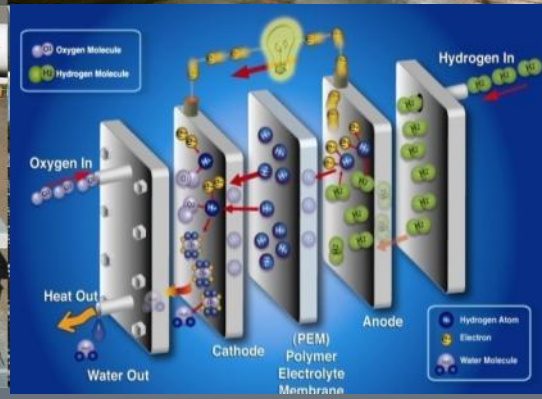
Fuel Cell Technologies Program Overview

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



US DOE Non-Metallic Materials Meeting

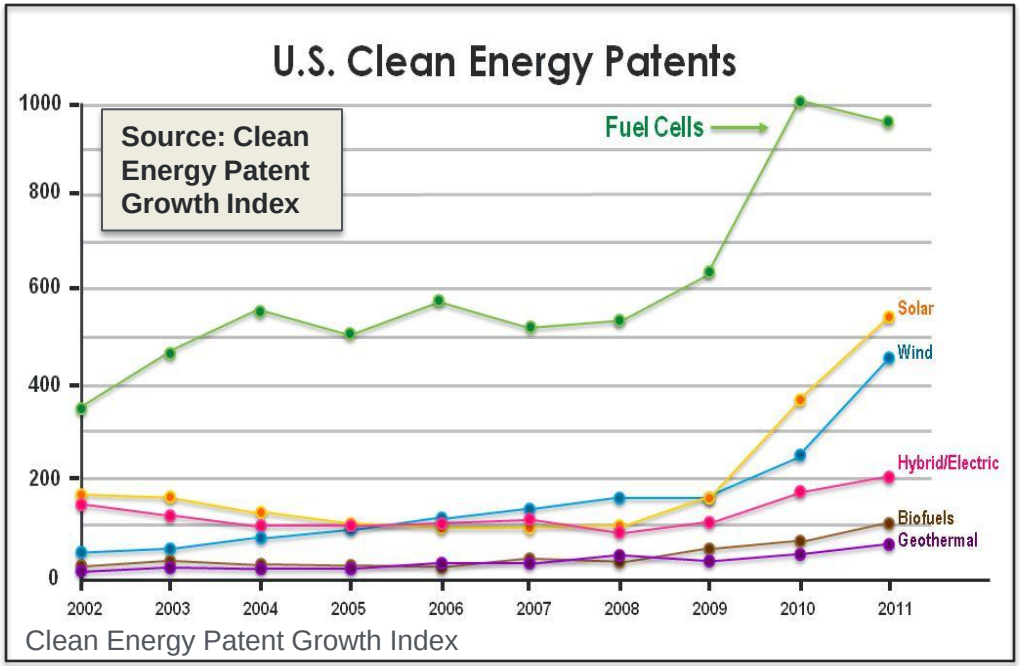
Washington, DC

10/17/2012

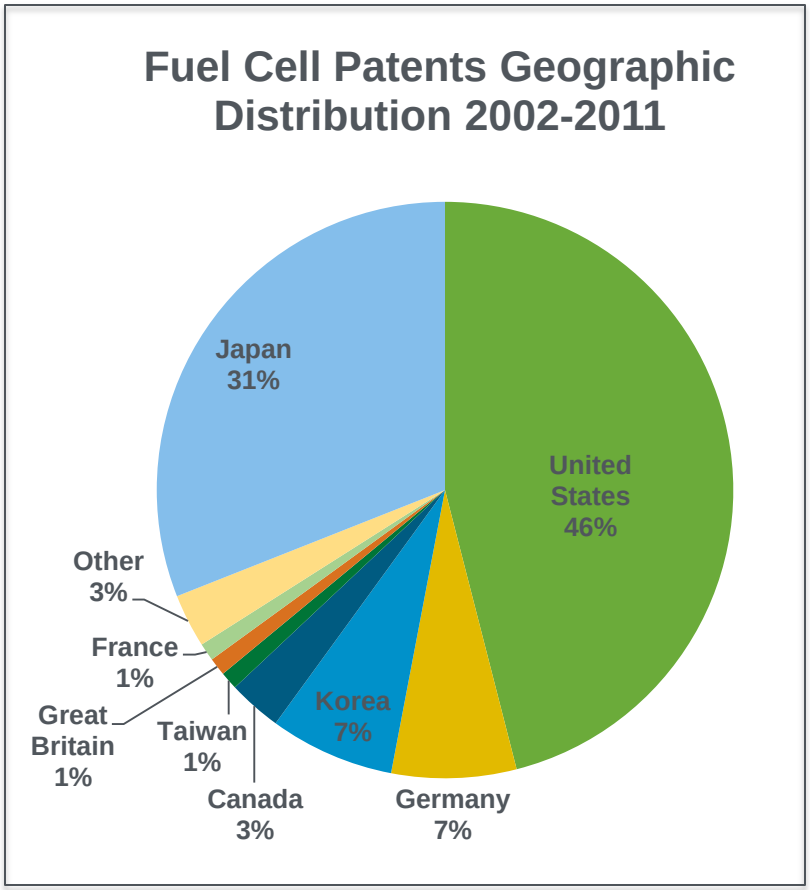
Dr. Sunita Satyapal

U.S. Department of Energy
Fuel Cell Technologies Program
Program Manager

Fuel Cells – An Emerging Global Industry



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



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

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

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

Worldwide Investment & Interest Are *Strong and Growing*

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Interest in fuel cells and hydrogen is global, with more than $1 billion in public investment in RD&D annually, and 17 members of the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE).

