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

Overview of Hydrogen & Fuel Cell Activities

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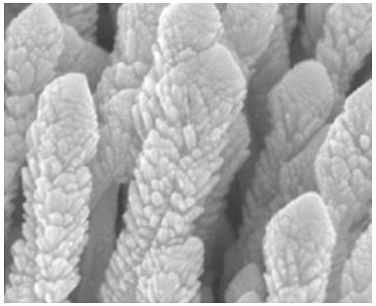
Agenda

- Overview
  - EERE Priorities
- FY12 Budget
- Examples of Collaboration & Leveraging Activities
  - Office of Science, DOD, DOT, SBIRs, International
  - Conferences and Workshops
- Analysis Update
- Recent HTAC Input & Future Needs

High Impact Innovation

Examples of Innovative Applied R&D

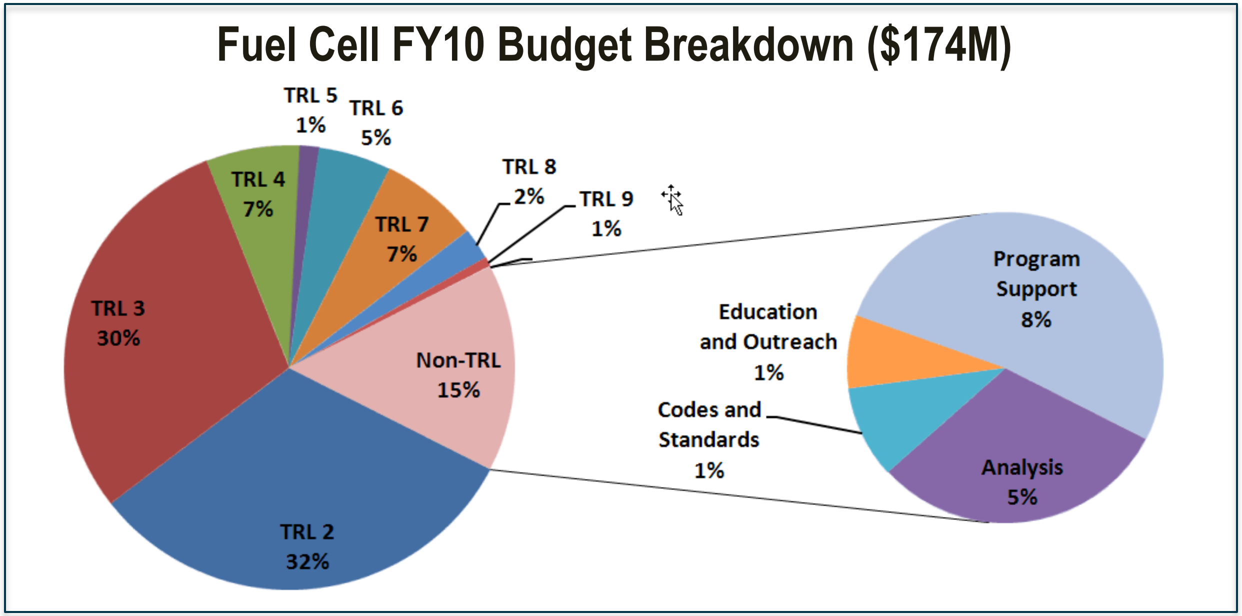
Developed high surface area nanostructures for fuel cell electrodes that helped increase fuel cell power density and reduce fuel cell system cost by >45% since 2007.



"Whiskerettes" of Pt grow off sides of organic crystalline whisker core

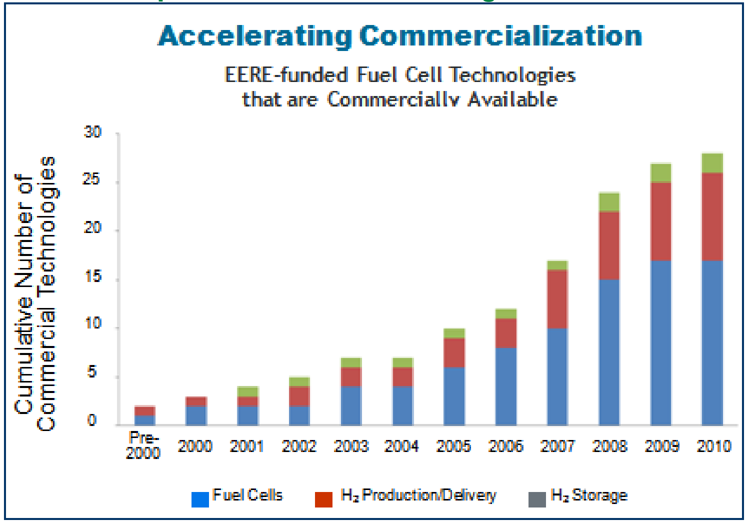
$51/kW high-volume projection on track to meet $30/kW 2015 target.

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



Microalgae – 300% increase in conversion of sunlight to energy

200 patents and nearly 30 commercial technologies have been developed due to EERE funding



Speed & Scale

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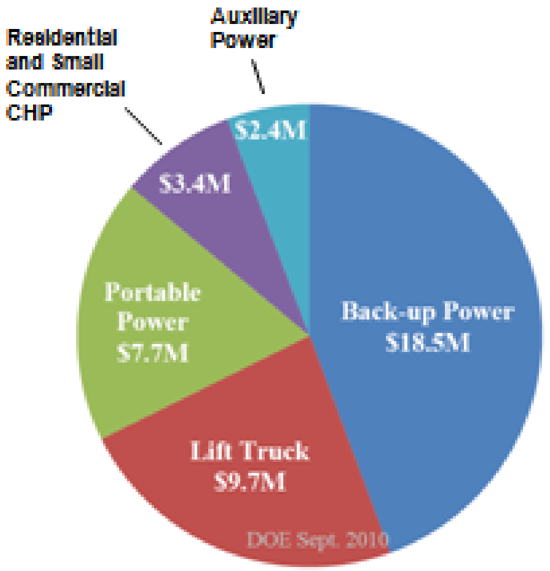
$42 million from the 2009 American Recovery and Reinvestment Act to fund 12 projects to deploy up to 1,000 fuel cells

Exceeded 2010 target for Recovery Act fuel cell installations by more than 90% at 230 fuel cells installed:

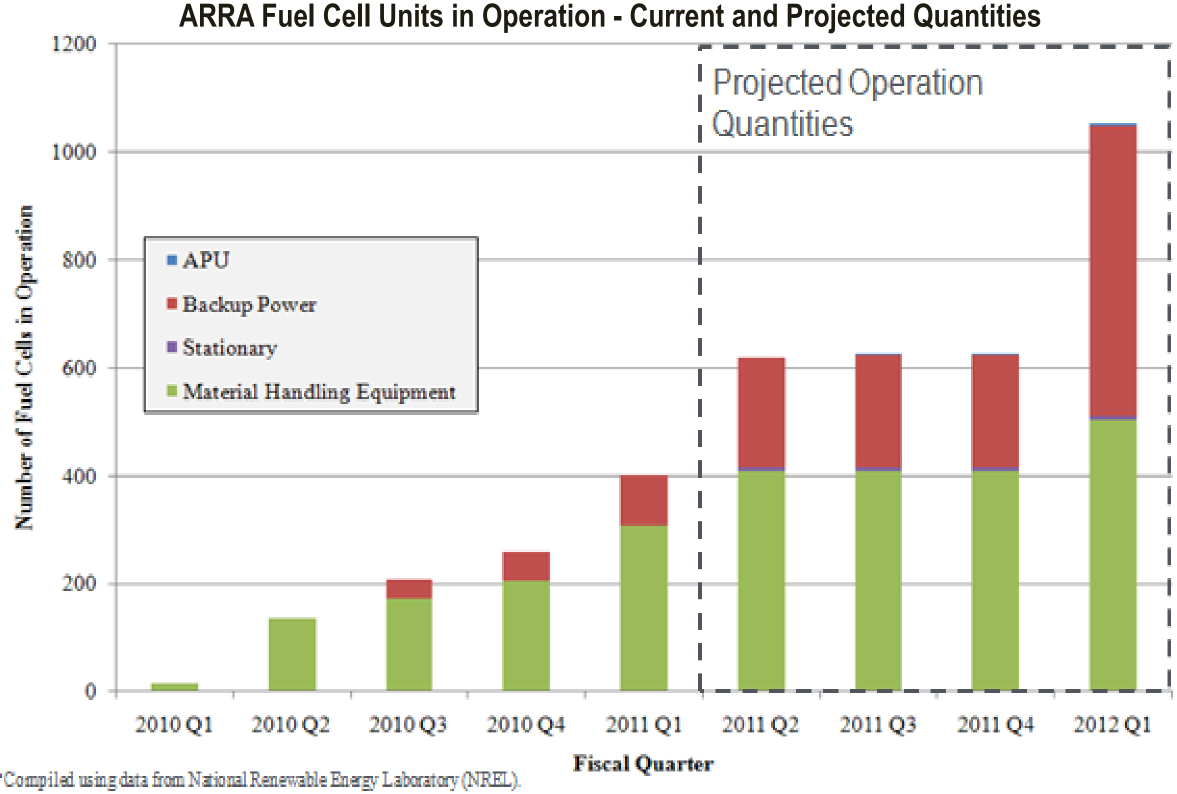
- 206 lift trucks (35 with FedEx, 14 with Nuvera, 98 with Sysco, and 59 with GENCO)
- 24 telecommunication backup power units provided by ReliOn for AT&T.



Approximately $54 million in cost-share funding from industry participants—for a total of about $96 million.

Major companies such as FedEx, Coca Cola, Whole Foods, Sprint, AT&T, Sysco and Wegmans are installing fuel cells

Federal Agencies: DOD-DLA: ~120 fuel cell life trucks to four distribution centers, FAA :~26 back-up power fuel cells ; CERL: >200 kW in fuel cell backup power across nine federal installations.



*Compiled using data from National Renewable Energy Laboratory (NREL).

Fostering Talent

The Program selects partners with strong technical skills. For example, three PIs have been recognized by the White House for their excellence.

3 Presidential Awardees:

- **Professor Susan Kauzlarich** – UC Davis, a 2009 recipient of the ***Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring***—and a partner of the Chemical Hydrogen Storage Center of Excellence
- **Dr. Jason Graetz** – Brookhaven National Laboratory, a 2009 recipient of the ***Presidential Early Career Award for Scientists and Engineers***—and a partner of the Metal Hydride Center of Excellence
- **Dr. Craig Brown** – NIST, a 2009 recipient of the ***Presidential Early Career Award for Scientists and Engineers***—and a Partner of the Hydrogen Sorption Center of Excellence

Communication and Outreach Activities include:

- Launched Webinar Series:
    - Genetic Optimization of Algae with almost 200 attendees
    - Next webinar scheduled for 03/07 – Carbon-Neutral Energy Research of Kyushu University
- MotorWeek: PBS to air a fuel cell vehicle episode in mid February 2011
- FedEx: 35 Hydrogen fuel cell fork lifts are have been deployed at the Springfield, Mo. service center
- Kimberly-Clark: 25 fork lifts are operational in Graniteville, S.C. distribution center
- Department of Defense: Largest defense depo in the US has deployed 55 fuel cell fork lifts

Technology to extend battery life coming soon

Blogs Published to Energy.gov website include:

- Civil War Icon (Fort Sumter)
- 2011 Hydrogen Student Design Contest
- Aiming to Green NASCAR's Future
- Sysco Deploys Hydrogen Powered Pallet Trucks

Road Tours and Ride & Drives

Today we have events to educate the community with Fuel Cell Vehicles from 6 OEMs.

Hydrogen fuel cells providing critical backup power

Hydrogen power lit Academy Awards

FCT Updates and Accomplishments

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- New fact sheets on:
  - FCT's Subprograms
    - Fuel Cells
    - Production & Delivery
    - Storage
    - Safety, Codes & Standards
    - Technology Validation
  - Case studies
    - Backup Power
    - MHE
    - CHHP
  - Financing
  - Accomplishments

FY 12 Budget

Funding priorities sustain Hydrogen Fuels R&D and Fuel Cell Systems R&D for near- and long-term technologies, including stationary, transportation, and portable applications.

The FY 2012 Budget Request:

Continues new sub-programs for:

- ***Fuel Cell Systems R&D***
  - Consolidates four sub-programs: *Fuel Cell Stack Components R&D, Transportation Fuel Cell Systems, Distributed Energy Fuel Cell Systems*, and *Fuel Processor R&D*
  - Technology-neutral fuel cell systems R&D for diverse applications
- ***Hydrogen Fuel R&D***
  - Consolidates *Hydrogen Production & Delivery* and *Hydrogen Storage* activities
- ***Recognizes critical need for Safety Codes and Standards***

Defers funding for

- ***Education***
- ***Market Transformation***

EERE H_2 & Fuel Cells Budgets

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Funding (*$ in thousands*)			
Key Activity	**FY 2009**[4]	**FY 2010 Current Appropriation**	**FY 2012 Request**
Fuel Cell Systems R&D[1]	-	75,609	45,450
Fuel Cell Stack Component R&D	61,133		
Transportation Systems R&D	6,435		-
Distributed Energy Systems R&D	9,750		-
Fuel Processor R&D	2,750		-
Hydrogen Fuel R&D[2]	-	45,750	35,000
Hydrogen Production & Delivery R&D	10,000		-
Hydrogen Storage R&D	57,823		-
Technology Validation	14,789[5]	13,005	8,000
Market Transformation[3]	4,747	15,005	-
Early Markets	4,747	15,005	-
Safety, Codes & Standards	12,238[5]	8,653	7,000
Education	4,200[5]	2,000	-
Systems Analysis	7,520	5,408	3,000
Manufacturing R&D	4,480	4,867	2,000
Total	$195,865	$170,297	$100,450[6]

[1] Fuel Cell 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 [3] No Market Transformation in FY 2012. [4] FY 2009 Recovery Act funding of $42.967M not shown in table [5] Under Vehicle Technologies Budget in FY 2009 [6] Includes SBIR/STTR funds to be transferred to the Science Appropriation; all prior years shown exclude this funding

DOE H_2 & Fuel Cells Budgets: *FY07 – FY12*

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	Funding *($ in thousands)*				
	FY 2007 Approp.	**FY 2008** Approp.	**FY 2009** Approp.	**FY 2010** Approp.	**FY 2012** Request
EERE Hydrogen & Fuel Cells	189,511	206,241	195,865	174,000[2]	100,450
Fossil Energy (FE)[1]	21,513	21,773	26,400	26,400	0
Nuclear Energy (NE)	18,855	9,668	7,500	5,000	TBD
Science (SC)	36,388	36,484	38,284	38,284	TBD
DOE TOTAL	**266,267**	**276,481**	**268,049**	**243,684**	**TBD**

Note: No funding requested for SECA Program FY12 (FE)

Program Focus: Develop cost competitive hydrogen and fuel cell technologies for diverse applications to meet long-term goals of $30/kW for transportation, $750/kW for stationary power, and $2-4/gge for hydrogen production and delivery.

