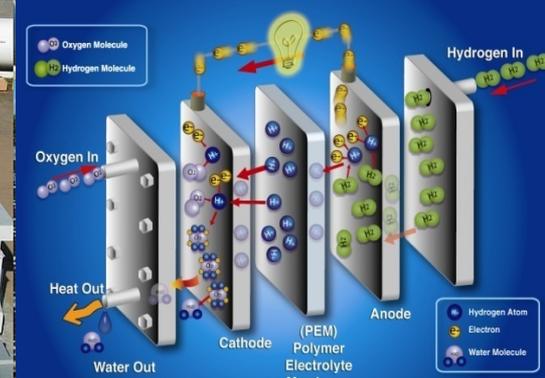
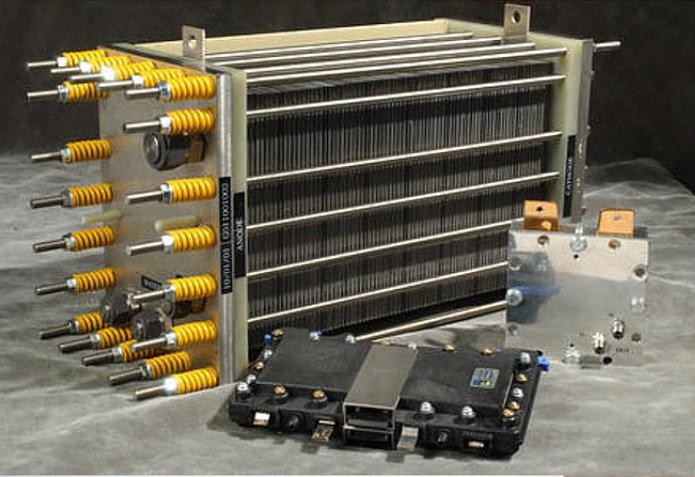


U.S Department of Energy Fuel Cell Technologies Office

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



Fuel Cells and Hydrogen Overview

Mike Mills

EERE

U.S. Department of Energy

Grenoble, France

November 30, 2015

Conclusions from this presentation:

- 1) H2 and FC markets are growing fast and have the potential to represent a large portion of our economy
- 2) Governments are expanding their focus beyond R&D to enable accelerated technology adoption in the marketplace

The industry needs skilled professionals to ensure success.

“When our children’s children look us in the eye and ask if we did all we could to leave them a safer, more stable world, with new sources of energy, I want us to be able to say *yes, we did.*”

– *President Barack Obama*

Jan. 28, 2014



Major Administration Energy Goals

Reduce GHG emissions by 17% by 2020, 26-28% by 2025 and 83% by 2050 from 2005 baseline Climate Action Plan

By 2035, generate 80% of electricity from a diverse set of clean energy resources Blueprint Secure Energy Future

Double energy productivity by 2030 Department of Energy

Reduce net oil imports by half by 2020 from a 2008 baseline Blueprint Secure

Reduce CO₂ emissions by **3 billion metric tons** cumulatively by 2030 through efficiency standards set between 2009 and 2016

CAP Progress Report

Oil Dependency is Dominated by Vehicles

- Transportation is responsible for **66%** of U.S. petroleum usage
- **27%** of GHG emissions
- On-Road vehicles responsible for **85%** of transportation petroleum usage
- **16.0M** LDVs sold in 2014.
- **240 million** light-duty vehicles on the road in the U.S
- **10-15 years** for annual sales penetration
- **10-15 years** to turn over fleet

Poses significant economic, energy and environmental risks to U.S.

