



Hydrogen and Fuel Cell Technologies Overview

8/11/2011

Dr. Sunita Satyapal

U.S. Department of Energy
Fuel Cell Technologies
Program Manager

Purpose

- Identify and prioritize challenges and barriers to manufacture of hydrogen and fuel cell systems and components
- Identify and prioritize R&D activities that government can support to overcome the barriers

Workshop Output:

- Preliminary list of R&D needs for hydrogen and fuel cell manufacturing
- Report of workshop proceedings including plenary presentations and summary of participant input (to be made available online)

Post-Workshop Output:

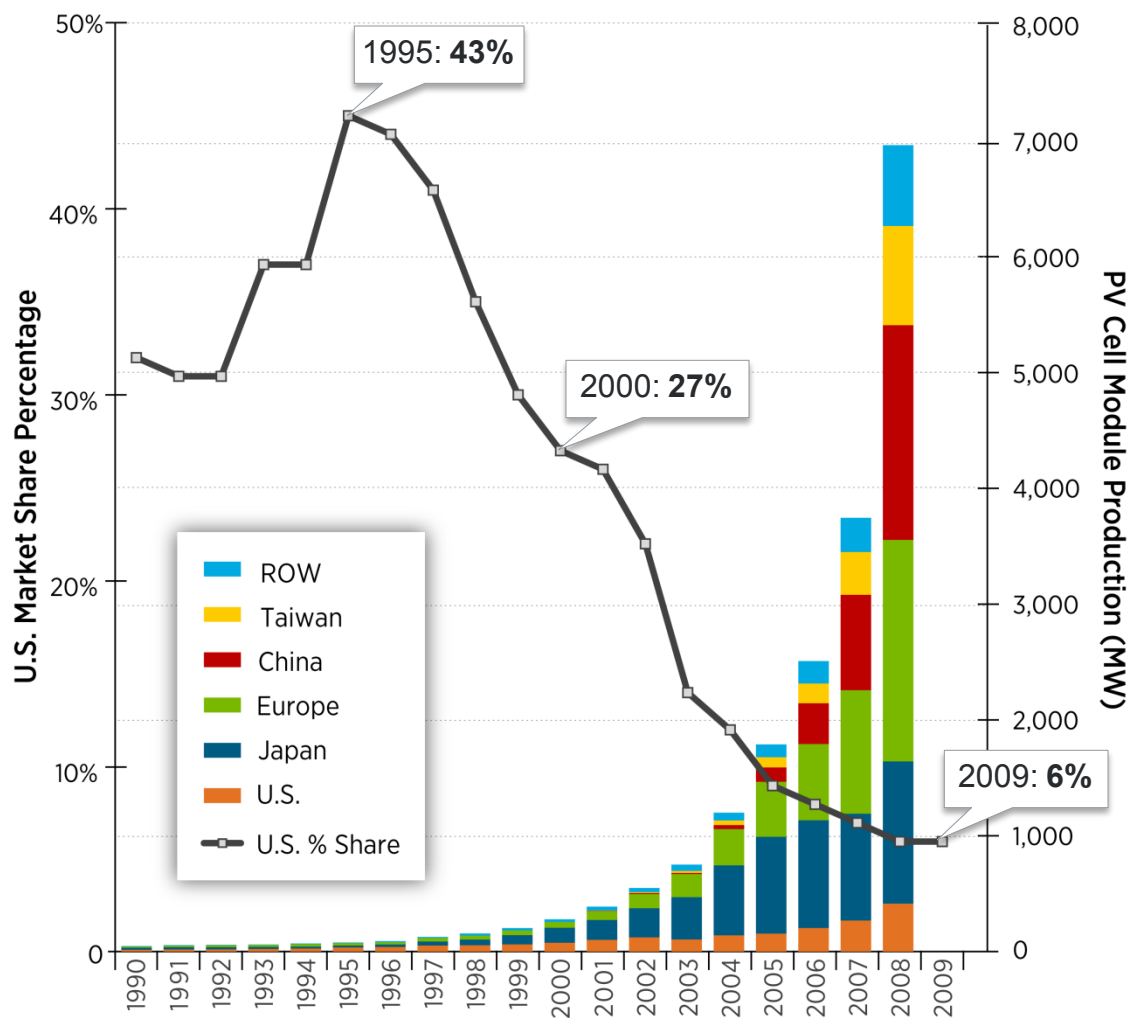
- Review and update prioritized lists of challenges/barriers and opportunities for government support