Activity by Key Global Players

Germany: >$1.2 Billion in funding ('07 – '16); projected demand for 1,000 hydrogen stations; >22,000 small fuel cells shipped.

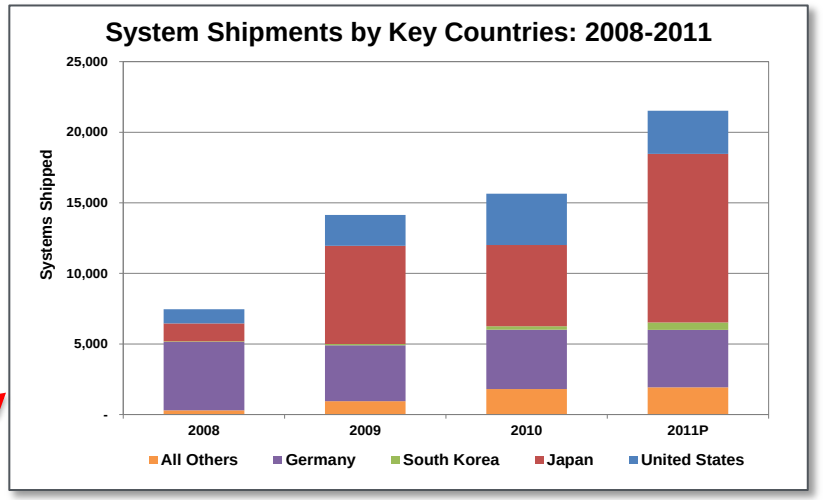
Japan: ~$1.0 Billion in funding ('08 – '12); plans for 2 million FCEVs and 1000 H_2 stations by 2025; 100 stations by 2015; 15,000 residential fuel cells deployed

European Union: >$1.2 Billion in funding ('08–'13)

South Korea: ~$590 M ('04-'11); plans to produce 20% of world shipments and create 560,000 jobs in Korea

China: Thousands of small units deployed; 70 FCEVs, buses, 100 FC shuttles at World Expo and Olympics

Many of the world's major automakers are planning commercialization of FCEVs in the 2012 – 2015 timeframe, including Toyota, Honda, GM, Daimler, Hyundai-Kia.



