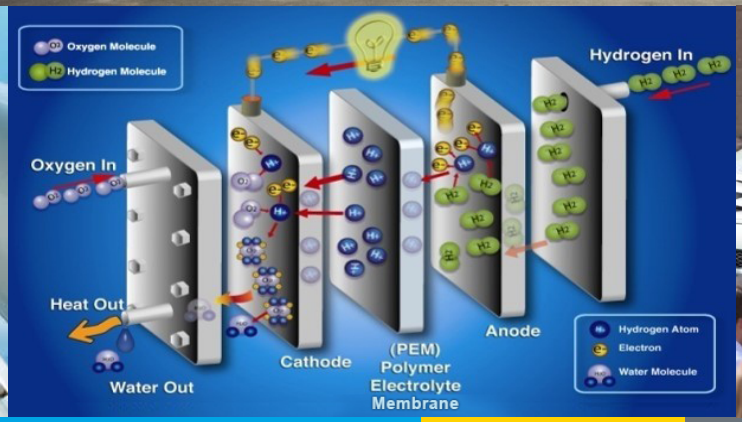
# U.S. Department of Energy Hydrogen and Fuel Cells Program

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









## $H_2$USA Breakout Session Introduction and Objectives

**Washington, DC**

July 12, 2016

**Dr. Sunita Satyapal**

Director
Fuel Cell Technologies Office
U.S. Department of Energy

# 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 $CO_2$ emissions by **3 billion metric tons** cumulatively by 2030 through efficiency standards set between 2009 and 2016
CAP Progress Report

# All-of-the-Above Energy Strategy

*"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*

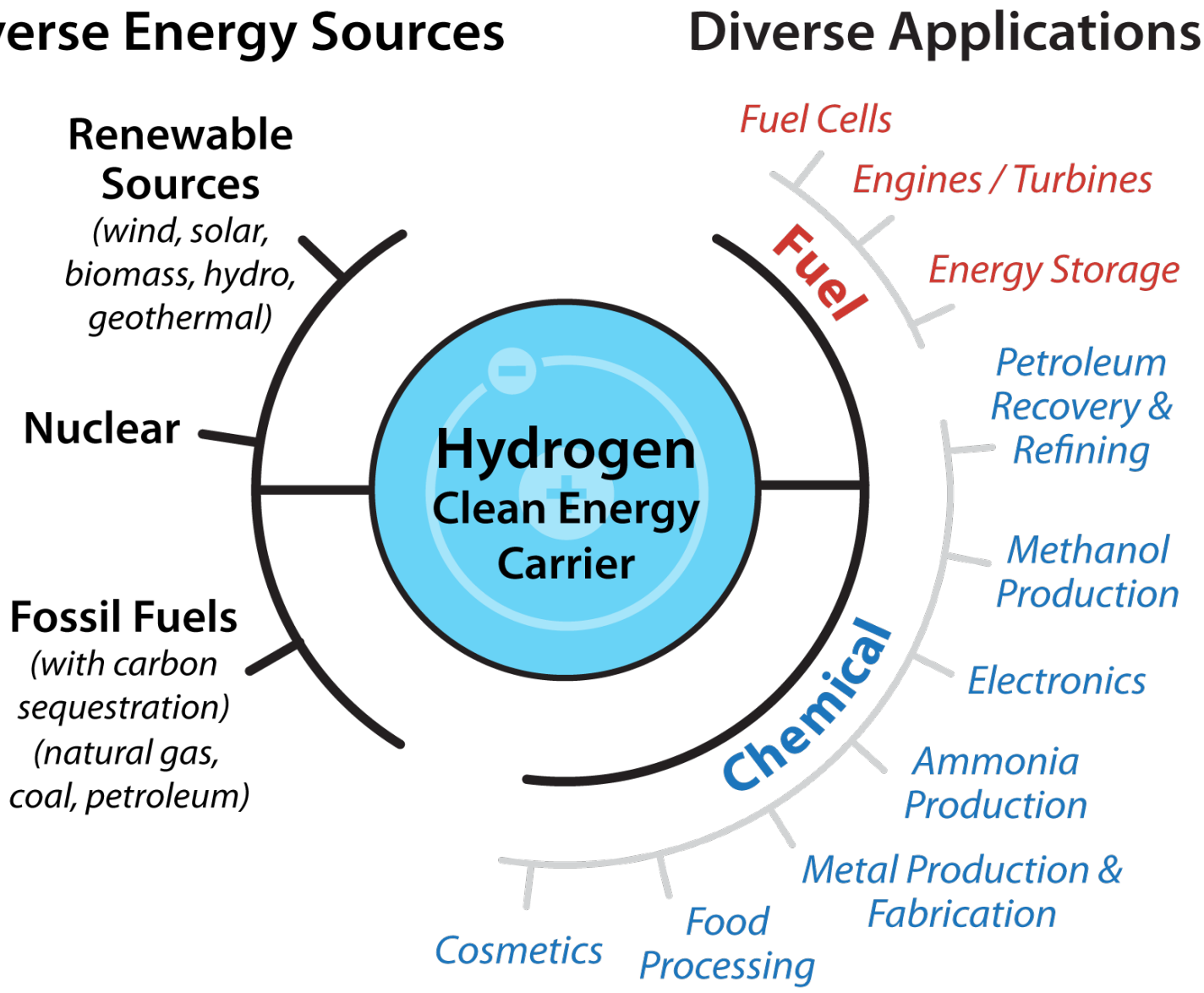
***"As part of an all-of-the-above energy approach, fuel cell technologies are paving the way to competitiveness in the global clean energy market and to new jobs and business creation across the country."***

