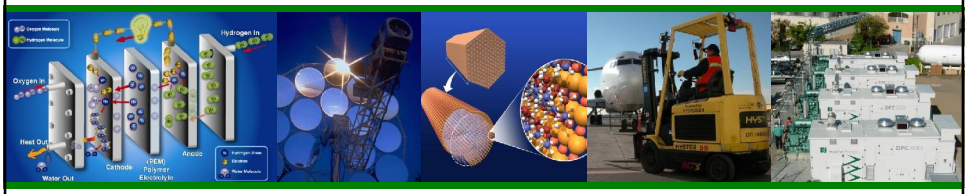
International Partnership for Hydrogen and Fuel Cells in the Economy



U.S. Country Update

IPHE Steering Committee Meeting

Sunita Satyapal
Director
Hydrogen and Fuel Cells Program
U.S. Department of Energy

May 20, 2014
Oslo, Norway

Fuel Cells are part of All-of-the-Above Energy Strategy

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

Secretary Moniz looks under the hood of the Hyundai Tucson fuel cell vehicle, which will be available in California in spring 2014.

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

- Dr. David Danielson Assistant Secretary for Energy Efficiency and Renewable Energy, 2012

"We've got to invest in a serious, sustained, all-of-the-above energy strategy that develops every resource available for the 21st century."

– President Barack Obama

President's Climate Action Plan Released June 2013
Plan to cut carbon pollution and combat global climate change.

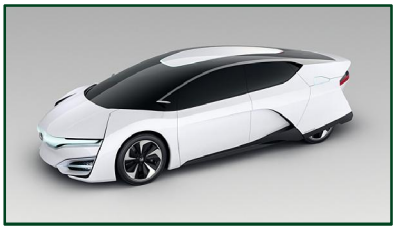
Fuel Cell Electric Vehicles at U.S. Auto Shows

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

FCEVs on display at North American auto shows.

Hyundai Tucson Fuel Cell Electric Vehicle

To be launched in California in Spring 2014—lease includes **free H_2 and maintenance**.



Honda Fuel Cell Electric Vehicle

Toyota Fuel Cell Electric Vehicle

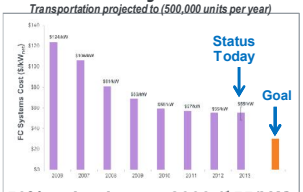
DOE R&D, Demonstration, & Deployment Successes

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

DOE R&D (>$2B)

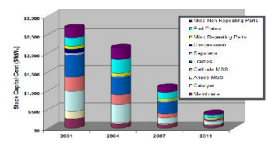
Fuel Cell System Cost

Transportation projected to (500,000 units per year)



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

Electrolyzer Stack Costs



60% reduction since 2007

DOE Demonstrations Technology Validation

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

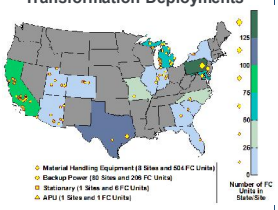
Demonstrated
- *>180 FCEVs*
- *25 stations*
- *3.6 million miles traveled*
- *World's first tri-gen station (250 kW on biogas, 100 kg/d)*

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

Deployments

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

Recovery Act & Market Transformation Deployments



Nearly 1,600 fuel cells deployed

Enabling Early Markets

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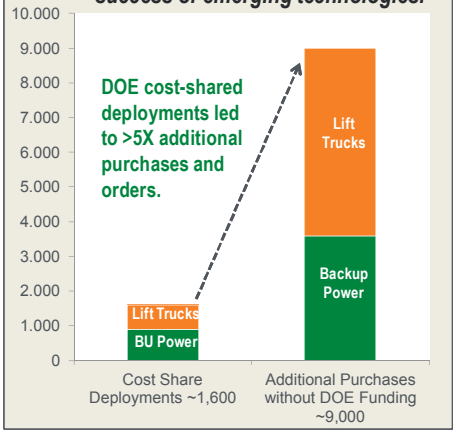
Deployments help catalyze market penetration and ensure continued technology utilization growth while providing data and lessons learned.

Leveraging DOE Funds:

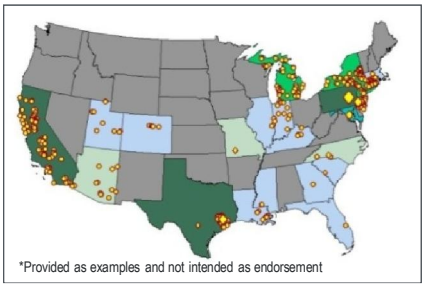
Government as "catalyst" for market success of emerging technologies.



~9,000 ADDITIONAL FUEL CELL LIFT TRUCKS AND BACKUP POWER UNITS PLANNED OR INSTALLED **with NO DOE funding**

Examples of industry* sectors in DOE ARRA projects

- Telecommunications (e.g. AT&T, PG&E. Sprint, etc.)
- Distribution Centers/Warehouses (e.g. FedEx, Genco, Sysco, Wegmans, Whole Foods, etc.)



