FUEL CELL TECHNOLOGIES PROGRAM

DOD-DOE Workshop: Shipboard APUs

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

Overview

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Fuel Cell Technologies Program
U.S. Department of Energy

U.S. share of PV production has fallen significantly over the last 10 years

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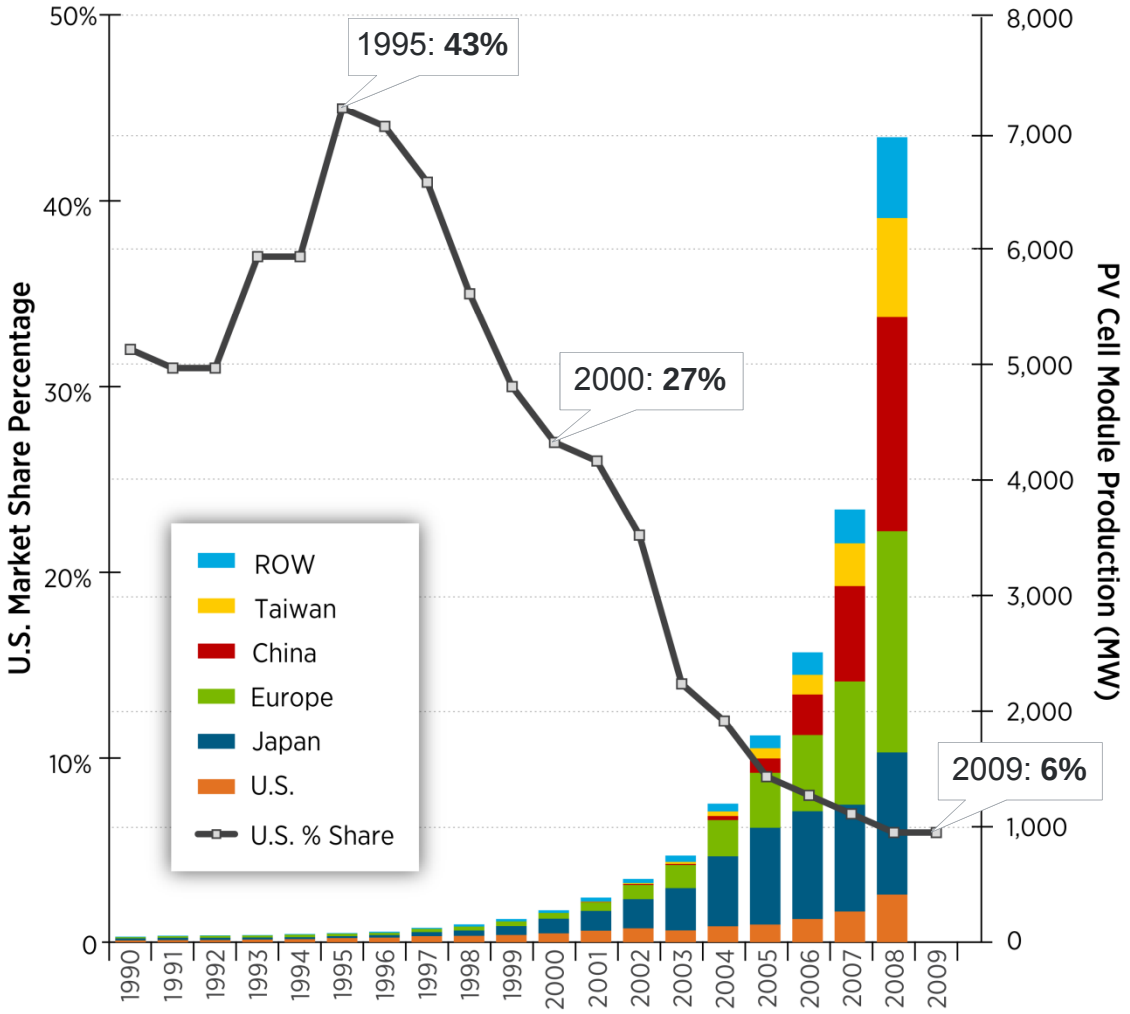
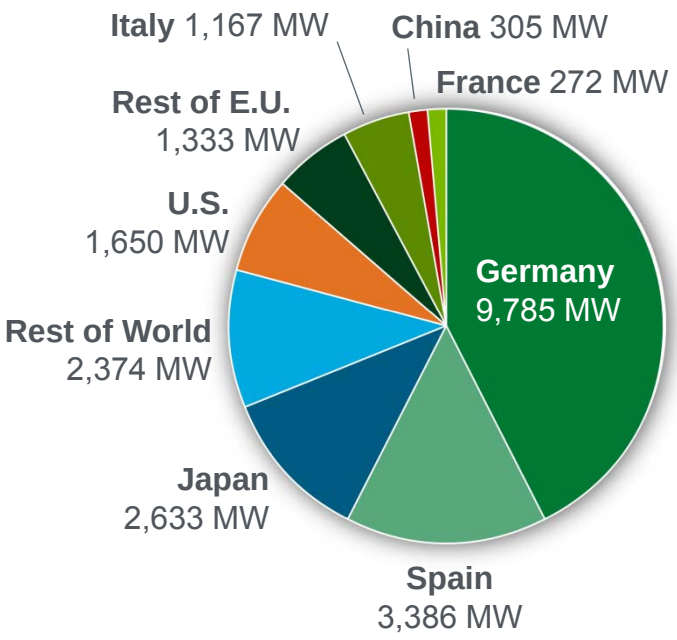
Global & U.S. Annual PV Production by Region



