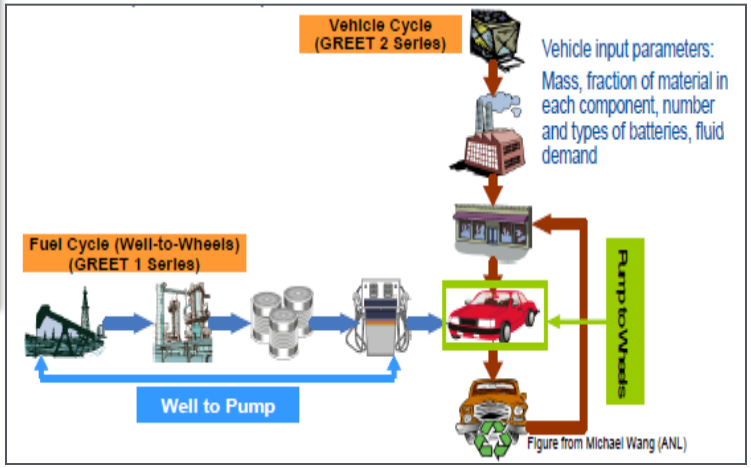
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Key analyses will continue to be updated and refined.
Example: Analysis by Argonne National Lab, DOE Vehicle Technologies Program, and FCT Program shows benefits from a portfolio of options

Well-to-Wheels Greenhouse Gases Emissions



Future plans include detailed cradle-to-grave analysis with USDRIVE Tech Teams (various vehicle types and pathways)

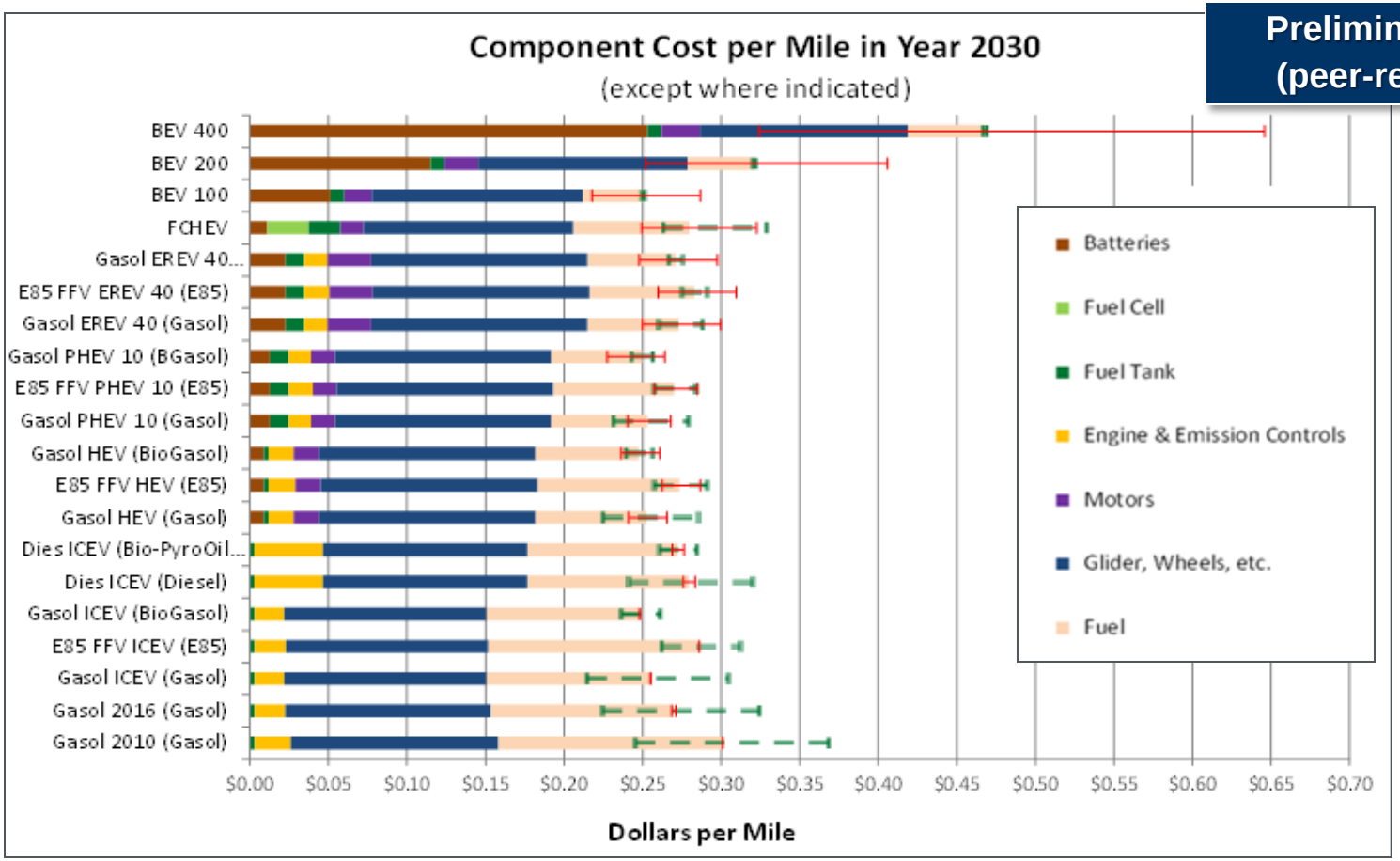


Notes:
For a projected state of technologies in 2035-2045. Ultra-low carbon renewable electricity includes wind, solar, etc. Does not include the lifecycle effects of vehicle manufacturing and infrastructure construction/decommissioning.
Analysis & Assumptions at: http://hydrogen.energy.gov/pdfs/10001_well_to_wheels_gge_petroleum_use.pdf

Vehicle Lifecycle Cost Analysis

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

Analysis by Argonne National Lab, National Renewable Energy Lab, DOE Vehicle Technologies Program, Biomass Program, and FCT Program shows benefits from a portfolio of options



Preliminary DOE analysis (peer-review in process)

RFI closes 3/1/2012

'Error bars' reflect range of assumptions:

Green: range of assumptions for fuel prices (EIA projections for fuels other than hydrogen; hydrogen range: $3.50 - $7.50 per kg)

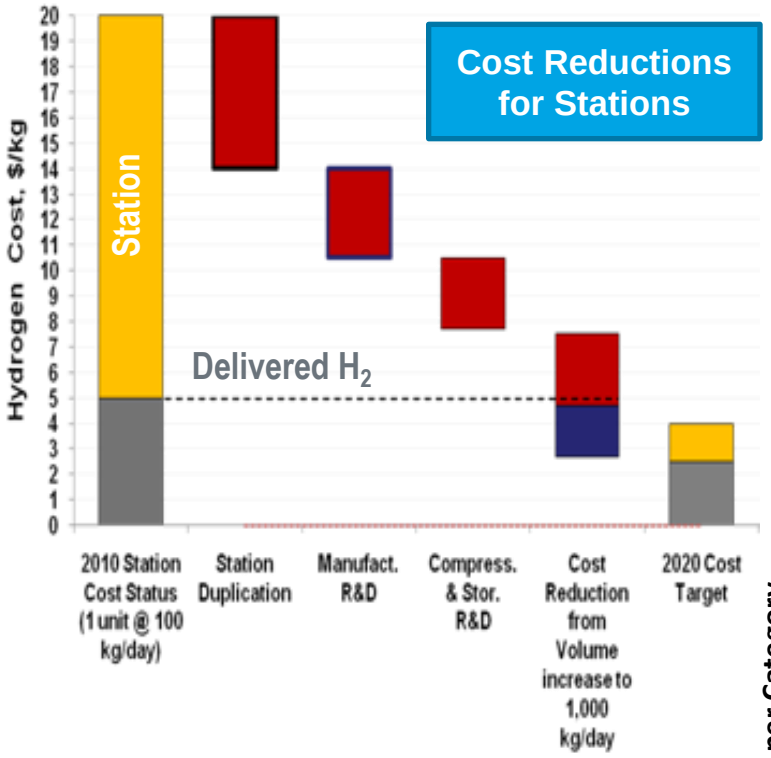
Red: range of assumptions for technology success

See RFI, http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/costs_mile_rfi.pdf, for range of assumptions.