FY12 Key Activities- Examples

- **Fuel Cell Systems R&D (45.5M): Maintains critical R&D for stationary, transportation and portable power**. 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 6.0 kW/g in 2012 and 8.0 kW/g by 2016.
- **Hydrogen Fuel R&D ($35.0M):** Will focus on materials R&D to achieve a 25% reduction in electrolyzer capital cost by 2012, reducing the total hydrogen cost to less than $5/gge compared to $6/gge in 2009. Develop materials with photoelectrochemical conversion efficiency of 10% in 2012 compared to 4% baseline.
- **Safety, Codes and Standards ($7.0M):** Will determine and demonstrate hydrogen storage system testing procedures to enable publication of a Global Technical Regulation by 2012.
- **Manufacturing R&D ($2.0M):** Will develop low-cost, high-volume, continuous in-line MEA quality control measurement technologies in 2012, on track to develop continuous fabrication and assembly processes for polymer electrolyte membranes by 2016.
- **Technology Validation ($8.0M):** Will collect real-world data from fuel cells operating in forklifts, backup power, vehicles, and buses including 2012 projects with DOD (e.g. Hawaii).
- **Systems Analysis ($3.0M):** Will determine technology gaps, economic/jobs potential, and quantify 2012 technology advancement.

[a] These activities are funded under Market Transformation in FY 2011.

[b] Due to deployments and ongoing data collection and analyses underway through the Recovery Act, these activities are deferred in FY 2012.

EERE Budget: *FY09 – FY12*

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Funding *($ in thousands)*			
Activity	**FY 2009**	**FY 2010 Current Approp.**	**FY 2012 *Request***
Biomass and Biorefinery Systems	214,245	216,225	340,500
Building Technologies	138,113	219,046	470,700
Federal Energy Management Program	22,000	32,000	33,072
Geothermal Technology	43,322	43,120	101,535
Hydrogen Technology	164,638	0	0
Hydrogen and Fuel Cell Technologies	0	170,297	100,450
Water Power	39,082	48,669	38,500
Industrial Technologies	88,196	94,270	319,784
Solar Energy	172,414	243,396	457,000
Vehicle Technologies	267,143	304,223	588,003
Weatherization & Intergovernmental Activities	516,000**	270,000	393,798
Wind Energy	54,370	79,011	126,859
Facilities & Infrastructure	76,000	19,000	26,407
Strategic Programs	18,157	45,000	53,204
Program Direction	127,620	140,000	176,605
Congressionally Directed Activities	228,803	292,135	0
RE-ENERGYSE	0	0	0
Adjustments	-13,238	0	-26,364
Total	**$2,156,865**	**2,216,392**	**3,200,053**

* SBIR/STTR funding transferred in FY 2009 was $19,327,840 for the SBIR program and $2,347,160 for the STTR program.
** Includes $250.0 million in emergency funding for the Weatherization Assistance Grants program provided by P.L. 111-6, “The Continuing Appropriations Resolution, 2009.”

Examples of Collaboration Leveraging Activities

DOE Collaboration Opportunities

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Fuel Cell Technologies Program

Program	Program Key Focus
Buildings ($471M)	Develop and scale up deployment of technologies, tools, and standards for making residential and commercial buildings more energy-efficient, affordable, and better performing.
Industrial Technologies ($320M)	Research and develop advanced manufacturing and materials technologies and accelerate industrial adoption of energy efficient and clean energy technologies. Help U.S. producers to become global leader in production of clean energy technologies.
Solar ($457M) (e.g. EFRC)	"Sun Shot" – Enable grid parity before the end of the decade by achieving $1/W installed price for PV (without subsidies). Develop new innovative materials and thermal storage to enable CSP to compete with intermediate and baseload power markets.
Biomass ($331M)	Develop and transform domestic biomass resources into biofuels, bioproducts, & biopower: 1) Complete steps to achieve a modeled cost of less than $2/gal (by volume) of cellulosic ethanol in 2012 and progress towards $3/gal for renewable hydrocarbon fuels by 2017 (both in 2007$), 2) Collaborate with Office of Sc. to develop synthetic-biology tools to enhance national capability in biomanufacturing, 3) validate 15 M gallons of annual advanced biofuel production capacity,4) Provide incentive for advanced biofuel production via a reserve auction.
Vehicle Technologies ($588M)	Strategic research, development and deployment activities supporting the goal of 1 M electric drive vehicles on U.S. roads by 2015.
FEMP ($33M) - Federal facilities - EO 13514	Facilitates the Federal Government's implementation of sound, cost effective energy management and investment practices resulting in lifecycle saving of over 52 trillion Btus. Increased funding for technical assistance will support Federal cost and GHG reduction efforts by developing guidance, technical assistance and GHG reporting protocols.
ARPA-E ($550M) **Innovative concepts**	Focuses exclusively on high risk, high payoff concepts - technologies promising genuine transformation in the ways we generate, store and utilize energy.

EERE-SC Coordination - Hydrogen and Fuel Cells

Management Coordination and Strategic Planning

- DOE Coordination Group (meets monthly)
- Participation in National Academies & GAO Reviews
- Interagency Working Group (meets monthly) & Interagency Task Force (Energy Policy Act of 2005)
- Integrated Program Plan (Strategic Plan) across SC, EERE, FE, NE
- Examples of Coordination:
    - Energy Frontier Research Center (EFRCs) Center for Electrocatalysis, Transport Phenomena and Materials for Innovative Energy Storage through LBNL (GE)
    - Participating in Office of Science program to stimulate competitive research (EPSCoR)
    - Project at University of New Mexico on Materials for Energy Conversion specifically ethanol reforming to produce hydrogen and direct electrochemical oxidation of ethanol.

Execution

- Working Groups (PIs)
    - Biological Hydrogen Production
    - Photoelectrochemical (PEC) Hydrogen Production

- Joint Workshops
    - Example: Theory Workshops for Hydrogen Storage Materials

- Identified areas for more R&D
    - Coordination at major conferences (e.g. ACS, MRS, etc.)

Evaluation

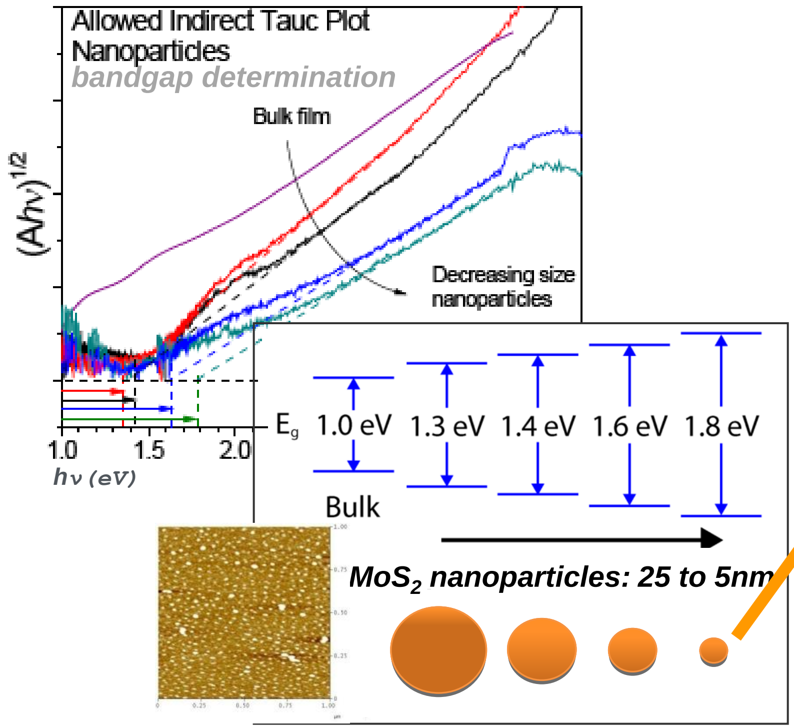
- Annual Merit Reviews
    - SC-funded PIs present posters/orals along EERE-funded PIs and serve as reviewers
    - Specific topic selected each year for SC focus (rotate between production, storage, and fuel cells)

- Review proposals for funding
- Provide input to SC RFPs
- Attend contractors' and proposal review meetings

Discovering new MoS_2 nano-catalysts, and developing novel macro-structures for integration into practical photoelectrochemical (PEC) hydrogen production devices

Fundamental Science:

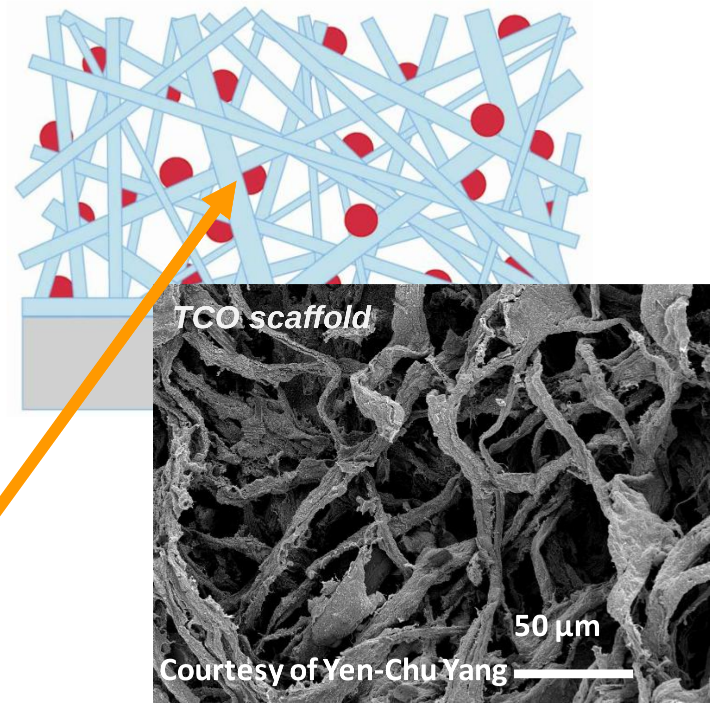
Based on fundamental principles of quantum confinement, nanoparticle MoS_2 catalysts exhibit bandgap enlargement from 1.2 eV (bulk) to ~1.8 eV when diameter is reduced to ~5 nm.



Bandgap blueshift in 5 nm MoS_2 nanoparticles sensitizes catalyst to efficiently absorb light in the solar spectrum

Applied R&D:

A macroporous scaffold consisting of a transparent conducting oxide (TCO) is being developed upon which the MoS_2 nanoparticles can be vertically integrated for support, confinement and electronic contact.



Stanford University
University of Louisville
NREL

Scaffold is enabling technology for development of MoS_2 photoelectrodes for effective solar H_2 production

Source: T. Jaramillo, et al. *Science 2007, 317, 100122;* Y. Aoki, J. Huang, T. Kunitake, *J. Mater. Chem., 2006, 16, 292-297*

Pt/Pd Core-Shell Catalysts

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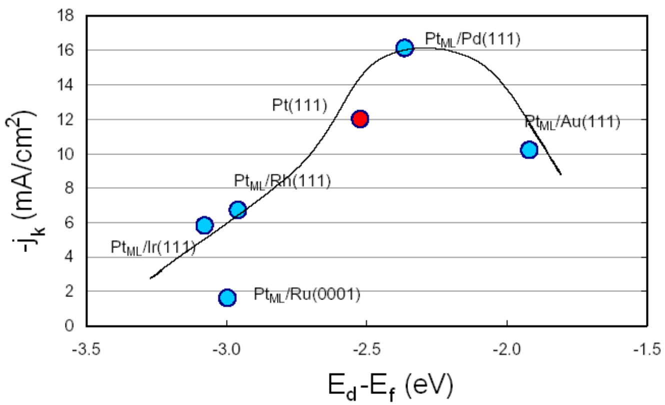
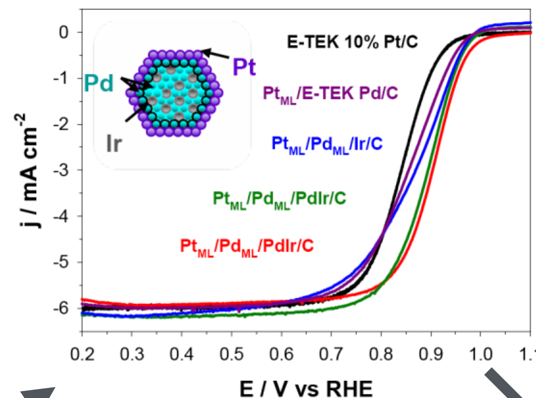
Fundamental research has demonstrated high activity of Pt monolayer catalysts, leading to development of practical core-shell catalysts through applied R&D

Fundamental Science

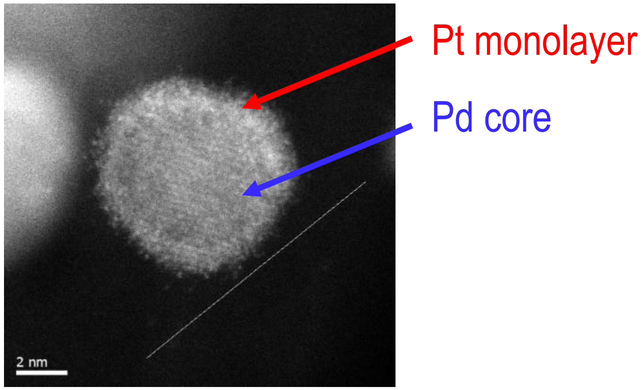
Applied R&D



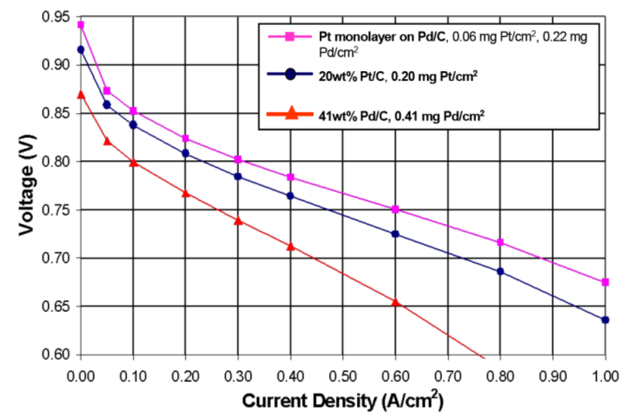
High activity of Pt monolayer surfaces was demonstrated on model (single-crystal) surfaces. Substrate metal modifies Pt electronic structure, allowing tuning of catalytic activity and durability.