Cumulative Installed PV
(through 2009)



Global Market Overview

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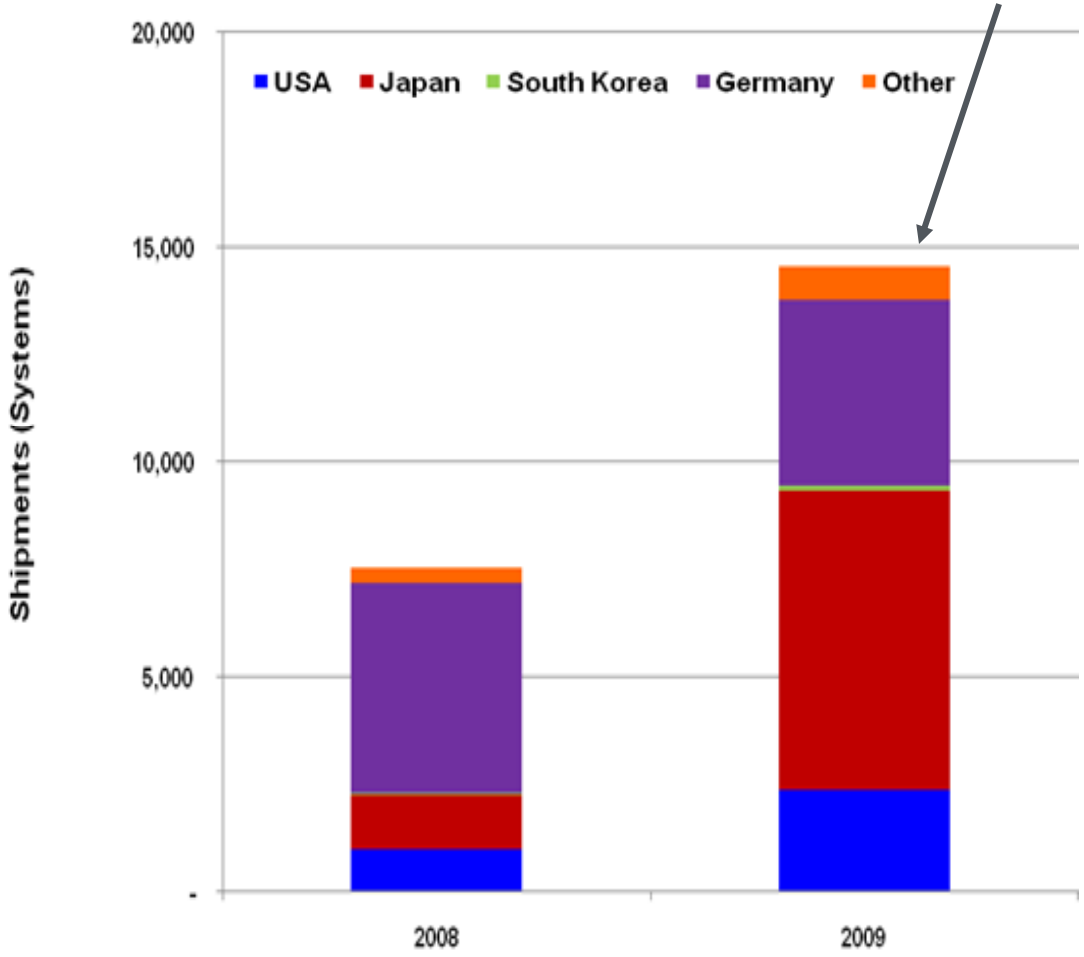
Global Shipments of Fuel Cell Systems by US Companies and Non-US Companies

Significant increase in units shipped by non-US companies >40% market growth in just one year



Preliminary market analysis

International Landscape favors H_2 & Fuel Cells

- Germany (>$1.2B; 1,000 H_2 stations)
- European Commission (>$1.2B, 2008-2013)
- Japan (2M vehicles, 1,000 H_2 stations by 2025)
- South Korea (plans to produce 20% of world shipments & create 560,000 jobs in Korea)
- China (thousands of small units; 70 FCVs, buses, 100 shuttles at World Expo, Olympics)
- Subsidies for jobs, manufacturing, deployments

