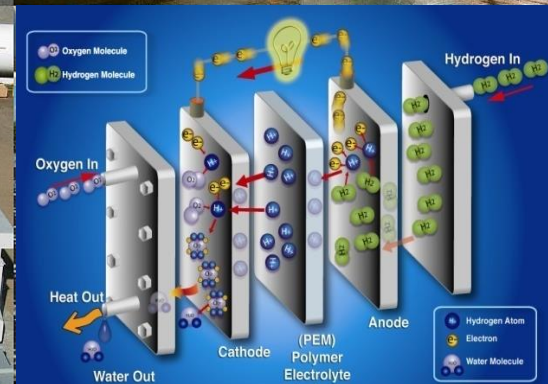


# U.S. Department of Energy: Fuel Cell Technologies Office Overview

U.S. DEPARTMENT OF  
**ENERGY**

Energy Efficiency &  
Renewable Energy



## 6<sup>th</sup> International Conference on Hydrogen Safety: Plenary

Yokohama, Japan

October 19-21, 2015

Will James

Project Manager  
Safety, Codes and Standards Program  
Fuel Cell Technologies Office  
U.S. Department of Energy



*“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*

*“As part of an all-of-the-above energy approach, **fuel cell technologies** are paving the way to competitiveness in the global clean energy market and to new jobs and business creation across the country.”*

*- Secretary Moniz,  
U.S. Department of Energy*



Secretary Moniz at DC Auto Show



## Sustainable TRANSPORTATION

## Renewable ELECTRICITY GENERATION

## Energy Saving HOMES, BUILDINGS, & MANUFACTURING



## Sustainable TRANSPORTATION

- Transportation Efficiency
- Diverse Fuel Sources
- Domestic & Renewable



### Hydrogen and Fuel Cells



### Vehicles



### Bioenergy

National Energy Goals  
&  
Climate Action Plan

Net Oil Imports

↓ **50%** by 2020

GHG Emissions

↓ **17%** by 2020  
**>80%** by 2050

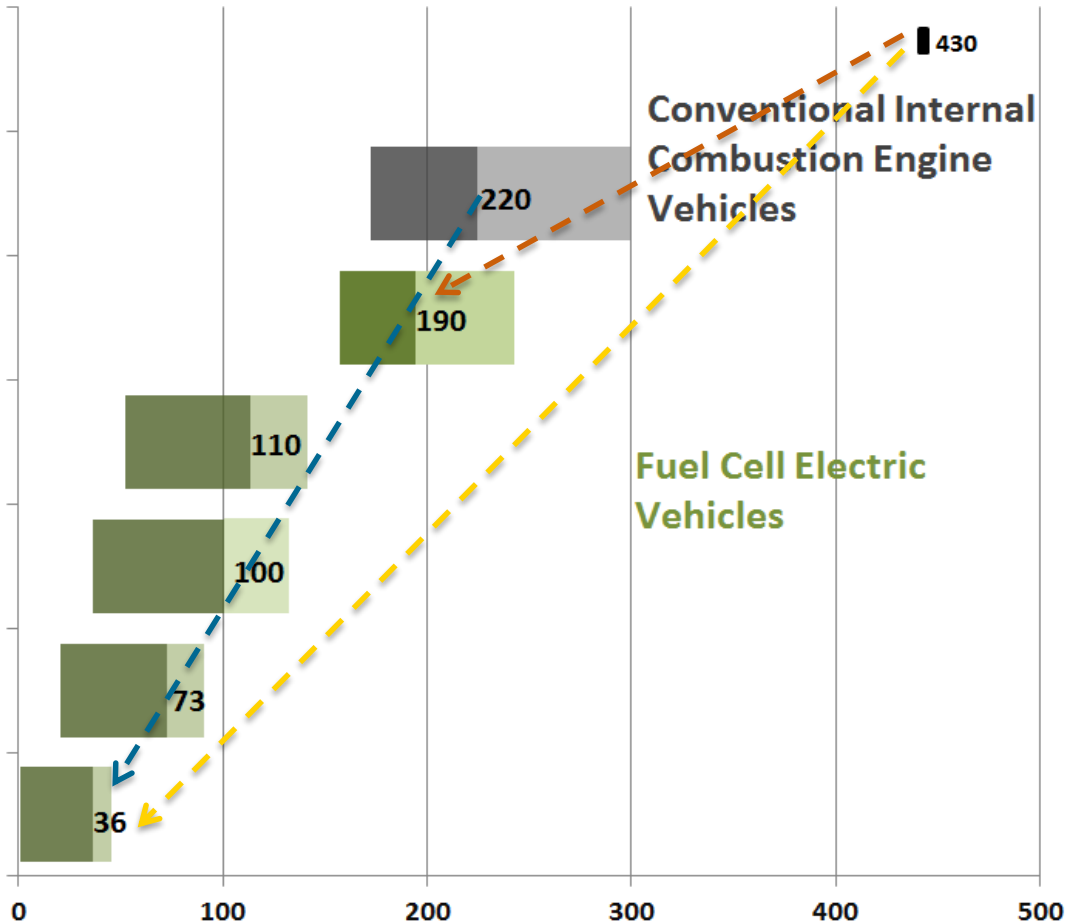
>50%  
with H<sub>2</sub> from  
Distributed  
Natural Gas\*