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

Secretary Moniz at DC Auto Show

# Hydrogen- An energy carrier feedstock



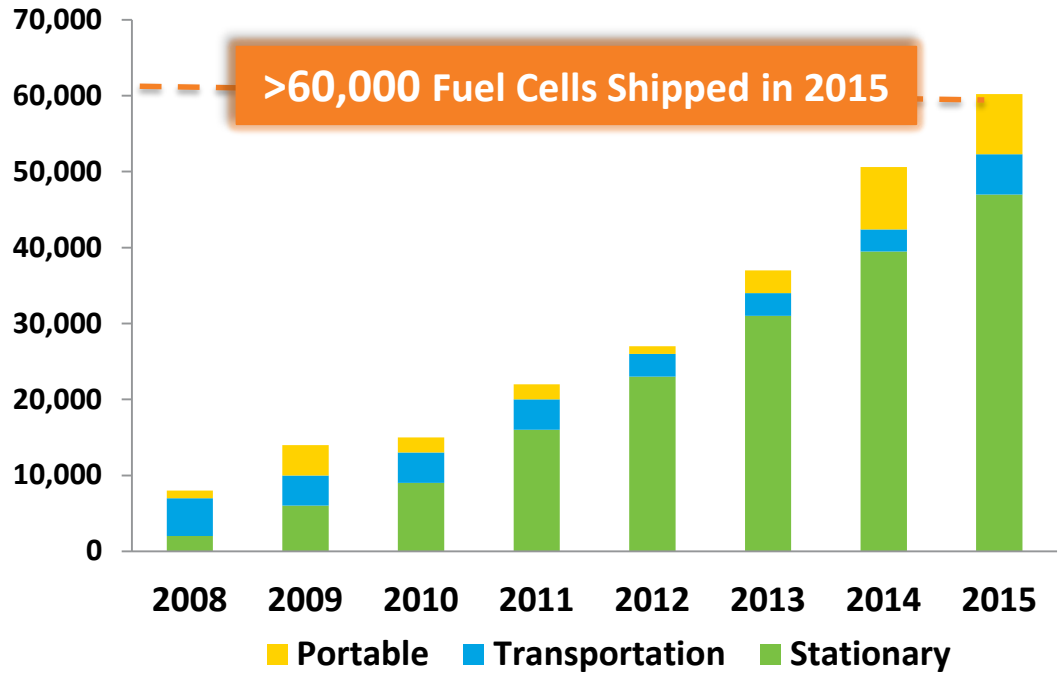



Source: DOE, NREL, Hydrogen and Fuel Cell Program

# Fuel Cells Market Overview



## Fuel Cell Systems Shipped Worldwide by Application




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

- Consistent **~30% annual growth** since 2010
- Global Market Potential in 10- 20 years*

$14B – $31B/yr for stationary power
$11B /yr for portable power
$18B – $97B/yr for transportation

*Fuel Cell Economic Development Plan, Connecticut Center for Advanced Technology, Inc. January 2008