Addition of other metals to core, along with interlayers between shell and core, further enhance core-shell activity and durability.



Demonstration of Pt monolayer on a Pd core – a promising high activity, high durability, low-loading PGM catalyst.



Scale-up to gram-level quantities of core-shell catalysts in EERE-funded partnership with Cabot, as well as external CRADAs.

Adzic *et al.*, BNL

Example for Potential Science Collaboration: Adsorbents

Weak chemisorption (Spillover) materials have potential to store hydrogen at ambient temperature, but have poor reproducibility & slow uptake kinetics.

Possible BES Topics

- Surface science studies of hydrogen bonding and surface diffusion as a function of surface composition
- Novel techniques to characterize bonding of low concentrations of hydrogen atoms on surfaces
- Theoretical modeling of hydrogen surface diffusion kinetics and thermodynamics
- Translate observed physisorption and/or chemisorption interactions to thermodynamic and kinetic barriers
- Theoretical modeling of possible reaction mechanisms to improve kinetics

EERE Activities

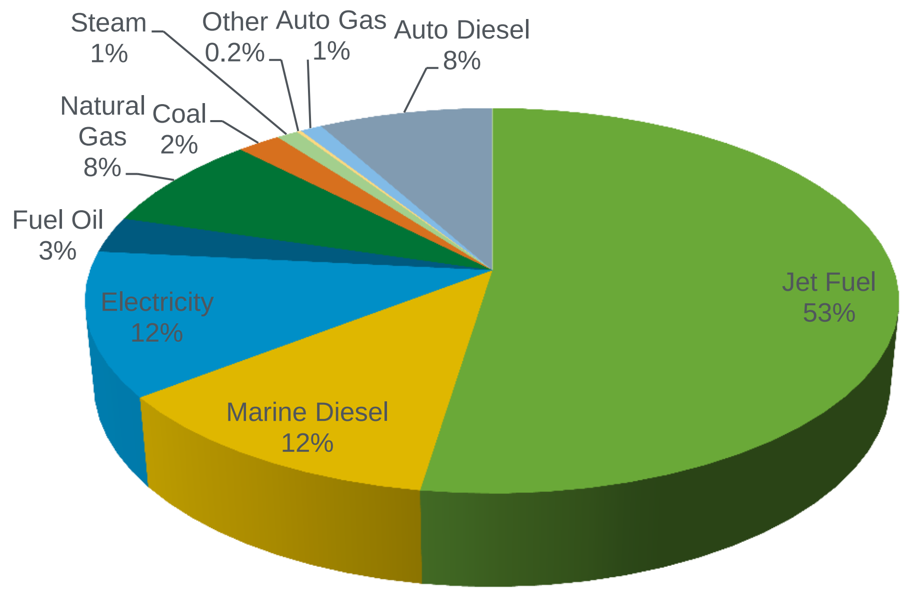
- NREL led task force in FY11
  - With 4 defined materials, establish uniform protocols, conduct round robin synthesis, testing and characterization effort
  - Partners in the US, Germany and France; leverages IEA HIA Task 22 Hydrogen Storage expertise
  - Not a material development effort; solely validation, determines likely potential
- Past modeling efforts included thermodynamic modeling to indicate when spillover is possible
  - Predictive versus observed hydrogen-catalyst-substrate interactions
  - Translate observed physisorption and/or chemisorption interactions to thermodynamic and kinetic barriers

DOD-DOE MOU

Enhance Energy Security MOU

Goals: Identify a framework for cooperation and partnership between DOE and DOD to strengthen coordination of efforts to enhance national energy security, and demonstrate Government leadership in transitioning America to a low carbon economy.

Percent of FY06 Total DoD Energy Use



DoD Energy Consumption by Type of Fuel

Source: *Report of the Defense Science Board Task Force* on DoD Energy Strategy, February 2008

DOD-DOE MOU: Workshops

Aviation APUs Workshop: 9/30/2010

Purpose:

- To begin discussing collaboration across DOD and DOE in keeping with the MOU
- To motivate RD&D for APU applications

Next Steps

- Identify specific POCs for DOD activities
- Develop GSE Strategic Demo Plan

Waste-to-Energy Workshop: 1/13/2011

Purpose:

- To identify DOD-DOE waste-to-energy opportunities using fuel cells
- To identify challenges and determine actions to address them

Next Steps

- Set up an on-going WG to begin coordination, collaboration, assistance
- Develop a guidance document for Feds using third party financing

Shipboard APUs Workshop: 3/29/2011

- **March 2011**
- **Organized by ONR**

Biogas Resource Example: Methane from Waste Water Treatment

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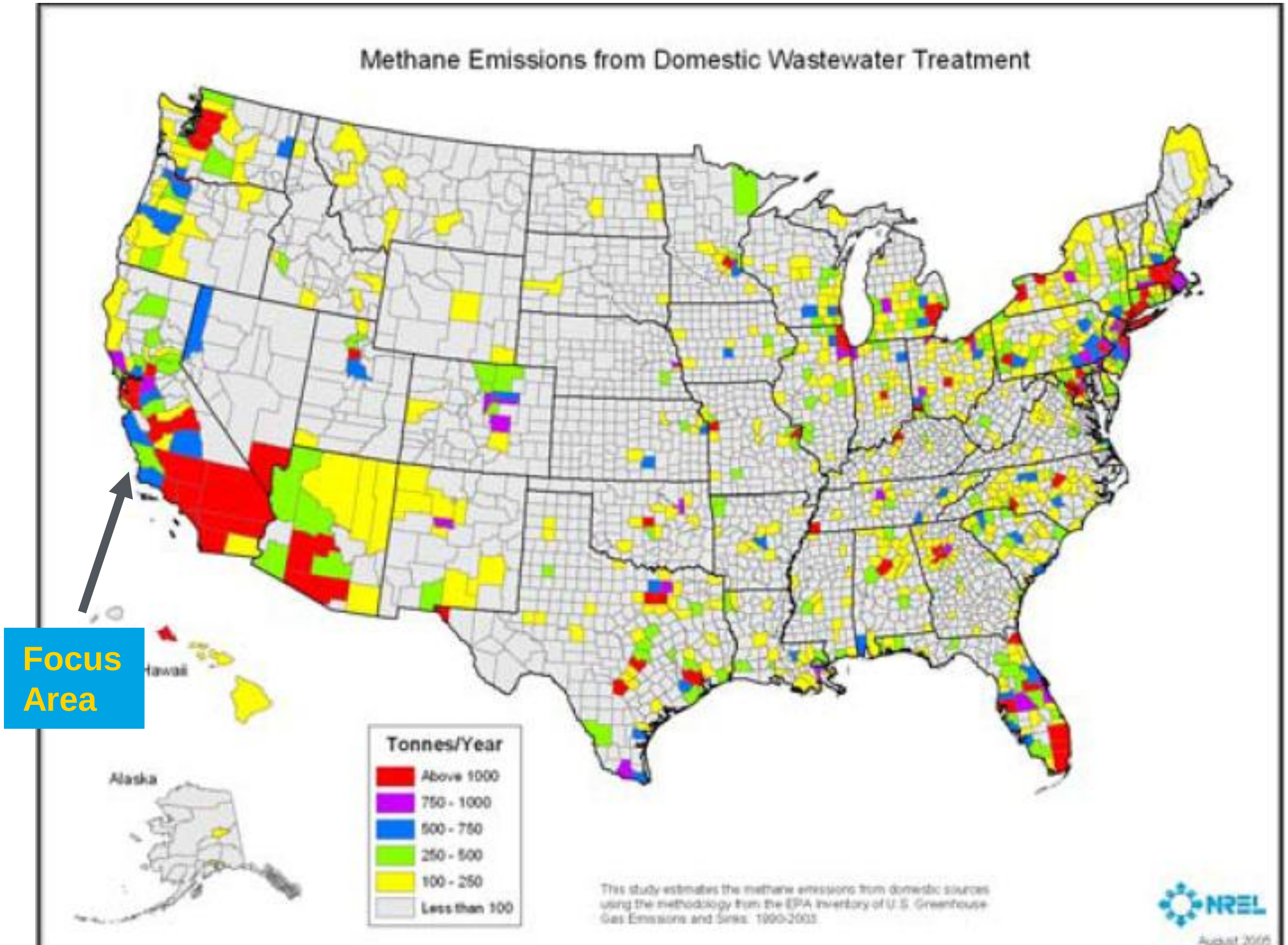
Biogas from waste water treatment plants is ideally located near urban centers to for stationary power or to supply hydrogen for fuel cell vehicles.

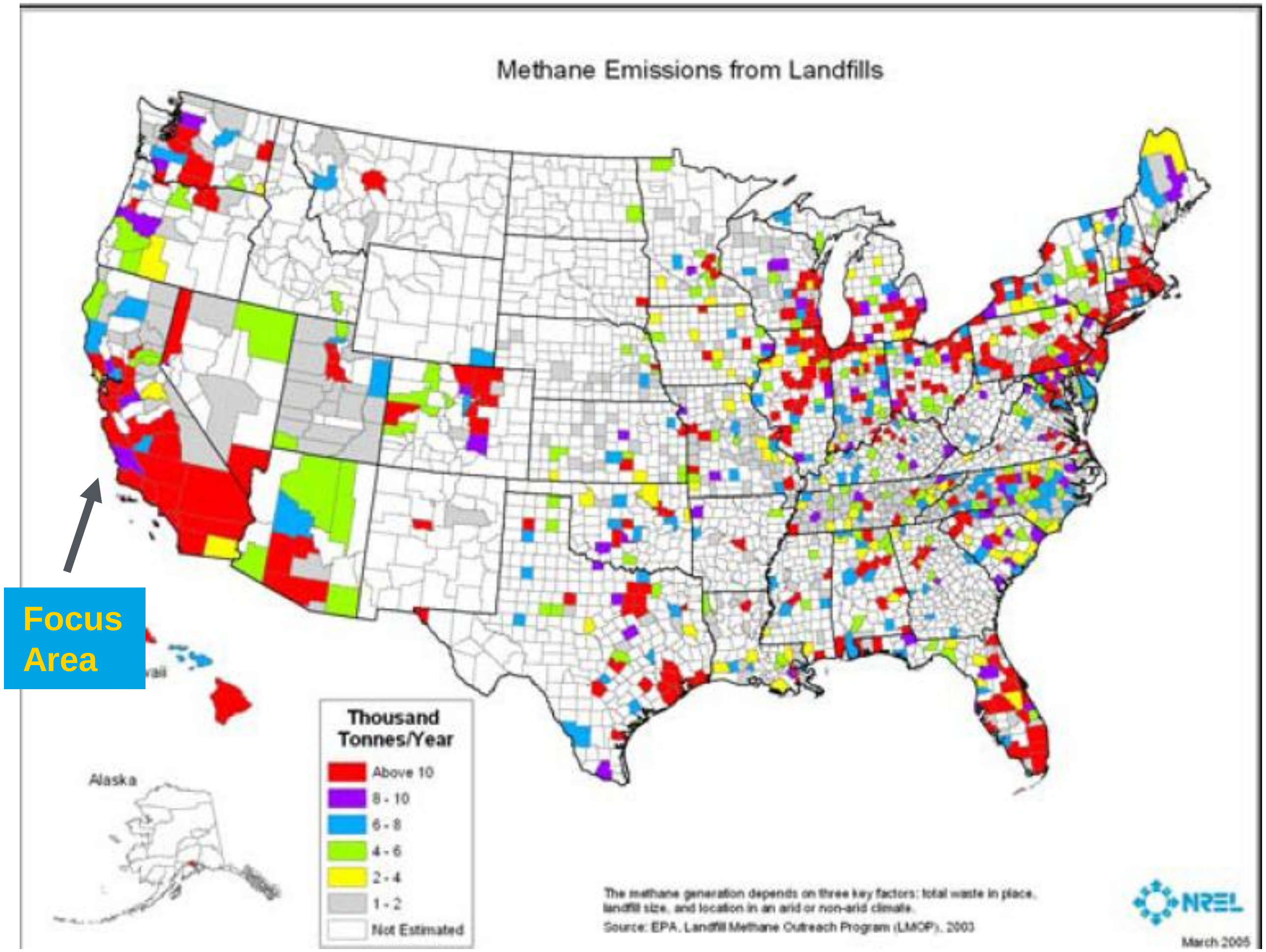


Source: NREL report *A Geographic Perspective on Current Biomass Resource Availability in the United States*, 2005

- ~ 500,000 MT/yr of methane available from waste water treatment plants
- If ~50% of the bio-methane was available, ~ 3,500 GWh could be produced from fuel cell CHP
- Could produce enough renewable hydrogen to fuel ~680,000 fuel cell vehicles per day (~680,000 kg/day)

Biogas Resource Example: Methane from Landfills

Biogas from landfills is located near large urban centers and could provide renewable energy for both stationary power and transportation.