*Provided as examples and not intended as endorsement

Data Collection & Analysis: Backup Power and Material Handling Equipment

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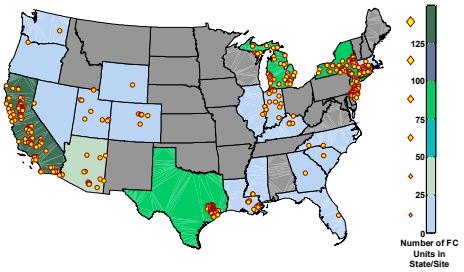
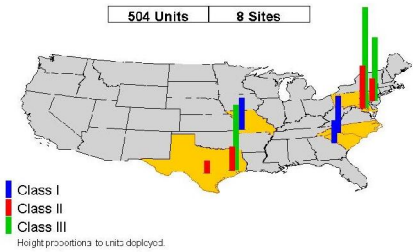
Validated over 800 backup power units with seven industry partners

- FedEx Freight East, GENCO, Nuvera Fuel Cells, Plug Power, ReliOn Inc., Sprint Communications, Sysco of Houston –

- **842 units in operation**[1]
- **1.94 MW installed capacity**, average site capacity of 4-6 kW
- **99.7% successful starts** (2,579 start attempts)
- **65 continuous hours demonstrated**
- **>1,600 operation hours**





Validated over 450 material handling equipment units with seven industry partners

- **490 units in operation**[2]
- **>1,800,000 operation hours**, 4.4 average operation hours between fills
- **~230,000 kg of hydrogen dispensed** during more than **290,000 hydrogen fills** with an average of **0.6 kg per fill**

[1]Not all systems have detailed data reporting to NREL. [2]One project has completed.

Data from 2009 Q1 to 2013 Q2.

$7M in New DOE-Funded Selections

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- Demonstrate and Deploy Fuel Cell Hybrid Electric Medium-Duty Trucks
  - **FedEx Express**
  - **Center for Transportation-Environment with United Parcel Service**
- Demonstrate Hydrogen Bulk Delivery
  - **Air Products & Chemicals with Structural Composites Industries**
- Demonstrate Rooftop Fuel Cell Back-up Power Installations
  - **Sprint Corporation**

New Announcement: H2 Fueling Infrastructure Research Station Technology Project

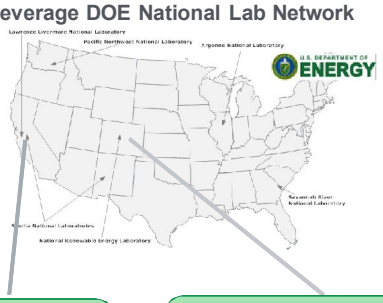
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

NREL and SNL Provide:

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

H2FIRST in support of H2USA

Leverage DOE National Lab Network



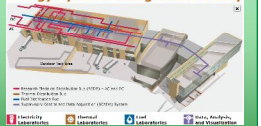
Current H_2USA partners

Sandia National Laboratories

Center for Infrastructure Research & Innovation

NREL

Energy Systems Integration Facility



Distributed Energy Resources Test Facility

Federal Policies Promoting Fuel Cells

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

Some tax credits affecting fuel cells were expanded and a new act was proposed that can help facilitate federal deployments.

Investment Tax Credit	• 30% for qualified fuel cell property or $3,000/kW of the fuel cell nameplate capacity (i.e., expected system output), whichever is less. • Equipment must be installed by Dec. 31, 2016. • 10% credit for combined heat-and-power-system property
Hydrogen Fuel Infrastructure Tax Credit	• 30% of cost, not to exceed $30,000 • Consumers who purchase qualified residential fueling equipment may receive a tax credit of up to $1,000
H-Prize	• Cash prizes to advance the commercial application of hydrogen energy technologies • $1M, $4M, and $10M categories. • Topic: Hydrogen Refueler (residential & commercial)

Fuel Cell Technologies Budget

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

(Dollars in Thousands)	FY 2014	FY 2015 Request
Fuel Cell R&D	33,383	33,000
Hydrogen Fuel R&D	36,545	36,283
Manufacturing R&D	3,000	3,000
Systems Analysis	3,000	3,000
Technology Validation	6,000	6,000
Safety, Codes and Standards	7,000	7,000
Market Transformation	3,000	3,000
NREL Site Wide Facility Support	1,000	1,700
Total, Fuel Cell Technologies	**92,928**	**92,983**

(Dollars in Thousands)	FY 2014
Basic Science	~$25M
Fossil Energy, SECA	~$25M
ARPA-E	~$30M
Total	**~$80M**

Total FY14 Budget: >$172M

Hydrogen and Fuel Cell Initiatives at the State Level

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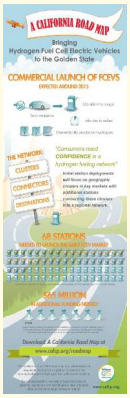
Several states—including California, Connecticut, Hawaii, Ohio, New York, and South Carolina—have major hydrogen and fuel cell programs underway.