Please Note:

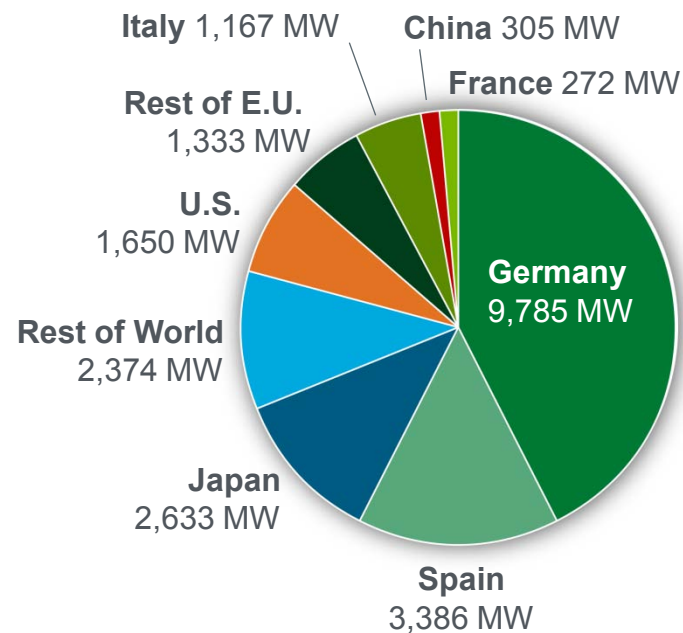
- *No sales pitches*
- *Not to present “mini-proposals” on particular RD&D ideas*
- *Not to think only “inside the box”*

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

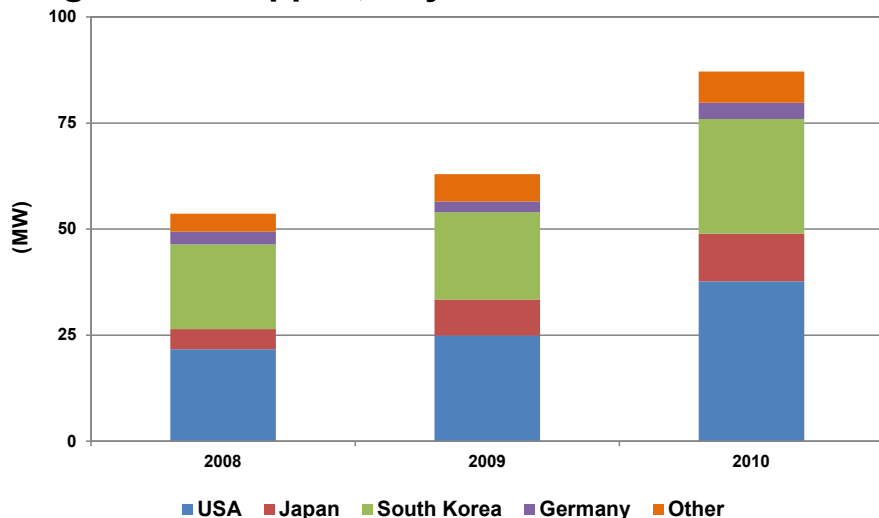
Global & U.S. Annual PV Production by Region



Cumulative Installed PV (through 2009)