- ~12.4 million MT per year of methane available from landfills in U.S.
- Bio-methane could be used to produce ~86,000 GWh from fuel cell CHP or enough renewable hydrogen to fuel ~8 million fuel cell vehicles per day (~ 8M kg/day)

Source: NREL report *A Geographic Perspective on Current Biomass Resource Availability in the United States*, 2005

Source: US DOE 2010

California Example: Potential Sources of Biogas

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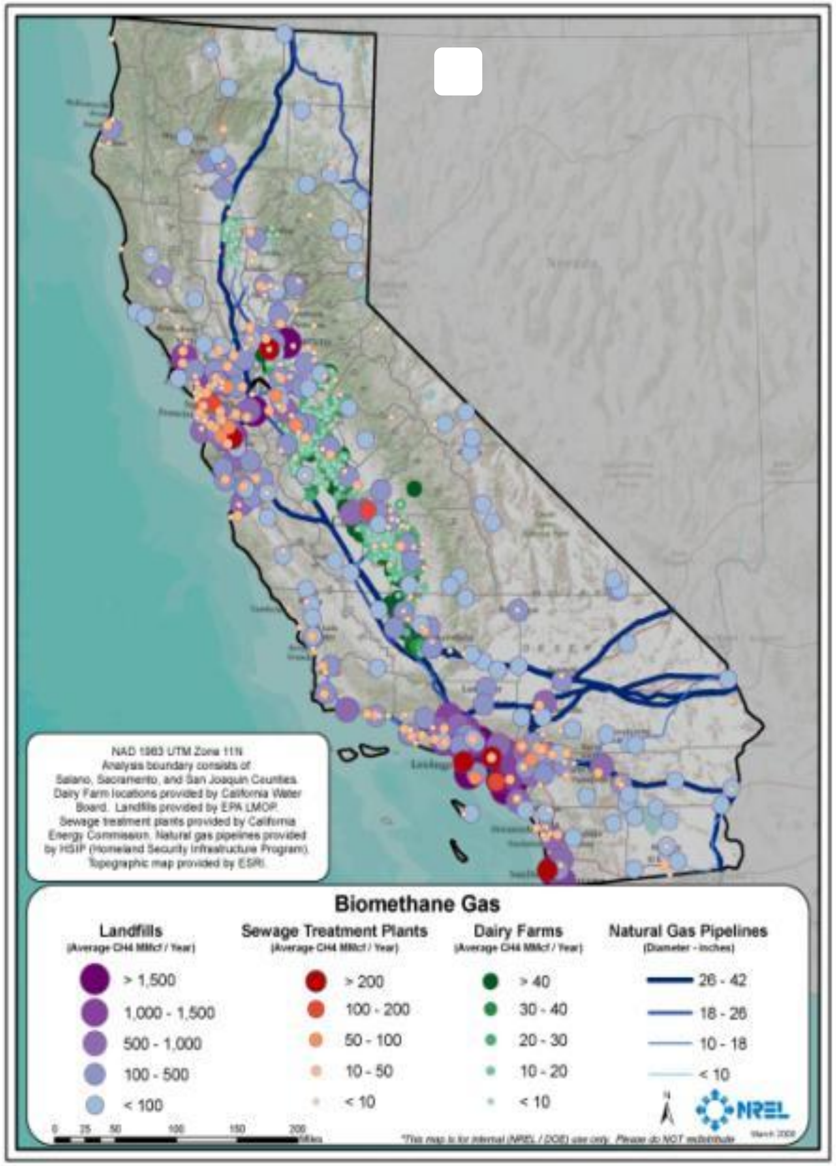
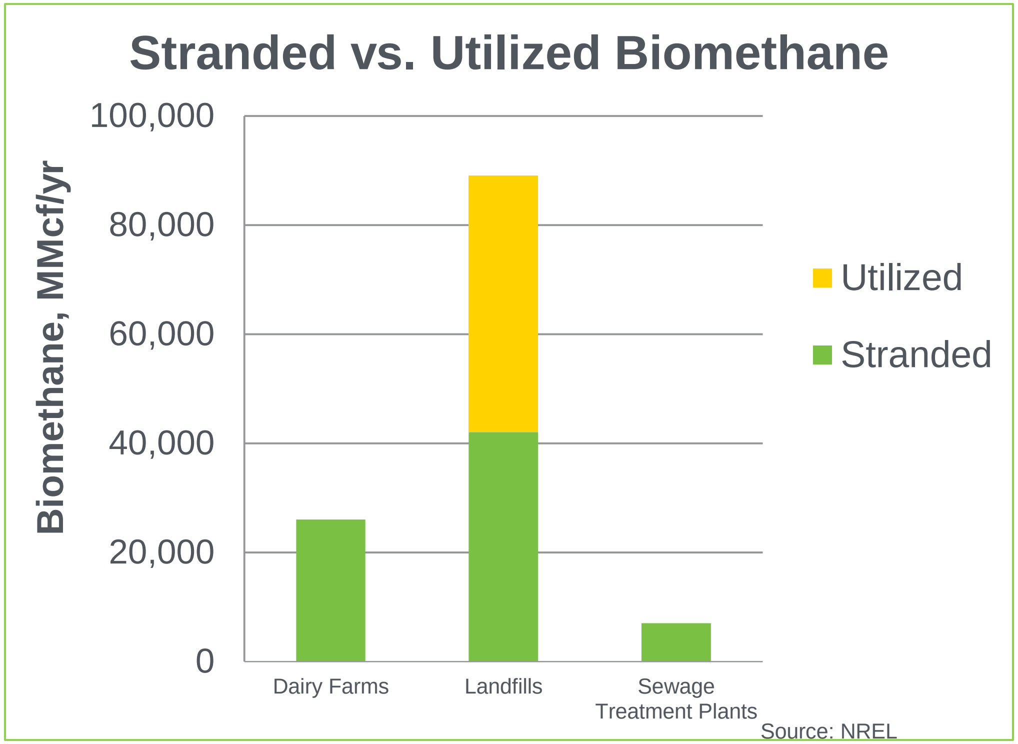




Source: NREL

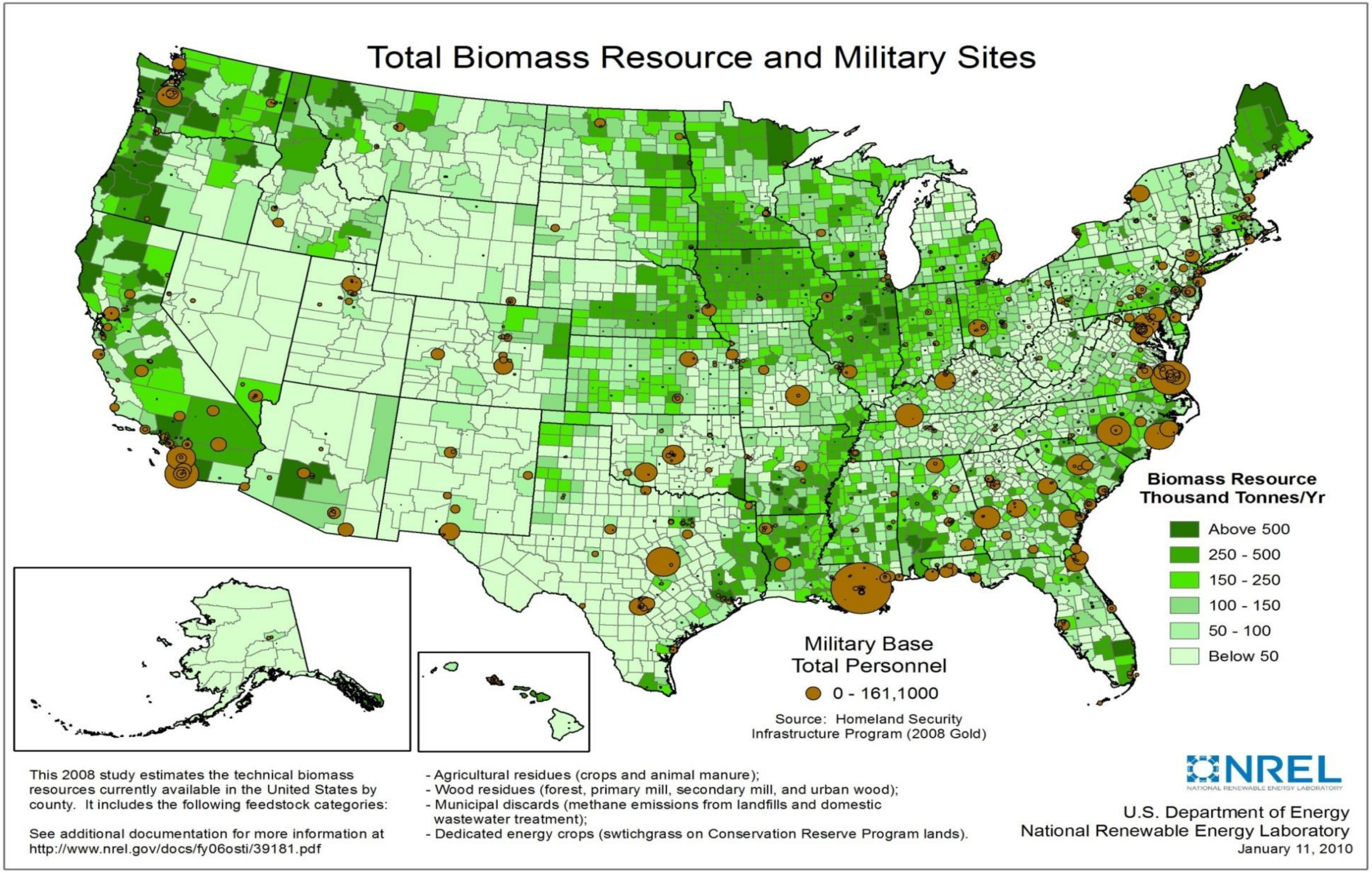
Example:

Landfills offer ~1.6 M tons/yr of bio-methane.

- Only ~50% of the landfill biomethane is used

Source: US DOE 2010

Preliminary Analysis- Resources near Military Sites



Hawaii's Hydrogen Initiative (H2I)

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A public/ private effort that seeks to be a major component of the solution to Hawaii's energy challenges

- **Letter of Understanding signed on Dec 8, 2010 by DOE and DOD, among others**
  - State of Hawaii, the Hawaii Gas Company, University of Hawaii, General Motors, Fuel Cell Energy, and others

- **Mission is to fill a strategic role that supports Hawaii's transformation to a clean energy economy**

- **Part of a portfolio approach of technologies and fuels for reducing emissions and petroleum use**
  - Supports the deployment of fuel cell vehicles to Hawaii as a means of reducing petroleum consumption as well as green house gas emissions
  - Takes advantage of the existing gas pipelines to deliver hydrogen for dispensing hydrogen to fuel cell vehicles

DOE – DOT Collaborations

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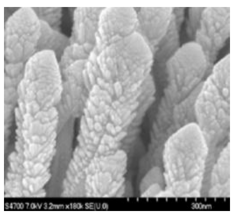
DOE and DOT support the development and deployment of fuel cell technology



Developed low Pt approach
Reduced cost by >30% since 2008, 80% since 2002

DOE RD&D

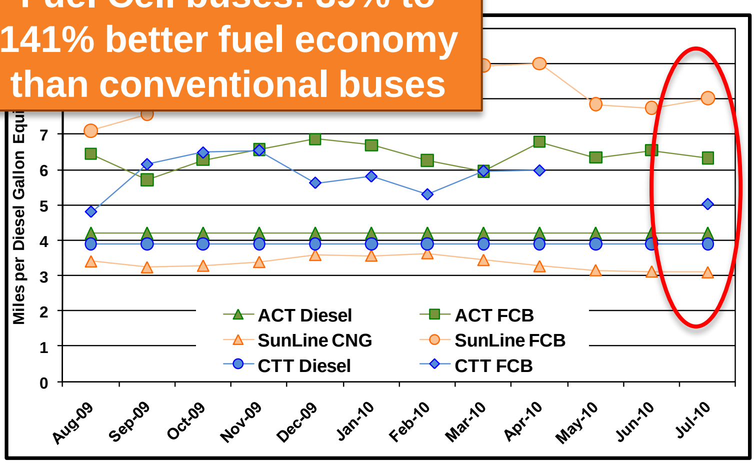
Data Collection & Validation

NREL
HSDC
NREL's Hydrogen Secure Data Center

National Bus Program
($49 million for 4 years)