## Fuel Cell Electric Vehicles (FCEVs) are here – more to come




*Honda Clarity Fuel Cell Vehicle*

# Life-cycle GHG Emissions- Today's Cars

## Low, Medium & High GHGs/Mile for 2015 Technology

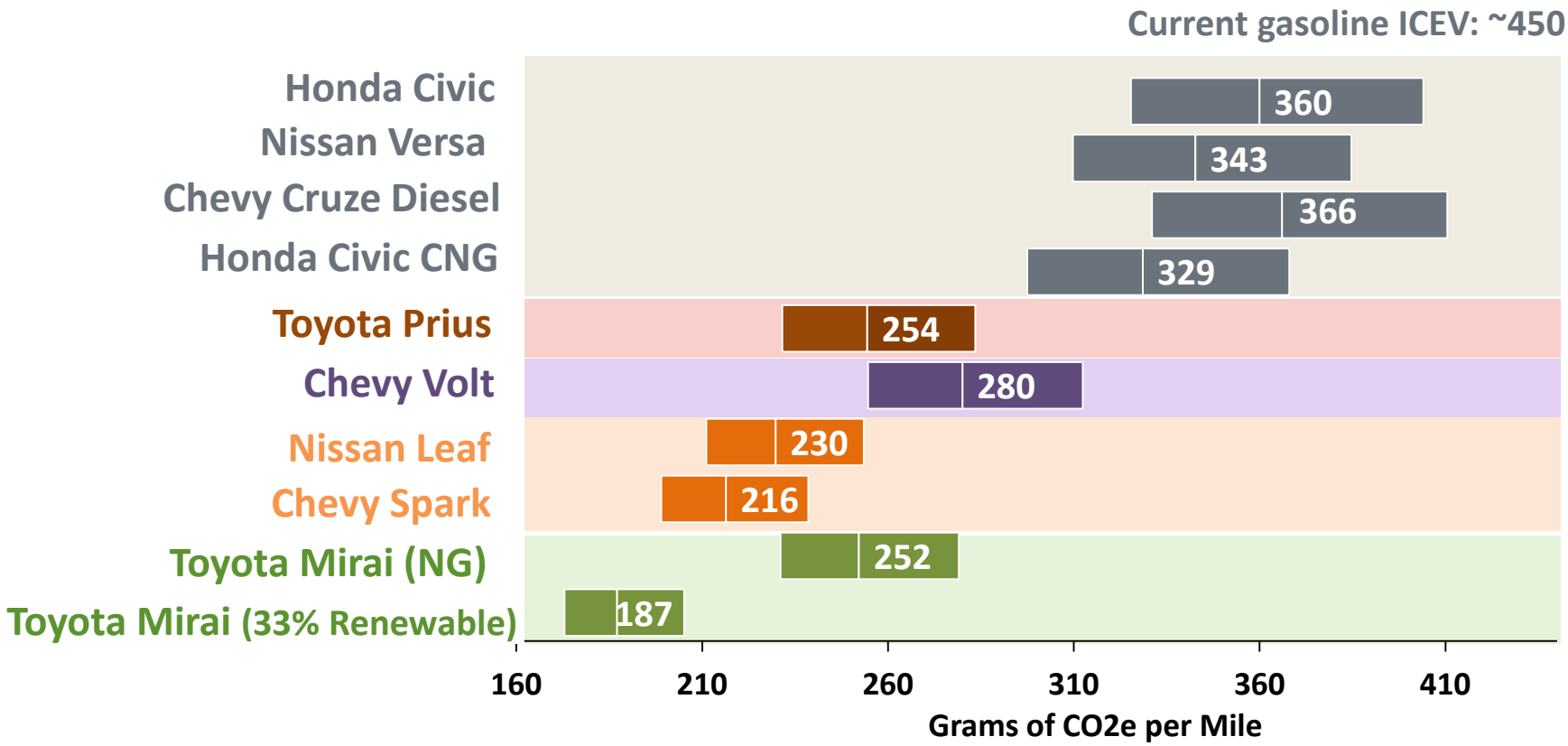

Internal Combustion Engine


Hybrid Electric


Extended-Range Electric


Battery Electric


Fuel Cell Electric




Joint VTO-FCTO Analysis Example

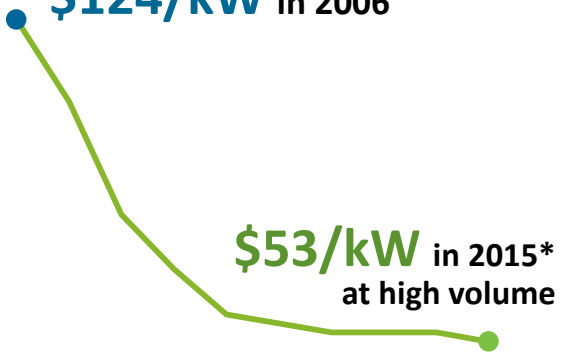
Source: Program Record 16004
(https://www.hydrogen.energy.gov/pdfs/16004_life-cycle_ghg_oil_use_cars.pdf)

