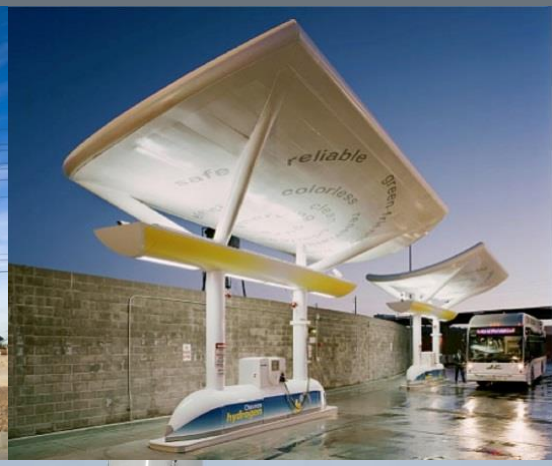
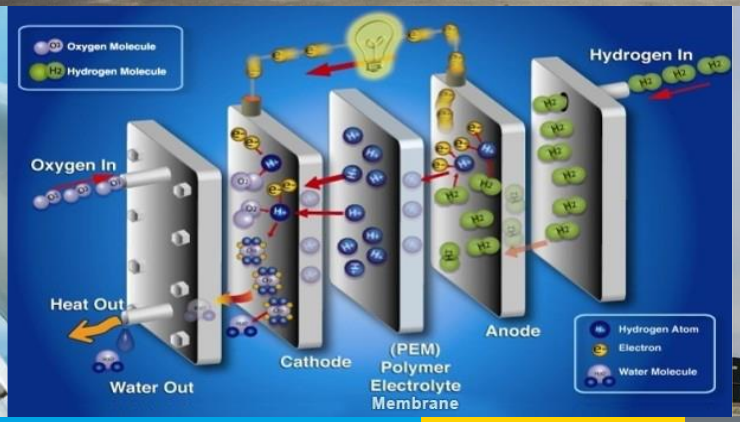
U.S. Department of Energy
Fuel Cell Technologies Office