Fuel cell and hydrogen markets continue to grow

- **>20,000 systems shipped in 2011 (>35% increase from 2010)**
- **>55 Mtons produced in 2011 and >70Mtons projected for 2016**

Widespread market penetration could create:

- **180,000 new jobs in the US by 2020**
- **675,000 jobs by 2035**

Projected Global Market Revenues over the next 10-20 Years		
Stationary Power	Portable Power	Transportation
$14-$31B/yr	$11B/yr	$18-$97B/yr

Worldwide Commitment to FCEVs

The world's leading automakers have committed to develop FCEVs. Germany and Japan have announced plans to expand the hydrogen infrastructure.

Major Auto Manufacturers' Activities and Plans for FCEVs

General Motors
- >120 vehicles deployed since 2007 in Project Driveway
- 2012: Technology readiness goal for FC powertrain

Toyota
- 2010-2013: U.S. demo fleet of 100 vehicles
- "FCHV-adv" can achieve 431-mile range &68 mpgge
- 2015: Commercialize cars at <$100K

Honda
- Clarity FCX named "World Green Car of the Year"; EPA certified 72mpgge; leasing up to 200 vehicles
- 2015: Launch all-new fuel cell electric model sequentially in Japan, U.S. and Europe.

Daimler
- Plans for tens of thousands of FCEVs/year in 2015 – 2017 and hundreds of thousands a few years after
- Partnership with Linde to develop fueling stations.
- ***Moved up commercialization plans to 2014***

Hyundai-Kia
- 2012-2013: 2000 FCEVs/year
- 2015: 10,000 FCEVs/year
- "Borrego" FCEV has achieved >340-mile range.

Volkswagen
- Expanded demo fleet to 24 FCEVs in CA
- Recently reconfirmed commitment to FCEVs

SAIC (China)
- SAIC Motor Company is planning 20-30 prototypes in 2013 and >1,000 FCEVs in 2015.

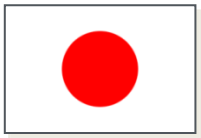
Nissan
- Commercial FCEVs planned for 2016. FCEVs are key part of "Nissan Green Program." Announced strategic partnership with Daimler on FCEVs.

BMW
- Fielding a fleet of "F-Cell" vehicles in the U.S. 40 currently leased with another 20 on the way.

Based on publicly available information during 2011 – 2012. Ford involved through Ballard-Daimler partnership (AFCC).

H_2Mobility - evaluate the commercialization of H_2 infrastructure and FCEVs
- Public-private partnership between NOW and 9 industry stakeholders including:
  - Daimler, Linde, OMV, Shell, Total, Vattenfall, EnBW, Air Liquide, Air Products
- FCEV commercialization by 2015.
- $40€ investment to ensure 50 hydrogen station by 2015.

UKH_2Mobility will evaluate anticipated FCEV roll-out in 2014/2015
- 13 industry partners including:
  - Air Liquide, Air Products, Daimler, Hyundai, ITM Power , Johnson Matthew, Nissan, Scottish & Southern Energy, Tata Motors, The BOC Group, Toyota, Vauxhall Motors
- Government investment of £400 million to support development, demonstration, and deployment.



13 companies and Ministry of Transport announce plan to commercialize FCEVs by 2015
- 100 refueling stations in 4 metropolitan areas and connecting highways planned, 1,000 station in 2020, and 5,000 stations in 2030.