DOT Deployment

Fuel Cell buses: 39% to 141% better fuel economy than conventional buses



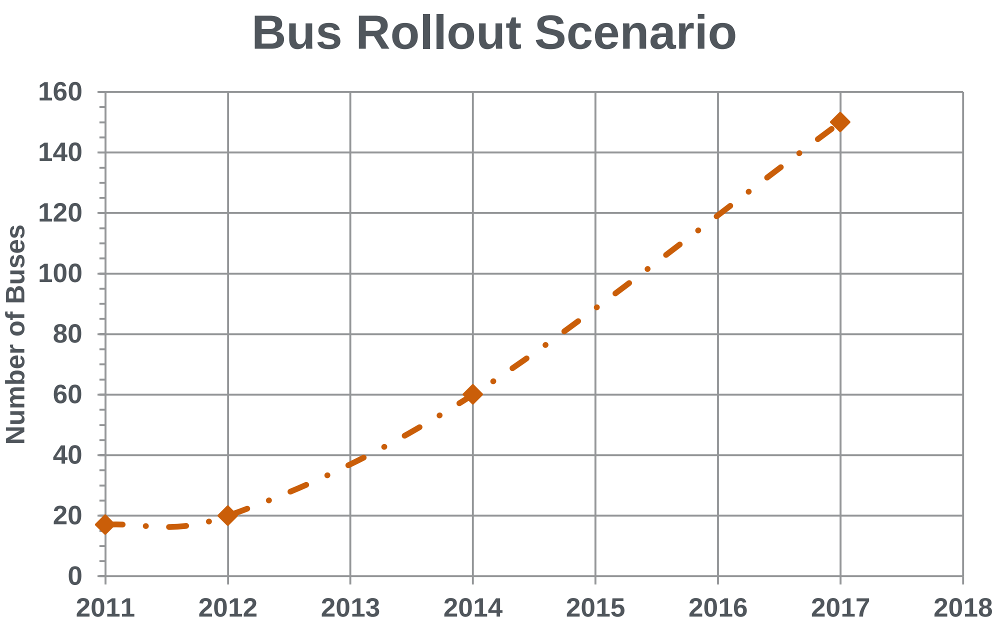
Accomplishments

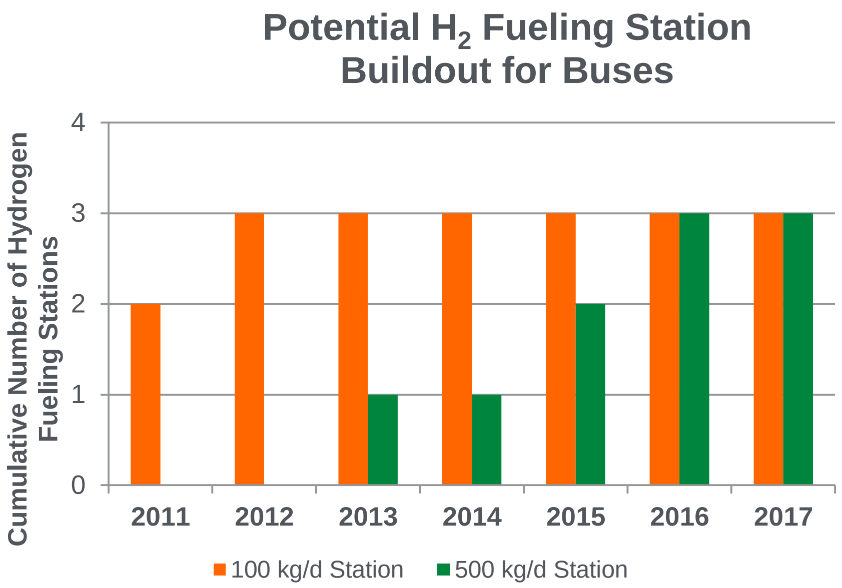
Demonstrated:

- Doubled fuel economies (8 mpg, >2X compared to diesel buses)
- 41% increase in average miles between roadcall with new fuel cell system (~8,500 MBRC)
- Demonstrated more than 7,000 hr fuel cell durability

Fuel Cell Bus Buildout Analysis

Potential deployment strategies envisioned for Fuel Cell Buses deployment scenario analysis identified in California's Action Plan.





	2011	2012	2013	2014	2015	2016	2017
	Phase I	Phase II			Phase III		
Number of Fuel Cell Buses*	17	20 – 60			60 – 150		
Minimum Number of 100 kg/d Stations	2	1	0	0	0	0	0
Minimum Number of 500 kg/d Stations	0	0	1	0	1	1	0

Notes: The station requirements for the fuel cell bus build out was based on ANL analysis with the HDSAM delivery model.

**Source:* California Fuel Cell Partnership, *Action Plan*, April 2010 based on industry input.

Leveraging SBIRs

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Topic 3: Hydrogen and Fuel Cells

- **Subtopic 3a – Reducing the Cost of High Pressure Hydrogen Storage Tanks**
- **Subtopic 3b – Fuel Cell Balance-of-Plant**
- **Subtopic 3c – Hydrogen Odorant Technology**
- **Subtopic 3d – Demonstration of Alternative-Fuel Cells as Range Extenders for Battery-Powered Airport Ground Support Equipment (GSE)**
- Subtopic 3e – Other: Should address one of the four subtopics (a-d). However, the proposal can take an approach that is not specified in the subtopic description but that will still meet the technical targets, goals or objectives, which are referenced in the description.

Closed on 11/15/2010
Currently in process of reviewing.
Announcement expected in May 2011.

FY10 Project Kick-Off Meetings

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

FY10 Phase II Project Kick-Off Meeting – November 2, 2010 at DOE Headquarters

- **"Utilized Design for Home Refueling Appliance for Hydrogen Generation to 5,000 psi"**
  (Giner Electrochemical Systems, LLC)
- **"Process Intensification of Hydrogen Using an Electrochemical Device"**
  (H2 Pump LLC)
- **"Hydrogen by Wire – Home Refueling System"**
  (Proton Energy Systems)

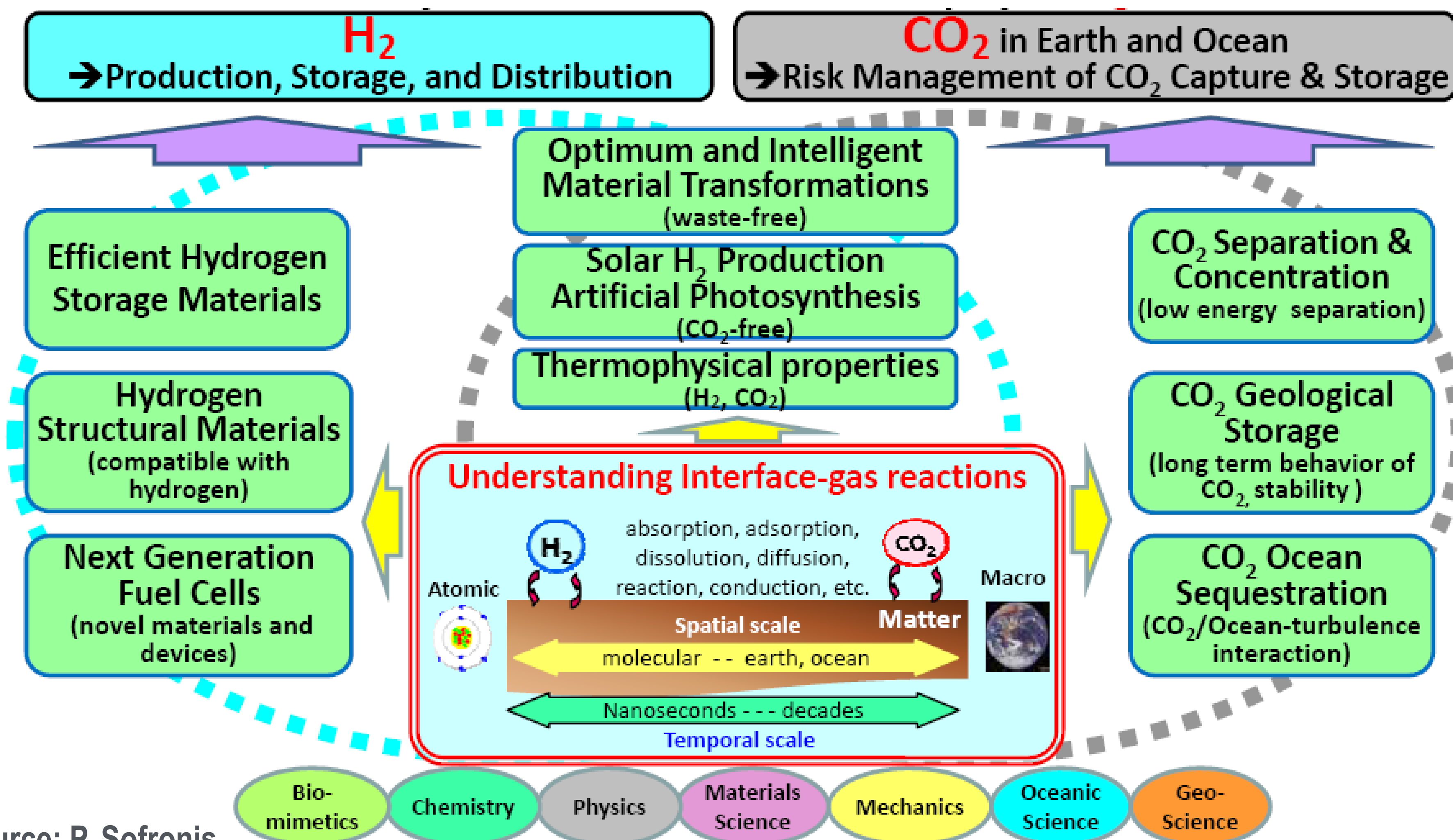
FY10 Phase III Project Kick-Off Meeting – Scheduled for March 10, 2011 at DOE Headquarters (Webex Meeting Link provided in hyperlink)

- **"Dimensionally Stable High Performance Membrane"**
  (Giner Electrochemical Systems, LLC)
- **"Bio-Fueled Solid Oxide Fuel Cells"**
  (TDA Research, Inc.)
- **"Power Generation from an Integrated Biomass Reformer and Solid Oxide Fuel Cell"**
  (InnovaTek, Inc.)
- **"Large-Scale Testing, Demonstration and Commercialization of the Nanoparticle-based Fuel Cell Coolant"**
  (Dynalene, Inc.)

https://srameeting.webex.com/srameeting/j.php?ED=143053917&UID=1148213232&PW=49ed0d3e2327217d757b

Example of Recent International Collaboration:

University of Illinois – Kyushu University collaboration directed by Petros Sofronis to advance the fundamental science for a "Carbon-Neutral Energy Fueled World" and offer science driven solutions for energy technologies that will enable environmentally friendly and sustainable development



Source: P. Sofronis

Upcoming Conferences and Workshops

Infrastructure Workshop – Market Readiness

Market Readiness Workshops – Feb 16th & 17th

Focus on reducing the cost of hydrogen while increasing availability for market readiness. Identify and collect stakeholder feedback on:

- Cost reduction opportunities from economies of scale
- Cost reduction opportunities from focused R&D areas and priorities
- Specific examples from which early markets can provide increased demand and reduce hydrogen infrastructure costs

Agenda

- Early Market End User Experiences
- Outlook for Infrastructure Cost Reductions
- Vehicle Deployment and Station Cost Questionnaires
- Cost Reductions & Rollout Strategies
  - Component level cost reductions
  - System station cost reductions
  - Planning and permitting
  - Business operations
- Requirements for Market Readiness
  - Stations for light duty vehicles
  - Fueling for material handling equipment
  - Fueling depots for transit buses
  - Station utilization, revenue and retail business models

2011 4th International Conference on Hydrogen Safety - ICHS

Organized by

Università di Pisa · Sandia National Laboratories · HySafe International Association for Hydrogen Safety

Endorsed by

U.S. Department of Energy · IPHE · HIA

September 12-14, 2011

San Francisco, CA-USA

The ICHS 2011 will focus on the improvement, knowledge, and understanding of hydrogen safety to overcome barriers to the wide spread use of hydrogen as an energy carrier.
Therefore, this conference seeks papers focused on the following three major themes:

1) **International Progress on Enabling Opportunities**
2) **Latest Advances in Hydrogen Safety R&D and**
3) **Risk Management of Hydrogen Technologies. All contributions to be included in the ICHS 2011 will be evaluated exclusively in the light of their scientific content and relevance to hydrogen safety.**

The conference will improve public awareness and trust in hydrogen technologies by communicating a better understanding of both the hazards and risks associated with hydrogen and their management.

March 1, 2011
Tokyo International Forum
Tokyo, Japan

This workshop will include government agencies, private companies and research organizations from key countries to present government policy and industrial activity in the area of stationary FC.

Examples of Participants:

- METI/NEDO, DOE, EU Fuel Cells and Hydrogen Joint Undertaking, NOW GmbH, Toshiba, INNOTECH, Ceramic Fuel Cells Ltd., Acumentrics Corp., E.ON Ruhrgas AG, KOGAS, Fuji, UTC, Fuel Cell Energy, Inc., POSCO Power, Ballard

Agenda

- Government Session
  - Focus on governmental programs and their main stationary technologies/ application areas.
- Residential & Micro CHP Applications
  - Focus on opportunities for cooperation, solutions for commercialization and best practices in overcoming hurdles.
- Industrial Applications
  - Focus on opportunities for cooperation, solutions for commercialization and best practices in overcoming hurdles.
- Technology and Market
  - Focus on challenges and solutions for overcoming hurdles to commercialization and ways to promote cooperation.

REVERSIBLE FUEL CELLS

You are invited to attend the
Reversible Fuel Cells Workshop
on
Tuesday, April 19, 2011
Renaissance Capitol View,
Crystal City, VA
9:00 AM to 4:00 PM

For information email
Robert.Remick@nrel.gov

2011 Alkaline Membrane Fuel Cell Workshop

You are invited to attend the
2011 Alkaline Membrane
Fuel Cell Workshop
on
May 8 - 9, 2011
Crystal Gateway Marriott,
Crystal City, VA

Organized with the
U.S. Army
Research Office
(ARO)

For information email
AMFCWorkshop@nrel.gov
Or visit
http://dell.communicateandgrow.com/nrelva.html

Organized by:

U.S. DEPARTMENT OF ENERGY

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Additional DOE Workshops- Summary

Delivery

- Participation in Systems Analysis and Storage workshops addressing Infrastructure and Physical Storage topics.