Global Market Overview

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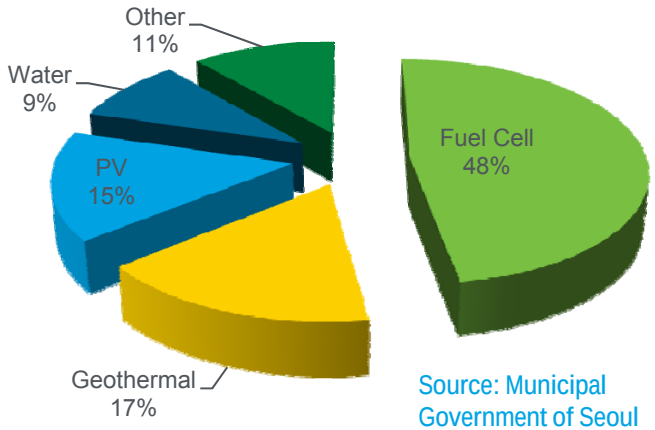
Example: Seoul's renewable energy generation plan includes **~ 48% fuel cells**

Anticipated Renewable Energy Generation in Seoul, Korea by 2030

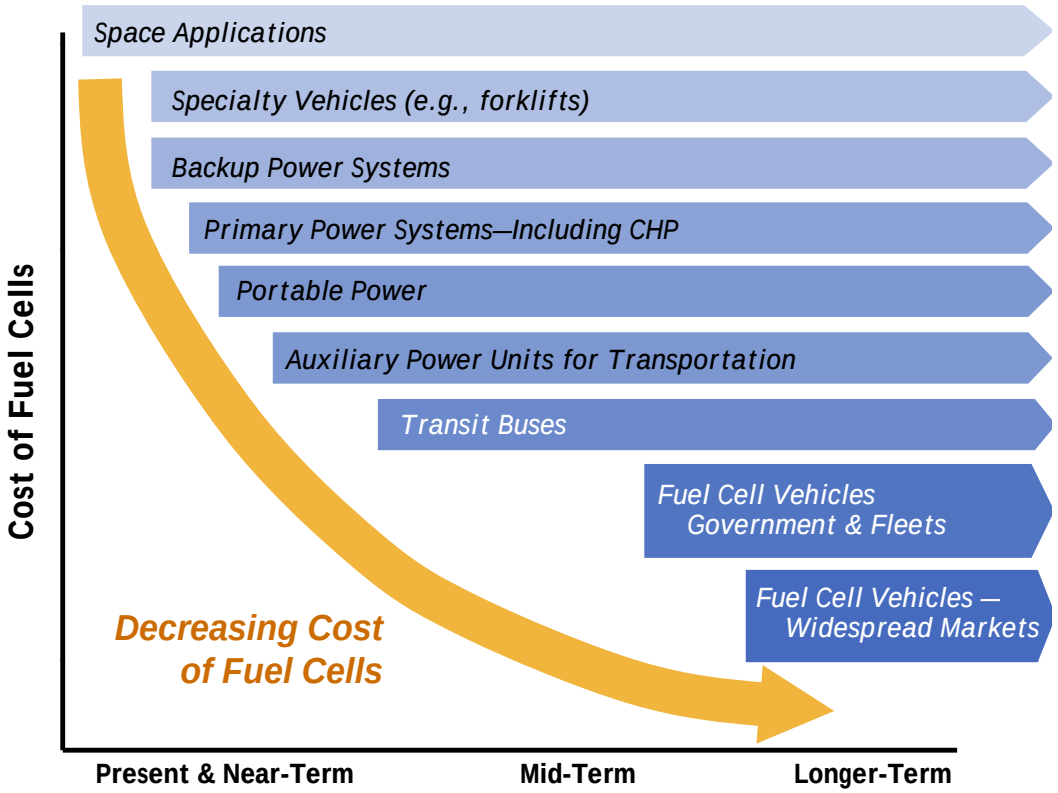


Source: Municipal Government of Seoul

Example: Denmark Backup Power Deployments

50,000 potential sites
>500 deployments worldwide

Early markets and diverse applications provide an opportunity to enable cost reductions and establish domestic leadership.