# DOE FCTO Activities: RDD&D

## 1. Research & Development

### Fuel Cells

- >50% decrease in cost since 2006
- 5X less platinum
- 4X increase in durability




*$280/kW low volume

## 2. Demonstration

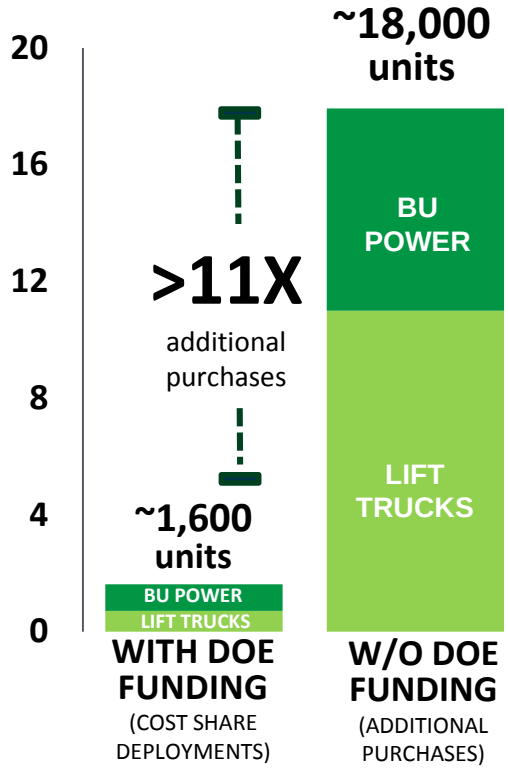
Forklifts, back-up power, airport cargo trucks, parcel delivery vans, marine APUs, buses, mobile lighting, refuse trucks

>220 FCEVs, >30 stations, >6M miles traveled

World's first tri-gen station


FCEV: Fuel Cell Electric Vehicle

## 3. Deployment




BU: Back Up Power

## Examples of consortia supporting R&D

- FCPAD (Fuel Cell Performance and Durability) — Fuel Cell Performance & Durability
- Advanced $H_2$ Storage Materials
- ElectroCat (Electrocatalysis Consortium) — PGM-Free Catalysts for Fuel Cells
- HydroGen (Advanced Water Splitting Materials) — Renewable $H_2$ Production