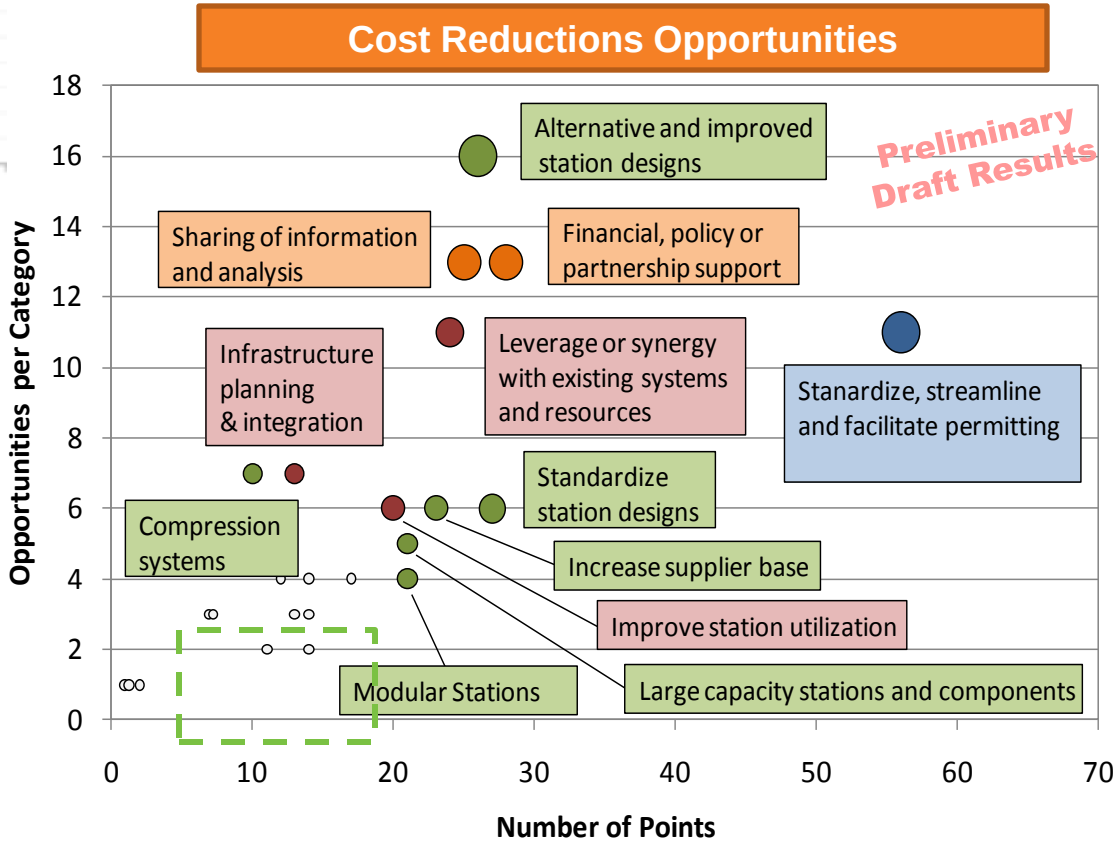
Key Assumptions

	Fuel Cell HEV	BEV100 100-mile BEV	BEV200 200-mile BEV	BEV400 400-mile BEV
Battery Cost, $/kWh	$600, $800, $1000		$125, $220, $300	
Fuel Cell Cost, $/kW	$25, $30, $40	--	--	--
Fuel Cost in $/gge (¢/kWh)	$3.50, $4.50, $7.50	$3.44 (10.3¢/kWh); $3.54 (10.6¢/kWh); $3.61 (10.8¢/kWh)		

Infrastructure Systems Analysis



Clear opportunities for reducing the cost of infrastructure. High-priority opportunities include station designs, streamlining of the permitting process, and financial, policy and partnership support. Cost calculator developed.



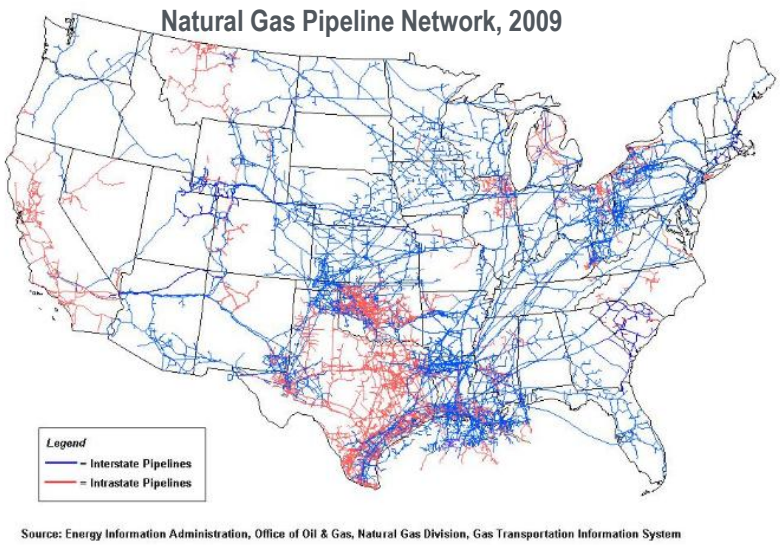
1. Cost reduction from station duplication will require ~120 stations and was based on 3% reduction for a doubling of capacity.
2. Cost of hydrogen delivered to station is ~$5/kg.
3. Station cost reductions based on ANL Hydrogen Delivery Scenario Analysis Model (HDSAM).
4. The current station cost is based on costs from the current California state funded stations. The capital cost for the station is $2.5 million.

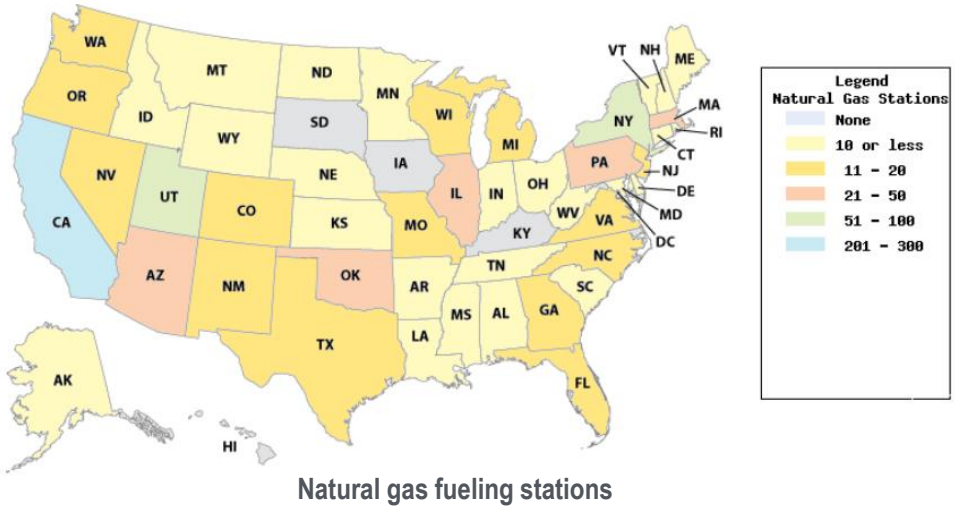
Two Main Options for Low-cost Early Infrastructure

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

Other options

1. Co-produce H_2, heat and power (tri-gen) with natural gas or biogas
2. Hydrogen from waste (industrial, wastewater, landfills)





Natural Gas and Hydrogen Infrastructure Opportunities

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

Workshop convened industry (including vehicle OEMs) and stakeholders with expertise in natural gas and hydrogen technologies, CHP, policy, and regulations. The focus of the workshop was to facilitate the growth of natural gas and hydrogen use in the U.S. for transportation and other applications.