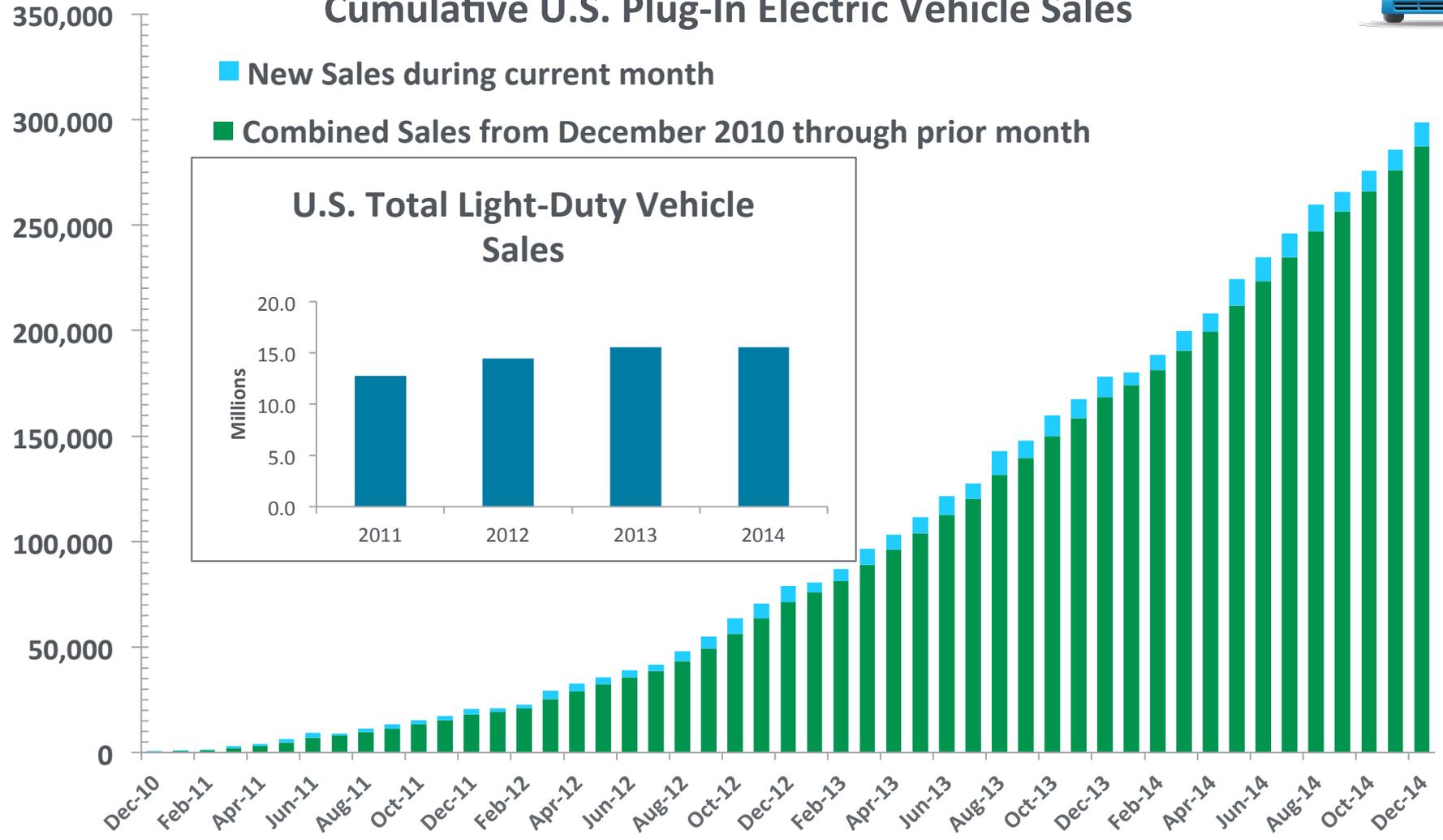


Photos courtesy of Spc. Jordan Huettl, U.S. Army; U.S. Environmental Protection Agency; and M. Studinger, NASA

It takes decades of sustained effort to turn over the fleet



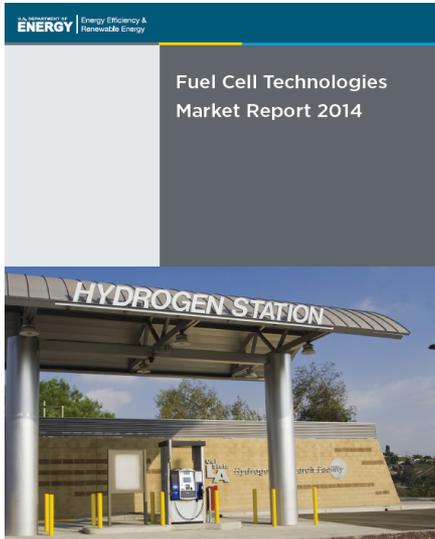
Cumulative U.S. Plug-In Electric Vehicle Sales



Rising faster than HEV sales in same time period after release

Fuel Cells - Steady Market Growth

Market Report Just Published!



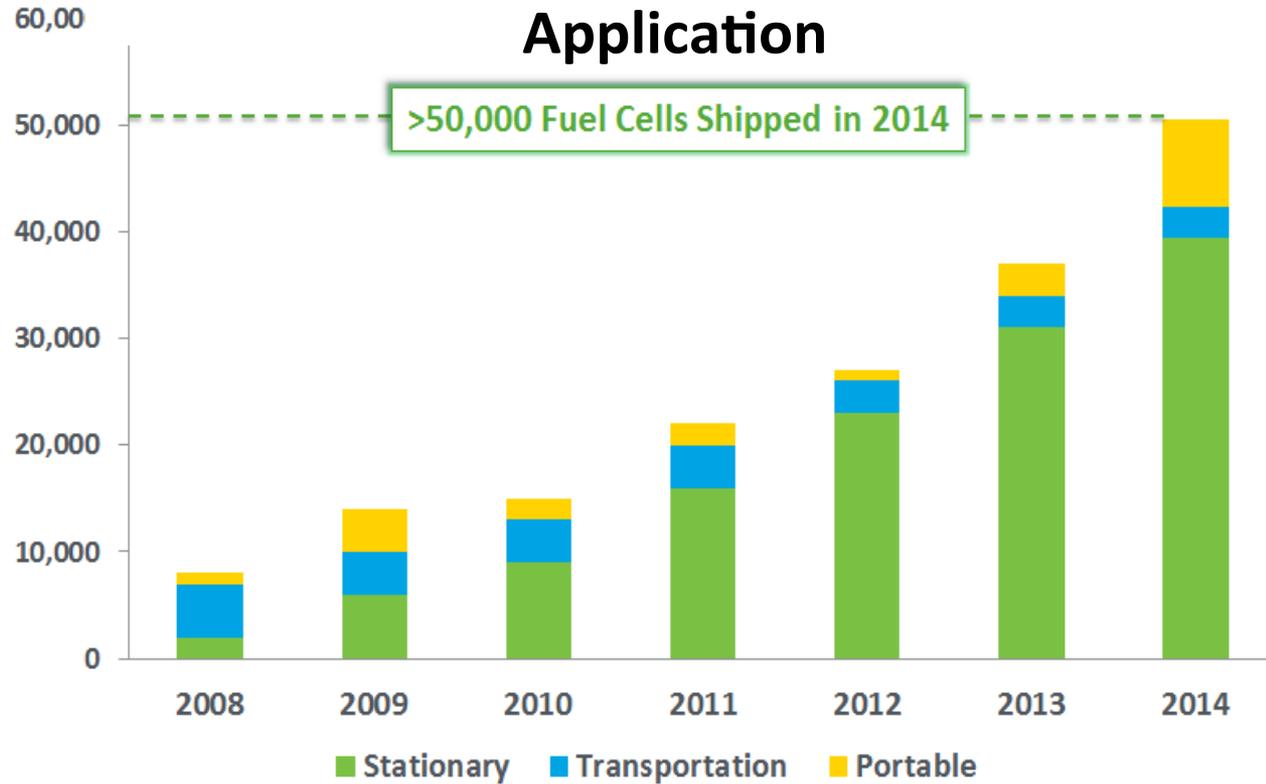
In 2014...