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





IPHE Education and Outreach Event

April 26, 2017

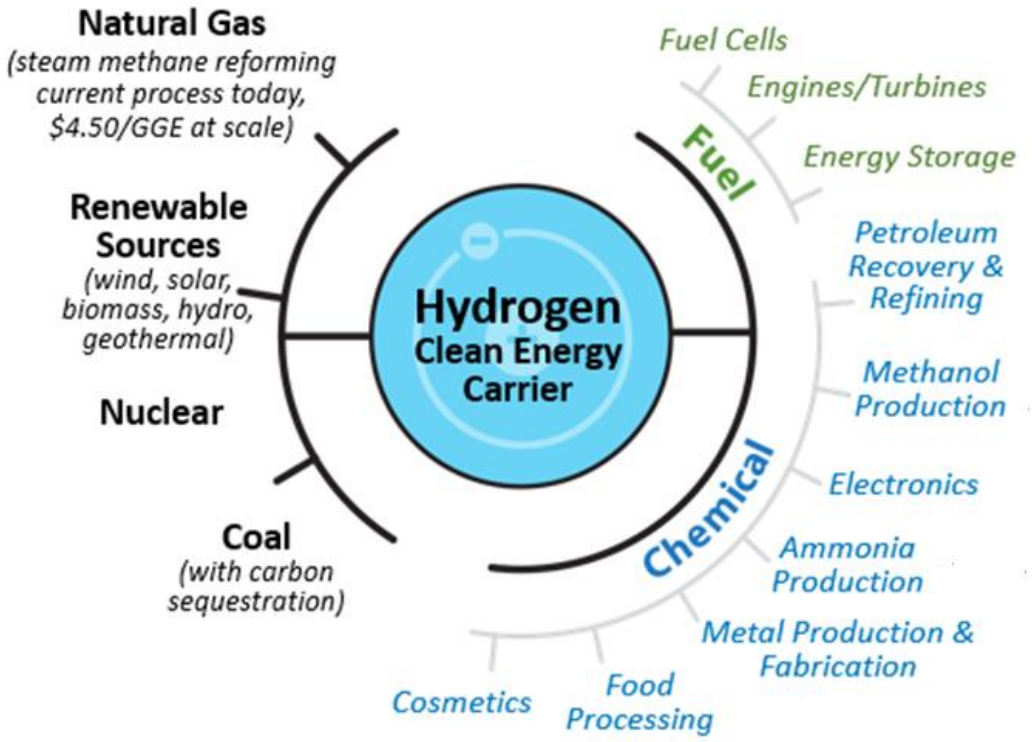
Mike Mills

Senior Advisor
Sustainable Transportation Office
U.S. Department of Energy

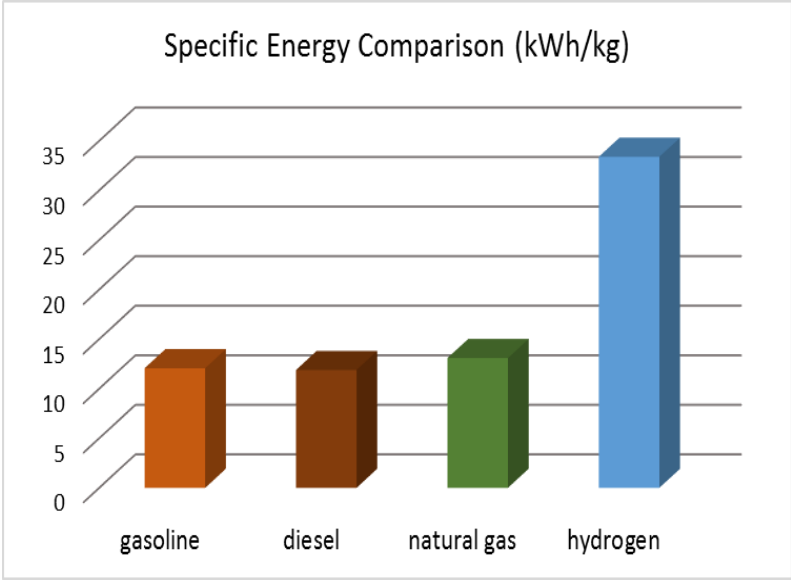
Advantages of hydrogen as an energy carrier

A multitude of sources can be used to produce H_2

Many applications rely on or could benefit from H_2



Very High Specific Energy



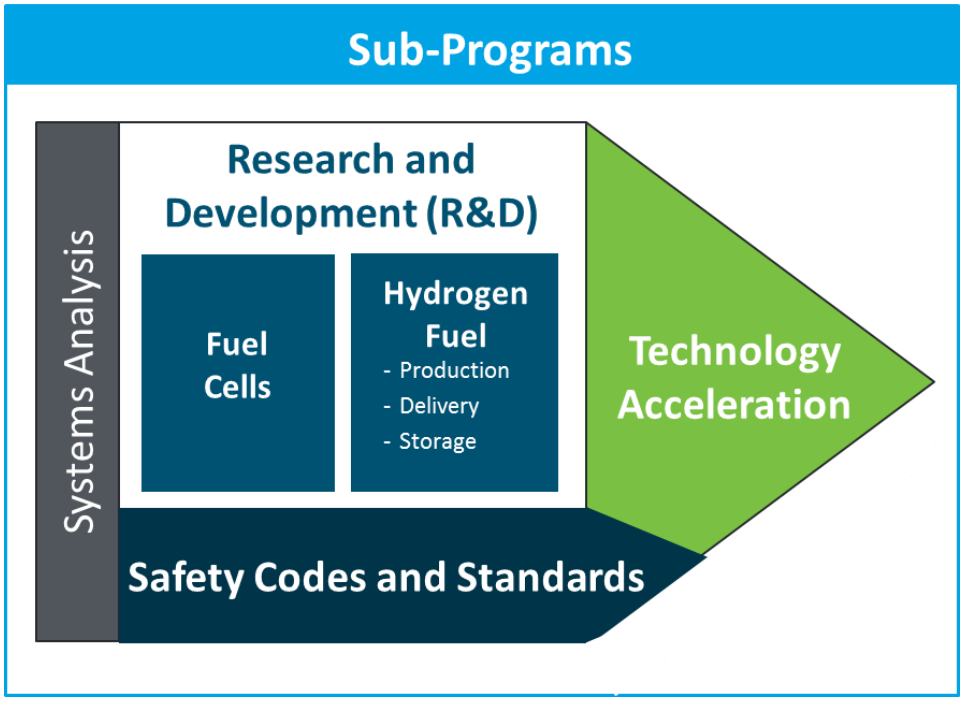
About *three times* more energy by mass than most other fuels!

Hydrogen is a clean , sustainable, versatile, and efficient energy carrier

DOE Hydrogen and Fuel Cells Program

Focus

Applied research, development and innovation of hydrogen and fuel cell technologies that enable **energy security, resiliency, and a strong domestic economy** in emerging markets.