Storage

- Workshop to develop roadmap for lower cost compressed H2 storage activities (February 14, 2011)- e.g. leverage C fiber cost reduction
- Workshop to identify key R&D issues for cryo-compressed/cryo-sorption H2 storage (February 15, 2011)
- Follow-up workshops on hydrogen sorbents (Q3/4 FY 2011)
- Workshops on interface issues between the infrastructure and on board storage (TBD)
- Workshop to develop roadmap/strategies for future storage materials R&D (TBD)

Fuel Cells

- Reversible fuel cells (4/19)
- AFC workshop: Status, prospects and R&D needs (5/8-9)

Safety, Codes and Standards

- Insurability of Hydrogen and FC Technologies (Spring-Summer 2011)
- Collaborative Safety R&D (March 2011, Japan)
- Assessment of Sensor Technology and Targets (Summer-Fall 2011)

Manufacturing

- Stationary Manufacturing R&D FY11 (TBD)

Market Transformation

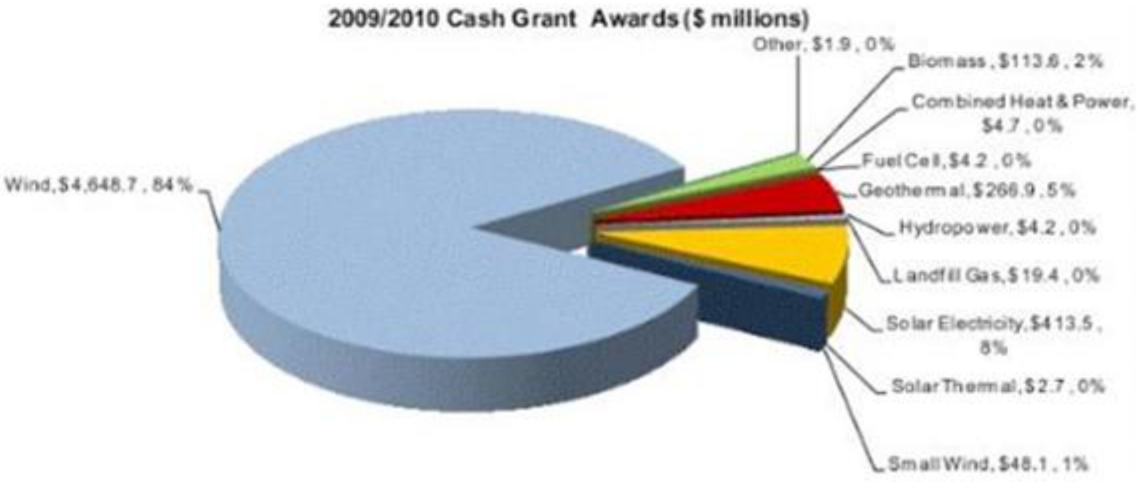
- DOD-DOE MOU Workshop on Shipboard APUs (March 2011)

Systems Analysis

- Infrastructure workshop on station cost identification and identification of R&D gaps
  - Workshop planned for FCHEA Conference (Feb. 16 & 17, 2011)

Analysis Update

Impact of 1603 and 48C



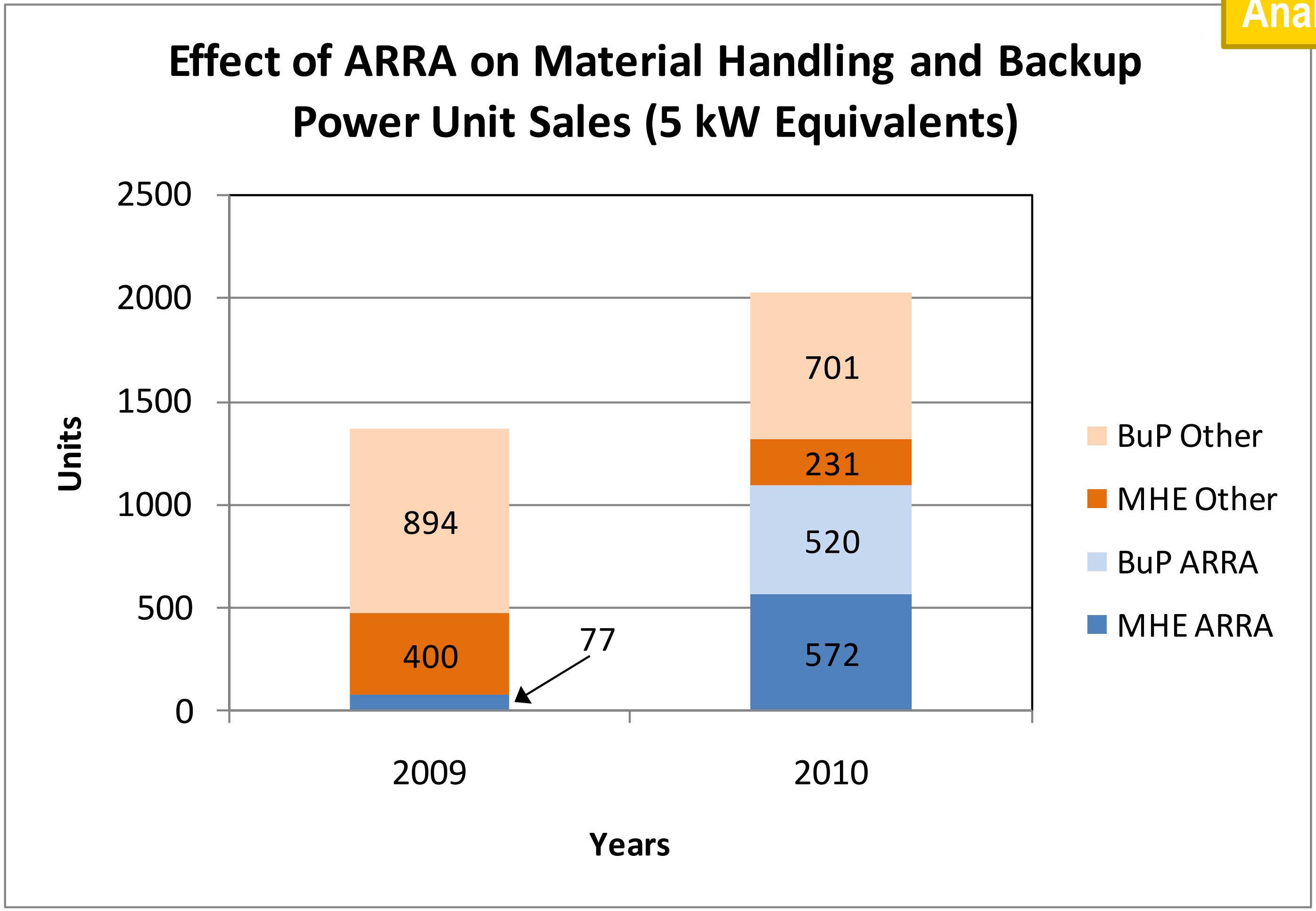
Section 48C: Manufacturing Tax Credit		
Business	**Location**	**Amount**
UTC Power Corporation	CT	$5,300,100
W.L. Gore & Associates	MD	$604,350
Total		**$5,904,450**

Section 1603: Payments in Lieu of Tax Credits			
Business	**Property Location**	**Fuel Cell MWe**	**Amount**
Gills Onions, LLC	California	0.6	$1,141, 560
M&L Commodities, Inc.	California	0.6	$997,913
Preservation Properties, Inc.	California	0.1	$300,000
Logan Energy Corporation	Hawaii	0.3	$900,000
Plug Power, Inc.	Illinois	0.28	$723,334
Logan Energy Corporation	South Carolina	0.05	$148,988
Totals		**1.9**	**$4,211,795**

 Source: US DOE 3/19/2013

ARRA purchases have had a measurable impact on fuel cell material handling and backup power .

Preliminary Analysis



Material handling fuel cell sales increased from 477 to 803 due to the ARRA, while backup power sales were boosted from 894 to 1,221 in spite of unfavorable economic conditions.

David Greene, et al

ORNL Model Summary

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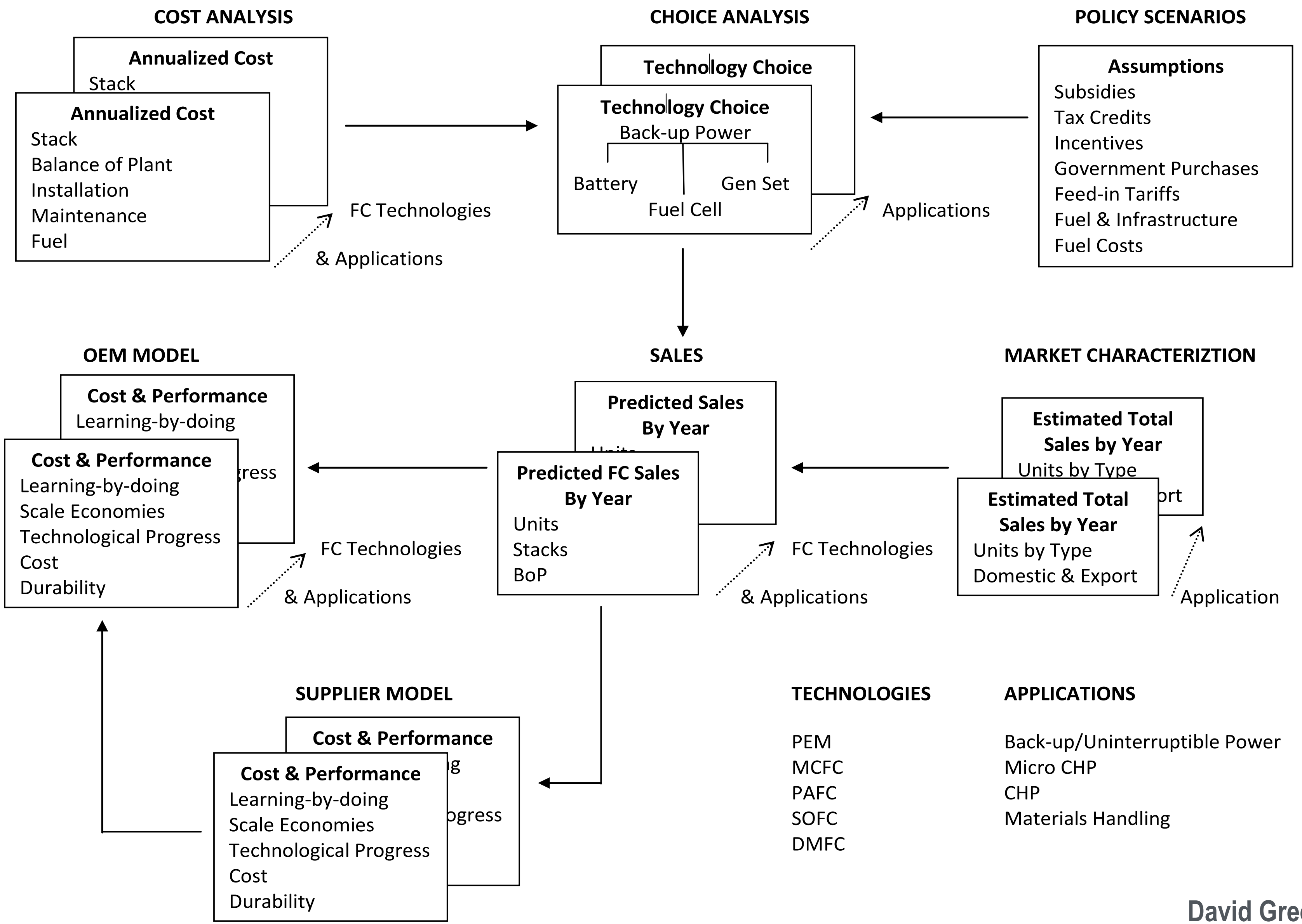
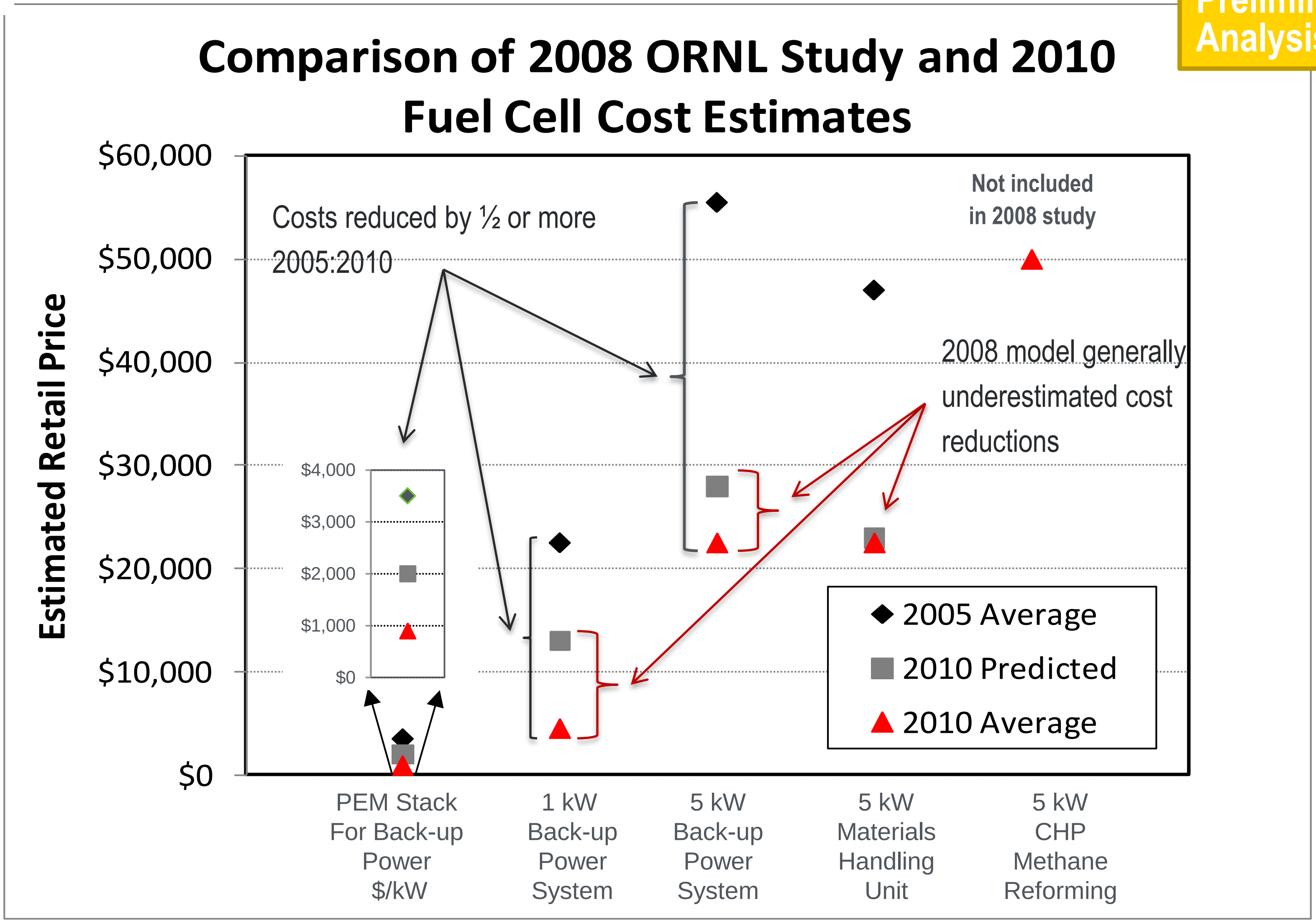


