

International Workshop On Hydrogen Safety Training for First Responders

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy



U.S. Perspectives on Hydrogen and Fuel Cells

Aix-en-Provence, France

September 3-4, 2014

Kym Carey

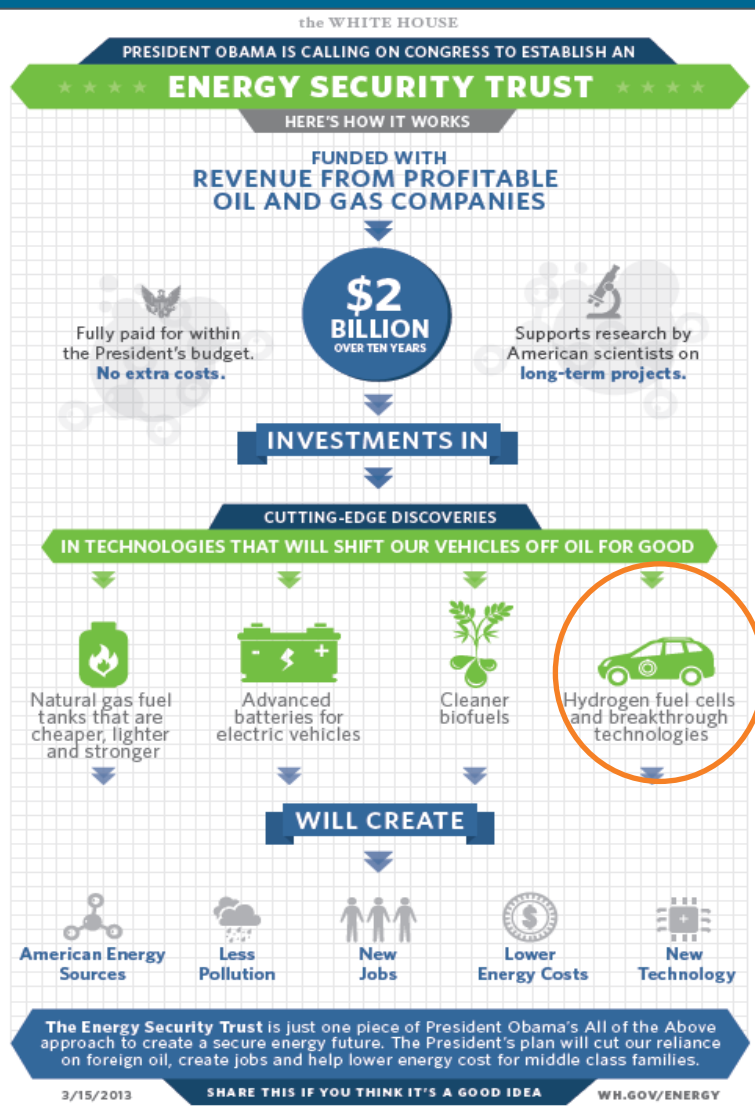
Project Manager

Safety, Codes and Standards Program

Fuel Cell Technologies Office

H₂ and Fuel Cells support our national energy strategy

H₂ and Fuel Cell Technologies are part of the “all-of-the-above” energy strategy and can reduce GHG emissions and our dependency of petroleum-based fuels



“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

Examples of Key National Energy Goals And Climate Action Plan

- ✓ Reduce oil imports by **50%** by 2020, compared to 2008
- ✓ Reduce GHG emissions **17%** below 2005 levels by 2020

Sustainable TRANSPORTATION

- Efficiency Improvement
- Fuel Diversification
- Domestic & Renewable Sources
- Reduced GHG