>\$2B in revenues

>180 MW fuel cells shipped

Available at: <http://energy.gov/eere/fuelcells/downloads/2014-fuel-cell-technologies-market-report>

Fuel Cell Systems Shipped Worldwide by Application



- Consistent **~30%** annual growth since 2010
- Global Market Potential in 10- 20 year 
 - \$14B – \$31B/yr for stationary power
 - \$11B /yr for portable power
 - \$18B – \$97B/yr for transportation

DOE Activities Span from R&D to Deployment



1.

Research & Development

Cost Reductions

- 50% for fuel cell systems
- 5x less platinum
- > 2x increase in durability
- 80% for electrolyzers

\$124/kW in 2006



*\$280/kW low volume



2.

Demonstration

Forklifts, back-up power, airport cargo trucks, parcel delivery vans, marine APUs, buses, mobile lighting, refuse trucks

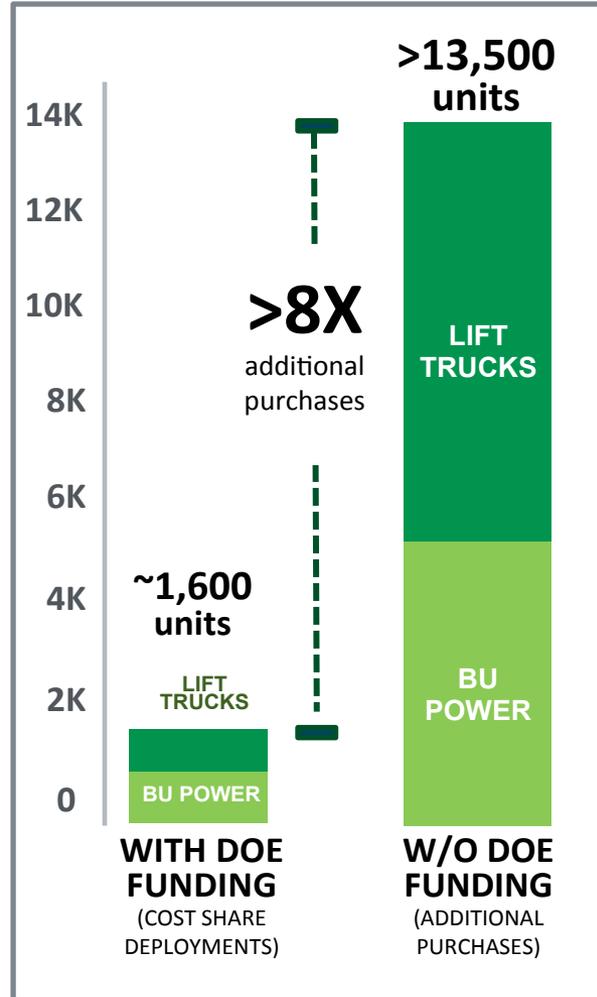
>215 FCEVs, 30 stations, 5.7M miles traveled

World's first tri-gen station



3.

Deployment

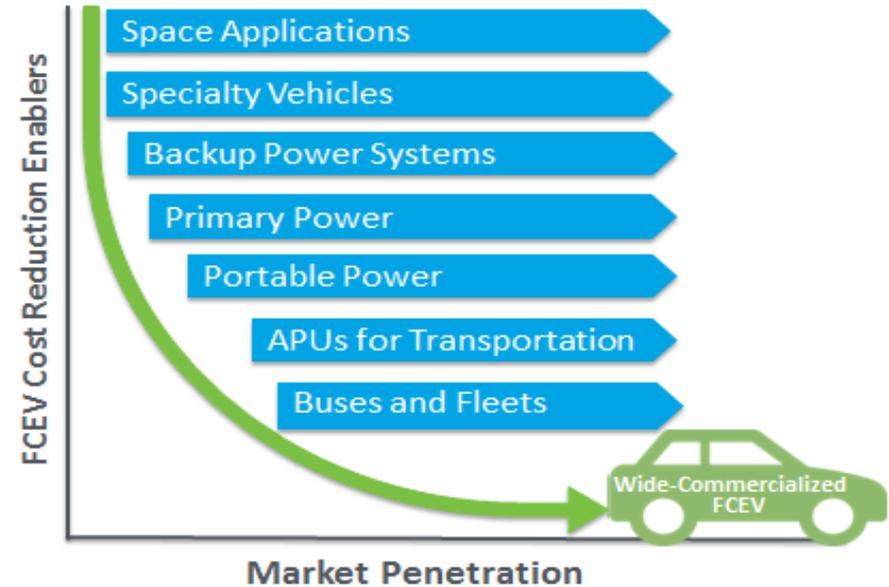


Early Market Activities

Pursuing an Early Market Strategy

Early Markets enable:

- ✓ Fuel cell **cost reduction**
- ✓ Robust **supply base**
- ✓ Emerging **infrastructure**
- ✓ Customer **acceptance**



Early Markets Applications Recently Deployed in the U.S.