Megawatts Shipped, Key Countries: 2008-2010



Fuel cell market continues to grow

- ~36% increase in global MWs shipped
- ~50% increase in US MWs shipped

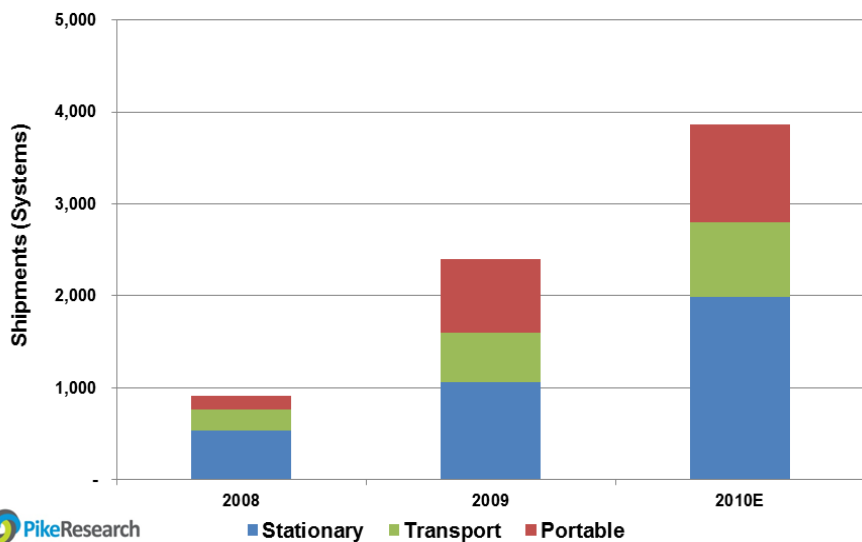
Various analyses project that the global fuel cell/hydrogen market could reach maturity over the next 10 to 20 years, producing revenues of:

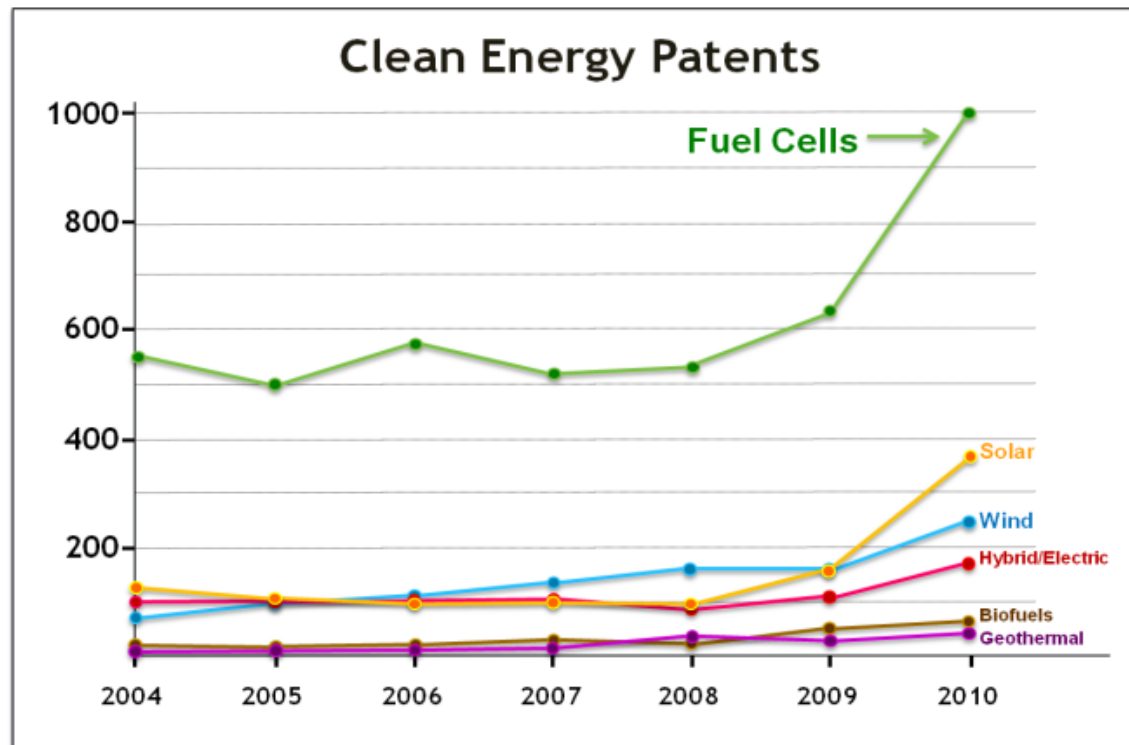
- \$14 – \$31 billion/year for stationary power
- \$11 billion/year for portable power
- \$18 – \$97 billion/year for transportation

Widespread market penetration of fuel cells could lead to:

- 180,000 new jobs in the US by 2020
- 675,000 jobs by 2035

North American Shipments by Application



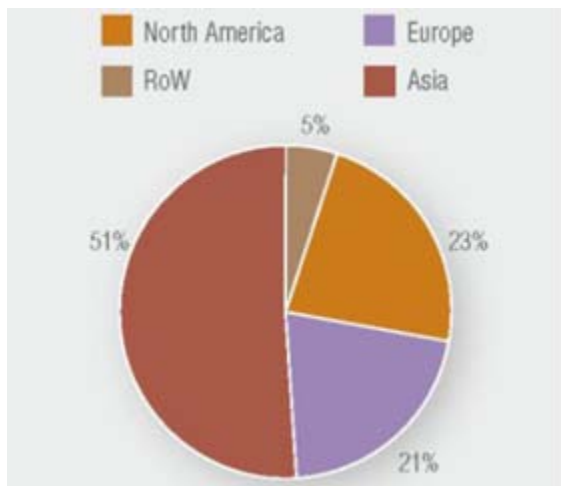


Clean Energy Patent Growth Index^[1] shows that fuel cell patents lead in the clean energy field with nearly 1,000 fuel cell patents issued worldwide in 2010.

- 3x more than the second place holder, solar, which has just ~360 patents.
- Number of fuel cell patents grew > 57% in 2010.

[1] http://cepgi.typepad.com/heslin_rothenberg_farley_/

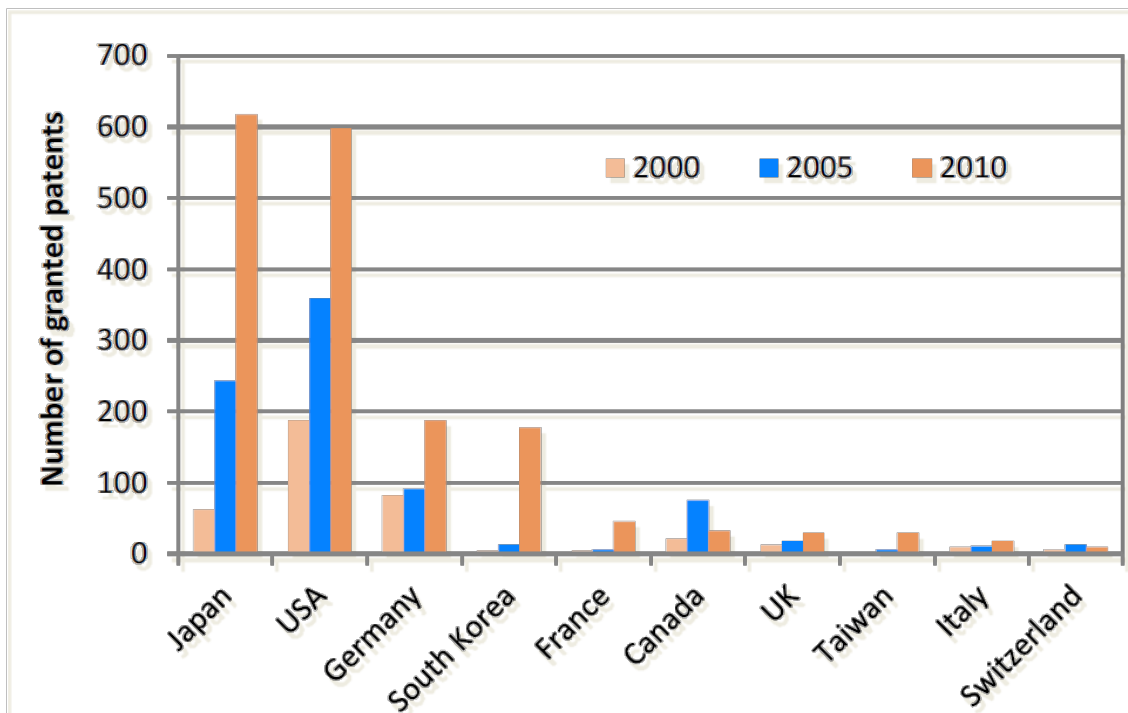
Job Creation by Region of Production 2009-2019



Source: FuelCellToday

Significant growth in number of patents filed by Japan, Korea, Germany, U.S.
Job creation projections show significant growth in Asia and Europe.