>80%  
with H<sub>2</sub> from  
Renewables\*  
(Wind)

>90%  
with H<sub>2</sub> from  
Renewables\*\*  
(Wind)



Well-to-wheels CO<sub>2</sub> emissions/mile



\*Compared to 2035 gasoline vehicle  
\*\*Compared to 2012 gasoline vehicle

Source: [http://hydrogen.energy.gov/pdfs/13005\\_well\\_to\\_wheels\\_ghg\\_oil\\_ldvs.pdf](http://hydrogen.energy.gov/pdfs/13005_well_to_wheels_ghg_oil_ldvs.pdf)  
Advanced 2035 technologies

Substantial GHG reductions with H<sub>2</sub> produced from renewables

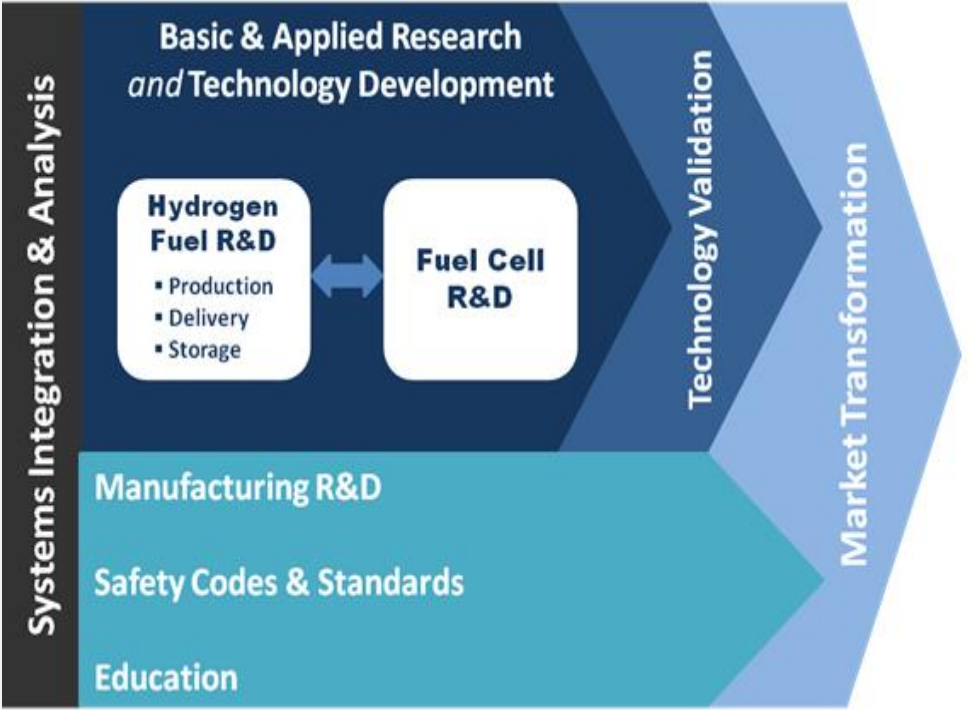
## Mission

To enable the **widespread commercialization** of hydrogen and fuel cell technologies, which will reduce petroleum use, greenhouse gas (GHG) emissions, and criteria air pollutants, and will contribute to a more diverse energy supply and more efficient use of energy.

## Impact

**2-4 million** barrels per day petroleum reduction by 2050  
**200- 450 million** metric tons/year GHG emissions reduction by 2050

## Strategy and Approach



## 2020 Targets



Fuel Cell Cost	<b>\$40/ kW</b>	<b>\$1,000/kW*</b> <b>\$1,500/kW**</b>
Durability	<b>5,000 hrs</b>	<b>80,000 hrs</b>
H <sub>2</sub> Storage Cost (On-Board)	<b>\$10/kWh</b>	
H <sub>2</sub> Cost at Pump	<b>&lt;\$4/gge</b>	

\*For Natural Gas  
\*\*For Biogas



Key Activity	FY 15	FY 15	FY 16
	(\$ in thousands)		
	Request	Approp.	Request
Fuel Cell R&D	33,000	33,000	36,000
Hydrogen Fuel R&D <sup>1</sup>	36,283	35,200	41,200
Manufacturing R&D	3,000	3,000	4,000
Systems Analysis	3,000	3,000	3,000
Technology Validation	6,000	11,000	7,000
Safety, Codes and Standards	7,000	7,000	7,000
Market Transformation	3,000	3,000	3,000
NREL Site-wide Facilities Support	1,700	1,800	1,800
<b>Total</b>	<b>\$92,283</b>	<b>\$97,000</b>	<b>103,000</b>

Office	FY 2015
EERE	\$97M
Basic Science <sup>2</sup>	~\$20M
Fossil Energy, SOFC	\$30M