David Greene, et al

Preliminary Analysis

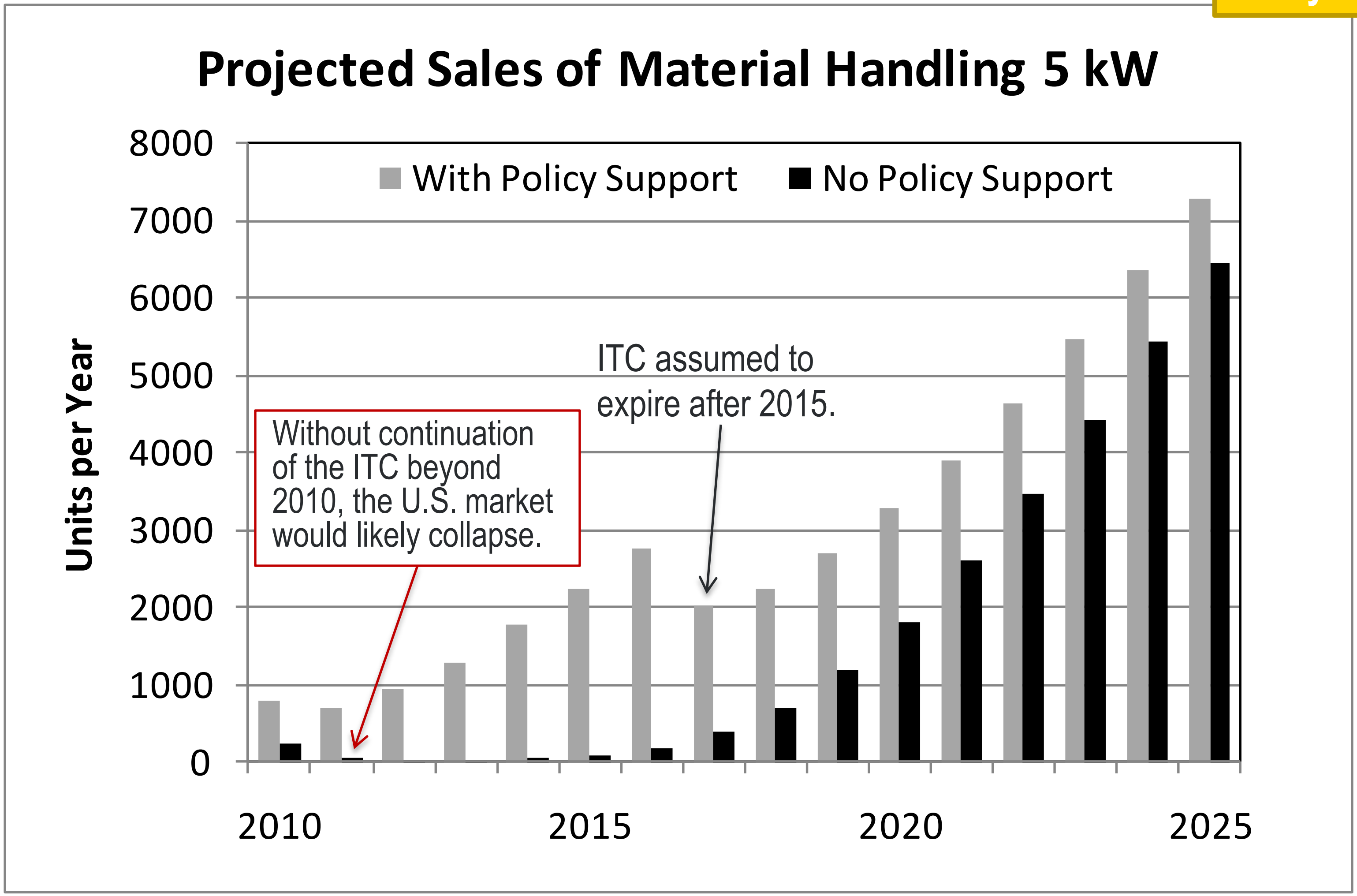


2005 and 2010 averages based on estimates supplied by OEMs. 2010 predicted assumed government procurements of 2,175 units per year, total for all market segments. Predictions assumed a progress ratio of 0.9 and scale elasticity of -0.2.

David Greene, et al

U.S. fuel cell material handling manufacturing would likely have ended in 2011 without existing policy support.

Preliminary Analysis

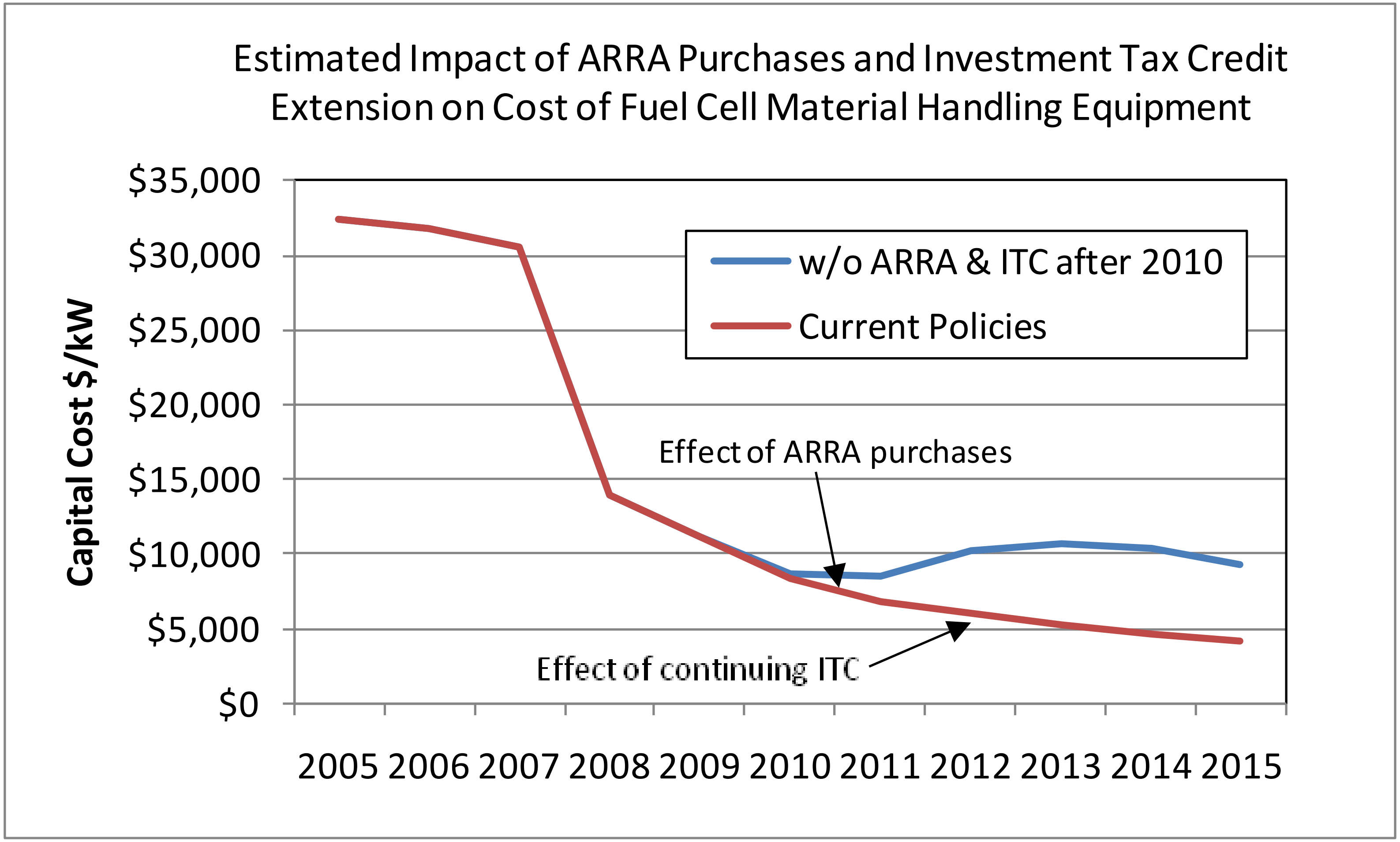


Only ARRA purchases have been excluded from the "No Policy" case. Other government procurements prior to 2011 are included in both cases. Progress ratio of 0.9, scale elasticity of -0.2. Government and private procurements of 100 units/yr. for demonstrations continue in the policy case.

David Greene, et al

Without current policy support, MHE fuel cell costs will increase or manufacturing facilities will close.

Preliminary Analysis



Progress ratio of 0.9, scale elasticity of -0.2. Government and private procurements of 100 units/yr. for demonstrations continue in the current policy case.

David Greene, et al

Assumptions and key points.

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

- Assumptions and generalizations:
  - All OEMs represented by three generic products
    - 5 kW CHP
    - 5 kW Backup Power
    - 5 kW Forklift
  - Number of OEMs constant until scale economies reached
  - No change in the cost of competing products
  - Progress ratios = 0.9, scale elasticities = -0.2
  - Model estimates indicative of status and trends, not precise
- Key Points:
  - Dramatic cost reductions and performance improvements have been achieved for all products since 2005.
  - Still, few firms could continue without current policy support.
  - Cost and performance appear to be on a trajectory to achieve competitiveness in niche markets in 5-10 years.

David Greene, et al

Recent HTAC Feedback & DOE Status

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

- Program Plan (revised Posture Plan)
  - Valuable feedback in the process of being incorporated
- Hydrogen Threshold Cost Analysis
  - Incorporated valuable feedback on analysis with National Lab experts and communication rollout strategy
- Working Groups
  - In process (TBD)
- Annual Report

Feedback from HTAC

- Examples of Future Needs
  - Portfolio optimization
    - Constrained budget scenario
    - Strategies for addressing early markets as well as sustaining long term goals
  - Infrastructure
    - Strategies for early markets as well as FCEVs
    - Fostering innovation for H2 production (e.g. point/local sources, energy storage, TBD)
  - Communication
    - Opportunities and venues for HFCT within broader portfolio
  - Policies
    - Opportunities for accelerating commercialization (lessons learned)

Future: Interaction with ERAC (EERE Advisory Committee)

Thank you

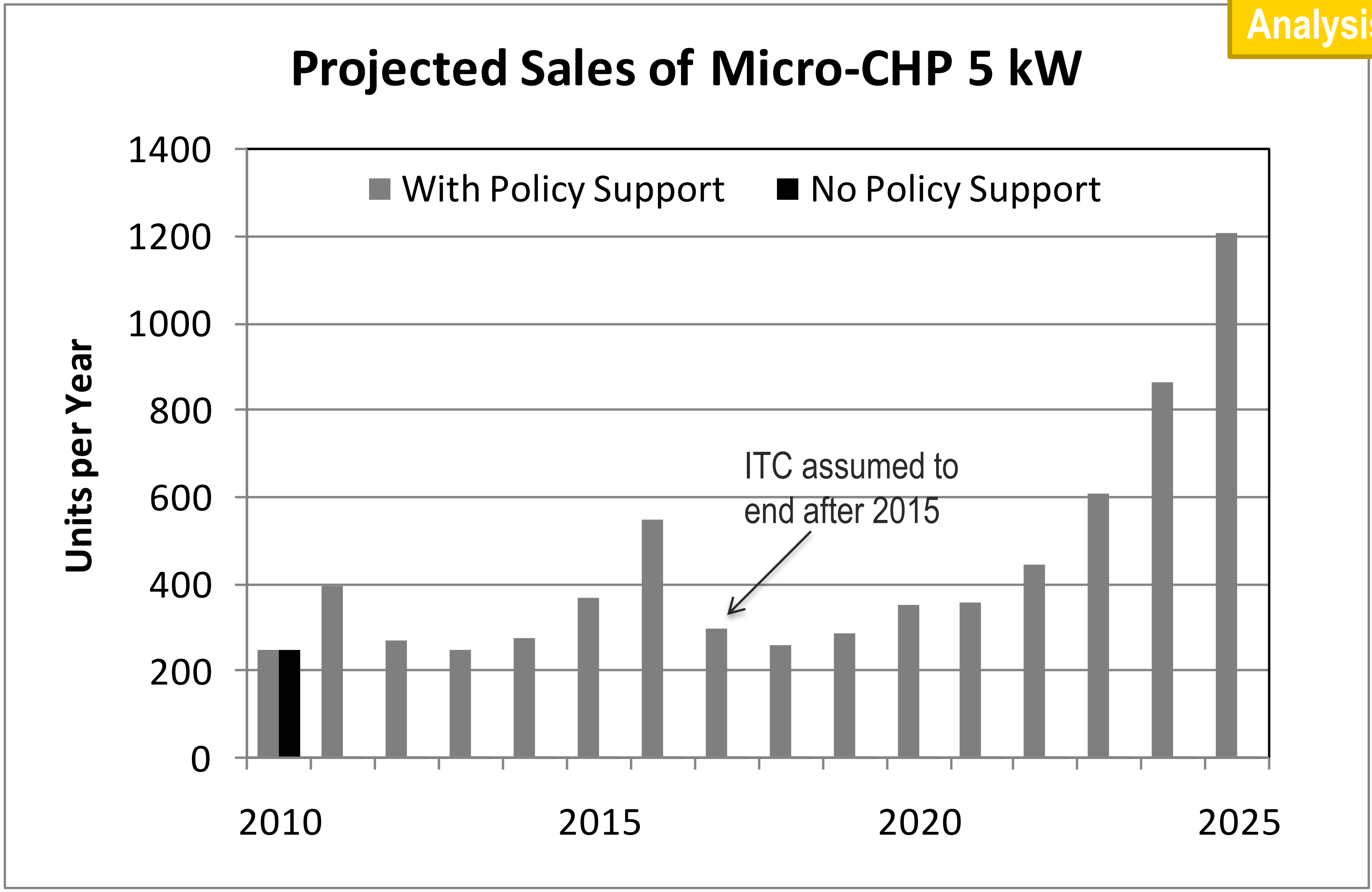
Sunita.Satyapal@ee.doe.gov

www.hydrogenandfuelcells.energy.gov

Back up

Without the ITC and California SGIP incentives, fuel cell CHP sales would likely disappear.