Fuel Cell Tow Trucks



Fuel Cell Bus Fleets

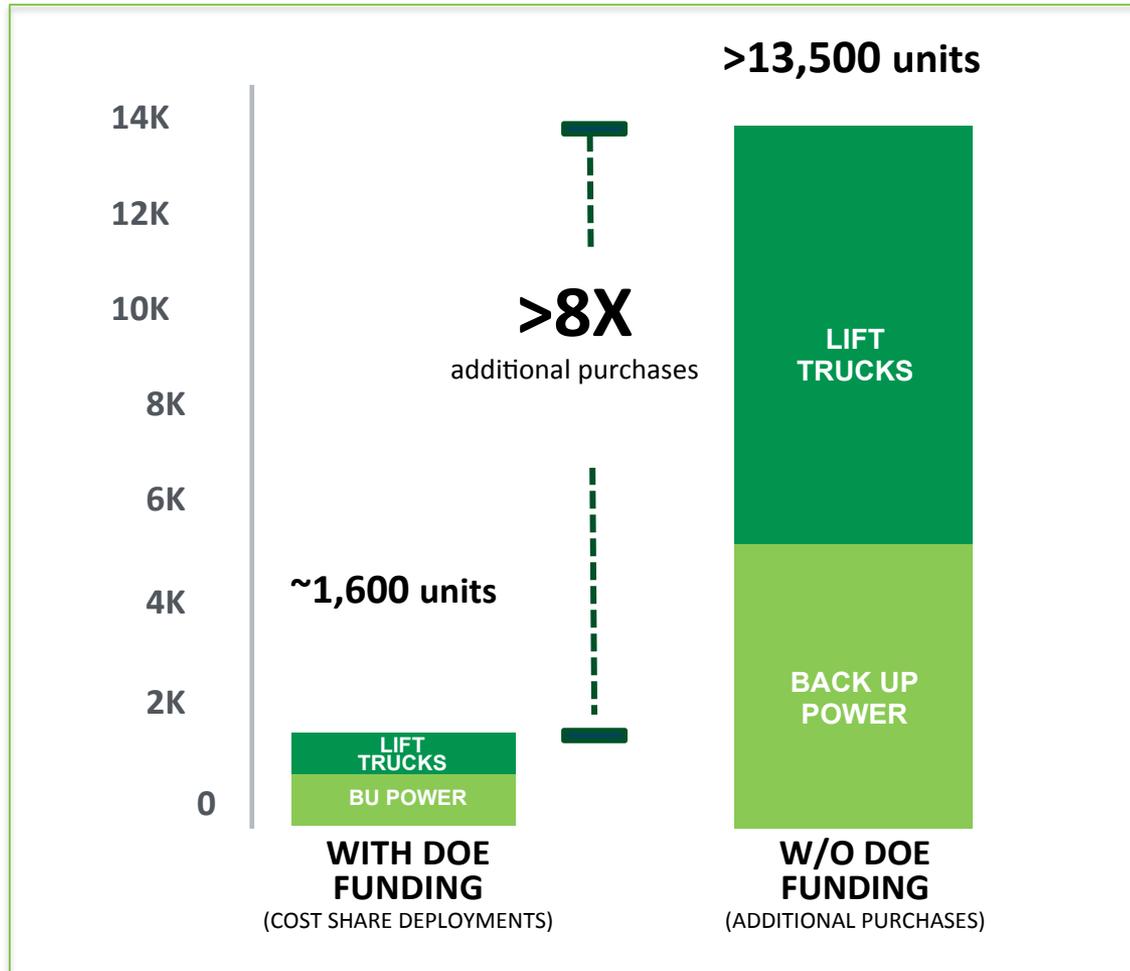


Forklifts



Backup Power

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

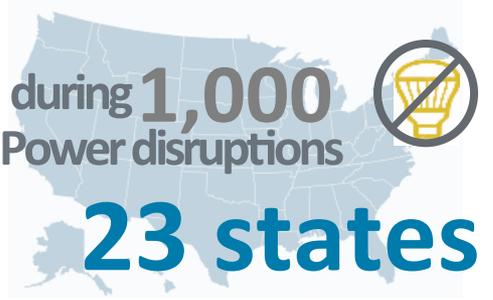


Back Up Power Fuel Cells Deployments- Example

800
Fuel Cells
for back up power
deployed



at cell phone
towers
providing
electricity



During
Hurricane
Sandy



the largest Atlantic hurricane on record



5 sites
operated
providing power
for over 100 hours

as validated by NREL

Source: "Hydrogen Fuel Cell Performance as Telecommunications Backup Power in the United States" NREL/TP-5400-60730