DOE Fuel Cell R&D — *Progress: Cost*

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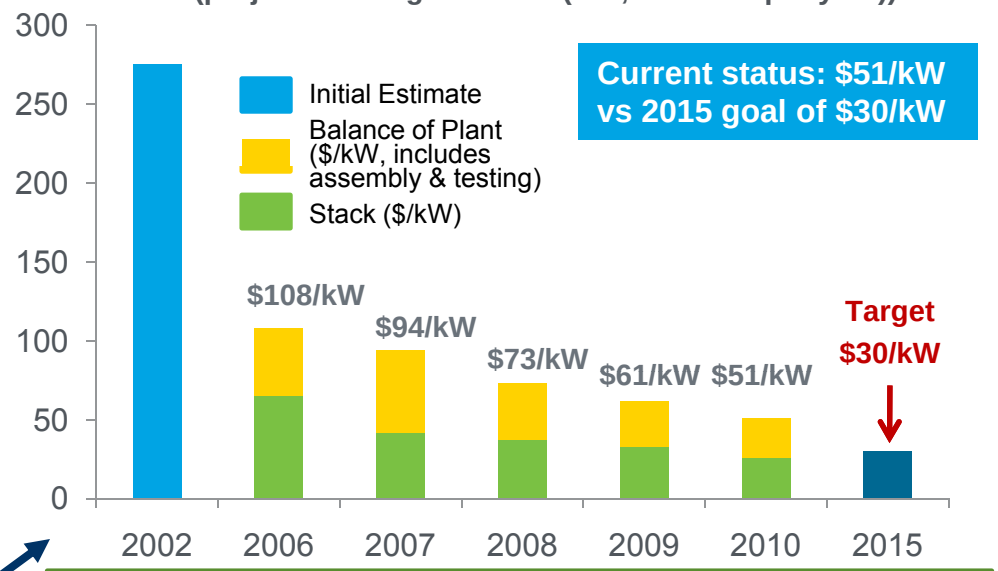
Projected high-volume cost of fuel cells has been reduced to $51/kW (2010)*

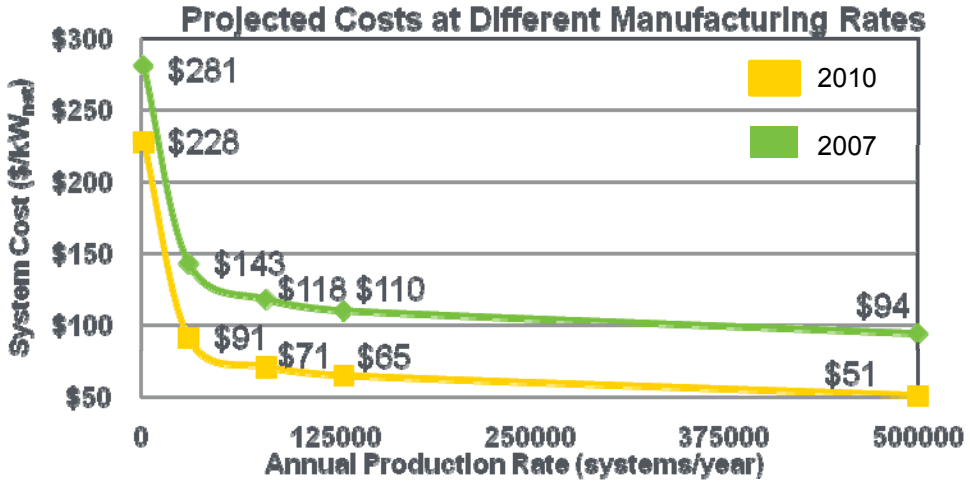
- ***More than 30% reduction since 2008***
- ***More than 80% reduction since 2002***
- ***2008 cost projection was validated by independent panel*****

As stack costs are reduced, balance-of-plant components are responsible for a larger % of costs.

Projected Transportation Fuel Cell System Cost
(projected to high-volume (500,000 units per year))



More than 80% cost reduction since 2002.