**FY 2015 DOE Total: ~\$150M**

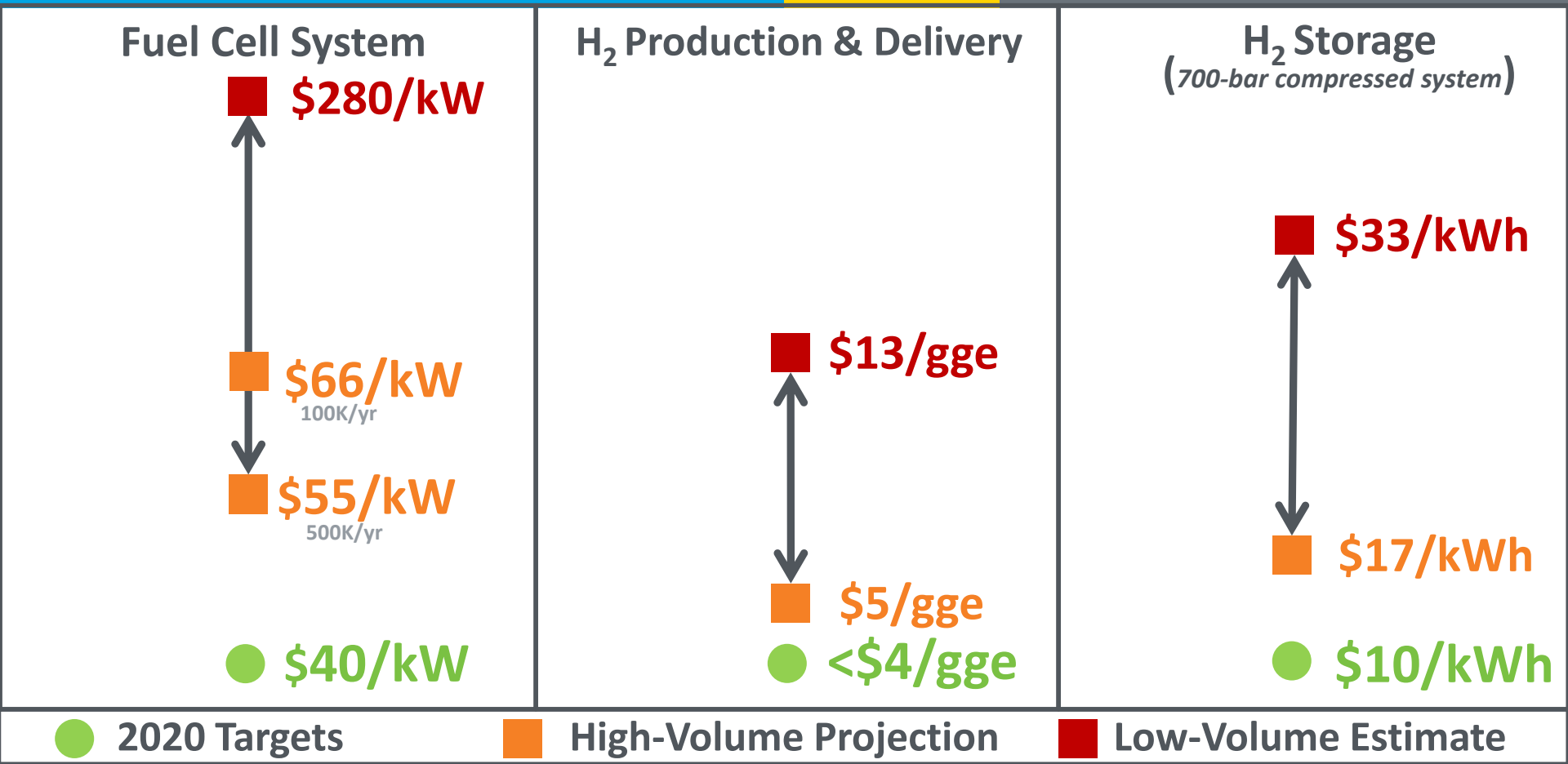
Number of Recipients funded from 2008-2015	
Industry	>110
Universities	>100
Laboratories	12

<sup>1</sup>Hydrogen Fuel R&D includes Hydrogen Production & Delivery R&D and Hydrogen Storage R&D

<sup>2</sup>Estimated from FY14 appropriation

***More stable R&D funding requests and appropriations in recent years  
> 20 new projects including 11 new Incubator projects (2014-2015)***

# DOE Cost Targets and Status



Key Challenges- Examples		
<ul style="list-style-type: none"> <li>PGM loading</li> <li>Catalyst and membrane durability</li> <li>Electrode performance and durability</li> </ul>	<ul style="list-style-type: none"> <li>Efficiency and