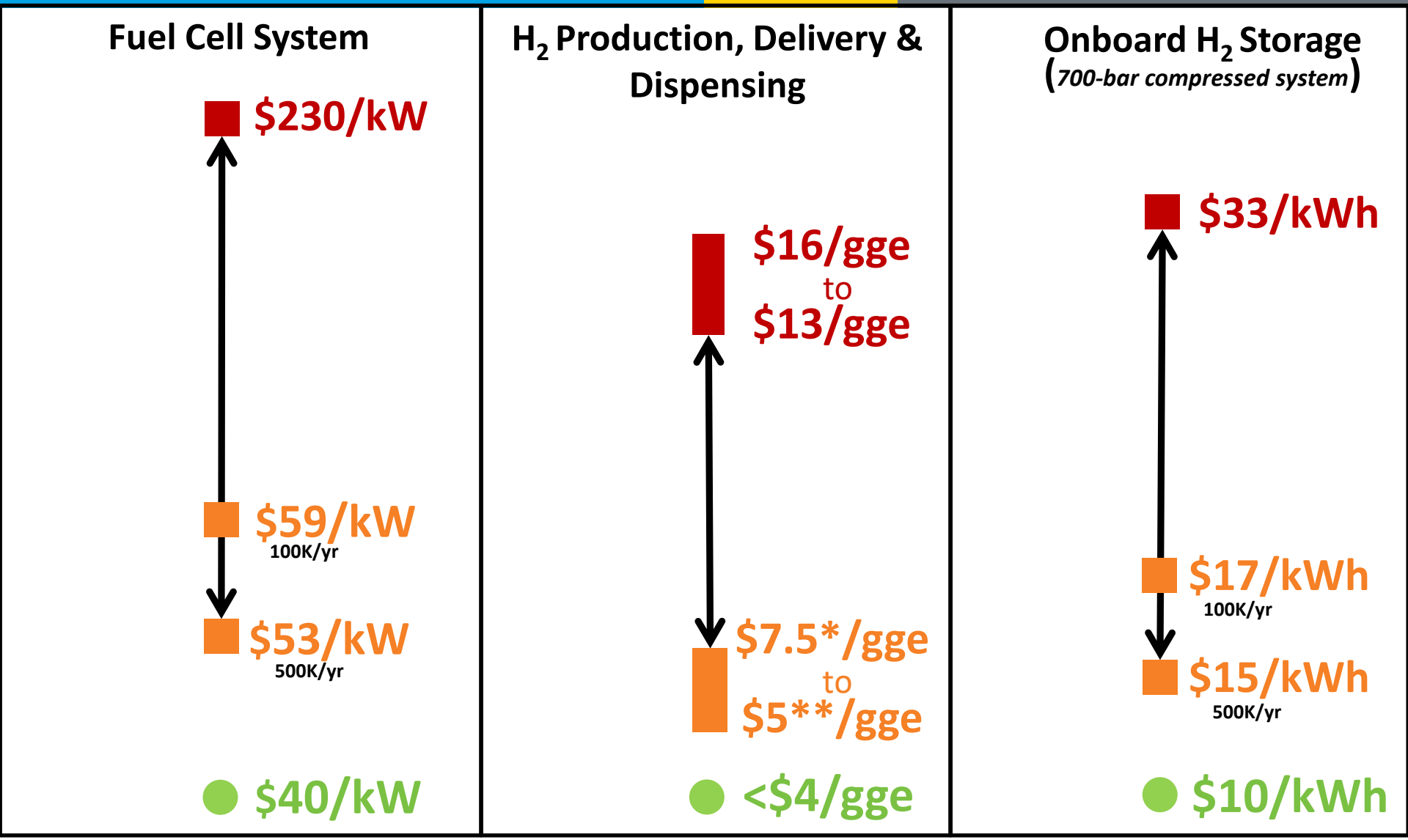
2020 Targets by Application

Fuel Cell Cost	$40/kW	$1,000/kW* $1,500/kW**
Durability	5,000 hrs	80,000 hrs
H_2 Storage Cost (On-Board)	$10/kWh 1.8 kWh/L, 1.3 kWh/kg	
H_2 Cost at Pump	<$4/gge <$7/gge (early market)	

*For Natural Gas
**For Biogas

Strengthening U.S. energy security and the economy through R&D on hydrogen and fuel cells