Completed world's largest single FCEV & H_2 Demonstration to date (50-50 DOE-Industry cost share)

- >180 fuel cell vehicles and 25 hydrogen stations
- 3.6 million miles traveled; 500,000 trips
  - ~152,000 kg of hydrogen produced or dispensed; >33,000 refuelings

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

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

Demonstrated world's first Tri-generation station

Anaerobic digestion of municipal wastewater (Orange County Sanitation District)

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

(Air Products, FuelCell Energy)

Demonstrated H_2 for Energy Storage (NREL)

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

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

Market Transformation- Early Market Deployment Summary

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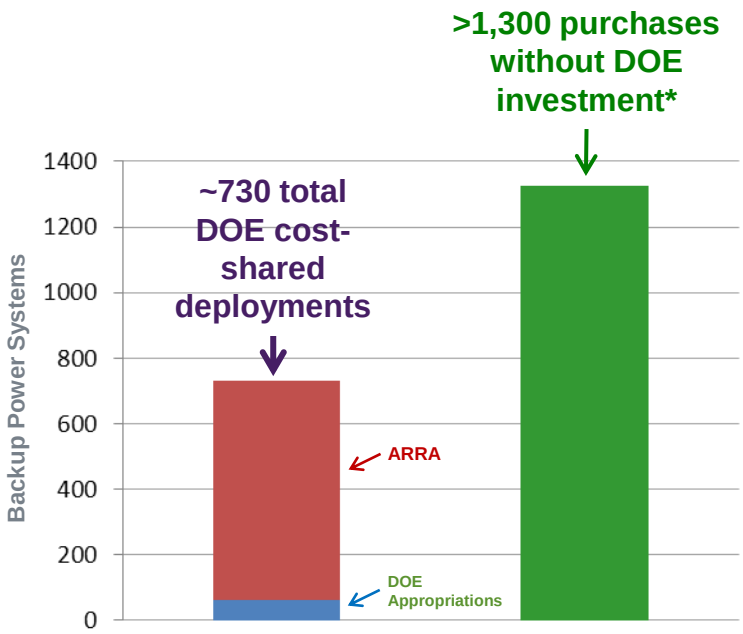
Early market deployments of approximately 1,400 fuel cells have led to more than 5,000 additional purchases by industry—with no further DOE funding.

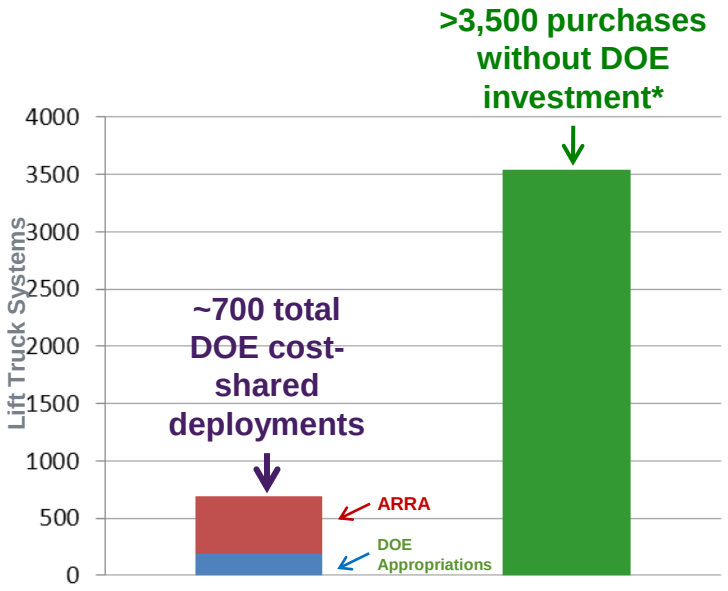
Backup Power Units



Leveraging DOE funds:

DOE deployments led to almost 2X additional purchases by industry.

Lift Truck Deployments



Leveraging DOE funds:

DOE deployments led to >5X additional purchases by industry.