1,034 out of 1,047 successful fuel cell starts for back-up power

GSE Deployment at Memphis Airport

Purpose

- To demonstrate lower carbon emissions with a fuel cell solution in airports

GSE Truck Specifications

- ✓ 87,600 fleet hours during two years
- ✓ Towing Capacity = Up to 40,000 lbs.
- ✓ 20 kW fuel cell power @ 80V
- ✓ H₂ Storage capacity = Up to 3.75 kg H₂ at 350-bar

Partners



Diesel Use & GHG Emissions Impact Potential

175,200 diesel gallons saved
1,717 MT CO₂ GHG saved

World Record Set by Fuel Cell Electric Bus

AC TRANSIT FLEET

 Operated for
more than
145,000 Hours*

**Includes hours operated by FC stacks in prototype buses*



US Hybrid-AC Transit Fuel Cell Electric Bus

FTA Funding and Collaboration with DOE- NREL Data collection

AC TRANSIT BUS

 Operated for
more than
19,500 hours



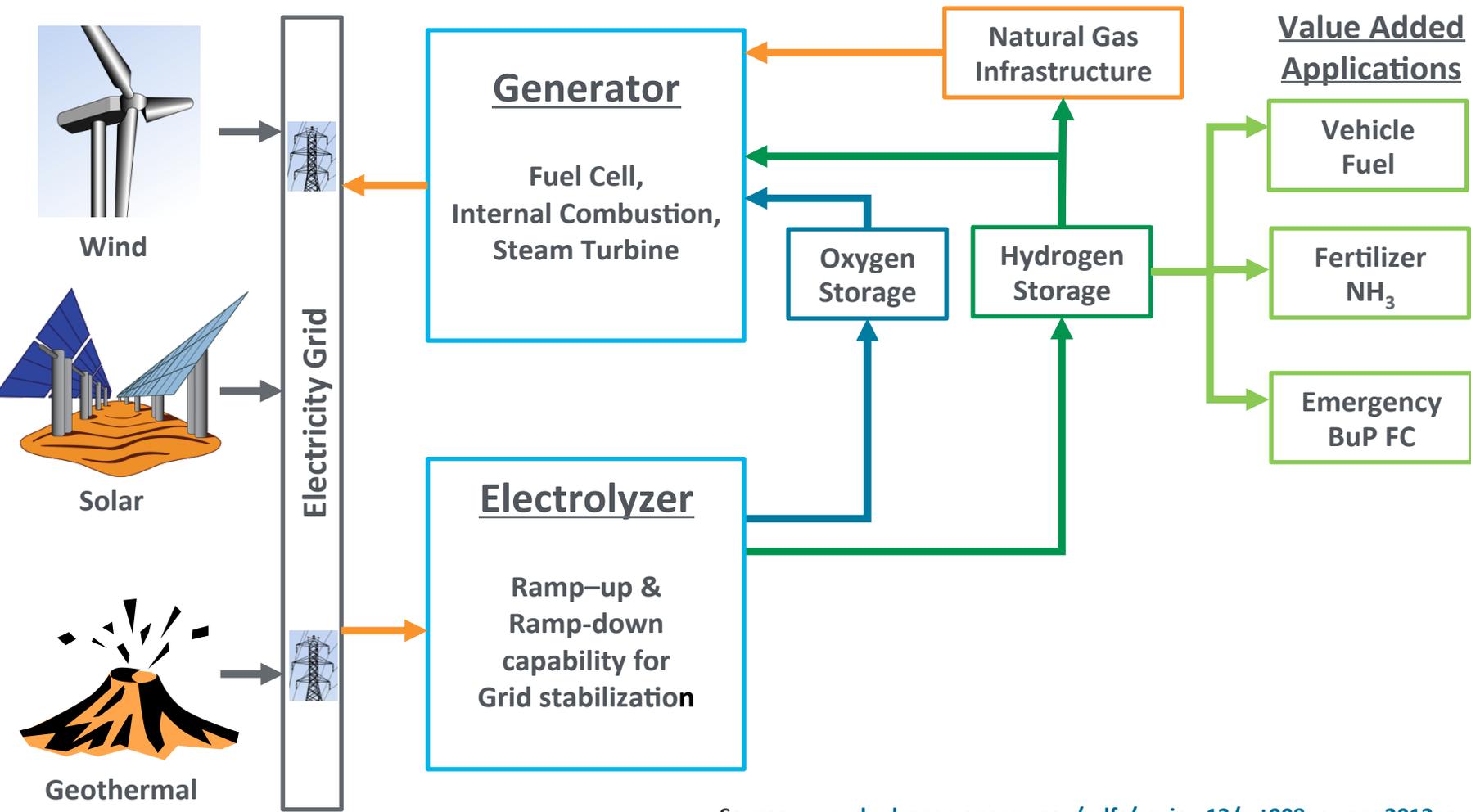
 With
ZERO
failure



 Exceeding DOE's
18,000 hours
2016 target

Fuel Cell Engine Demonstrated Reliability for Transit Bus Fleet

H₂ for Energy Storage



Source: www.hydrogen.energy.gov/pdfs/review12/mt008_ewan_2012_o.pdf
 Hawaii Natural Energy Institute Mitch Ewan, GE Transient PSLF™

Hydrogen may be produced from a variety of renewable resources, and hydrogen-based energy storage could provide value to many applications and markets.

FCEVs are on U.S. Roads Now!

Toyota Mirai FCV / Hyundai Tucson FCV

Currently available for commercial
sale / lease in California



Toyota Mirai Fuel Cell Vehicle

Now Leasing...



Hyundai Tucson Fuel Cell SUV

In Auto Shows...