Hydrogen and Fuel Cells



Vehicles

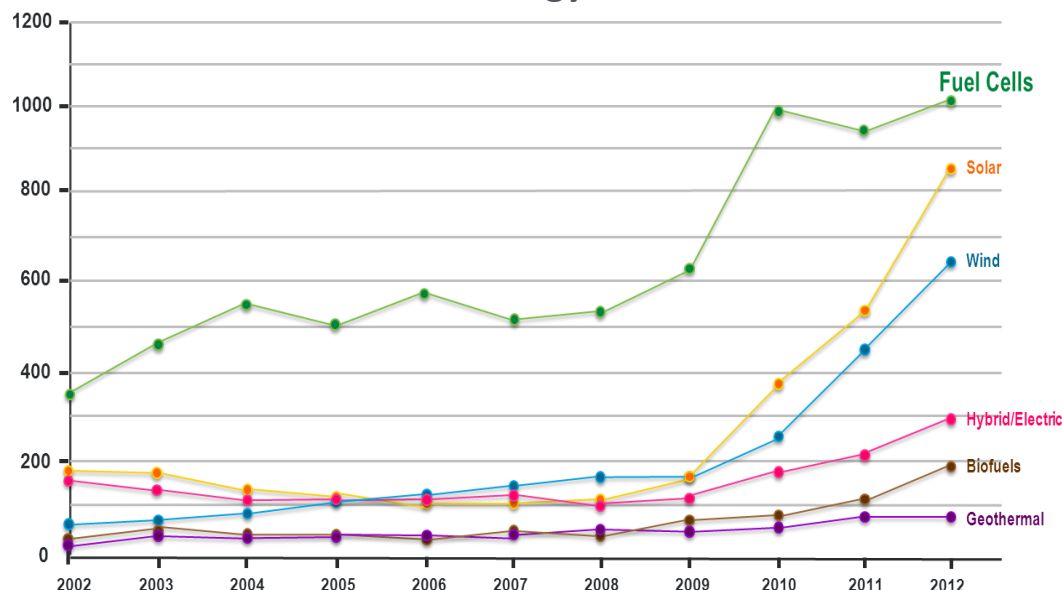


Bioenergy

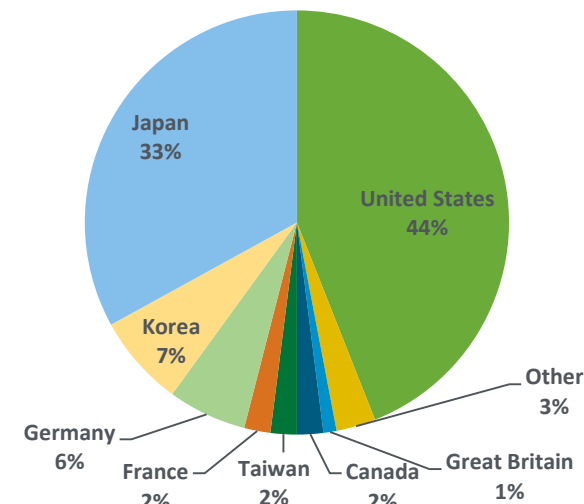
Growing Number of Patents for Fuel Cells Domestically and Internationally

The number of patents in clean energy technologies continues to grow and fuel cell patents in the U.S. outnumber patents from any other clean energy industry

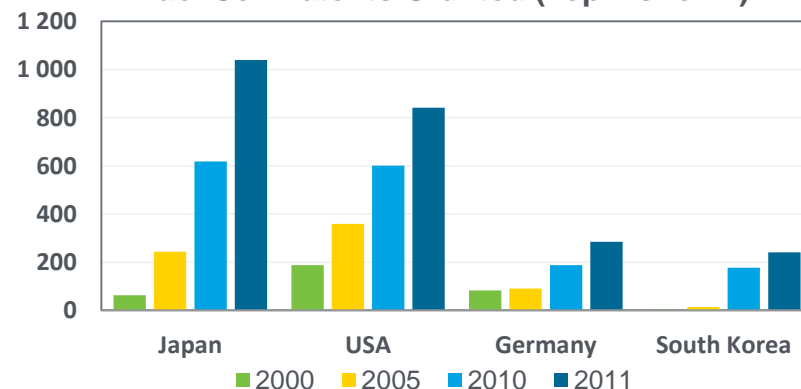
US Clean Energy Patents¹



Fuel Cell Patents Geographic Distribution 2002-2012



Fuel Cell Patents Granted (Top 4 shown)