DOE Cost Status and Targets



*Based on Electrolysis **Based on NG SMR

*For illustration purposes only, not drawn to scale

Techno-Economic Analysis Guides R&D Portfolio

Fuel Cells

Bipolar Plates
Membranes
BOP
MEA
Frames/Gaskets
GDLs

Focusing on…

Low and Non PGM Catalysts,

Alkaline Membranes

H_2 Station

Storage
Cooling
Dispensing
Other

Advanced Compression

Alternate Approaches

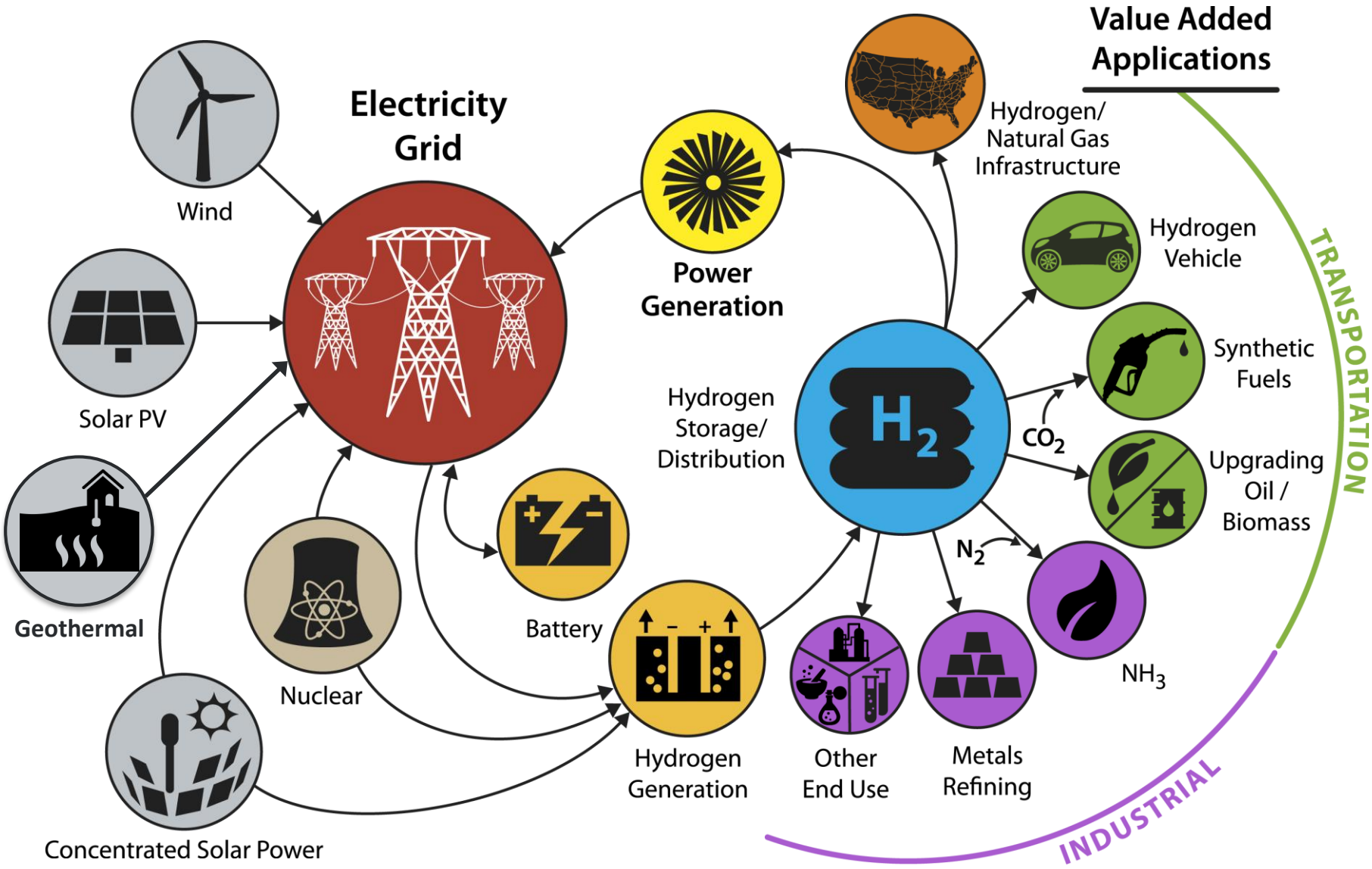
H_2 Storage

BOP/Assembly
Other processing
Resin

Low Cost Carbon Fiber (CF)