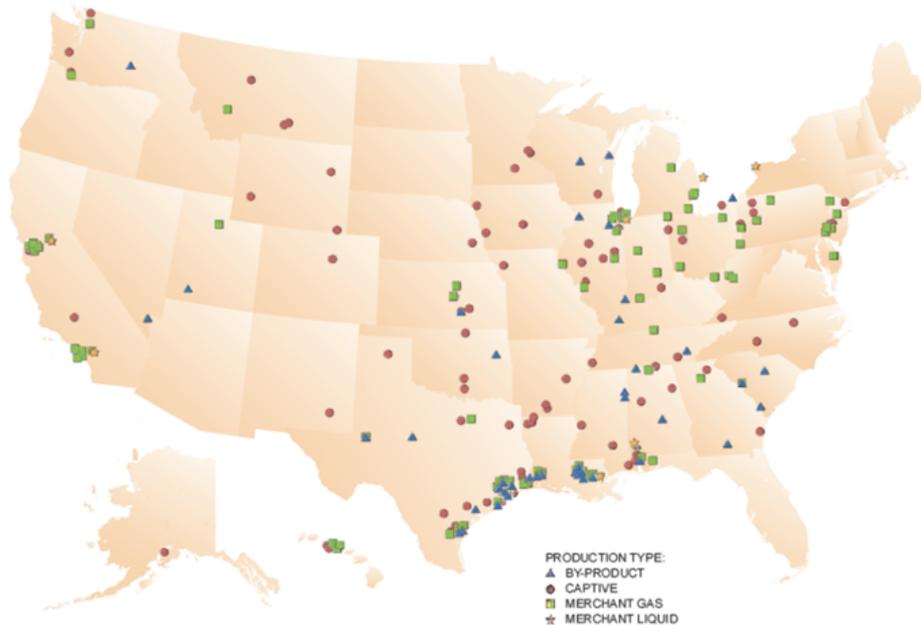
Honda Fuel Cell Electric Vehicle

OEMs bringing fuel cells vehicles to showrooms and driveways

Where does H₂ Infrastructure stand?

Nationwide

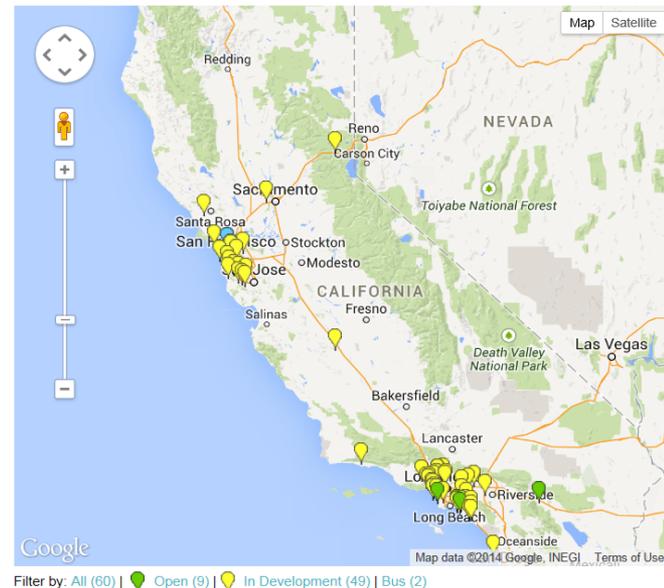
- **1600 mi.** of H₂ pipeline
- **>9M** metric tons produced/yr
- **~50 stations** (~10 public)



Centralized H₂ Production Facilities (source: NREL)

States

- **CA- 100 stations, ~\$100M** planned through 2023
- **8 State MOU- 3.3M ZEVs** by 2025
- **Northeast states, Hawaii**



H₂ stations in CA (source: CAFCP)

NE states, California and Hawaii have H₂ infrastructure efforts underway

Partnerships

H₂USA: Public-Private Partnership

H₂USA

Partners



More than 45 Partners in 2015

Mission

To address hurdles to establishing hydrogen fueling infrastructure, enabling the large scale adoption of fuel cell electric vehicles

Structure

4 Working Groups coordinated by the Operations Steering Committee

Working Groups addressing H₂ Infrastructure Challenges:

Hydrogen Fueling Station



Locations Roadmap



Financing Infrastructure



Market Support & Acceleration



More than 45 partners working towards adoption of FCEVs and H₂

International Partnerships



International Partnership for Hydrogen and Fuel Cells in the Economy

- Representatives from 17 member countries & the European Commission
- Facilitates international collaboration and a forum for advancing policies education
- Recent Activities (thru RCS WG):
 - Launched international round robin testing of Type IV tanks



International
Energy Agency

International Energy Agency

- Implementing Agreements
 - Advanced Fuel Cells Implementing Agreement: 13 member countries currently implementing seven annexes
 - Hydrogen Implementing Agreement: 18 member countries, plus the European Commission currently implementing nine tasks
 - New Task on Hydrogen Safety being defined

Strong International Collaboration on Safety



6th International Conference on Hydrogen Safety
October 19-21, 2015 in Kawasaki/Yokohama, Japan (Hosted by Technova)