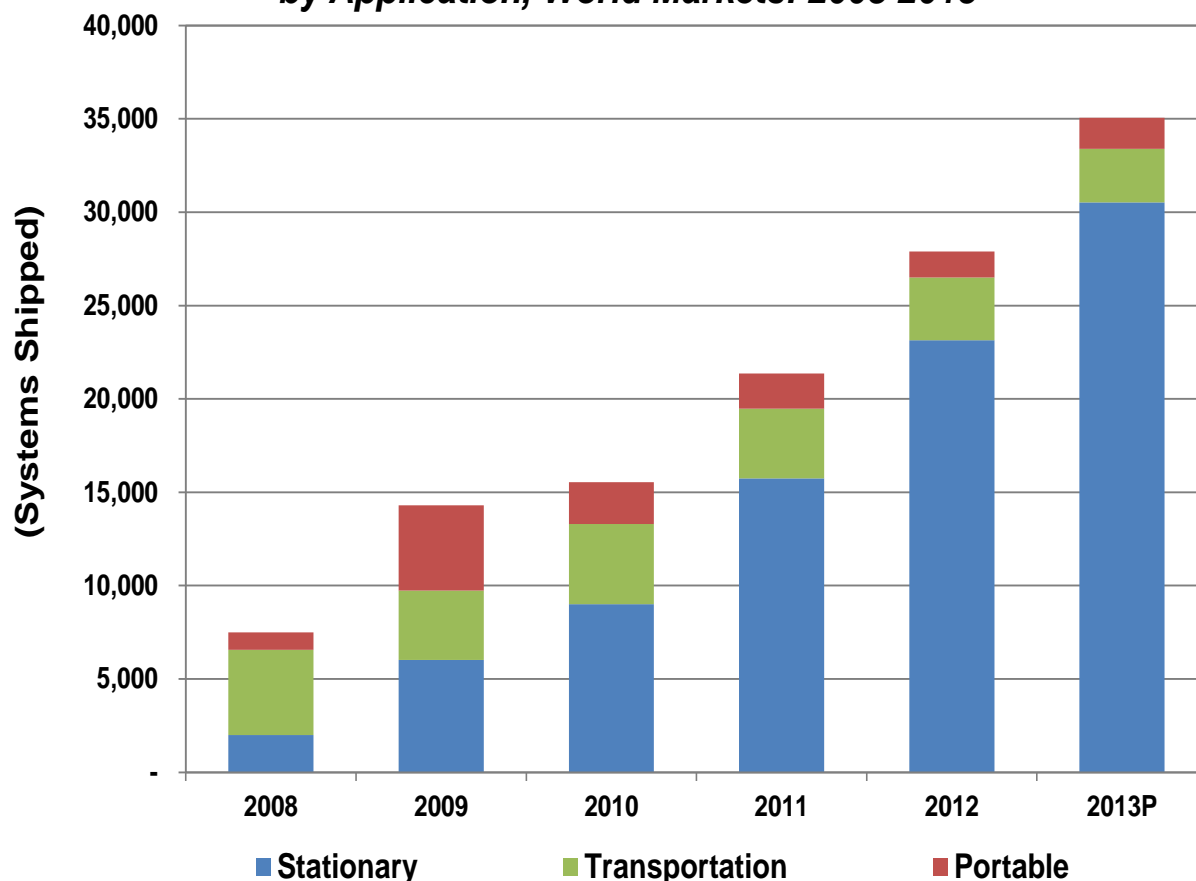
>1,000 U.S. fuel cell patents issued

The U.S. produced **44%** of fuel cell patents followed by Japan with **33%** from 2002 to 2012

¹ Clean Energy Patent Growth Index http://cepgi.typepad.com/heslin_rothenberg_farley_/2013/03/clean-energy-patent-growth-index-2011-year-in-review.html

Steady world market increase signals a need for greater commitment to enable commercialization in this emerging technology

Fuel Cell Systems Shipped
by Application, World Markets: 2008-2013



26% growth in fuel cell systems shipments worldwide over 2012

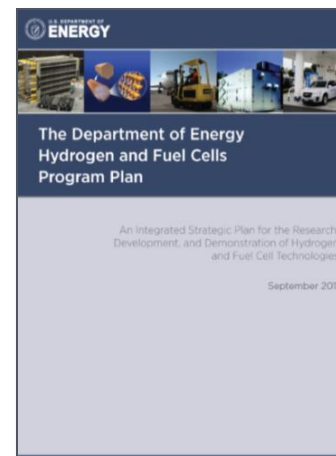
~30% consistent annual market growth

>30K units shipped in 2013

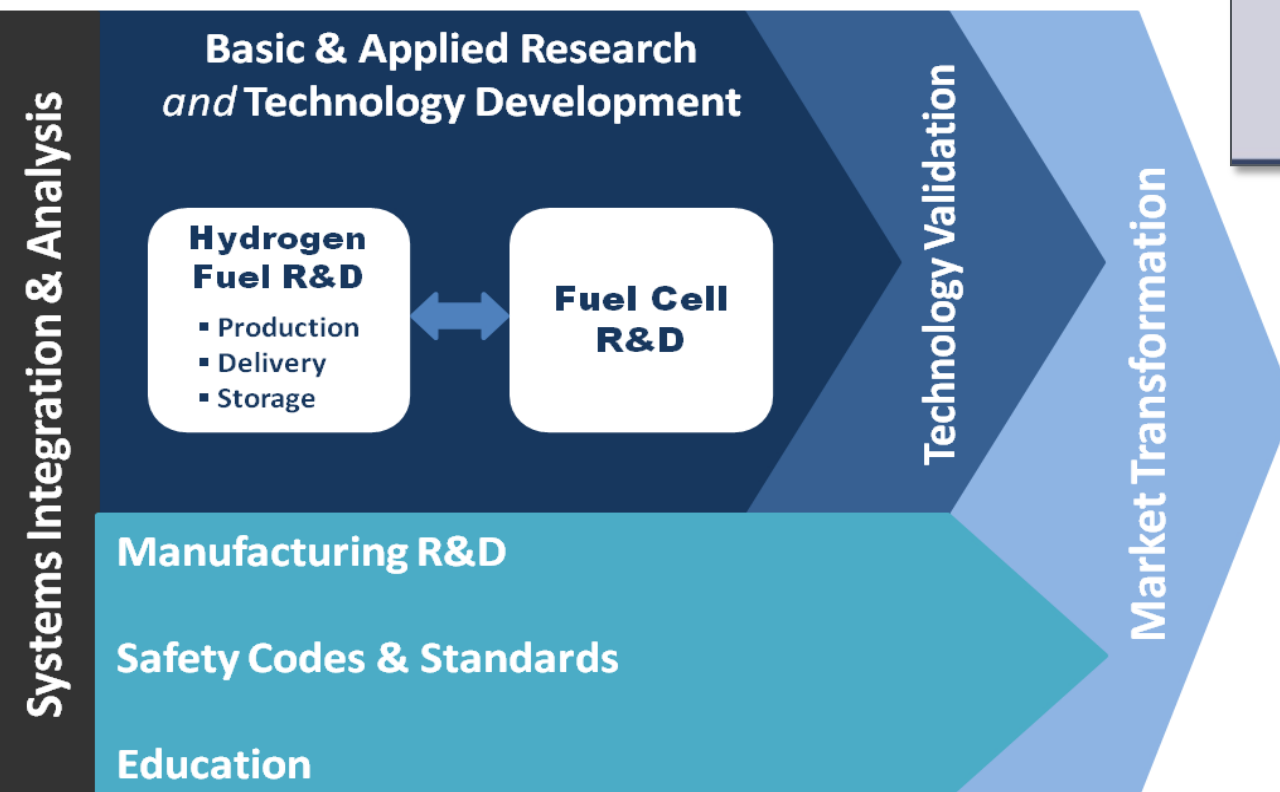
DOE Program Overview

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

More than 200 projects currently funded at companies, national labs, and universities/institutes