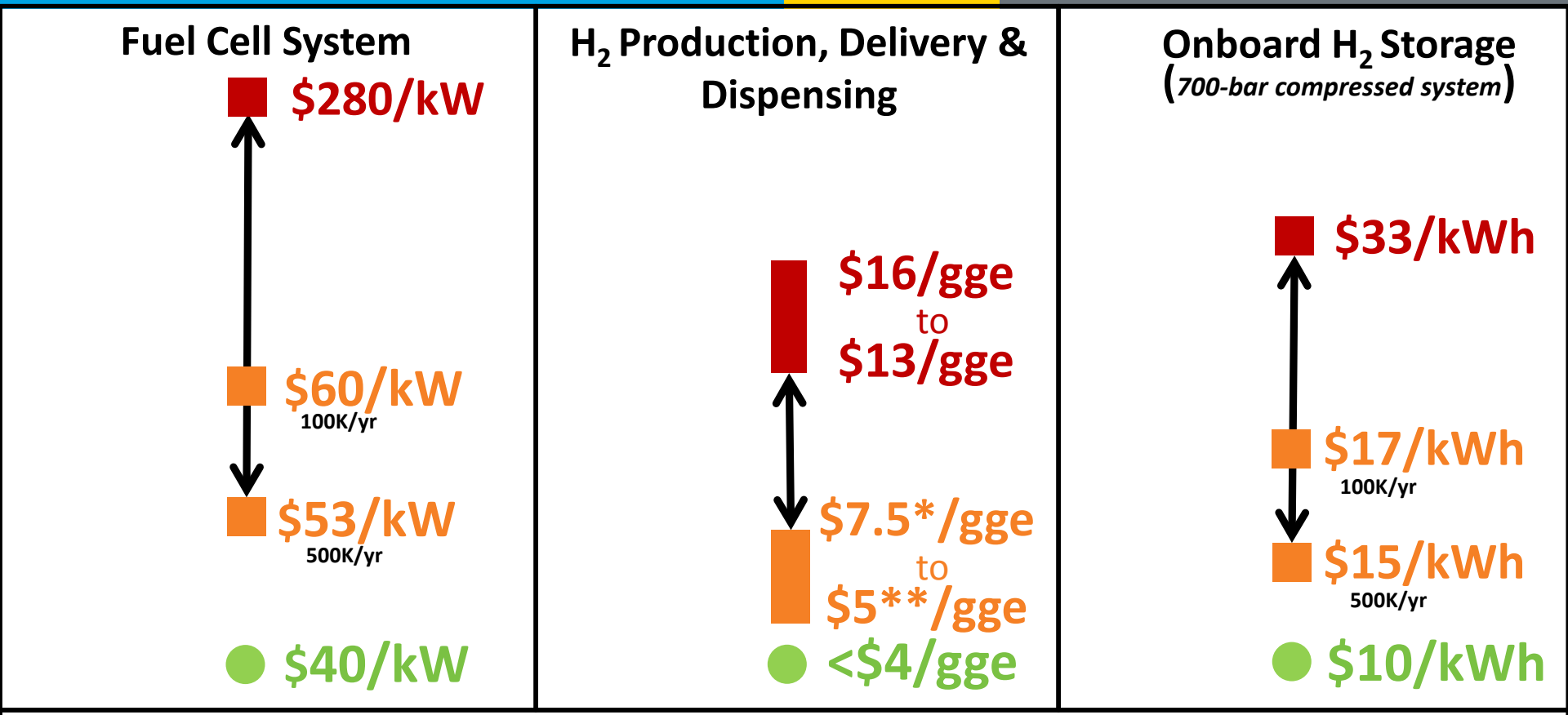
## Supporting Deployment

$H_2$ USA

Public-Private Partnership to address $H_2$ Infrastructure Barriers

# DOE Cost Targets and Status






## Key Challenges- Examples

- PGM loading
- Catalyst and membrane durability
- Electrode performance and durability

- Efficiency and Reliability
- Feedstock and Capital Costs
- Compression, Storage and Dispensing (CSD) Costs

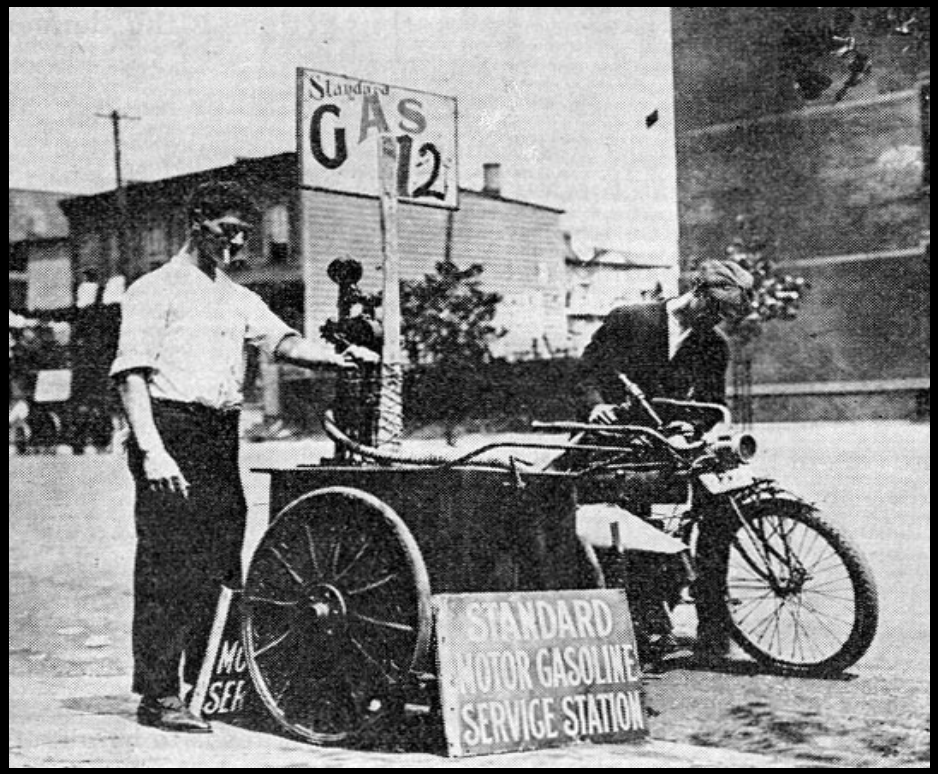
- Carbon fiber precursors and conversion
- Composite/resin materials
- BOP and assembly costs