Reliability</li> <li>Feedstock and Capital Costs</li> <li>Compression, Storage and Dispensing (CSD) Costs</li> </ul>	<ul style="list-style-type: none"> <li>Carbon fiber precursors and conversion</li> <li>Composite/resin materials</li> <li>BOP and assembly costs</li> </ul>



## Fuel Cells

Bipolar Plates  
Membranes  
BOP  
MEA  
Frames/Gaskets  
GDLs



Focusing on...



**Low and Non PGM Catalysts,  
Alkaline  
Membranes**

## H<sub>2</sub> Station

Storage  
Cooling  
Dispensing  
Other



**Advanced  
Compression  
Alternate  
Approaches**

## H<sub>2</sub> Storage

BOP/Assembly  
Other processing  
Resin



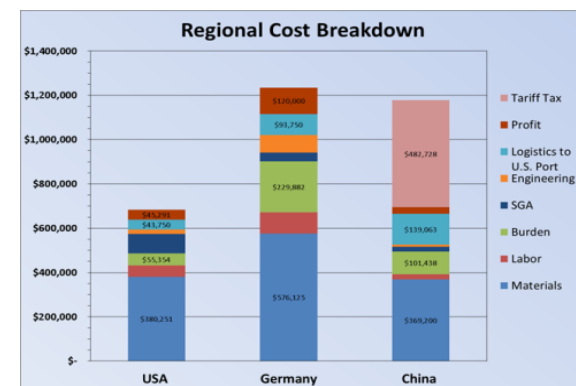
**Low Cost Carbon  
Fiber (CF)  
Long term Materials  
Approaches**