The DOE Hydrogen and Fuel Cells Program Plan Released Sept 2011 Update to the Hydrogen Posture Plan (2006) Includes Four DOE Offices EERE, FE, NE and Science



WIDESPREAD COMMERCIALIZATION ACROSS ALL SECTORS

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

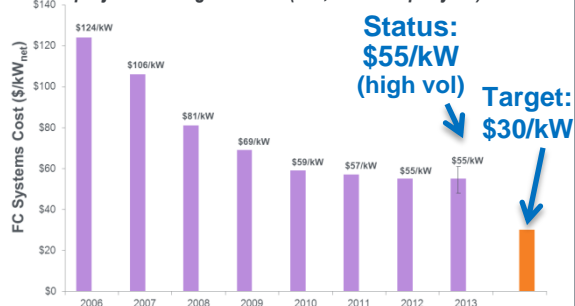
DOE R&D

- Reduces cost and improves performance

Examples of progress:

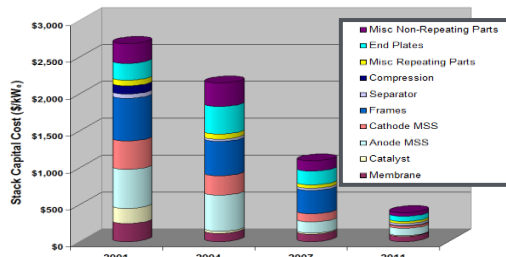
Transportation Fuel Cell System Cost

- projected to high-volume (500,000 units per year) -



→ Reduced cost of fuel cells 50% since 2006

→ 2020 target \$40/kW, ultimate target \$30/kW



→ Reduced cost of electrolyzer stacks 60% since 2007

DOE Demonstrations & Technology Validation

- Validate advanced technologies under real-world conditions
- Feedback guides R&D



Demonstrated >180 FCEVs, 25 stations, 3.6 million miles traveled

Examples—validated:

- 59% efficiency
- 254 mile range (independently validated 430-mile range)
- 75,000-mi durability

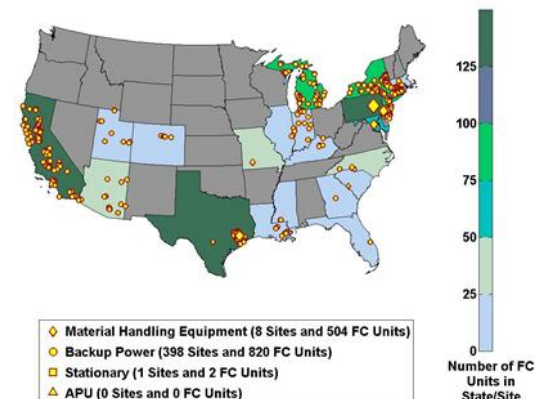
Demonstrated world's first tri-gen station (250 kW on biogas, 100 kg/d)

Program also includes enabling activities such as codes & standards, analysis, and education.

Deployments

- DOE Recovery Act and 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

Technology Validation; Safety, Codes & Standards; and Market Transformation are strategically balanced and closely coordinated. All three of these subprograms are essential to the Office's successful strategy for moving laboratory successes into commercial markets.

Technology Validation

- Demonstrates and validates pre-commercial technologies before deployment by collecting and analyzing performance data
- Validate vehicles and infrastructure (>180 vehicles; world's first Tri-Gen station)
- Future focus includes high pressure electrolyzers, ionic & electrochemical compressors, Reefers, and range extenders.

Safety, Codes and Standards

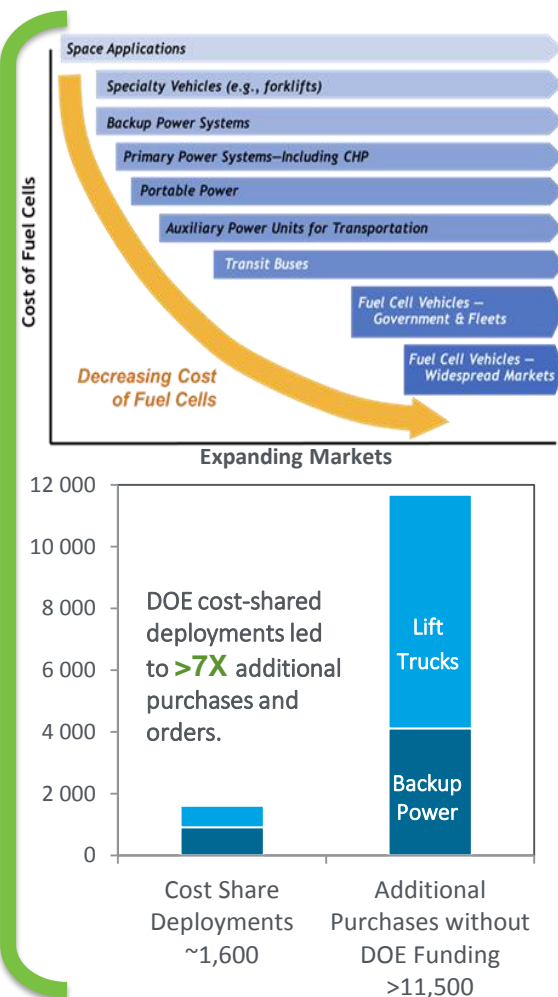
- Enables development of necessary codes & standards and provides critical safety information with hydrogen community.
- Enables smooth introduction of new technologies. Highlights include work on separation distances, refueling protocols, GTR, and MHE tank cycle-life testing.