Long term Materials Approaches

Conceptual H_2 at Scale Energy System

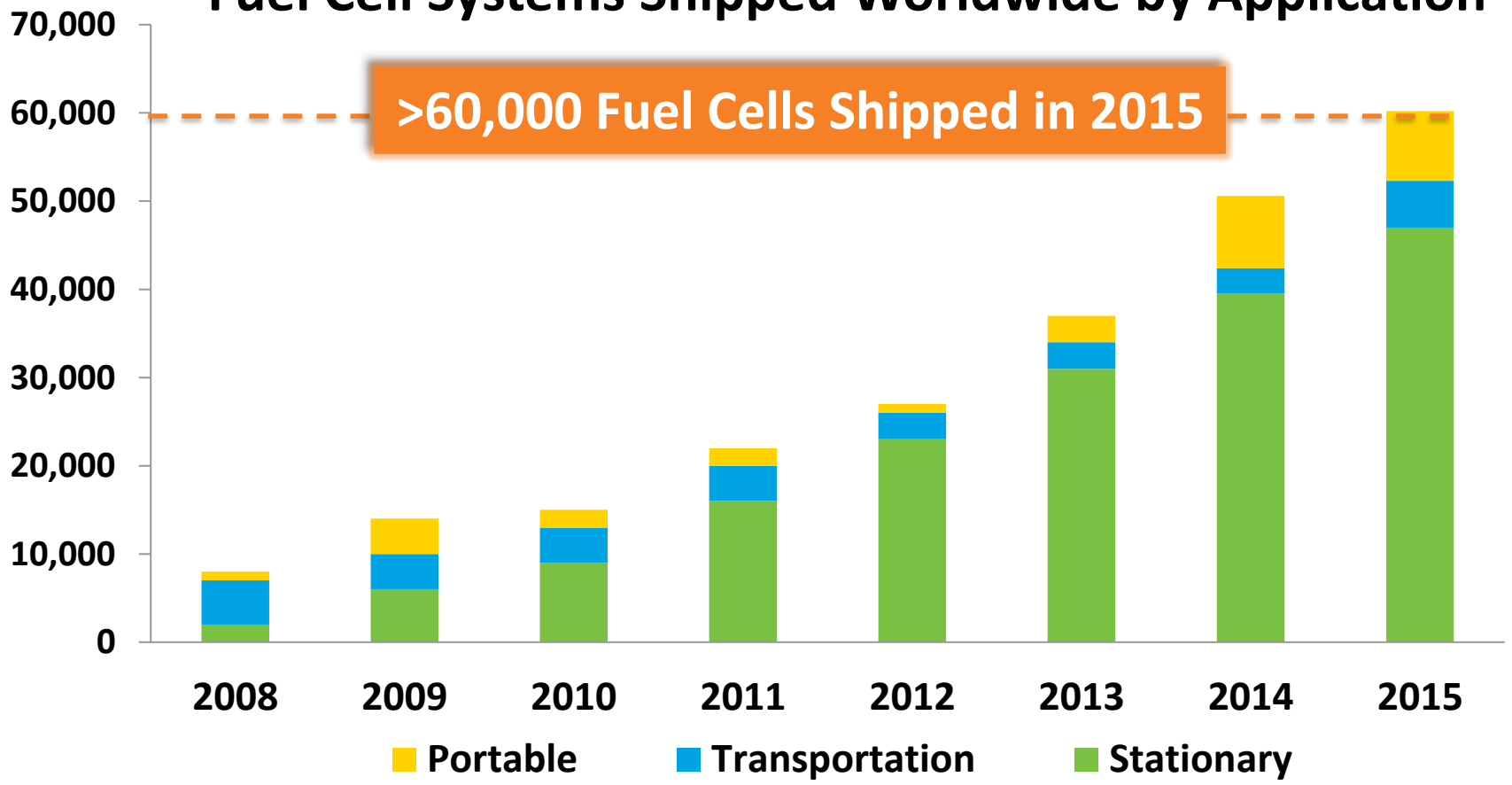


*Illustrative example, not comprehensive

Source: NREL

Market Growth in Fuel Cell Sales

Fuel Cell Systems Shipped Worldwide by Application



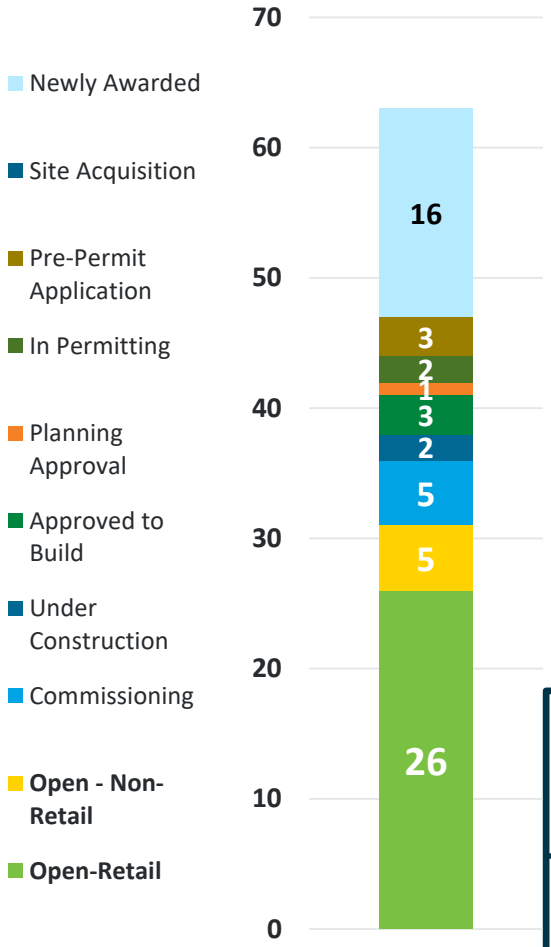
Capacity shipped **in 2015** → Approximately **300 MW** & **~2X** → the capacity **in 2014**