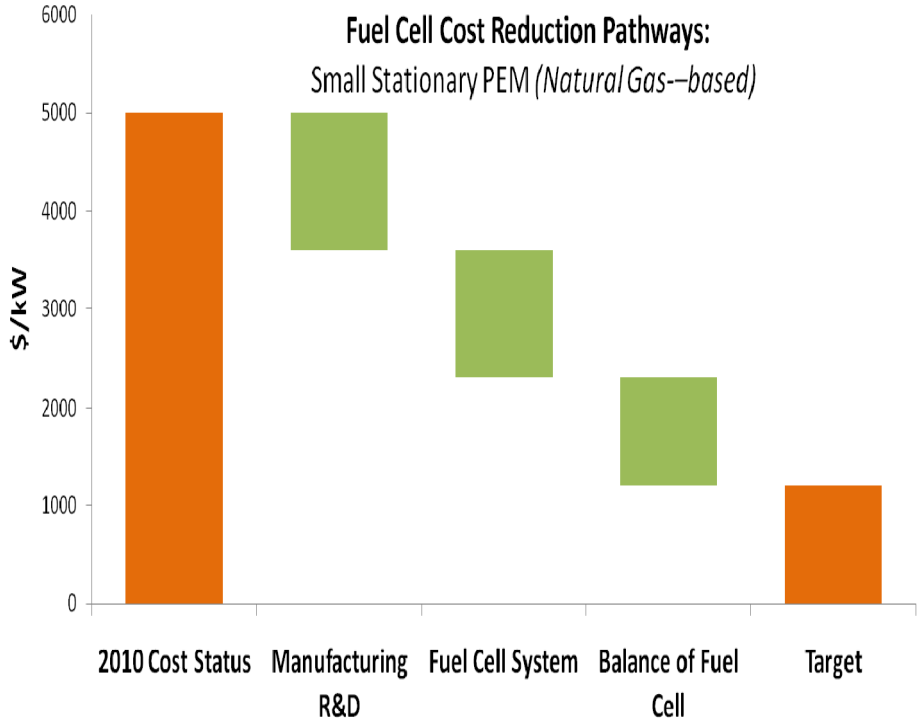


***Based on projection to high-volume manufacturing (500,000 units/year).**

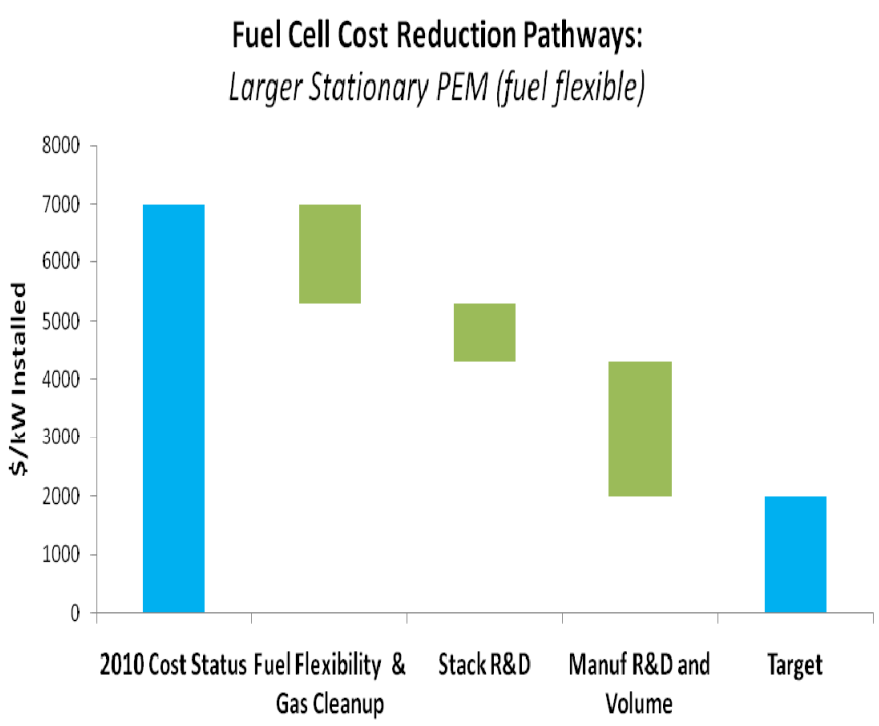
****Panel found $60 – $80/kW to be a "valid estimate": http://hydrogendoedev.nrel.gov/peer_reviews.html**

Preliminary analysis shows potential areas for stationary fuel cell cost reduction