Workshop Activities Included:

- Discussion led by plenary speakers and expert panels
- Break-out sessions to identify key questions and resolutions on:
  - R&D Needs
  - Regulatory / Environmental Barriers
  - Innovative Approaches

U.S. DEPARTMENT OF ENERGY

Argonne NATIONAL LABORATORY

Outcomes:

- Summarized the status of natural gas and hydrogen infrastructure
- Identified opportunities and barriers for expanding the infrastructure
- Identified synergies between natural gas and H_2 use
- Identified and prioritize specific actions to address barriers
- Identified the roles of government and industry in promoting growth of natural gas and H_2 infrastructure

Organized by the Argonne National Laboratory for the U.S. Department of Energy
Minutes to be posted at:
http://www1.eere.energy.gov/hydrogenandfuelcells/wkshp_proceedings.html

Jobs Tool Under Development for Employment Impacts of Early Markets

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

REQUIRED USER INPUT FIELDS	
Select State or Region	NE
Type of Fuel Cell	PEMFC
Application	Stationary - Backup
Average Size of Manufactured Fuel Cell	5
Fuel Cells Manufactured by Year	2000
Annual Fuel Cell Production (kW/year)	10,000
Time Frame (years)	5

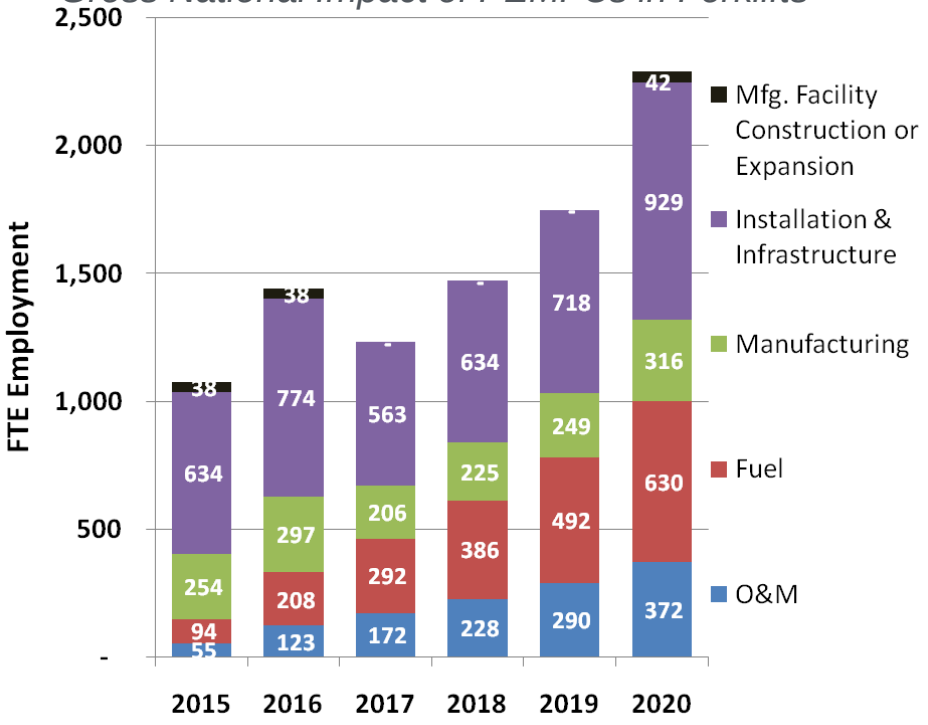
OPTIONAL USER INPUT FIELDS	
Existing Fuel Cell Production Capacity (kW/year)	0
Additional Manufacturing Capacity to be Constructed (kW/year)	10,000
Sales Price ($/kW)	$2,000
Production Cost ($/kW, initial)	$1,301
Progress Ratio	0.97
Production Volume for Initial C…	10,000
Scale Elasticity	-0.2
Full …	25,000
Annu…	2%
Averag… …Frame ($/kW)	$1,098
Installation Cost ($/kW)	TBD
Operations & Maintenance Cost ($/kW, annual)	TBD

Currently undergoing beta testing
Will be available ~ May 2012

Argonne National Lab/RCF

Preliminary Analysis

Gross National Impact of PEMFCs in Forklifts



Includes *short-term jobs* (construction/ expansion of mfg capacity, installation & infrastructure) & *on-going jobs* (manufacturing, O&M and fuel production & delivery)

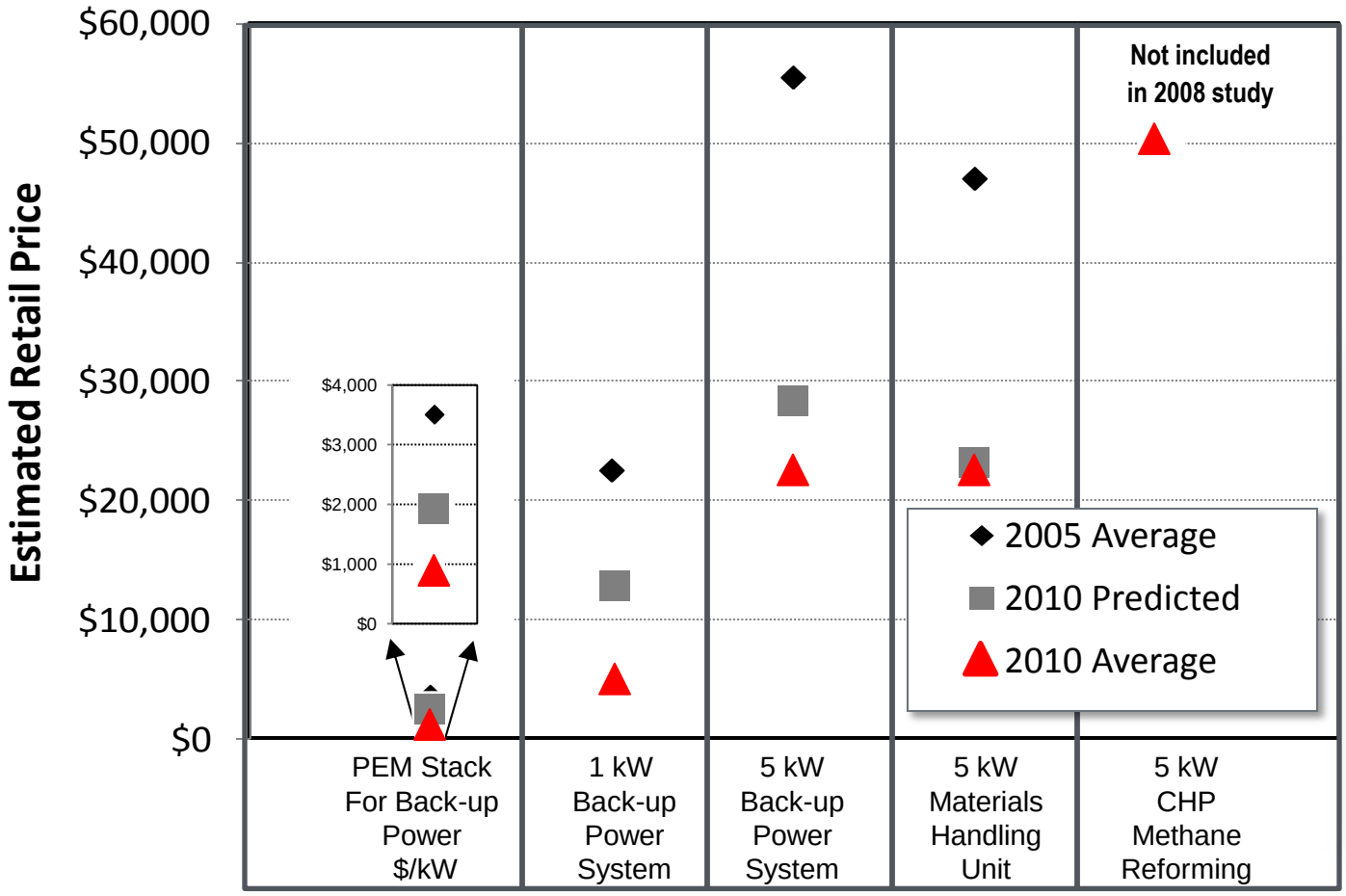
Technology/Market Assumptions:

- $1,300/kW initial mfg cost (*Battelle*), $4,200/kW retail price.
- Shipments reach 3,300 annually by 2020 *(Greene et. al.)* out of ~100,000.
- 15,000 FC forklifts in operation by 2020 (<2 percent of Class 1-3 forklifts).
- Average of 60 fuel cells/site, 250 site installations by 2020.
- Tax credit expires in 2016.

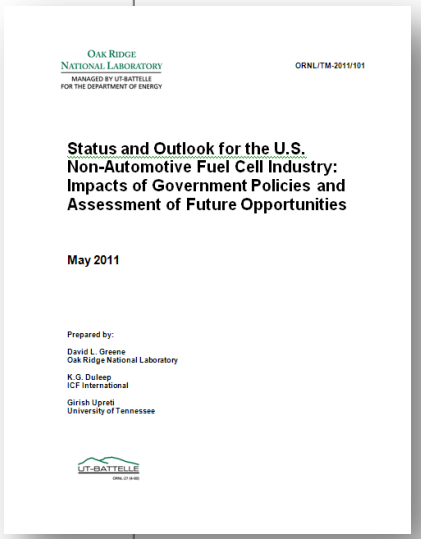
Early Market Cost Reduction Analysis

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

Cost Analysis, Modeling, and Validation (ORNL)



- 50% or greater reduction in costs
- 2008 model generally underestimated cost reductions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ORNL/TM-2011/101

Status and Outlook for the U.S. Non-Automotive Fuel Cell Industry: Impacts of Government Policies and Assessment of Future Opportunities

May 2011

Prepared by:
David L. Greene
Oak Ridge National Laboratory
K.G. Duleep
ICF International
Girish Upreti
University of Tennessee

UT-BATTELLE

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

2005 and 2010 averages based on estimates supplied by OEMs. 2010 predicted assumed government procurements of 2,175 units per year, total for all market segments. Predictions assumed a progress ratio of 0.9 and scale elasticity of -0.2.