Source: Navigant Research (2008-2013) & E4tech (2014-2015)

Consistent ~30% annual growth since 2010

Hydrogen Infrastructure Activities- Status

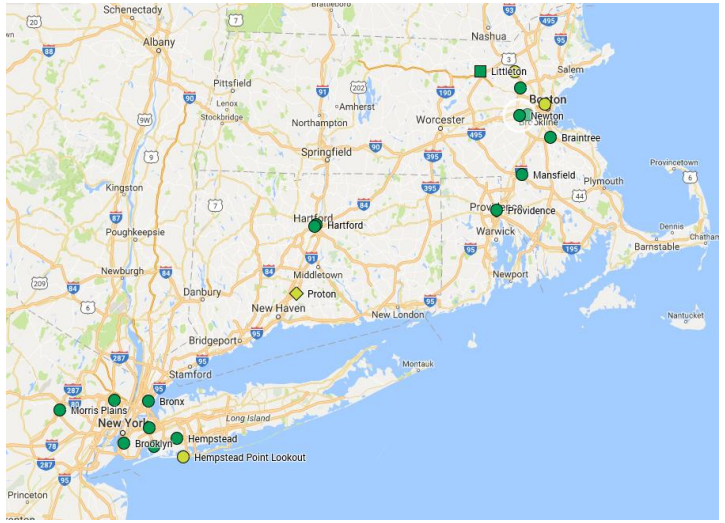
California



As of November 30 (Data from CaFCP June 2016 status report- http://cafcp.org/sites/default/files/h2_station_list.pdf

H_2 Stations
26 retail
Approx. 60 underway
Funding for: 100

Northeast



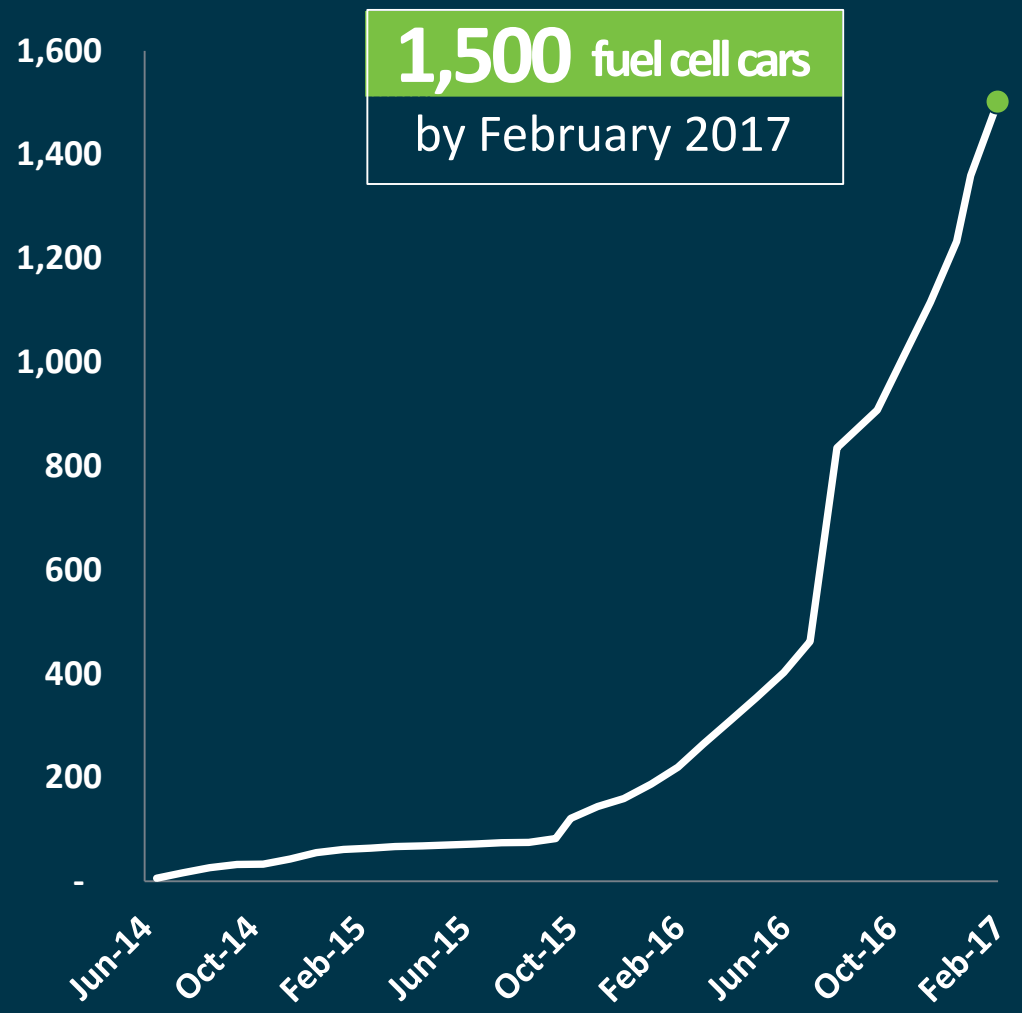
~ 12 to 25 Retail H_2 Stations (planned)