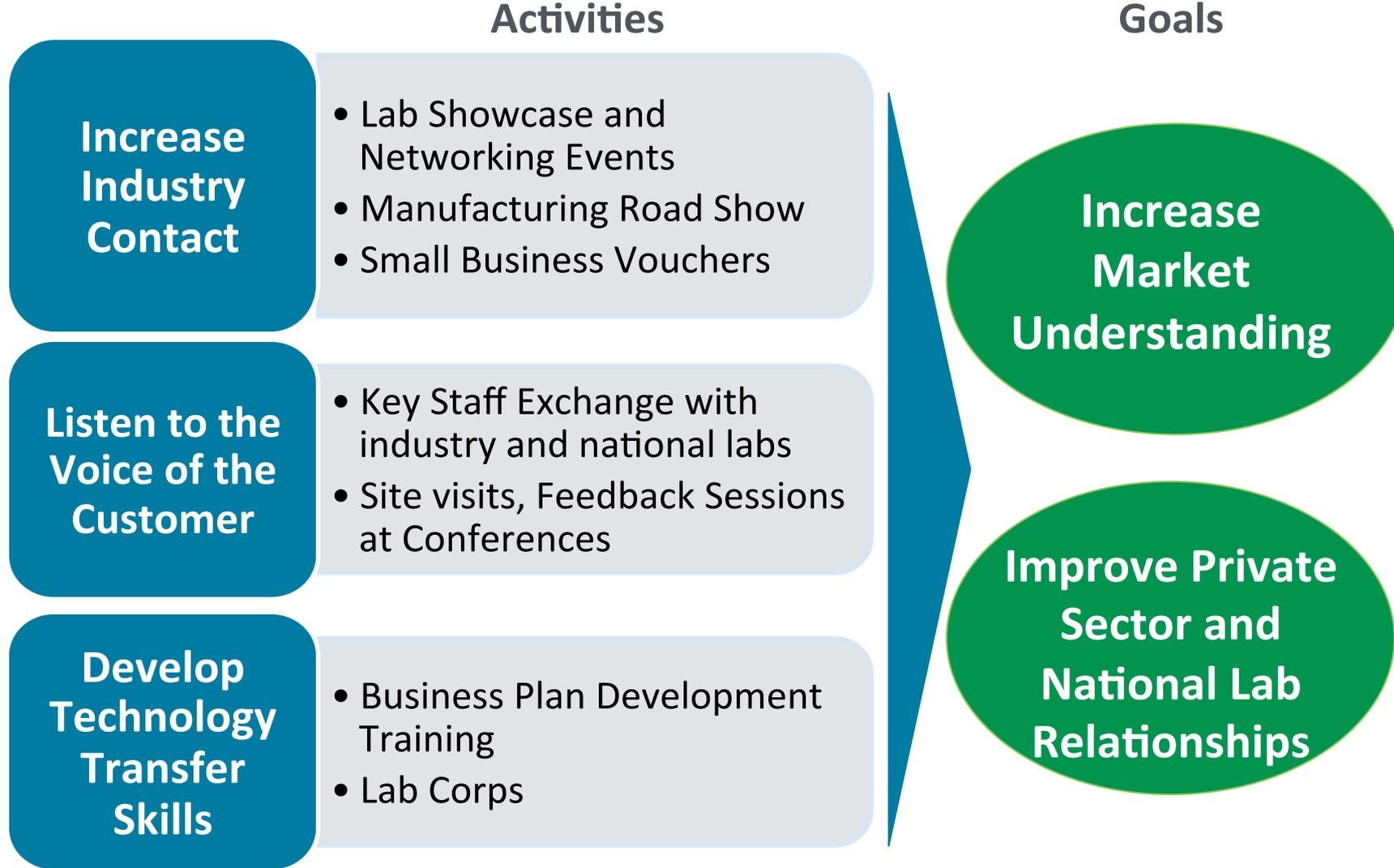
IA HySafe Research Priorities Workshop

- Facilitate knowledge sharing for further development and dissemination of knowledge and coordination of international research activities in the field of hydrogen safety