Annual granted fuel cell patents per country of origin (top ten)



Source: FuelCellToday

Developed user-friendly tool to calculate economic impacts

REQUIRED USER INPUT FIELDS

Select State or Region	NE
Type of Fuel Cell	PEMFC
Application	Stationary - Backup
Average Size of Manufactured Fuel Cell	5
Fuel Cells Manufactured by Year	2000
Annual Fuel Cell Production (kW/year)	10,000
Time Frame (years)	5

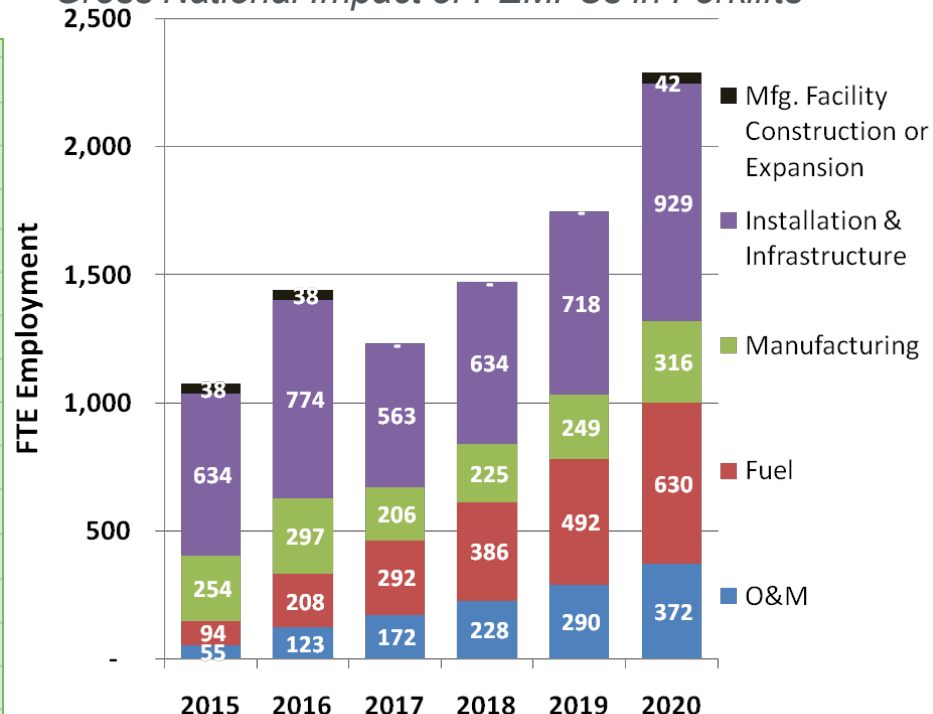
OPTIONAL USER INPUT FIELDS

Existing Fuel Cell Production Capacity (kW/year)	0
Additional Manufacturing Capacity to be Constructed (kW/year)	10,000
Sales Price (\$/kW)	\$2,000
Production Cost (\$/kW, initial)	\$1,301
Progress Ratio	0.97
Production Volume for Initial Construction	10,000
Scale Elasticity	-0.2
Full Scale Production Capacity (kW/year)	25,000
Annual Fuel Cell Production (kW/year)	2%
Average Fuel Cell Production Cost (\$/kW)	\$1,098
Installation Cost (\$/kW)	TBD
Operations & Maintenance Cost (\$/kW, annual)	TBD

Will be available for beta testing (2011)