8 states sign MoU to put 3.3M zero-emission vehicles on roads by 2025

States include California, Connecticut, Massachusetts, Maryland, New York, Oregon, Rhode Island, & Vermont

- Represents a new vehicle market penetration of ~15%

California



FCEVs and Fuel Cell Buses

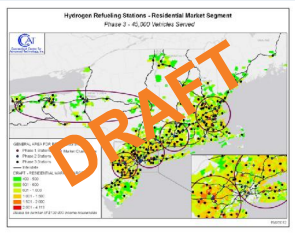
- **> 560 vehicles** in operation since 1999 — ~230 currently operating
- **> 6 million miles** driven
- **> 1 million passengers** on fuel cell buses

H_2 Station Investment

- **$51.5M invested** *(CARB and CEC)*
- **~$13M invested** by SCAQMD
- **~$46.6M for 28 stations and 1 mobile refueler** (CEC PON 13-607)
- **$20M planned annually** thru 2023 for at least 100 stations (AB8)

Northeast (e.g. MA, NY, CT)

Preliminary Plans: *3 phase plan modelled by CCAT for the development of hydrogen infrastructure and deployment of fuel cell electric vehicles (FCEVs) in the north eastern coastal metro centers.*



Hawaii

Agreement signed by 12 stakeholders—including GM, utilities, hydrogen providers, DOD, DOE—to establish hydrogen as a major part of the solution to Hawaii's energy challenges.

- **15 GM FCEVs** currently in demonstrations with military
- **Renewable hydrogen** (from geothermal and wind energy) will be used for buses
- Goals include a public access nascent refueling infrastructure on Oahu by 2020 to support initial deployments of government and industry FCEV fleets

Future Plans - Summary

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Continue to promote and strengthen R&D activities

- Hydrogen, fuel cells, safety, manufacturing, etc.
- Cost, performance, durability need to be addressed

Conduct strategic, selective demonstrations of innovative technologies

- Industry cost share and potential to accelerate market transformation

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

- Life cycle cost; economic & environmental analyses, etc.

Leverage activities to maximize impact

- U.S. and global partnerships
- H2USA: Public-Private partnership to enable widespread commercialization of hydrogen vehicles in the United States
- NHTSA preparing to adopt Global Technical Regulation for FCEVs. Co-sponsors planning Phase 2 activities.

Global Collaboration is Critical

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To meet global fuel needs and reduce emissions, sustained and effective worldwide collaboration is critical.

"It is literally true that you can succeed best and quickest by helping others to succeed."

- Napoleon Hill, American Author 1883-1970

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Thank You

Sunita.Satyapal@ee.doe.gov

hydrogenandfuelcells.energy.gov

Fuel Cell Cost Reduction

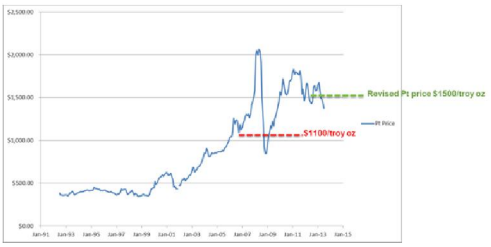
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Projected high-volume cost of fuel cells has been reduced to $55/kW (2013)*

- ***More than 30% reduction since 2008***
- ***More than 50% reduction since 2006***

***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.*

Projected Transportation Fuel Cell System Cost
-projected to high-volume (500,000 units per year)-



Hydrogen Production Strategies

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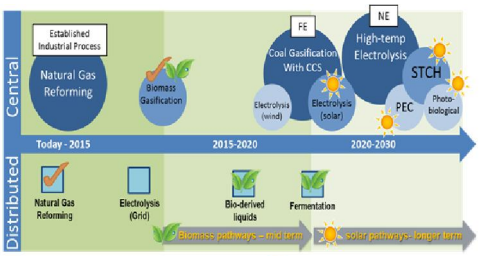
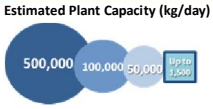
Goal: Develop technologies to produce hydrogen from clean, domestic resources at a delivered and dispensed cost of $2-$4/gge H_2



Estimated Plant Capacity (kg/day)

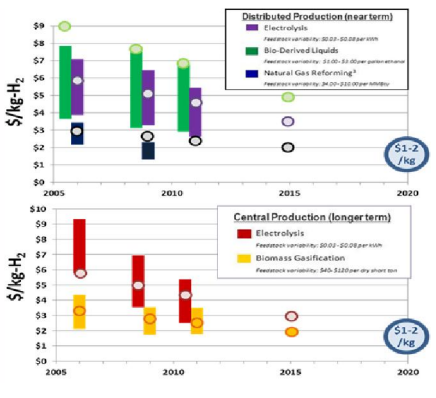


P&D Subprogram R&D efforts successfully concluded

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

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

Projected High-Volume Cost of Hydrogen Production for Different Pathways



- Cost ranges are shown in 2007 dollars, based on projections from H2A analyses, and reflect variability in major feedstock pricing and a bounded range for capital cost estimates.
- Projections of costs assume Nth-plant construction, distributed station capacities of 1,500 kg/day, and centralized station capacities of ≥50,000 kg/day.