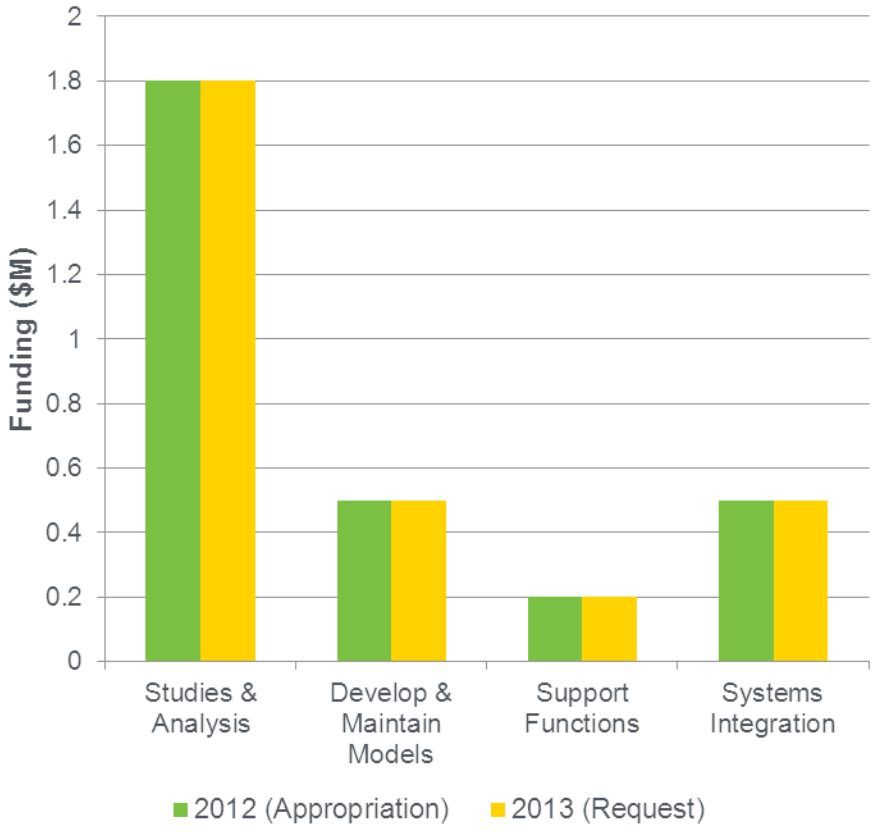
ORNL

Systems Analysis - Plans

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

FY 2013 Request = $2.9M

FY 2012 Appropriation = $2.9M



Subject to appropriations, project go/no go decisions and competitive selections

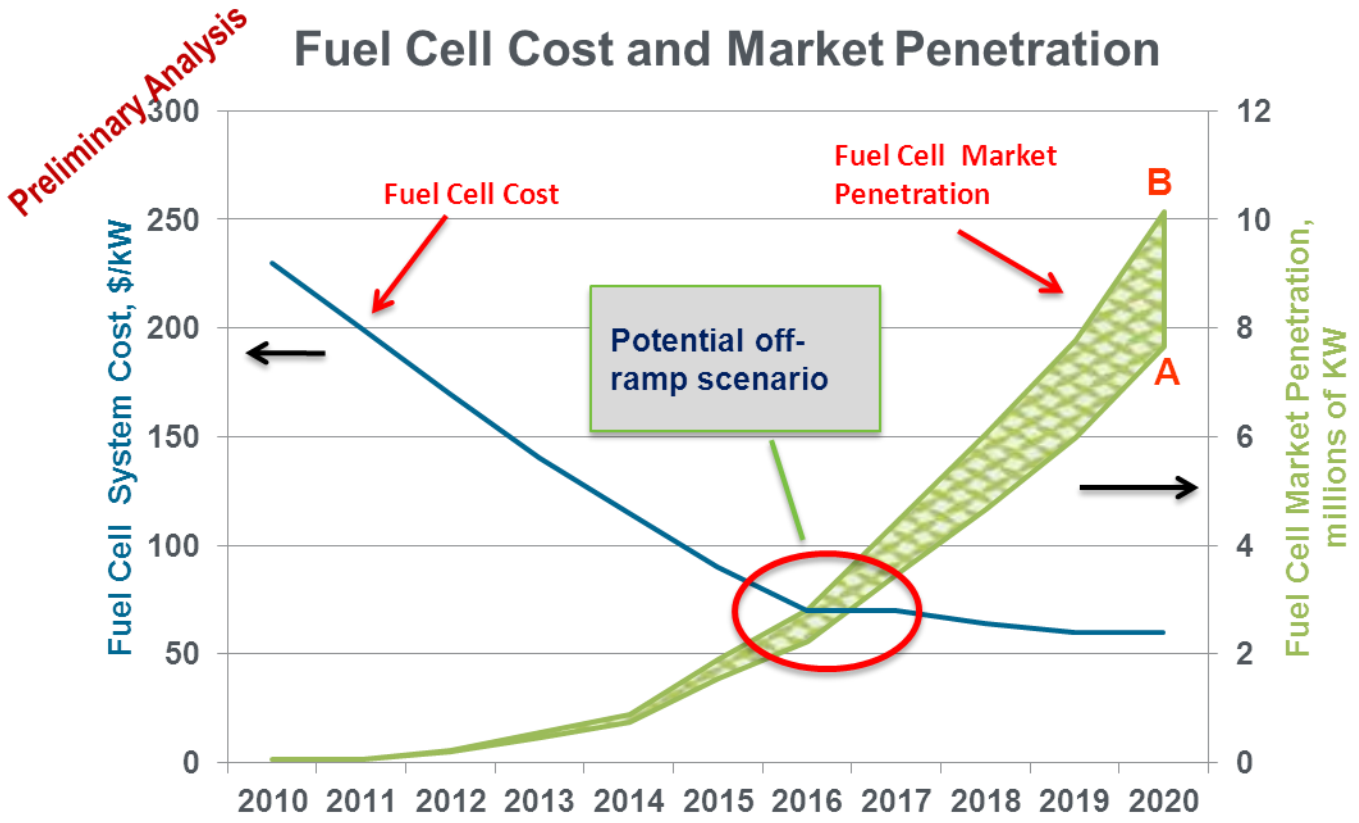
EMPHASIS

- Update and refine models for program analysis using cost, performance and environmental (emissions, etc.) information.
- Continue analyses on life cycle cost, greenhouse gas emissions, petroleum use and criteria emissions.
- 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.

Market Penetration Analysis

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

Preliminary analysis identifies potential off-ramps for government funding, aligned with incentives and policies (e.g. Investment Tax Credit ends 2016)



- **Fuel cell economies of scale could be achieved by 2016-2017**
- **About 3 million kW/year will be required in stationary, specialty (lift trucks), and transportation markets**

Fuel cell economies of scale cost information based on DTI fuel cell cost studies.

Assumptions:

- Fuel cell market penetration of annual applications in 2020 for 4,000 forklifts, 6,000 stationary power units, 60,000 light duty vehicles and 20,000 buses based on current PEM market and market growth projections from ORNL and Pike Research market reports. (*Status and Outlook for the U.S. Non-Automotive Fuel Cell Industry: Impacts of Government Policies and Assessment of Future Opportunities* by Oak Ridge National Laboratory (ORNL) and *Fuel Cell Vehicles: Passenger Vehicles, Medium and Heavy Duty Trucks, Transit Buses, Hydrogen ICEs and Fueling* by Pike Research).
- Additional fuel cell market penetration is projected as a range extender application for the 2 million+ drayage and short-haul truck market based on information provided by Vision Motor Corporation.