Preliminary Analysis

Gross National Impact of PEMFCs in Forklifts

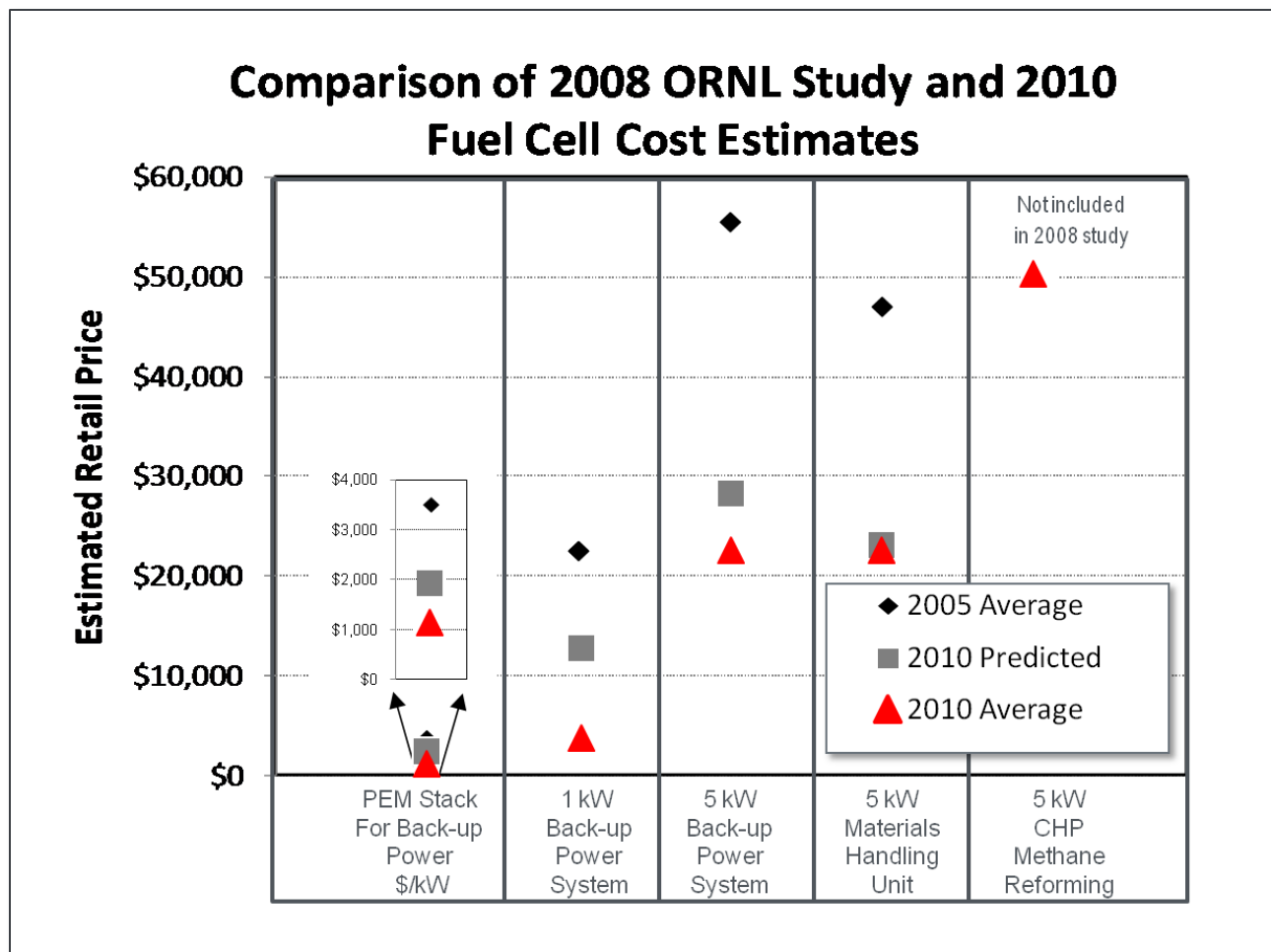


Includes *short-term jobs* (construction/expansion of mfg capacity, installation & infrastructure) & *on-going jobs* (manufacturing, O&M and fuel production & delivery)

Technology/Market Assumptions:

- \$1,300/kW initial mfg cost (*Battelle*), \$4,200/kW retail price.
- Shipments reach 3,300 annually by 2020 (*Greene et. al.*) out of ~100,000.
- 15,000 FC forklifts in operation by 2020 (<2 percent of Class 1-3 forklifts).
- Average of 60 fuel cells/site, 250 site installations by 2020.
- Tax credit expires in 2016.