Small-scale PEM Fuel Cells with Natural Gas



Medium-Scale Fuel Cell CHP with Biogas



Hydrogen R&D – Production, Delivery, Storage

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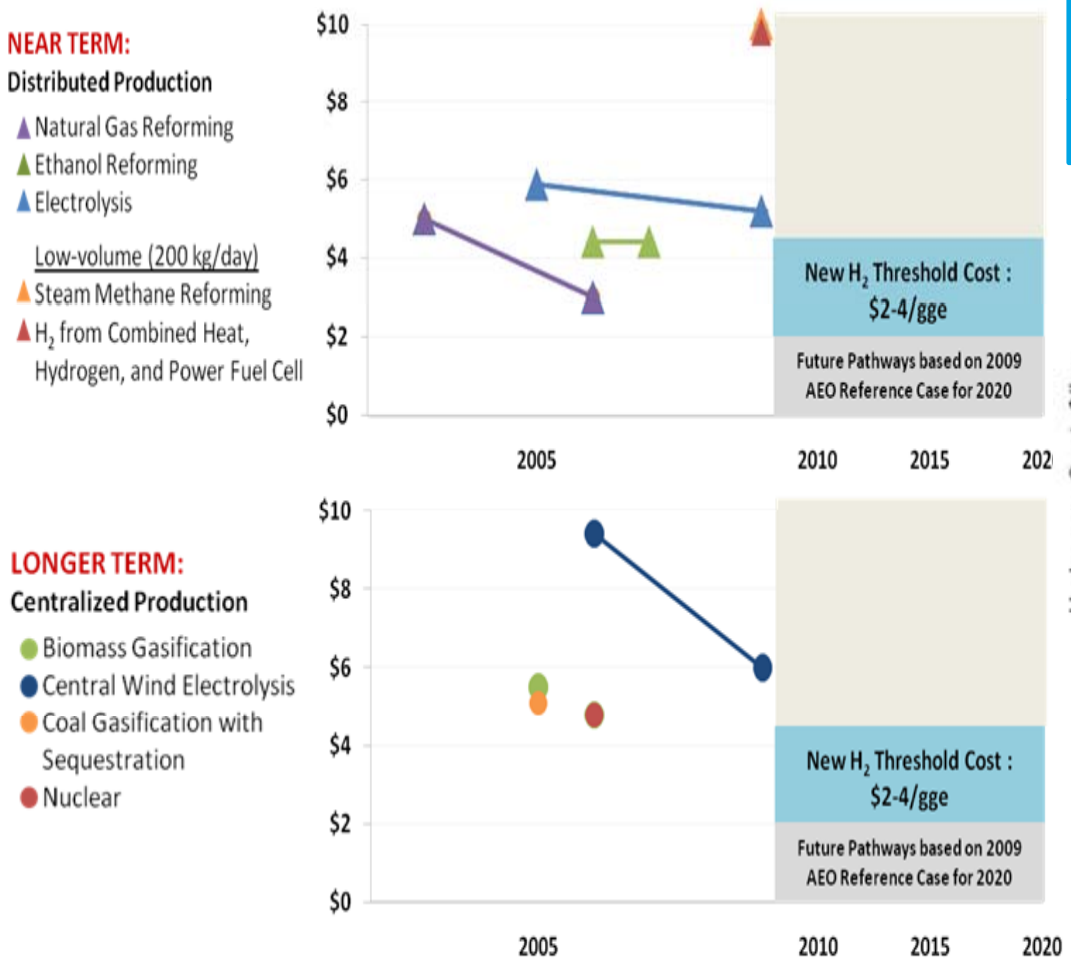
Projections of high-volume / nth plant production and delivery of hydrogen meet the targets for most technologies.

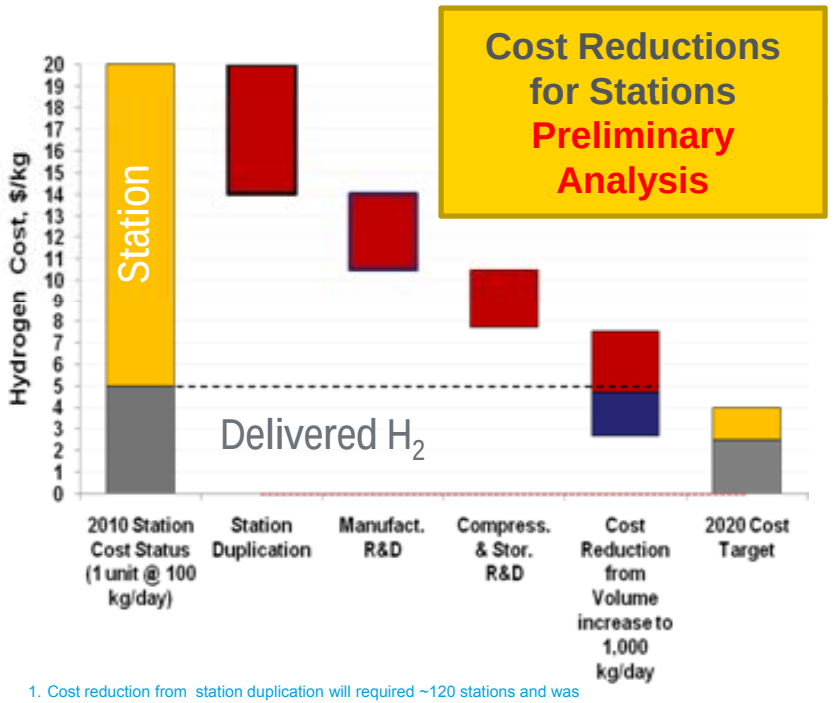


Notes: Data points are being updated to the 2009 AEO reference case. The 2010 Technology Validation results show a cost range of $8-$10/gge for a 1,500 kg/day distributed natural gas and $10-$13/gge for a 1,500 kg/day distributed electrolysis hydrogen station.