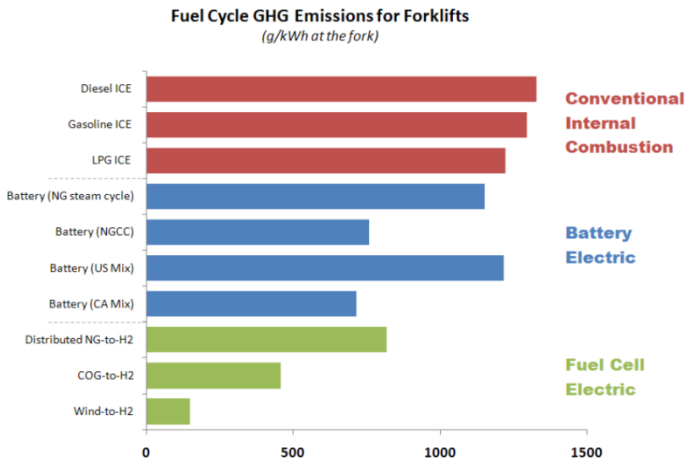
Recovery Act as Catalyst for Deployments

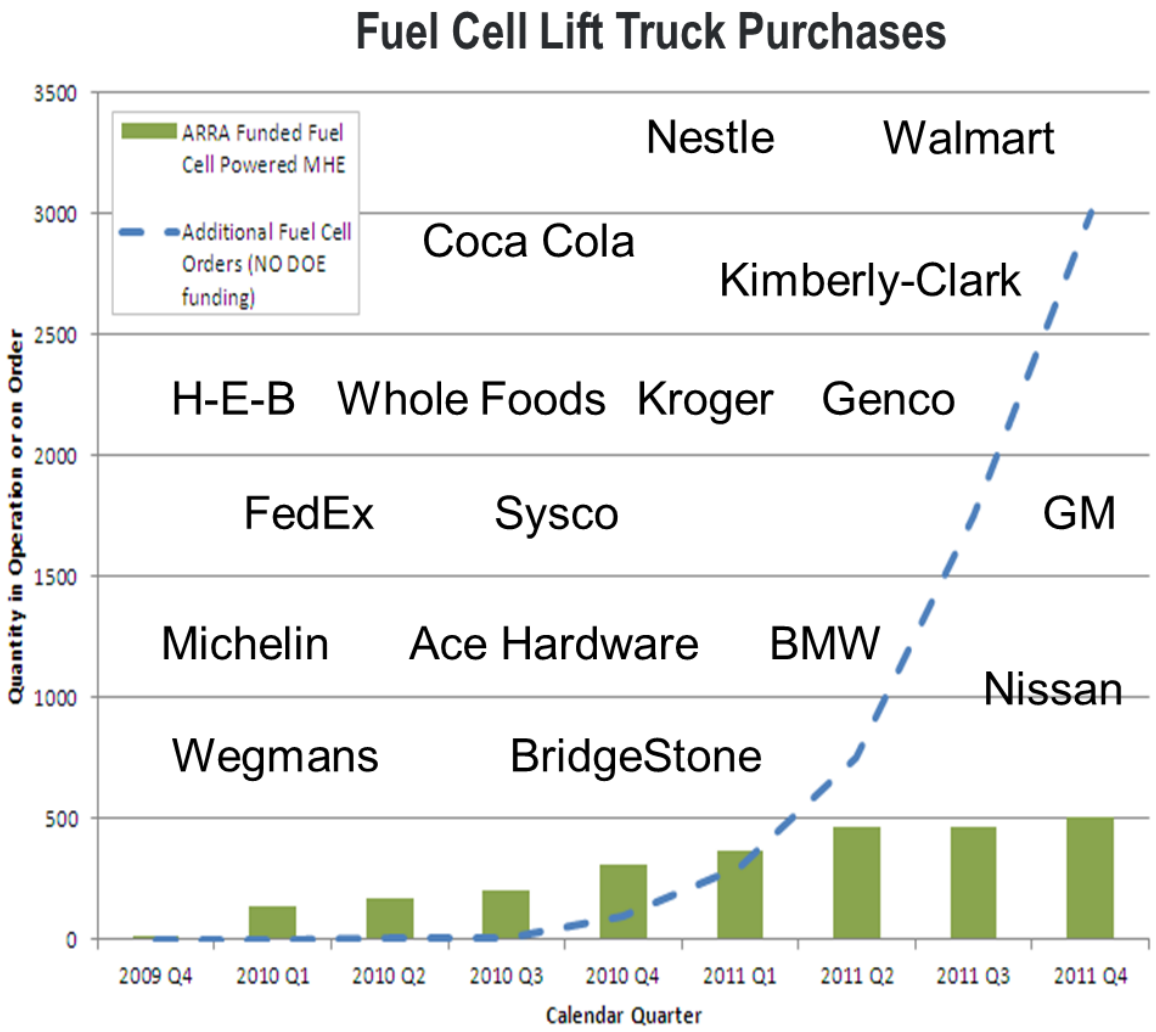
ARRA deployments of fuel cells for lift trucks (~400) led to industry purchases/orders of >3,000 additional fuel cell lift trucks with NO DOE funding

The Case for Forklifts*

Compared to conventional forklifts, fuel cell forklifts have:

- **1.5 X lower maintenance cost**
- **8 X lower refueling labor cost**
- **2 X lower net present value of total system cost**





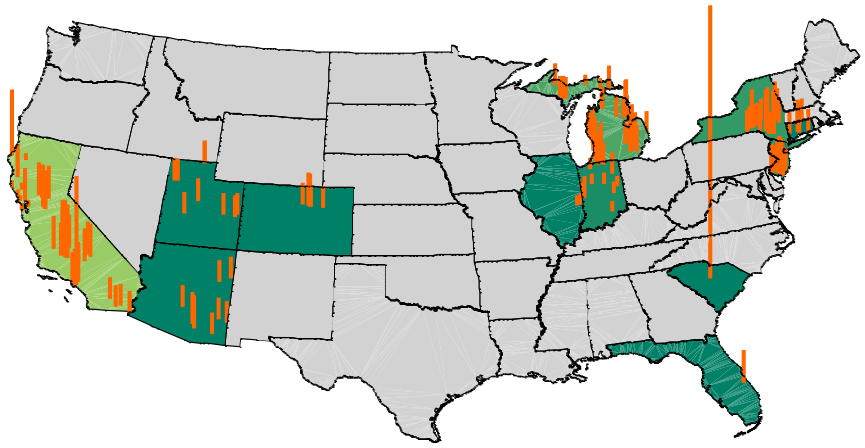
**Preliminary Analysis*

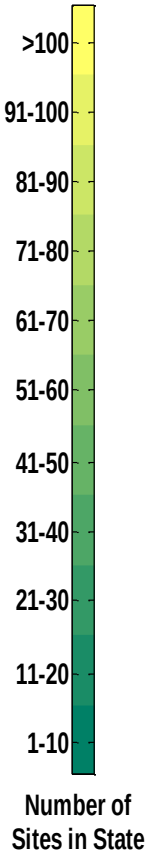
Backup Power Deployments

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

Nearly 900 kW deployed at ~200 sites

State	kW Capacity	Sites	State	kW Capacity	Sites
Arizona	40	9	Indiana	46	15
California	304	63	Michigan	148	36
Colorado	24	5	New Jersey	84	21
Connecticut	32	8	New York	116	29
Florida	6	1	South Carolina	50	1
Illinois	4	2	Utah	36	9
Totals	**kW Capacity**	**890**	**Totals**	**Sites**	**199**





Next Steps

- Quantify benefits
- Determine lessons learned and key areas for government support (if any)

Includes ARRA and DOE Interagency Agreement (IAA) Deployments

Tracked by NREL

RFI for Early Market Opportunities and Appropriations

RFI Closes: March 2, 2012 - For Questions, Email: FCTtransportationRFI@go.doe.gov

Requesting Stakeholder feedback on the commercial readiness of hydrogen and fuel cell technologies, specifically:

- Innovative, commercially ready fuel cell systems for specific applications
  - ***Auxiliary power*** on board commercial, heavy duty road vehicles for refrigeration
  - Fuel cell ***battery rechargers*** for all electric commercially available vehicles used for transporting freight or passengers (on or off road applications)
- Deployment projects for other ***on or off road transportation*** markets including
  - ***Airport ground support equipment*** and seaport drayage and short haul trucks

Additional Appropriations and Funding in FY 2012 (Vehicle Technologies Program)