## Global Competitiveness Analysis

including:

- Global Cost Breakdown
- Design for Manufacturing
- Value Stream Mapping

GLWN.org



## Integrated Network of Regional Technical Centers



### Located at

1. East Coast (CCAT)
2. Midwest at the OFCC
3. Central States at NREL's National Fuel Cell Technology Evaluation Center
4. West Coast (UC Irvine)

### Activities (Examples)

- Hold supply chain exchanges
- Promote cooperation between suppliers & standardization of component specs



## Fuel Cell and H<sub>2</sub> Opportunity Center

- Comprehensive **online database**
- **Project activities include:**
  - Encourage **supplier engagement**
  - Release and maintain **public directory**
  - Conduct **outreach campaign** (social media, etc.)



## H<sub>2</sub>USA

### 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 H<sub>2</sub> Infrastructure Challenges:

**Hydrogen  
Fueling Station**



**Locations  
Roadmap**



**Financing  
Infrastructure**



**Market Support &  
Acceleration**



***More than 45 partners working towards adoption of FCEVs and H<sub>2</sub>***





## 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

- **Publications- ~100/yr**
  - Monthly Newsletter
  - Success Stories
  - News Alert
  - Blogs
- **Educated:**
  - >12,000 teachers
  - >35,000 code officials & first responders
- **Investor Days**
  - New York and California
- **House Senate Caucus Events**
- **Annual Merit Review & Peer Evaluation**
  - June 2015- >1,800 attendees
- **Ride-n-Drives**



*U.S Department of Energy Secretary Ernest Moniz test driving the Toyota Mirai*

*Increasing public awareness and understanding about fuel cells and H<sub>2</sub>*

- Continue to strengthen **R&D** Activities
- Accelerate **Tech to Market**
- Conduct strategic and selective **demonstrations**
- Conduct key **analyses** to guide RD&D
- Leverage **partnerships** to maximize impact

*Focus- R&D, Tech-To-Market, Demonstrations, Analysis and Partnerships*



# Thank you

[hydrogenandfuelcells.energy.gov](http://hydrogenandfuelcells.energy.gov)

# U.S. Hydrogen and Fuel Cells Progress

## In R&D...

**50%** Cost Reduction in  
fuel cell systems

**\$124/kW** in 2006

**\$55/kW**  
today\* at high  
volume

\*\$280/kW low volume

**2X** Increase in fuel  
cell durability

**5X** Platinum content  
reduction in fuel cells

## In the Market...

### FCEVs in the US:

Recently announced



Now Leasing



In Auto Shows



**Public-private partnership addressing infrastructure:**

**H<sub>2</sub> USA**

**4X** Increase in partners and  
growing since 2013

### State Activities:

- 8 states committed to 3.3 million ZEVs by 2025
- CA has committed to 100 H<sub>2</sub> stations

## Key Challenges

- Fuel Cell Cost and Durability
- Hydrogen Production
- Hydrogen Delivery
- Hydrogen Storage
- Infrastructure
- Manufacturing and supply chain
- Safety codes and standards
- Widespread public acceptance