*Based on Electrolysis **Based on NG SMR

# What can we learn from early gasoline infrastructure?

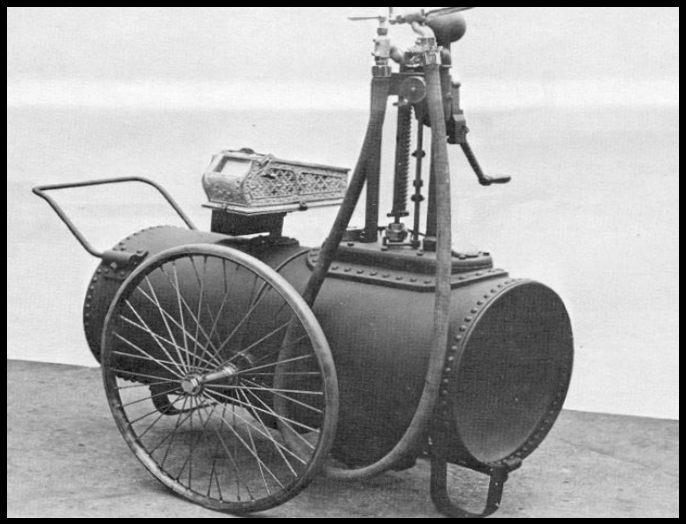
# Many diverse options

## Cans, barrels, home models, mobile refuelers




Source: M. Melaina 2008.