- "Further, within available funds up to $10,000,000 is made available to fund section 131 of the 2007 Energy Independence and Security Act [EISA] to promote zero emission cargo transport in areas of severe non-attainment and severe traffic congestion. Eligible recipients must provide 1-to-1 matching funds."
- Funding Opportunity Planned (VTP)- fuel cells are eligible

Market Transformation

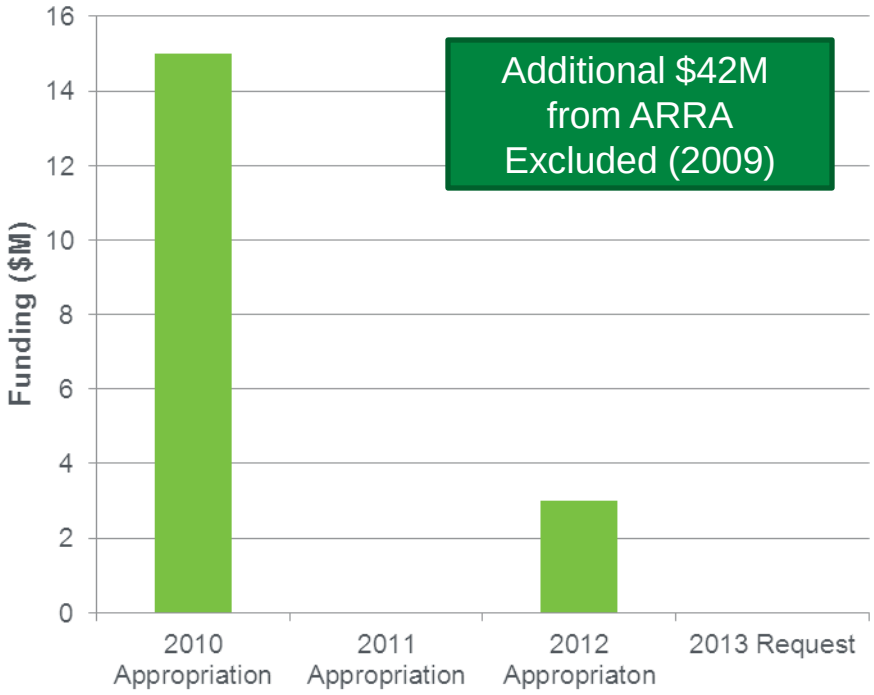
Market Transformation activities are focused on supporting early market successes such as emergency backup power and specialty vehicle applications. The goal is to enable emerging markets to achieve the needed economies of scale to reduce fuel cell life-cycle cost to be on a par with conventional technologies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

FY 2013 Request = $0M

FY 2012 Appropriation = $3.0M

FY2011 Appropriation = $0M

FY2010 Appropriation = $15.0M



Subject to appropriations, project go/no go decisions and competitive selections

ACCOMPLISHMENTS

- Examples of deployed fuel cells for niche markets that support readiness for full scale market penetration:
  - ARRA investment of $9.7M in fuel cell powered lift trucks have led to more than 3000 additional lift truck orders/purchases at no cost to government (~$60 M in industry revenues).*
  - ARRA investment of $18.5M in fuel cell back up power is leading to approximately 1,800 additional deployments at no cost to government (~$45 M in industry revenues).*
  - Appropriation investment of $3 M in micro CHP fuel cells is leading to more than 1500 planned deliveries through 2015 (~$500 M).*

*Preliminary estimates

Education Activities

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

Education: *Based on prior year funds – projects are being completed*

ACTIVITIES

- Increase acceptance and inclusion of technologies as a part of a clean energy portfolio
- Reduce "soft costs" associated with early adoption (e.g., insurance, permitting, uniform codes and standards)
- Increase general knowledge of the benefits multiple applications
- Increase awareness of broad range of applications—beyond light-duty vehicles and buses

PROGRESS (key examples)

Educated **over 23,000** first responders and code officials through introductory web-based courses and advanced hands-on training.

Continued to promote and deploy the "H2 Educate" middle-school learning module—reaching a total of **more than 9,550 teachers** in 35 states since the project was launched.

Conducted seminars and developed fact-sheets and case studies for end-users

Conducted **more than 80 workshops** to help state officials identify deployment opportunities

2011 Hydrogen Student Design Contest had 54 university teams registered from 19 countries, including seven of the top 20 engineering schools in the world.

Increased offering of university certificates and minors at universities (examples include: Michigan Tech, Univ. of NC at Charlotte)

Communication & Outreach

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

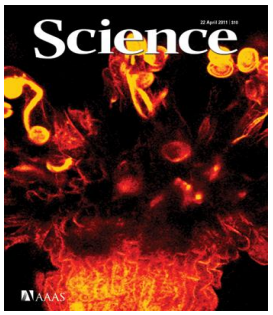
Communication and Outreach Activities include:

- Webinar Series:
  - Feb. 6 – National Hydrogen Learning Demonstration Status
  - Feb. 27 – Federal Facilities Guide to Fuel Cells
  - Continuing series of informational webinars led by FCT and partners on various topics.
- News Items:
  - Energy Department Awards More Than $7 Million for Innovative Hydrogen Storage Technologies in Fuel Cell Electric Vehicles
  - DOE Launches Comprehensive Hydrogen Storage Materials Clearing House
- Monthly Newsletter

Blogs Published to Energy.gov website include:

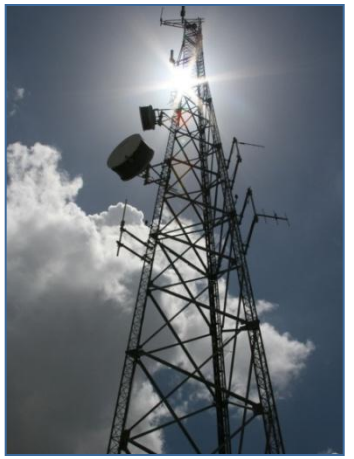
- Fuel Cell Powers Up Festivities at Sec. Chu's Holiday Party
- Fuel Cell Lift Trucks: A Grocer's Best Friend

"These technologies are part of a broad portfolio that will create new American jobs, reduce carbon pollution, and increase our competitiveness in today's global clean energy economy."



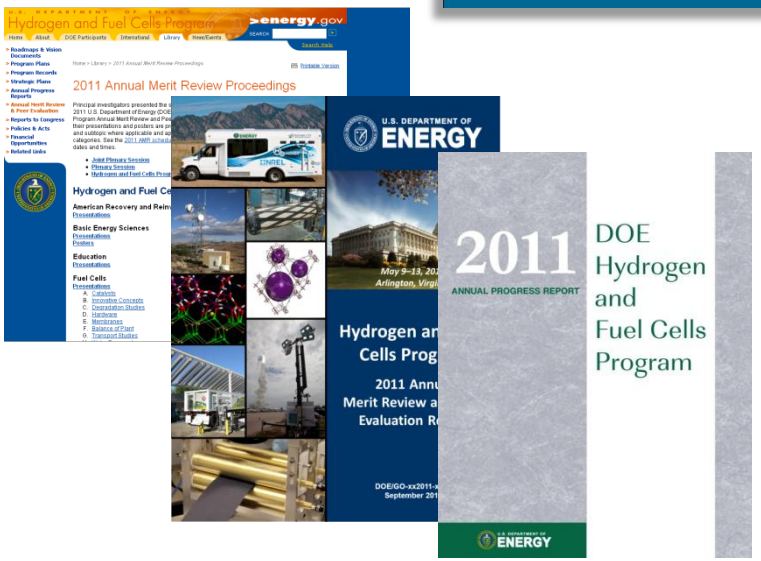
Progress in low and zero Pt catalysts highlighted in Science

Hydrogen power lights at the 2011 Golden Globes



Hydrogen fuel cells providing critical backup power

Key Reports



The Business Case for Fuel Cells: Why Top Companies are Purchasing Fuel Cells Today

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

See report: http://www.fuelcells.org/BusinessCaseforFuelCells.pdf

State of the States: Fuel Cells in America

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

See report: ttp://www.fuelcells.org/StateoftheStates2011.pdf

2010 Fuel Cell Market Report

By Breakthrough Technologies Institute, Inc. http://www.btionline.org/

See report:

http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/2010_market_report.pdf

The Program will continue to fund the development and publication of key reports

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 14 – 18, 2012 Arlington, VA

http://annualmeritreview.energy.gov/

FCT Monthly Newsletter

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

In the News

DOE Releases Request for Information on Early Market Opportunities for Fuel Cell Technologies

The Department of Energy (DOE) has issued a Request for Information asking for stakeholder feedback on the commercial readiness of fuel cell and hydrogen technologies. Topics covered include: auxiliary power on board commercial, heavy duty road vehicles for refrigeration; fuel cell battery rechargers for all electric vehicles used for transporting freight or passengers; and technology deployment projects for other on or off road transportation markets. The deadline for responses is March 2, 2012.