Recovery Act and Market Transformation Activities – Government as "Catalyst" for market success of emerging technologies

**Industry purchases include units on order*

Safety, Codes & Standards Overview

Goals: Support the widespread commercialization of hydrogen and fuel cells by facilitating development of regulations, codes, and standards (C&S), and by developing and implementing practices to ensure the safe use of hydrogen and fuel cell technologies

Approach

Identify R&D needs

- Lead stakeholder workshops, develop R&D roadmaps
- Analyze existing codes and standards, safety knowledge
- Participate in technical working groups

Perform High-Priority R&D

- Understand foundational hydrogen behavior
- Quantitative Risk Assessments
- **Compatible materials and components**
- Develop and harmonize test protocols

Impact Codes and Standards

- Participate in and lead technical committees to develop requirements
- Publish R&D results
- Disseminate critical data and safety information

Harmonize Internationally

Global Technical Regulations (GTR Phase 1-SAE J2578, SAE J2579)
International Standards Development Organizations(e.g., ISO, IEC)
International Partnerships and Agreements (IPHE, IEA)

Key challenges include:

- Lack of sufficient hydrogen safety information (including materials compatibility in a hydrogen environment)
- Need to synchronize codes and standards development with technology deployment needs
- Lack of coordination of R&D with codes and standards development cycle and revision schedule
- Need to harmonize C&S domestically and internationally
- Need to standardize the permitting process for H_2 infrastructure

Open Energy Information

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Hydrogen

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Related Links

- List of Hydrogen Incer... hydrogen related polic... be sorted by state an... provided by DSIRE.
- Controlled Hydrogen F... Demonstration and Va...
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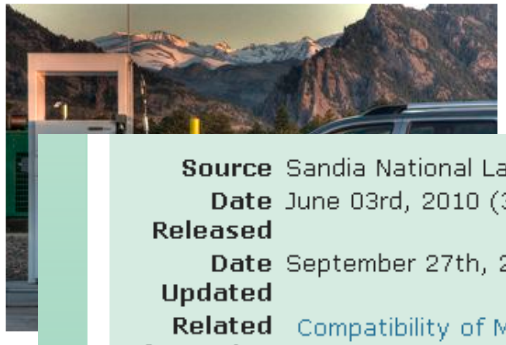
Technical Reference for Hydrogen Compatibility of Materials



Guidance on materials selection for hydrogen service is needed to support the deployment of hydrogen as a fuel as well as the development of codes and standards for stationary hydrogen use, hydrogen vehicles, refueling stations, and hydrogen transportation. Materials property measurement is needed on deformation, fracture and fatigue of metals in environments relevant to this hydrogen economy infrastructure. The

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Source Sandia National Laboratories

Date Released June 03rd, 2010 (3 years ago)

Date Updated September 27th, 2012 (3 weeks ago)

Related Information Compatibility of Materials | hydrogen | NREL | Sandia | Technical Database | Technical Reference

Data

- 1100_cia85_ten_fra_fat.xlsx (xlsx, 60.9 KiB)
- 1100_san10_fra_fat.xlsx (xlsx, 58.5 KiB)
- 1100_san10b_fra_fat.xlsx (xlsx, 59.4 KiB)
- 1100_san11_fra_fat.xlsx (xlsx, 48.4 KiB)
- 1100_san11b_fra_fat.xlsx (xlsx, 48 KiB)
- 1211_nib10_fra_fat.xlsx (xlsx, 56 KiB)
- 1211_san11_fat.xlsx (xlsx, 58.4 KiB)
- 3230_san11_fra_fat.xlsx (xlsx, 48 KiB)

Other Metadata accessible through RDF/XML

Temporal and Spatial Coverage

Frequency

Time Period

Comments

For more information, visit:
http://en.openei.org/wiki/Main_Page

Meeting Objectives

Objective: Discuss knowledge gaps and data needs for using polymers and composite material systems in hydrogen service, particularly at high pressures (up to 100 MPa), demanding duty cycles, and long service life.

Provide important input to enable lower cost, higher performance systems through improved knowledge and revised codes and standards.

The product of the meeting will help inform testing needs to better enable near-term applications of polymers and composite systems in hydrogen service, including components at high pressure and extreme temperatures.

Thank You

Sunita.Satyapal@ee.doe.gov

New energy data initiative to share the latest energy information and data. Please visit:

http://en.openei.org/wiki/Gateway:Hydrogen

hydrogenandfuelcells.energy.gov