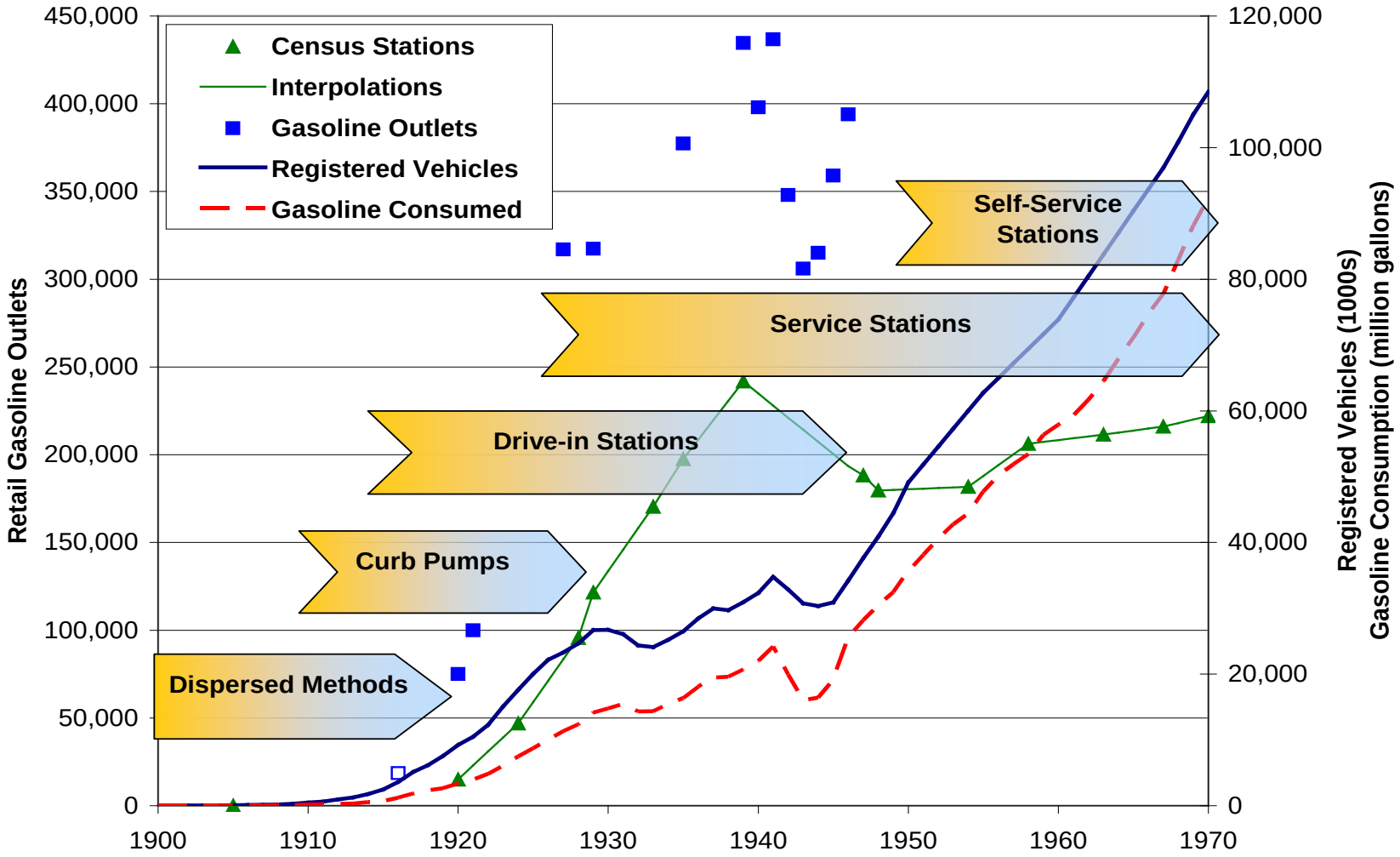

Source: Vieyra, 1979



Source: Milkues, 1978

# Examples of Gasoline Refueling Methods






*Source: Turn of the Century Refueling: A Review of Innovations in Early Gasoline Refueling Methods and Analogies for Hydrogen (Melaina 2007)*

***History shows phased introduction of different refueling methods***

# Global Landscape: Examples of Infrastructure Activities

Japan

## Hydrogen Supply/Utilization Technology (HySUT)

- 2016 Status: ~80 stations & >570 FCEVs
- Goals: FCEVs 40K by 2020, 200K by 2025, 800K by 2030
  Stations: 160 by 2020, 320 by 2025, 900 by 2030

Germany

## H2Mobility

- 2016 Status: >40 stations & >100 FCEVs
- Goals: Stations- 100 by 2018-2019 and 400 by 2023

UK

## UKH2Mobility

- 2016 Status: 16 stations and 12 fuel cell electric buses (FCEBs)
- Goals: 65 H2 Stations by 2020

Denmark
Norway
Sweden

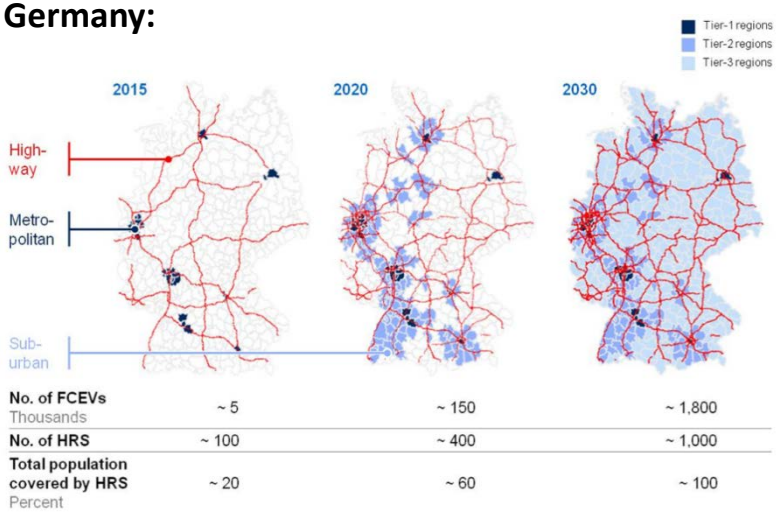
## Scandinavian H2 Highway Partnership (SHHP)

- 2016 Status: ~20 stations, >70 FCEVs
- 45 $H_2$ stations and a fleet of ~1K vehicles.
- Projects include H2Moves Scandinavia and Next Move

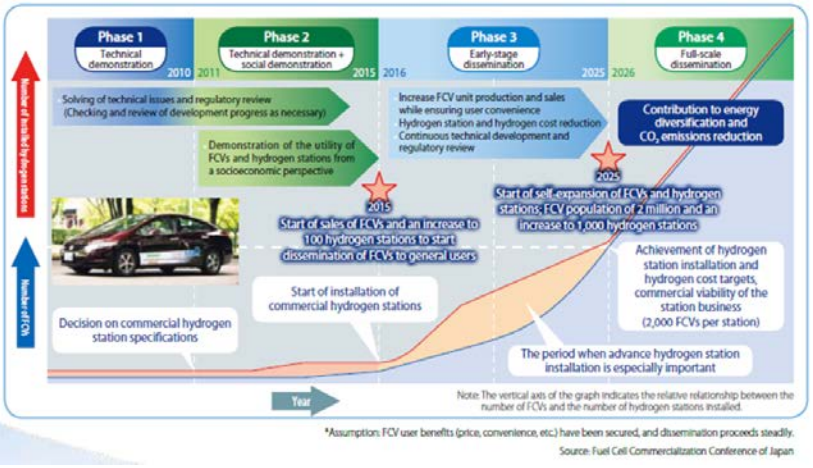
*Korea and France also have plans to accelerate hydrogen and FCEV market