Hydrogen and Fuel Cells Interagency Action Plan Released

The Hydrogen and Fuel Cells Interagency Task Force and Interagency Working Group released their Interagency Action Plan (IAP) on January 30. The Hydrogen and Fuel Cells Interagency Action Plan guides collaborative federal agency efforts to research, develop, demonstrate, and deploy hydrogen and

Inaugural Newsletter for Program issued January 2012.

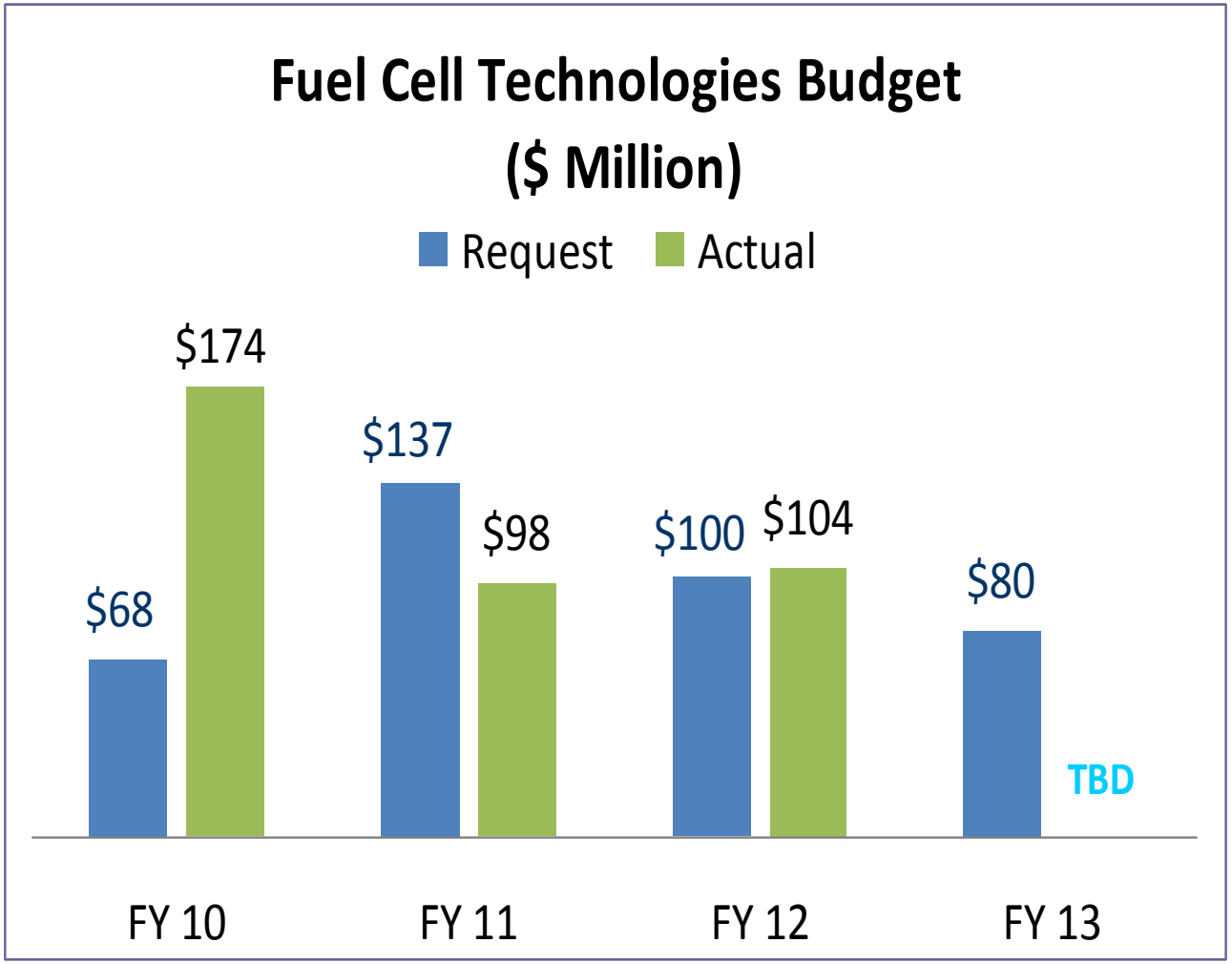
Subscribe

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

Summary and Additional Opportunities

FY 2010 to FY 2013 Request and Appropriation

The Fuel Cell Technologies budget requests and appropriations summary



Funding Changes for New Awards

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

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

SC-EERE-ARPA-E Collaborations

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

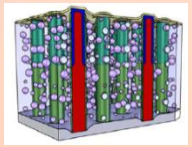
Examples of Cross-Office Collaborative Successes.
Need to continue to leverage activities across other Programs

Office of Science U.S. DEPARTMENT OF ENERGY

Advancing fundamental science knowledge base

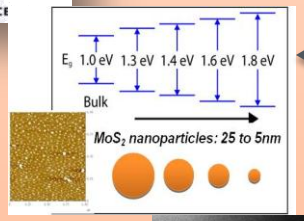
JCAP

Solar to Fuels Hub



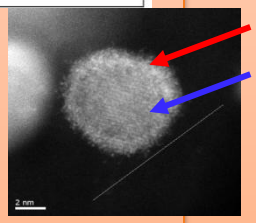
Nanowire based solar fuels generation (CalTech)

EFRC ENERGY FRONTIER RESEARCH CE



Bandgap tailoring (Stanford)

Mechanistic understanding of catalysts



Pt monolayer

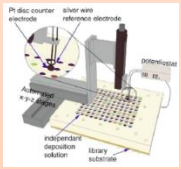
Pd core

Biological H_2 production
Materials-based H_2 storage

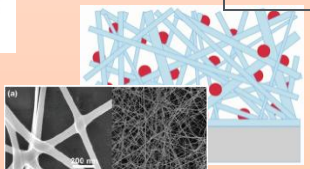
U.S. Department of Energy EERE

Applied RD&D of innovative technologies

High Throughput Processes (UCSB)



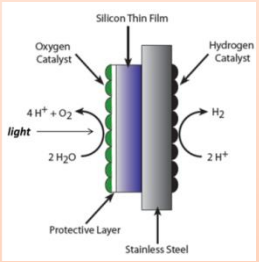
Standard protocols and benchmarking



Nano-catalyst support scaffold (Stanford)

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

Using ARPA-E developed catalyst in water splitting device



Midwest Optoelectronics

arpa·e

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

Sun Catalytix

Developing novel catalysts (high risk/high impact)

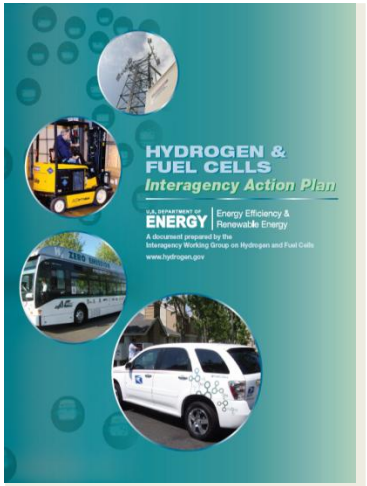
Alkaline Membranes

DOE and Interagency Activities

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

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



December 2011

Goals

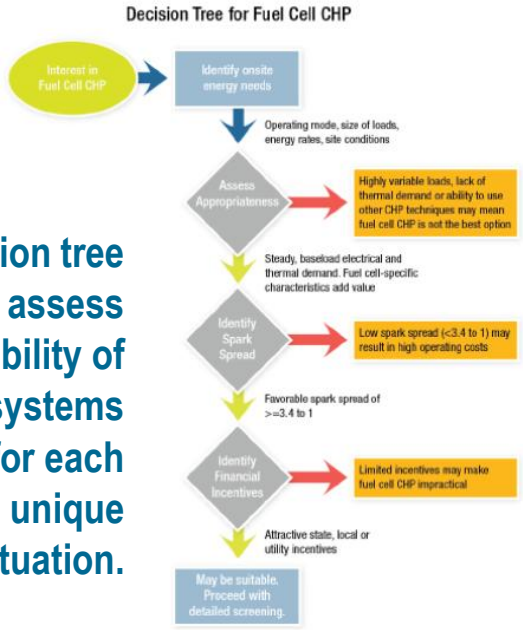
1. Strengthen and Accelerate Research and Development
2. Accelerate Development & Adoption of Codes, Standards & Safe Practices
3. Work with Industry to Validate Technologies under Real-World Conditions
4. Adopt Technologies in U.S. Government Operations
5. Track and Communicate Results

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.