## Toyota Mirai FCV

*1<sup>st</sup> commercially available FCEV  
for sale in the US*



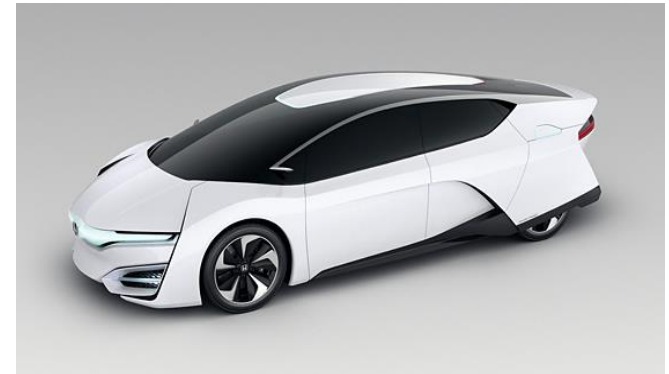
Toyota Mirai Fuel Cell Vehicle

## Now Leasing...



Hyundai Tucson Fuel Cell SUV

## In Auto Shows...



Honda Fuel Cell Electric Vehicle

*OEMs bringing fuel cells to showrooms and driveways*

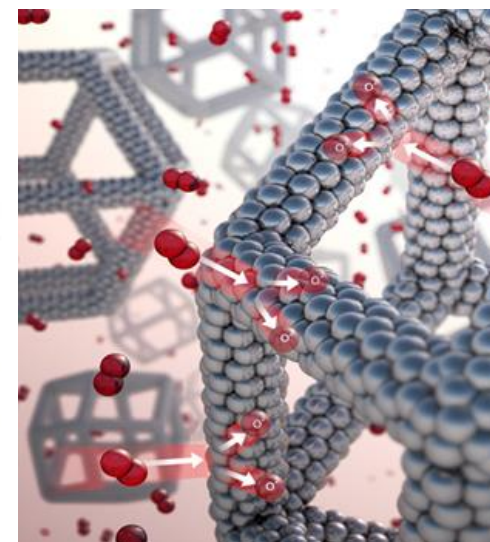
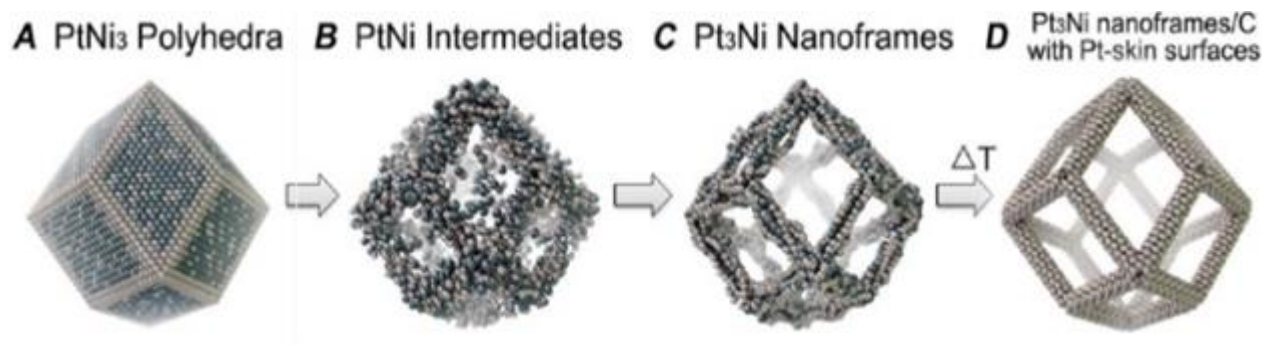


**5X** decrease in platinum loading

**2X** reduction system cost since 2006

**30X** increase in catalyst activity recently demonstrated in the lab

## Collaboration between UC Berkeley and ANL



*Potentially disruptive technologies are still possible*

# Hydrogen Production Strategies

## Current Technology

- Natural Gas (D/C)
- Electrolysis (D)