California
Connecticut
Massachusetts
Maryland
New York
Oregon
Rhode Island
Vermont

To find a H_2 station near you: **afdc.energy.gov/locator/stations/**

Commercial Fuel Cell Cars are Here

Fuel Cell Cars Sold/Leased in the U.S



Note: Cumulative number of vehicles sold/leased. Source: hybridcars.com


Hyundai Tucson


Toyota Mirai

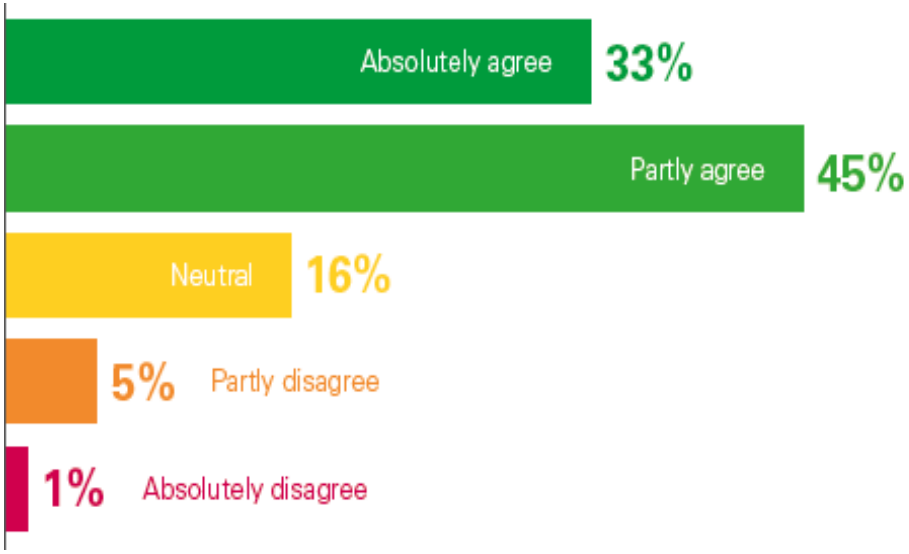

Honda Clarity

Executive Opinions Worldwide - Jan 2017

Fuel Cell Electric Vehicles (FCEVs)

78% of executives

Absolutely or partly agree that **FCEVs will be the real breakthrough for electric mobility**



Source: KPMG, Global Automotive Executive Survey 2017 (Jan. 2017)

Stationary Fuel Cells- Opportunities Emerging

Data centers require non-stop electrical power

Reliable power is vital at hospitals

Supermarkets- growing interest for reliable power

Fuel Cell Stationary Power in the U.S.

Installations

More than
235 MW
in at least
43 states

Top States

- **By unit size:** DE (30 MW) and CT (14.9 MW)
- **By number of units** CA (480 systems)

Source: DOE Fuel Cell Technologies Office. State of the States Report (2016)

New World Trade Center using fuel cells

Complementing Retail Stations: H_2 Refuel H-Prize

H2refuel
U.S. Department of Energy

$1M Competition: On-site H_2 fueling

Winner Announced:
More at hydrogenprize.org

simple.fuel.™

Competition Timeline

- Launched- Oct. 2014
- Testing phase completed- Dec. 2016
- Winner announced- Jan. 2017

System Details

- Hydrogen produced via **electrolysis**
- **Up to 10 kg H_2 per day**
- **700 bar** refueling