DOE - DOD Collaborations

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

Extensive coordination and collaboration have allowed the Program to successfully deploy fuel cells at 30 DOD sites. Efforts continue in promising new areas. Key focus will be to increase Federal deployments.

Coordination

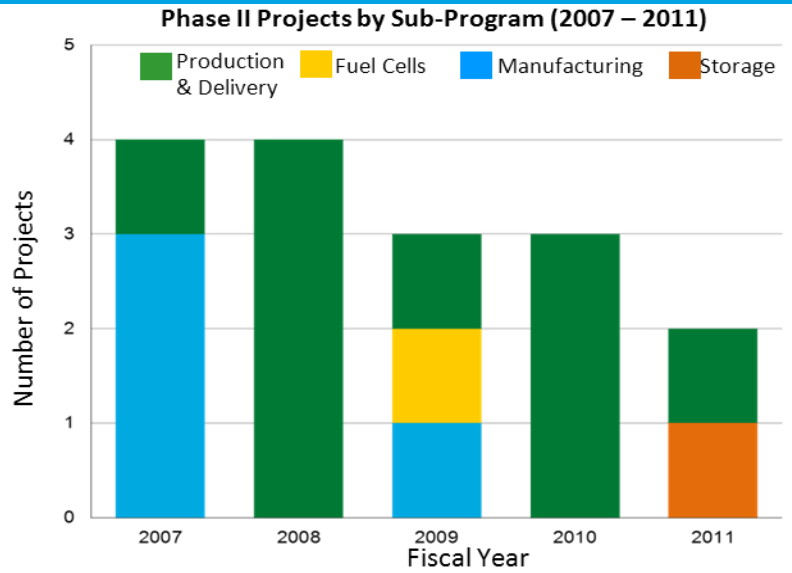
- Interagency Task Force
- Interagency Action Plan
- Interagency Working Group
- Workshops
  - Aviation APUs
  - Waste-to-Energy
  - Shipboard APUs
- Hawaii Hydrogen Initiative (H2I)

Army CERL - Backup power deployments

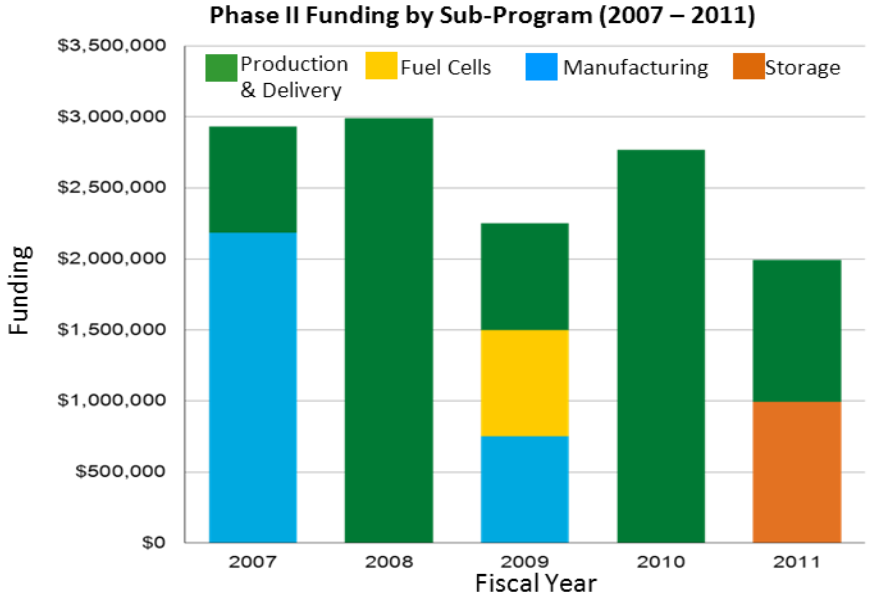
- U.S Army Aberdeen Proving Ground, MD
- Fort Bragg, NC
- Fort Hood, TX
- National Guard, OH
- Picatinny Arsenal, NJ
- Ames Research Ctr, CA
- USMC AGGC 29 Palms, CA
- U.S. Military Academy West Point, NY
- U.S. Air Force Cheyenne Mountain Air Station

- Defense Logistics Agency
  - Nearly 100 FC lift trucks deployed
- Office of Naval Research
  - Utility scale renewable hydrogen generation and grid management for transportation fuel
- Army/Marine Corps
  - Soldier power: battery rechargers for forward operation bases
- Navy, Army, Air Force
  - Deploy fuel cell vehicles and infrastructure at bases in Hawaii.
- Army/AF (Joint Base Lewis McCord)
  - Biogas reforming and material handling equipment.

SBIR Grants continue to provide opportunities - Examples



Note: 2 Fuel Cells Projects & 1 Production & Delivery Project from 2004 - 2006



Note: $1.5M for 2 Fuel Cells Projects & $0.75M for 1 Production & Delivery Project from 2004 – 2006

Total of 19 Projects and $15.2 Million in funding*

Production & Delivery
- Hydrogen Compression Technology
  - Mohawk Innovative Technology (2 projects), FuelCell Energy
- Hydrogen Production
  - Genesis Fueltech, Physical Optics Corporation, Synkera Technologies Inc., H_2 Pump, LLC, Proton Energy Systems, Giner Electrochemical Systems, LLC
- Hydrogen from Waste
  - Directed Technologies, Inc.
- Energy Storage for Intermittent Renewable Resources
  - Proton Energy Systems

Storage
- Advanced Hydrogen Storage for Early Market Applications
  - Hawaii Hydrogen Carriers/Select Engineering Services JV

Fuel Cells
- Fuel Cell Systems Coolants and Membranes
  - Advanced Fluid Tech Inc., Dab Dynalene Heat Trans
- Dimensionally Stable High Performance Membrane
  - Giner Electrochemical Systems, Loc
- Bio-Fuel Solid Oxide Fuel Cell
  - Innovatek, Inc.

Manufacturing
- Manufacturing of Hydrogen Storage Containers
  - Innosense, Loc
- Manufacturing of Proton Exchange Membrane (PEM) Fuel Cells
  - Nanotek Instruments, Inc., Scribner Assoc. Incorporated
- Manufacturing of Bipolar Plates
  - Faraday Technology, Inc.

*Includes all SBIR Phase II Projects from 2004 to present

DOE FY 2012 SBIR Funding Opportunity

Applied Programs Phase I FOA:

- Issued on 11/28/2011
- Applications due 1/19/2012
- Preliminary award notification date is May 2012
- FCT Program topics included:
  - Distributed Production of Hydrogen from Waste Water
  - Hydrogen Storage Technologies for Near-Term Fuel Cell Applications

New elements: letter of intent required and increased emphasis on commercialization plan

Phase II FOA:

- To be issued on February 14, 2012
- Applications due April 4, 2012
- Preliminary award notification date is June 2012

EERE Budget: *FY 2011 – FY 2013*

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

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

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

Summary

Continue key R&D activities

- Hydrogen fuel production (from renewables), delivery, and storage
- Fuel cell cost and durability

Conduct strategic, selective demonstrations of innovative technologies and address institutional & market barriers

- Technology Validation – solicitations planned
- Market Transformation – solicitation planned (Request for Information closes March 2)
- Continue critical safety, codes and standards activities

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

- Life-cycle cost, economic & environmental impacts, technology gaps, infrastructure needs, jobs potential, market analyses, etc.

Leverage activities (other programs, inter-agency, state and global partnerships)

Acknowledgements

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

Federal Agencies

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

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

External Input

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

Industry Partnerships & Stakeholder Assn's.

Examples:

- Tech Teams (USCAR, energy companies- U.S. DRIVE)
- Fuel Cell and Hydrogen Energy Association (FCHEA)
- ~ 65 projects with 50 companies

Universities

~ 50 projects with 40 universities

DOE Hydrogen & Fuel Cells Program

State & Regional Partnerships

Examples:

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

International

- IEA Implementing agreements – 25 countries
- International Partnership for Hydrogen & Fuel Cells in the Economy – 17 countries & EC, 30 projects

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

Thank you

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www.hydrogenandfuelcells.energy.gov