## Near to Mid-Term:

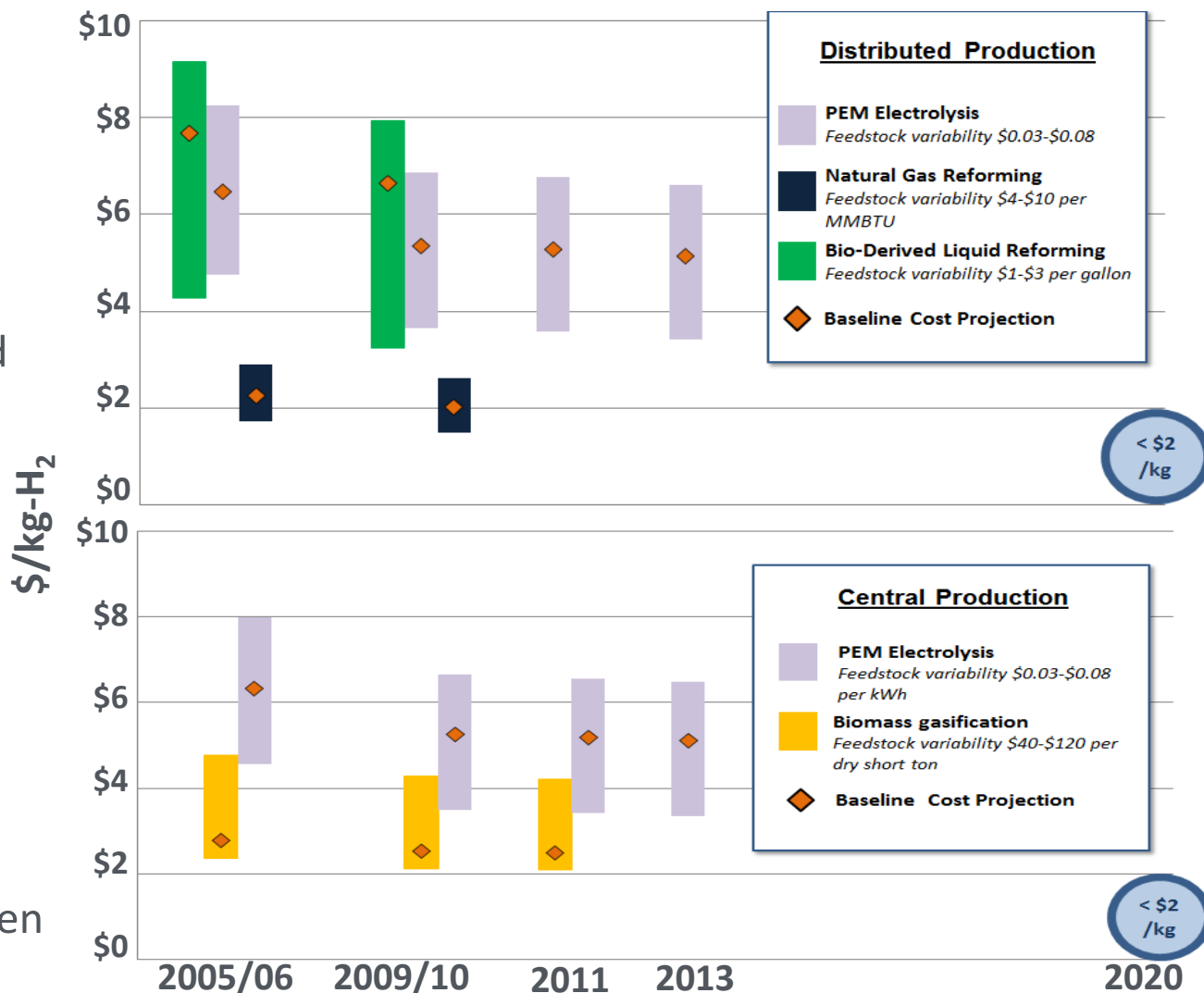
- Electrolysis- Wind and Solar Powered (D/C)
- Bio-derived Liquids (D/C)
- Fermentation (D/C)

## Long-Term (not shown):

### Central Renewable $H_2$

- Solar-based water splitting
- Photolytic Bio-hydrogen

D- Distributed      C- Central



*$H_2$  from NG can be competitive today - renewables is a longer-term focus*