Fuel Cells: Recent Progress

ZH2: TARDEC and GM collaboration
First of its kind

Fuel Cells: Recent Progress

Fuel cell buses surpass 15 million passengers

Fuel Cells: Material Handling Applications

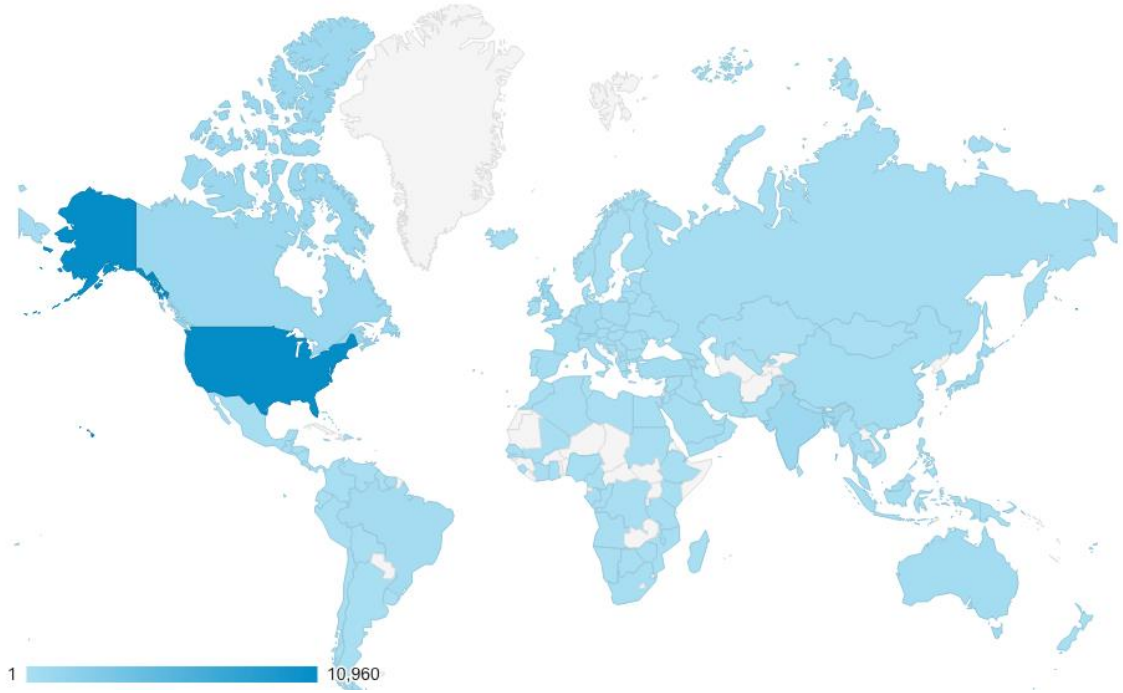
Over 10,000 fuel cell forklifts

~ 5 million H_2 refuelings

Fuel Cells: New Applications Demonstrated

World's first fuel cell for maritime ports

H_2Tools: One-stop for H_2 safety knowledge



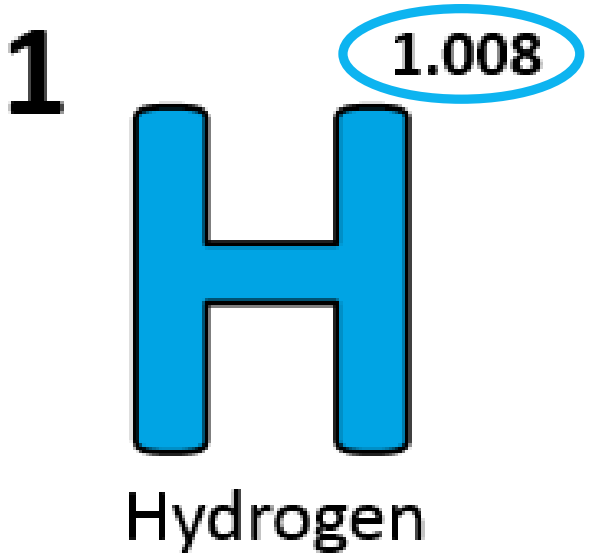
- Includes resources on **safety** best practices, **first responder training**, and **H_2 codes & standards**

- Site visit tracking shows a **global reach: 50%** of visits are **international!**
- Over **31,000 site visits** in the first year alone
- Training resource **translated into Japanese**

Enabling dissemination of safety information around the world

Increasing outreach and visibility…

National Hydrogen & Fuel Cell Day | 10·08



Celebrate National Hydrogen & Fuel Cell Day on 10/8 (Held on its very own atomic- weight-day)

Learn more: energy.gov/eere/fuelcells

Thank You

Mike Mills

Senior Advisor, Sustainable Transportation

Michael.Mills@ee.doe.gov

hydrogenandfuelcells.energy.gov

Save the date: Annual Merit Review (AMR)

June 5-9, 2017- Washington DC

2018 Summer: AMR + Industry Expo!