Market Transformation

- Provides financial and technical assistance to enable deployments of **proven technologies** to spur early markets and build business cases
- Successes in material handling equipment and back up power deployments leading to additional purchases.

An integrated strategy enables expanding commercial markets ...

... and successful deployments that catalyze early market growth

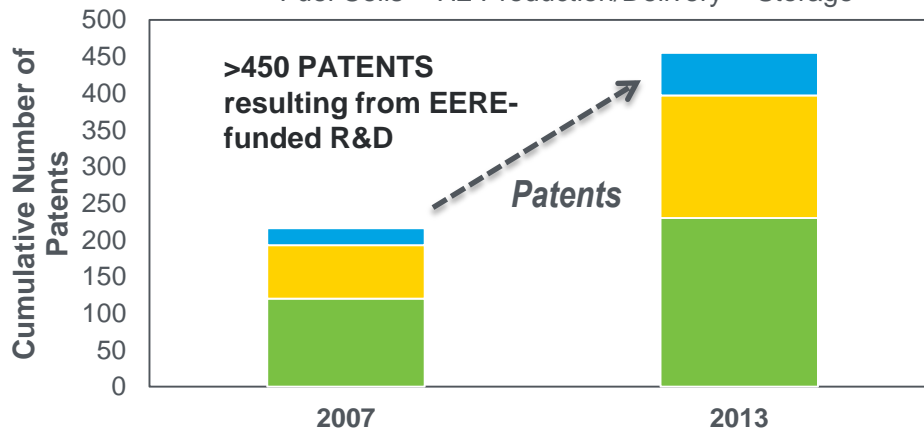
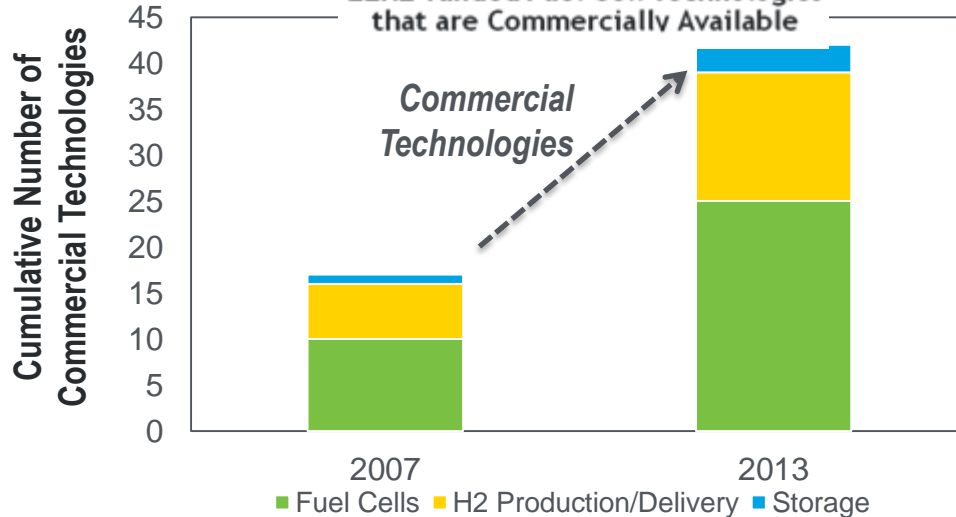


Assessing the Impact of DOE Funding

DOE FCTO funding has led to >450 patents, 42 commercial hydrogen and fuel cell technologies and 65 emerging technologies.