Tech 2 Market Activities

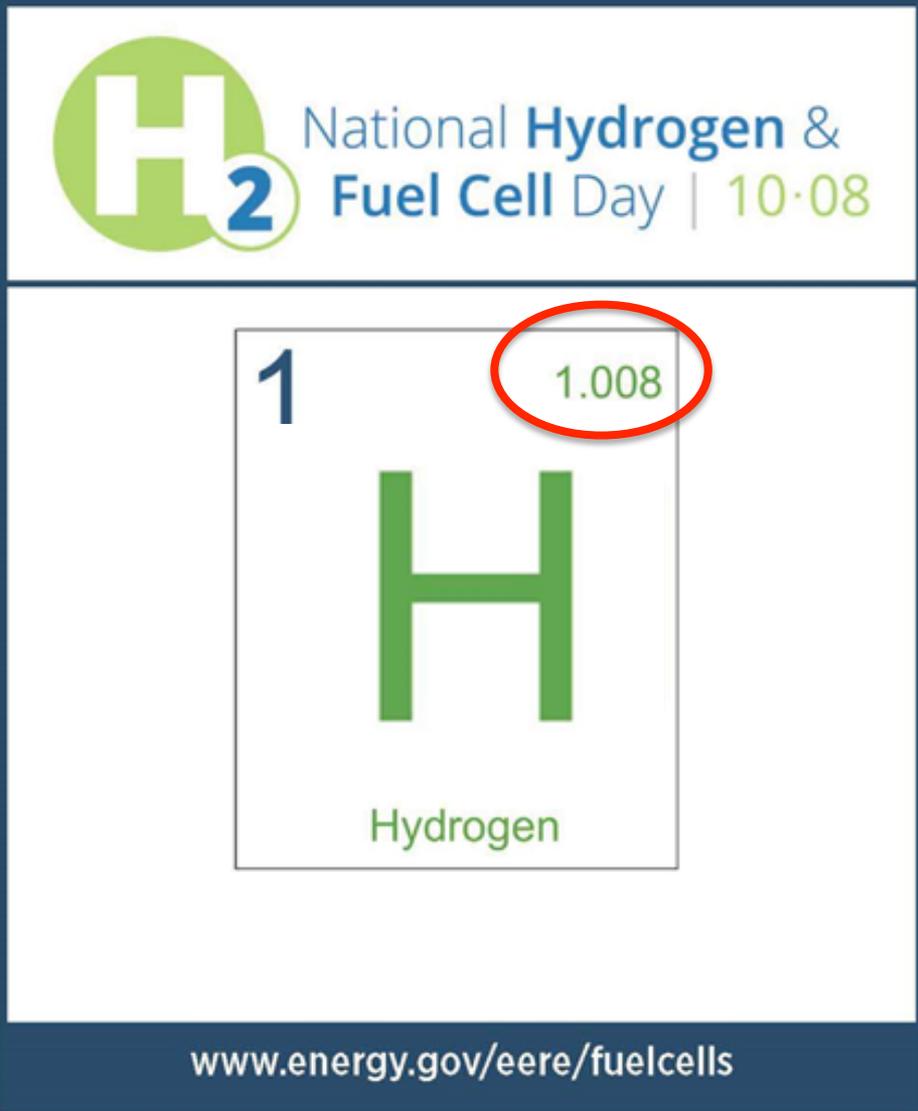
Tech-to-Market (T2M) Strategy

FCTO T2M Strategy



Improving technology transfer and targeted impact from lab to market

Outreach Activities



The image features a logo for National Hydrogen & Fuel Cell Day. The logo consists of a green circle containing a white 'H' and a smaller green circle containing a white '2'. To the right of this logo, the text reads 'National Hydrogen & Fuel Cell Day | 10-08'. Below the logo is a representation of the periodic table element for Hydrogen. The element's atomic number '1' is in the top left, the symbol 'H' is in the center, and the name 'Hydrogen' is at the bottom. The atomic weight '1.008' is in the top right and is circled in red. At the bottom of the graphic is the website address 'www.energy.gov/eere/fuelcells'.

H₂ National Hydrogen & Fuel Cell Day | 10-08

1 1.008
H
Hydrogen

www.energy.gov/eere/fuelcells

The U.S. joined celebrating the 1st ever Hydrogen and Fuel Cells Day

2016 Theme Recently Announced!

- Hydrogen Powered Micro-Grid to provide grid support during peak hours and full back-up power



Who can apply?

- Undergraduate and graduate students worldwide!

When?

- Registration will open on early 2016.

For more information

- <http://hydrogencontest.org/>



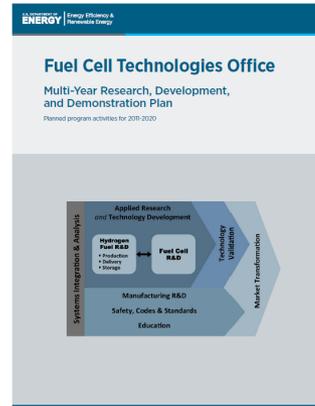
The Grand Prize winning team from Washington State University at the Advanced Clean Transportation Expo 2014 in Long Beach, CA.
7 countries participated in last year's contest

- **Continue to strengthen R&D activities and accelerate Tech to Market (Lab impact)**
 - H₂, fuel cells, safety, manufacturing, etc.
 - Cost, performance, durability need to be addressed
- **Conduct strategic, selective demonstrations**
 - Industry cost share and potential to accelerate market transformation
- **Continue to conduct key analyses to guide RD&D and path forward**
 - Life cycle cost; infrastructure, economic & environmental analyses, etc.
 - Medium/heavy duty vehicle target setting underway
- **Leverage activities to maximize impact**
 - U.S. and global partnerships, H2USA, States

More Information

MYRD&D Plan

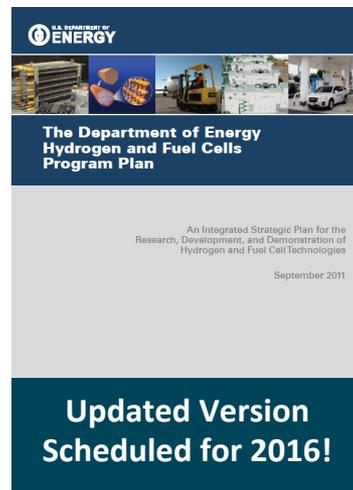
describes the goals, objectives, technical targets, tasks, and schedules for all activities



<http://energy.gov/eere/fuelcells/downloads/fuel-cell-technologies-office-multi-year-research-development-and-22>

Program Plan

outlines the strategy, activities, and plans of the DOE Hydrogen and Fuel Cells Program



SAVE THE DATE

Annual Merit Review (AMR)

June 6-10, 2016

2015 AMR

- More than **1,800 attendees**
- 2015 AMR Proceedings Available Online
- **2015 AMR Report- Recently Published!**

http://www.hydrogen.energy.gov/annual_review15_report.html

Thank You

hydrogenandfuelcells.energy.gov