Preliminary Analysis

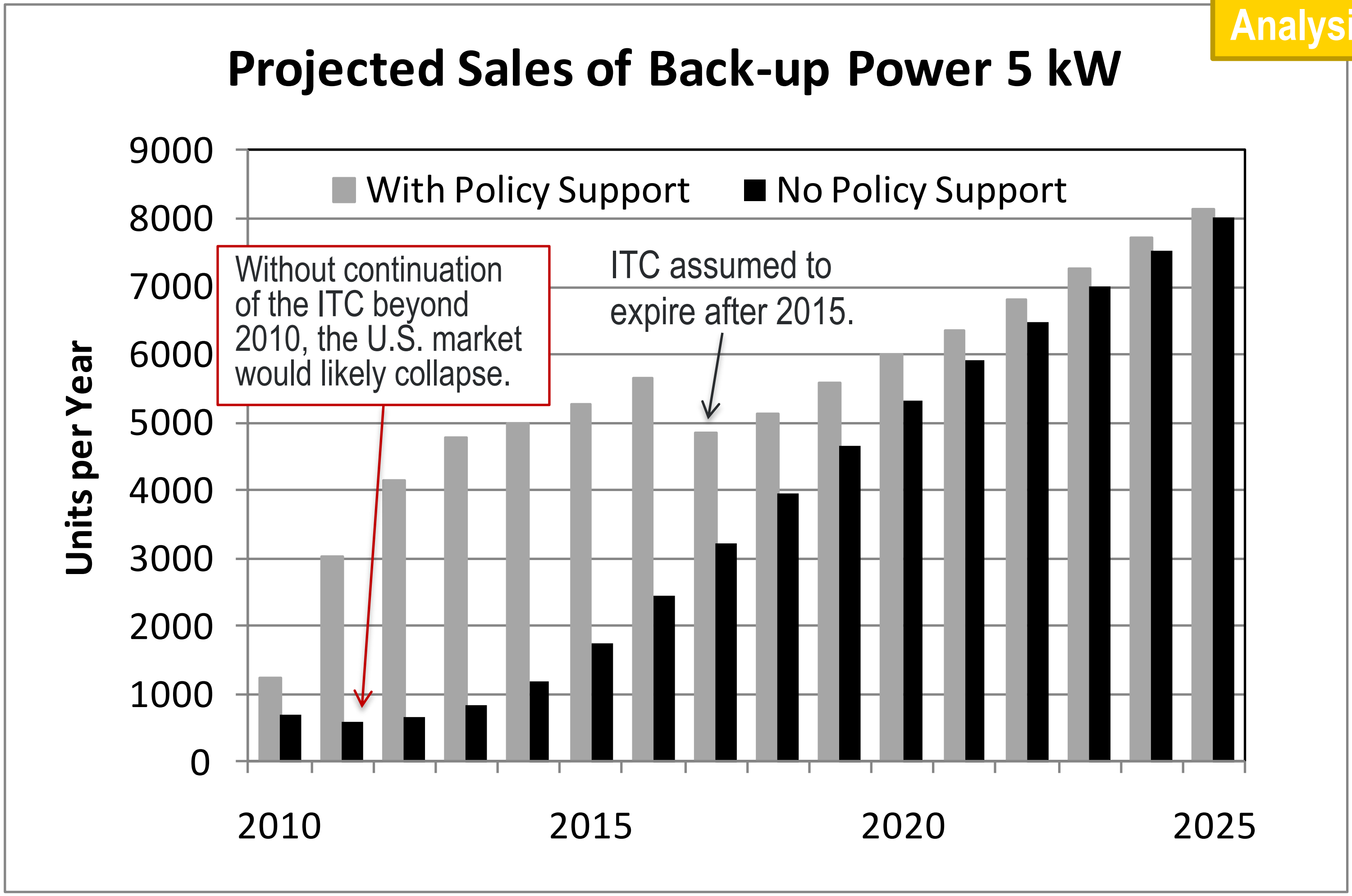


Purchases for demonstrations by private sector and all levels of government assumed to continue at 100 units per year from 2011 to 2020.
Assumed progress ratio of 0.9 and scale elasticity of -0.2. At productions levels shown, only one OEM is assumed.

David Greene, et al

Domestic sales of backup power fuel cells would be low for several years without existing incentives.

Preliminary Analysis



Only ARRA purchases have been excluded from the "No Policy" case. Other government procurements prior to 2011 are included in both cases.

Progress ratio of 0.9 and scale elasticity of -0.2. Number of OEMs is assumed to be 3. Government and private purchases for demonstration are 100 units/yr. in the policy case.

David Greene, et al

Collaborations

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.*

Universities

~ 50 projects with 40 universities

International

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

DOE Fuel Cell Technologies Program*

– ***Applied RD&D***
– ***Efforts to Overcome Non-Technical Barriers***
– ***Internal Collaboration with Fossil Energy, Nuclear Energy and Basic Energy Sciences***

Industry Partnerships & Stakeholder Assn's.

- **FreedomCAR and Fuel Partnership**
- **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)**

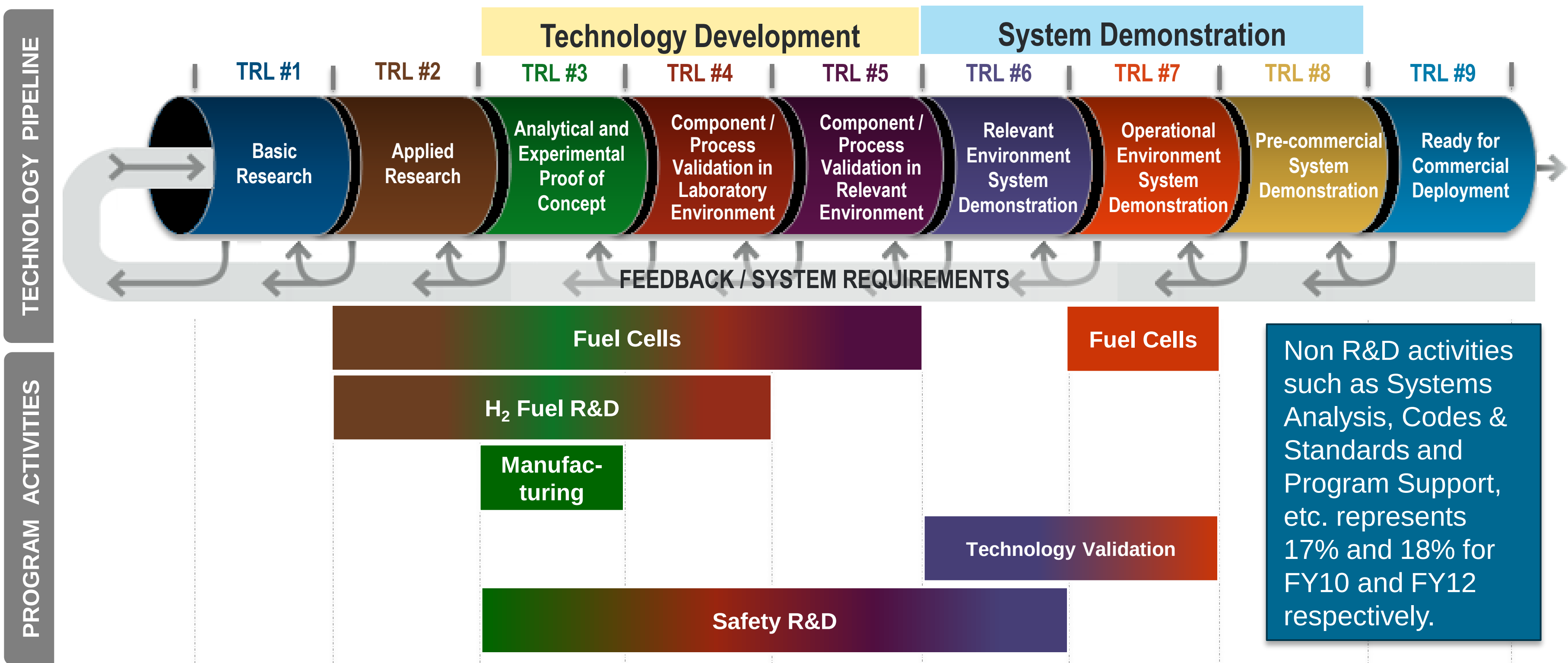
***P&D** = Production & Delivery; **S** = Storage; **FC** = Fuel Cells; **A** = Analysis; **SC&S** = Safety, Codes & Standards; **TV** = Technology Validation, **MN** = Manufacturing*

* Office of Energy Efficiency and Renewable Energy

Fuel Cell Technologies Program RD&D Activities

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

Fuel Cell RD&D activities range from applied research to operational environment demonstration.

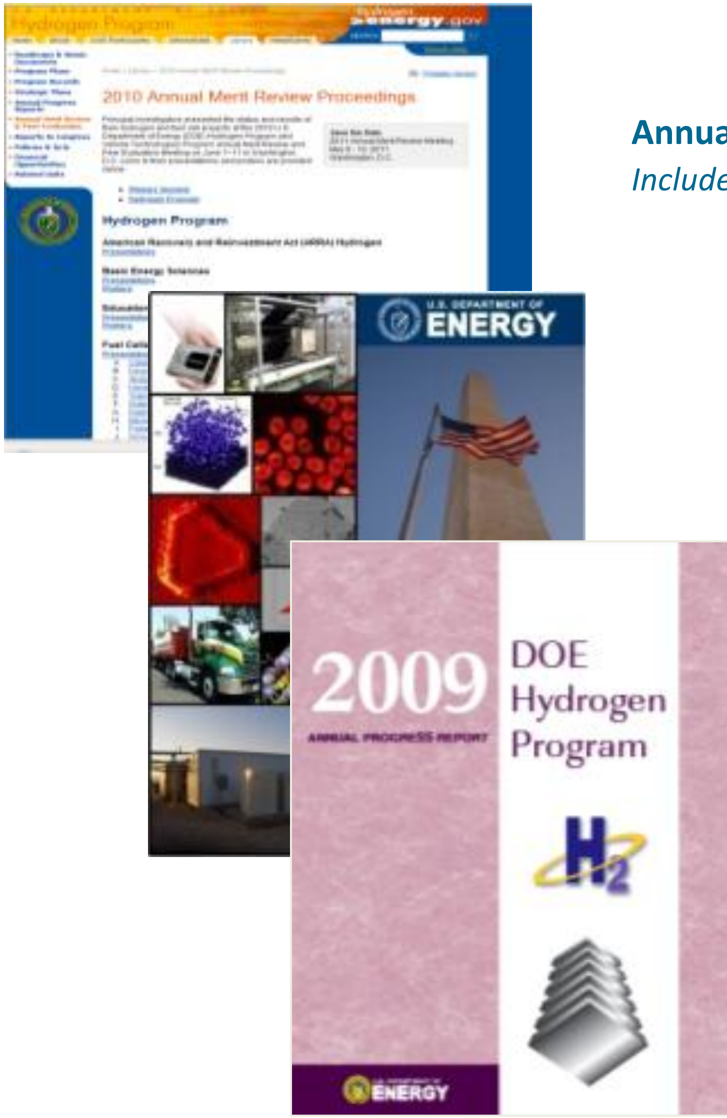


		TRL #1	TRL #2	TRL #3	TRL #4	TRL #5	TRL #6	TRL #7	TRL #8	TRL #9	Sum
FY 10	Total (millions of $)	0	55.7	47.6	11.7	2.4	9.1	12.4	4.0	1.2	144.1
	% of Total	0%	32%	27%	7%	1.4%	5.2%	7.1%	2.3%	0.7%	83%
FY 12	Total (millions of $)	0	40	29.8	3.4	1.4	0.3	7.2	0	0	82.1
	% of Total	0%	40%	30%	3.4%	1.4%	0.3%	7%	0%	0%	82%

The Office of Science conducts basic research (TRL#1)

To maintain a balanced portfolio, the percentage of funding for each TRL changes as advances are made.

Annual Merit Review



Annual Merit Review & Peer Evaluation Proceedings

Includes downloadable versions of all presentations at the Annual Merit Review

- **Latest edition released June 2010**

  www.hydrogen.energy.gov/annual_review10_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

- **Released January 2011**

  http://www.hydrogen.energy.gov/annual_review10_report.html

Annual Progress Report

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

- **Released February 2011**

  www.hydrogen.energy.gov/annual_progress.html

Next Annual Review: May 9 – 13, 2011

Washington, D.C.

http://annualmeritreview.energy.gov/