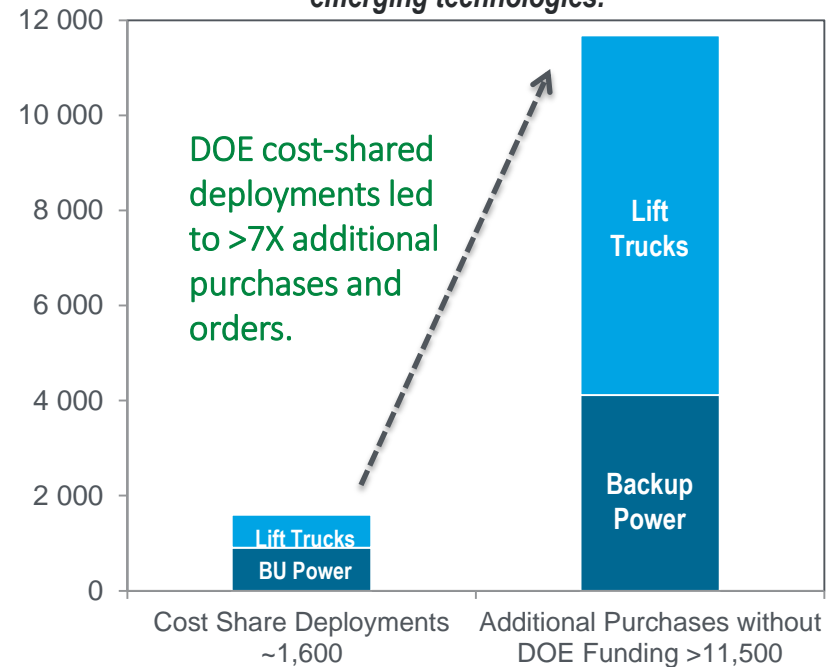
Accelerating Commercialization

EERE-funded Fuel Cell Technologies
that are Commercially Available



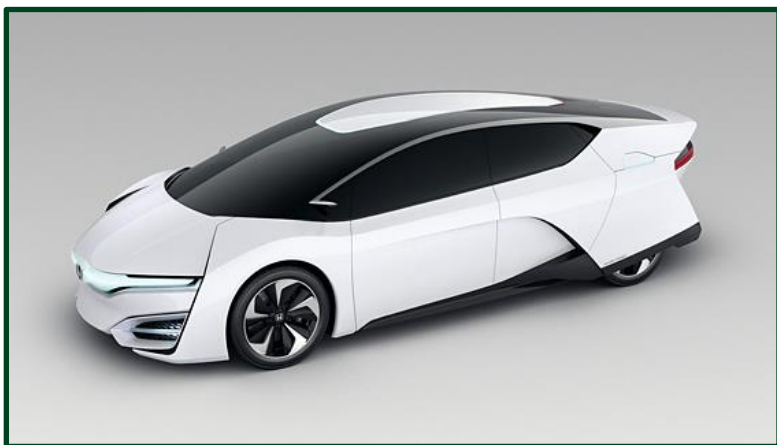
Leveraging DOE Funds:

Government as “catalyst” for market success of
emerging technologies.



Over **\$37M** saved in the last 5
years through active project
management

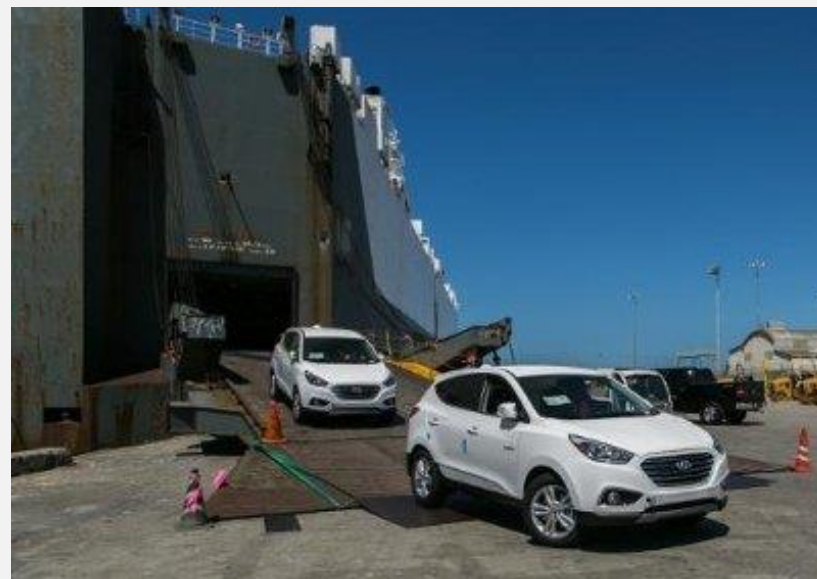
FCEVs on display at North American auto shows.



Honda Fuel Cell Electric Vehicle



Toyota Fuel Cell Electric Vehicle



**Hyundai's first mass-produced
Tucson Fuel Cell SUVs arrive in
Southern California
May 20, 2014**

Lease includes **H₂ and
maintenance.**

State Initiatives -California

A CALIFORNIA ROAD MAP

Bringing Hydrogen Fuel Cell Electric Vehicles to the Golden State

COMMERCIAL LAUNCH OF FCEVS
EXPECTED AROUND 2015

250-400 mile range
Zero-emissions
Minutes to refuel
Domestically produced hydrogen

THE NETWORK:
CLUSTERS
CONNECTORS
DESTINATIONS

"Consumers need **CONFIDENCE** in a hydrogen fueling network"

Initial station deployments will focus on geographic clusters in key markets with additional stations connecting these clusters into a regional network.

68 STATIONS
NEEDED TO LAUNCH THE EARLY FCEV MARKET

\$65 MILLION
IN ADDITIONAL FUNDING NEEDED*

\$10M

Download A California Road Map at
www.cafcp.org/roadmap

The California Fuel Cell Partnership is a collaboration of organizations that work together to promote the commercialization of hydrogen fuel cell electric vehicles.