We've reduced the cost of H2 delivery*

- ~30% reduction in tube trailer costs
- >20% reduction in pipeline costs
- ~15% reduction liquid hydrogen delivery costs

**Projected cost, based on analysis of state-of-the-art technology*



1. Cost reduction from station duplication will required ~120 stations and was based on 3% reduction for a doubling of capacity. Reference: "A portfolio of power-trains for Europe: a fact-based analysis" by McKinsey & Co.
2. Cost of hydrogen delivered to station is ~$5/kg based on TTC Hydrogen Market Study 2009.
3. Station cost reductions based on ANL Hydrogen Delivery Systems Analysis Model (HDSAM). 4. The Current station cost is based on costs from the current California state funded stations. The capital cost for the station is $2.5 million.. 5. The starting station capacity is 100 kg/day.

Systems Analysis – *WTW Updates*

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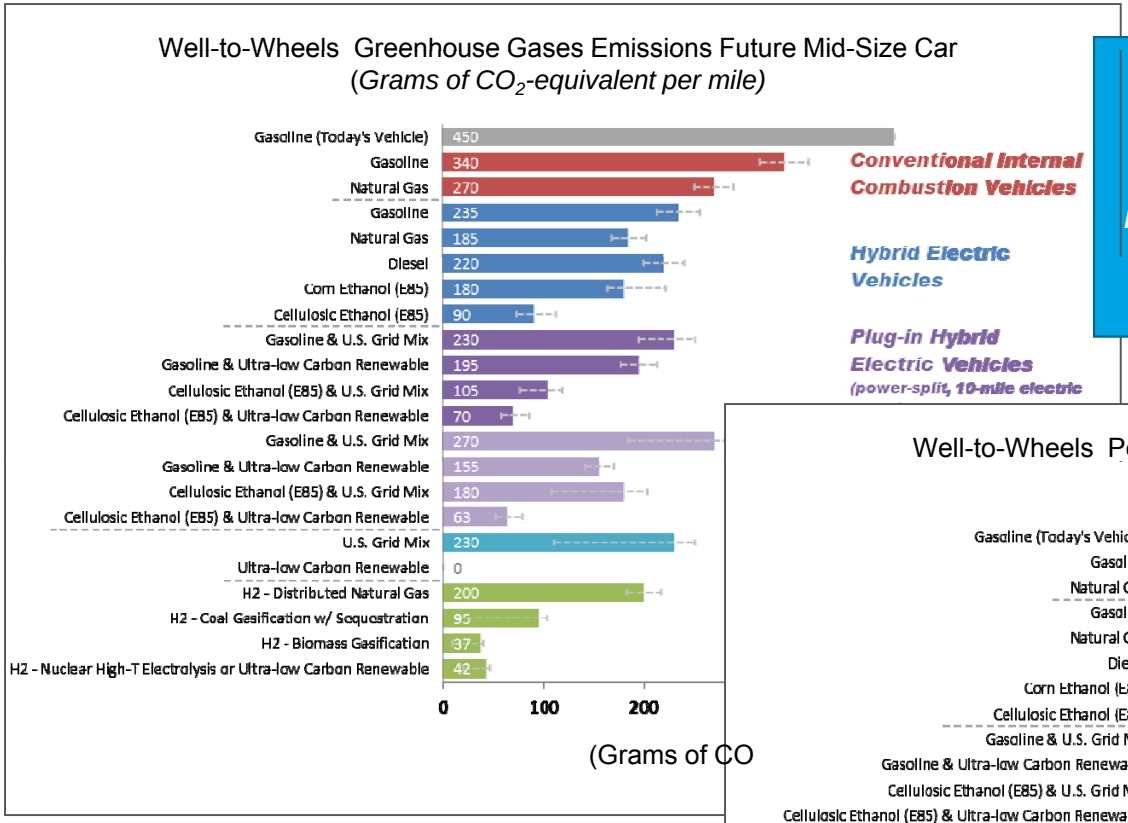
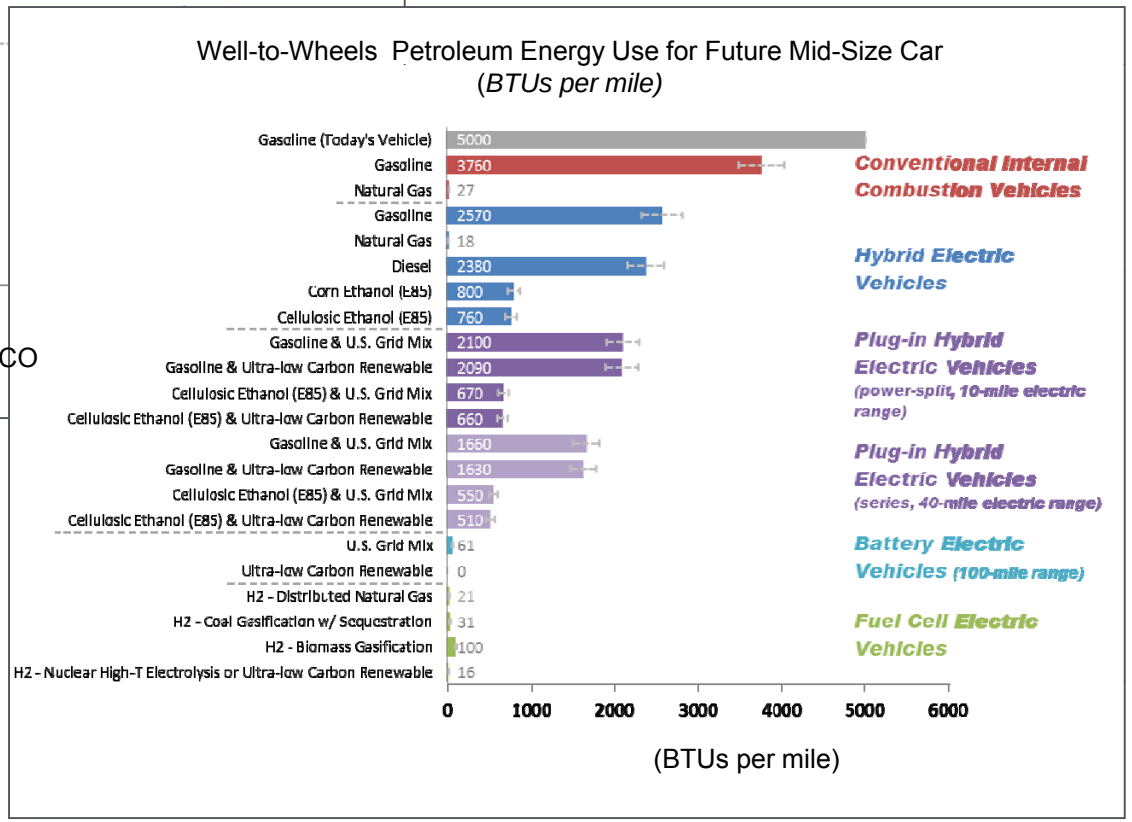