## Examples of Roadmaps

### Germany:




### Japan:




***International partnerships established to accelerate hydrogen infrastructure***

Cost

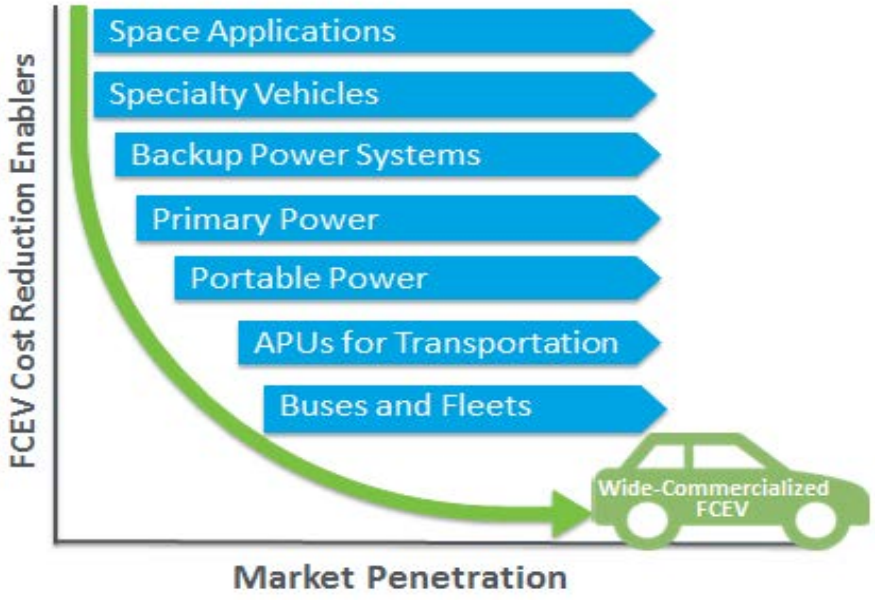
Volume

Availability

# Early Market Strategies Increase Volume

## Early Markets enable:

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




## Early Markets Applications Deployed in the U.S.

- **>1,300 fuel cell** systems **deployed**
- **MHE** (Material Handling Equipment) with **>2M hrs. of operation**
- **Backup power for 1,000** unscheduled system **disruptions**


Forklifts


Fuel Cell Tow Trucks


Backup Power


Fuel Cell Bus Fleets

# Hydrogen & Fuel Cells Budget



| Key Activity | FY 15 | FY 16 | FY17 |
|---|---|---|---|
| | ($ in thousands) | | |
| | Approp. | Approp. | Request |
| Fuel Cell R&D | 33,000 | 35,000 | 35,000 |
| Hydrogen Fuel R&D[1] | 35,200 | 41,050 | 44,500 |
| Manufacturing R&D | 3,000 | 3,000 | 3,000 |
| Systems Analysis | 3,000 | 3,000 | 3,000 |
| Technology Validation | 11,000 | 7,000 | 7,000 |
| Safety, Codes and Standards | 7,000 | 7,000 | 10,000 |
| Market Transformation | 3,000 | 3,000 | 3,000 |
| Technology Acceleration | 0 | 0 | 13,000[2] |
| NREL Site-wide Facilities Support | 1,800 | 1,900 | N/A |
| **Total** | 97,000 | 100,950 | 105,500 |

**Emphasis in FY17 Request**

[1]Hydrogen Fuel R&D includes Hydrogen Production & Delivery R&D and Hydrogen Storage R&D

[2]Combines Manufacturing R&D, Technology Validation, Market Transformation.

***FY17 Pending Appropriations (Senate mark: $92M, House: $97M)***

# Appropriations Subcommittee Recommendations

**Examples relevant to H2@Scale:**

Senate:

- $7M to demonstrate an integrated hydrogen renewable energy production, storage, and transportation fuel distribution and retailing system.

House:

- $2M for the EERE share of the integrated energy systems work with the Office of Nuclear Energy and $7M to enable integrated energy systems using high and low temperature electrolyzers with the intent of advancing the H2@Scale concept.

***Pending final appropriations***

# Objectives for Today



- **Provide an overview of H2USA** activities in addressing $H_2$ infrastructure challenges and H2 supplier perspectives
- **Introduce H2@Scale concept and potential** for penetration of renewables
- **Provide grid/utility and end user perspectives on H2@Scale**
- **Share stakeholder feedback on H2@Scale** opportunities and remaining questions

# Thank You

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**hydrogenandfuelcells.energy.gov**