By working together, we help ensure that vehicles, stations, regulations and people are in step with each other as the technology comes to market.

www.cafcp.org

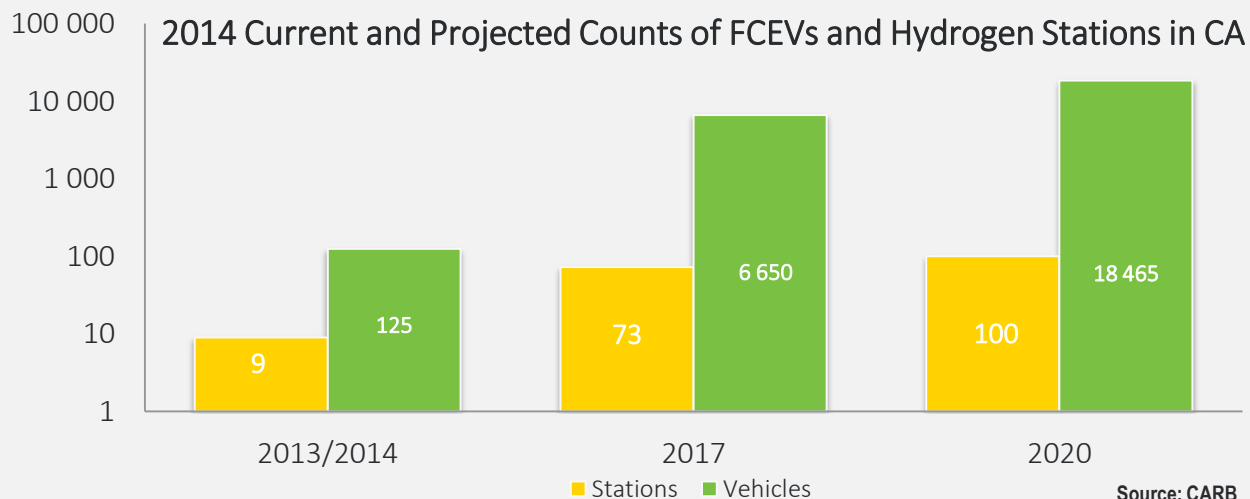
FCEVs and Fuel Cell Buses

- > **560** vehicles in operation since 1999 — 240 currently operating
- > **6** million miles driven
- > **1** million passengers on fuel cell buses



H₂ Station Investment

- **20** stations - including planned/funded
- \$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)

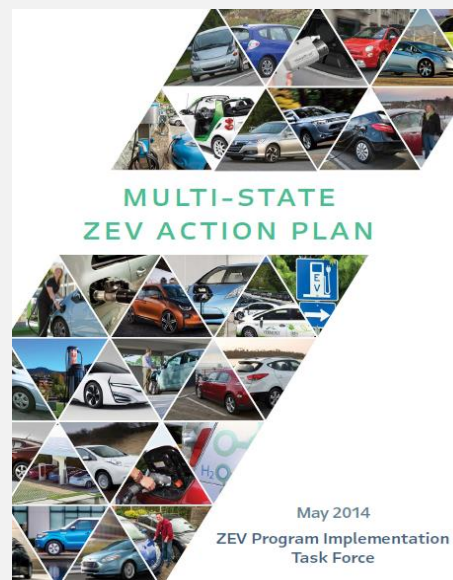
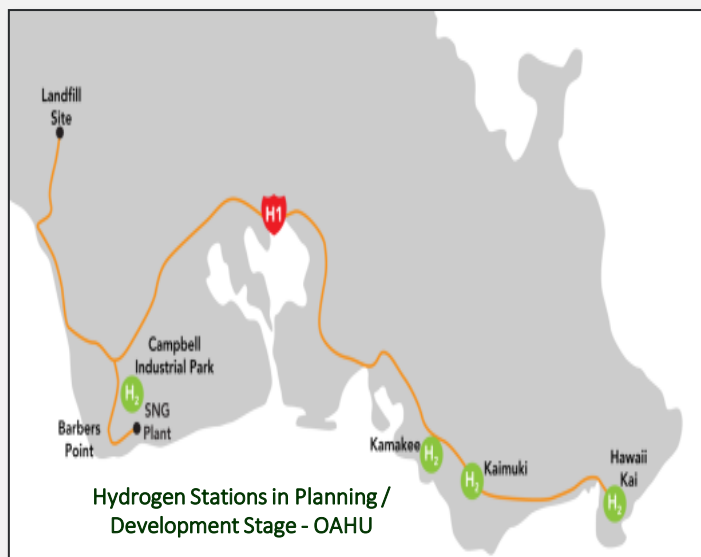


Many states have major hydrogen and fuel cell programs or partnerships underway

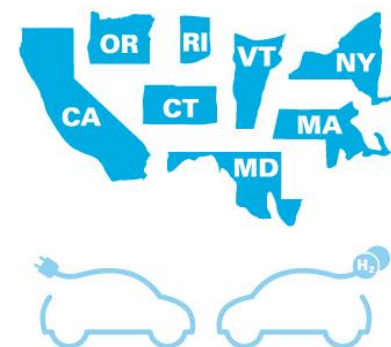
HAWAII

- Agreement signed by **12** stakeholders—including GM, utilities, hydrogen providers, DOD, DOE—to establish hydrogen as a major part to Hawaii's energy strategy.

15 GM FCEVs currently in demonstrations with military



3.3 MILLION
ZERO-EMISSION VEHICLES
BY 2025



ZEV STATES

- Multi-state MOU signed aimed to ensure successful implementation of ZEV programs
- California, Oregon, Rhode Island, Connecticut, Maryland, Massachusetts, New York and Vermont
- Represents roughly a **15%** new vehicle market penetration

H₂ USA

Mission: To promote the commercial introduction and widespread adoption of FCEVs across America through creation of a public-private partnership to overcome the hurdle of establishing hydrogen infrastructure.