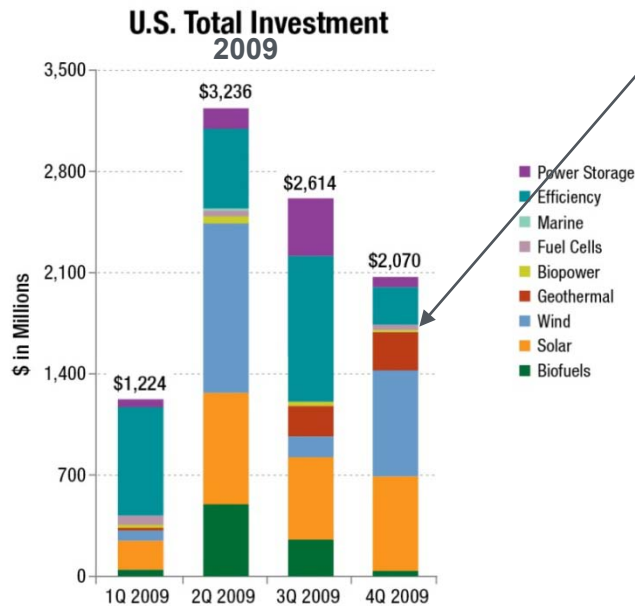
Deployments of fuel cells in early markets have reduced costs substantially.



- *50% or greater reduction in costs*
- *2008 model generally underestimated cost reductions*

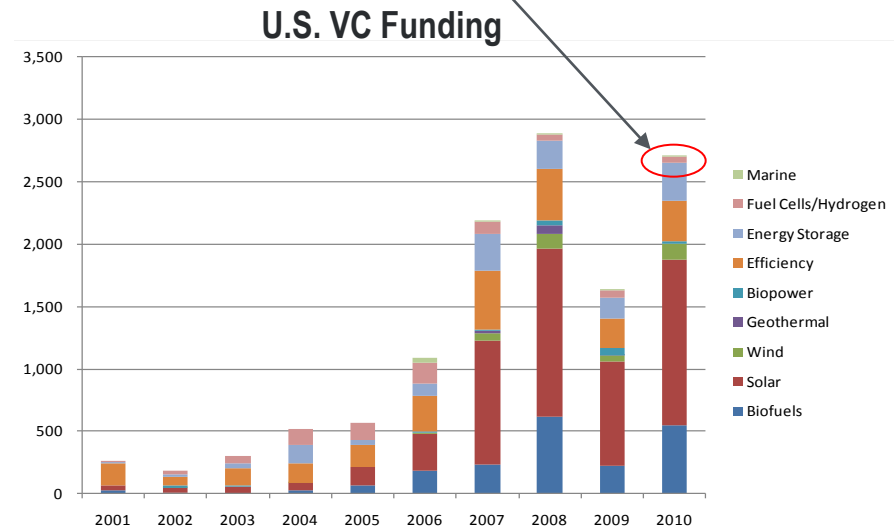


2005 and 2010 averages based on estimates supplied by OEMs. 2010 predicted assumed government procurements of 2,175 units per year, total for all market segments. Predictions assumed a progress ratio of 0.9 and scale elasticity of -0.2.



Source: Bloomberg New Energy Finance; completed and disclosed deals only; includes VC/PE, public market activity, asset financing, and acquisition transactions.

DOE's funding is critical to the emerging fuel cell industry



Source: Bloomberg New Energy Finance, as of June 8th, 2011. Completed and disclosed deals only.

Fuel cell industry is less established than other clean energy industries—DOE funds have significant impact on smaller, emerging industries such as fuel cells.