Analysis includes portfolio of transportation technologies and latest models and updates to well-to-wheels assumptions



Analysis & Assumptions at:

http://hydrogen.energy.gov/pdfs/10001_well_to_wheels_gge_petroleum_use.pdf

Notes:
For a projected state of technologies in 2035-2045.
Ultra-low carbon renewable electricity includes wind, solar, etc.
Does not include the life-cycle effects of vehicle manufacturing and infrastructure construction/decommissioning.
Global warming potential of primary fuels excluded.

Thank you

For more information, please contact

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hydrogenandfuelcells.energy.gov

Additional Information

Collaborations

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

Federal Agencies

- DOC
- DOD
- DOE
- DOT
- EPA
- GSA
- DOI
- DHS
- NASA
- NSF
- USDA
- USPS

– *Interagency coordination through staff-level Interagency Working Group (meets monthly)*

– *Assistant Secretary-level Interagency Task Force mandated by EPACT 2005.*

Universities

~ 50 projects with 40 universities

International

- **IEA Implementing agreements – 25 countries**
- **International Partnership for Hydrogen & Fuel Cells in the Economy – 17 countries & EC, 30 projects**

DOE Fuel Cell Technologies Program*

– ***Applied RD&D***

– ***Efforts to Overcome Non-Technical Barriers***

– ***Internal Collaboration with Fossil Energy, Nuclear Energy and Basic Energy Sciences***

Industry Partnerships & Stakeholder Assn's.

- **FreedomCAR and Fuel Partnership**
- **Fuel Cell and Hydrogen Energy Association (FCHEA)**
- **Hydrogen Utility Group**
- **~ 65 projects with 50 companies**

State & Regional Partnerships

- **California Fuel Cell Partnership**
- **California Stationary Fuel Cell Collaborative**
- **SC H_2 & Fuel Cell Alliance**
- **Upper Midwest Hydrogen Initiative**
- **Ohio Fuel Coalition**
- **Connecticut Center for Advanced Technology**

National Laboratories

National Renewable Energy Laboratory P&D, S, FC, A, SC&S, TV, MN
Argonne A, FC, P&D, SC&S
Los Alamos S, FC, SC&S
Sandia P&D, S, SC&S
Pacific Northwest P&D, S, FC, SC&S, A
Oak Ridge P&D, S, FC, A, SC&S
Lawrence Berkeley FC, A
Lawrence Livermore P&D, S, SC&S
Savannah River S, P&D
Brookhaven S, FC
Idaho National Lab P&D

Other Federal Labs: **Jet Propulsion Lab, National Institute of Standards & Technology, National Energy Technology Lab (NETL)**

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