Current partners include (additional in process):



U.S. DEPARTMENT OF
ENERGY

DAIMLER

HYDROGENICS
Advanced Hydrogen Solutions



HONDA
The Power of Dreams



Mercedes-Benz



DRIVING FOR THE FUTURE



Sandia
National
Laboratories



PROTON
THE LEADER IN ON SITE GAS GENERATION.

Pacific Northwest
NATIONAL LABORATORY



ARC: HYDROGEN



NUVERA

Making hydrogen make sense.



Massachusetts
Hydrogen
Coalition



TOYOTA

Argonne



NATIONAL LABORATORY



Photo Credits Top: NREL, Middle: NREL, Bottom:
Hexagon Lincoln

➤ Station Cost Reduction

- Specification, design, and deployment
- Fueling resources & delivery
- Station and dispensing technology improvement
- State and local regulations

➤ Station Locations

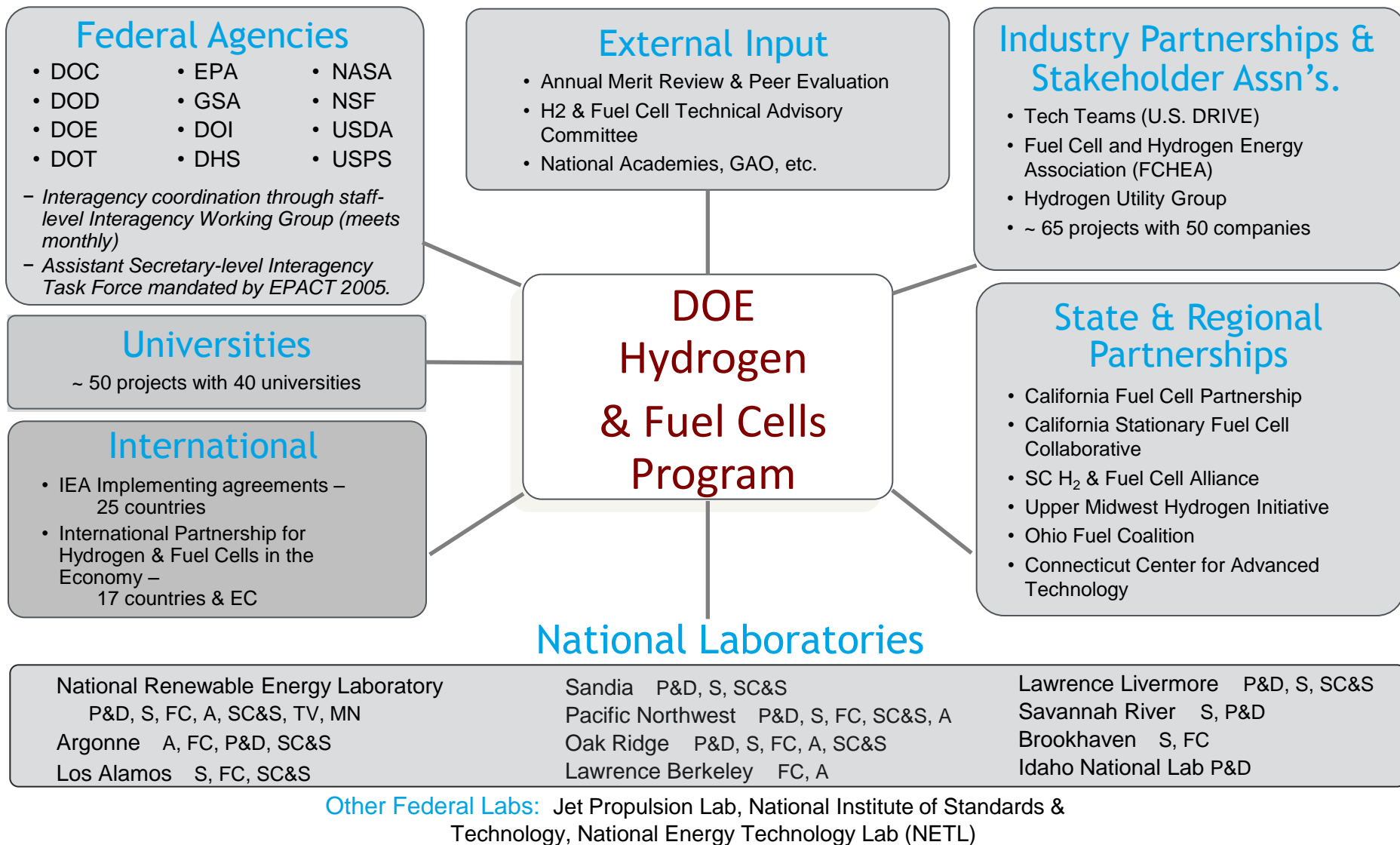
- Identify and prioritize markets
- Regulatory barriers (zoning)
- Station rollout timing

➤ Investment and Finance

- Private sector financing
- Government support

➤ Market Support and Acceleration

- Product launch and timeline
- Codes and standards (non-vehicle related)
- Public education



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

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

For more information contact:

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<http://energy.gov/eere/fuelcells/fuel-cell-technologies-office>