* Source: www.cleandedge.com/reports/pdf/Trends2009.pdf

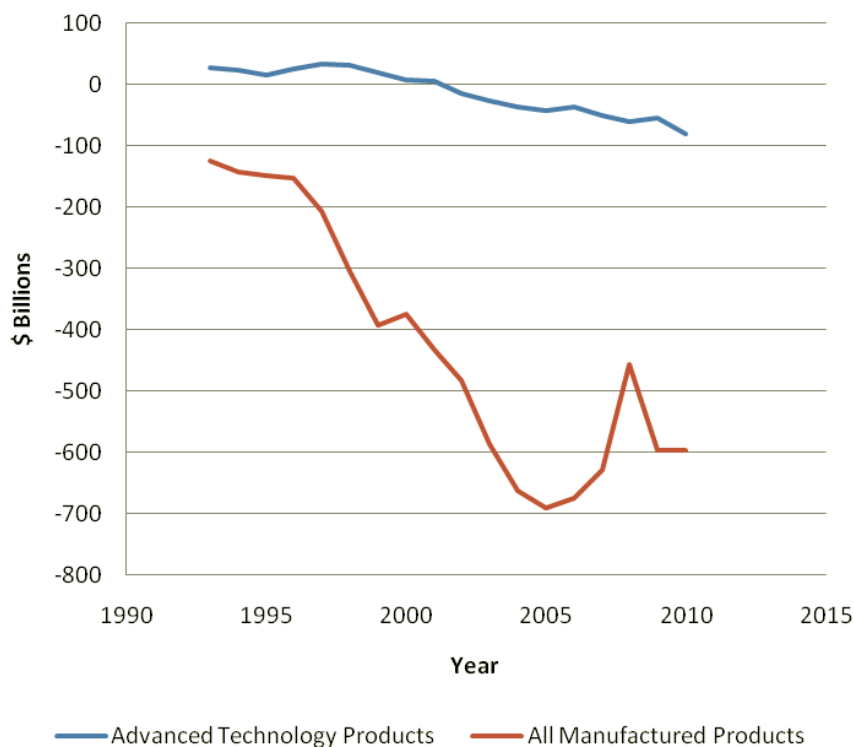
Additional Information

Funding (\$ in thousands)		
Key Activity	FY 2011 Appropriation (\$ thousands)	FY 2012 Request (\$ thousands)
Fuel Cell Systems R&D	43,000	45,450
Hydrogen Fuel R&D	33,000	35,000
Technology Validation	9,000	8,000
Safety, Codes & Standards	7,000	7,000
Systems Analysis	3,000	3,000
Manufacturing R&D	3,000	2,000
Total	98,000	100,450

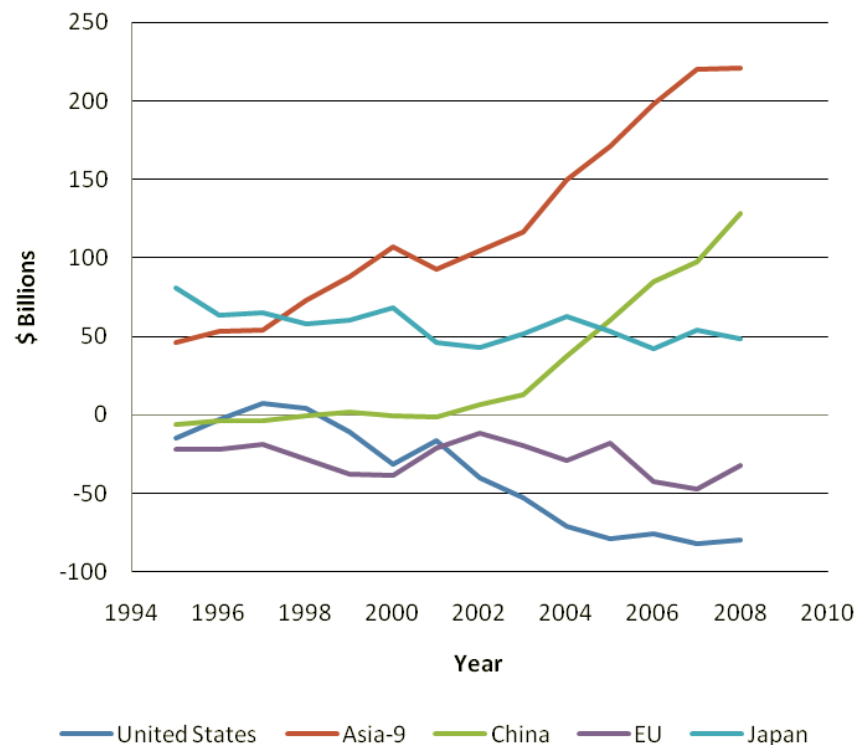
Budget is approximately \$100 million per year

High-tech U.S. trade balances are struggling.

US Trade Balances for High-Tech and All Manufactured Products



Trade balance in high-technology goods for selected regions/countries: 1995-2008



The mission of the **Defense Production Act** (DPA) Title III Program (Title III) is to "create assured, affordable, and commercially viable production capabilities and capacities for items essential for national defense."

Methanol Fuel Cell Components for Soldier Power, DuPont 2006.



- Aid transition from pilot/demonstration to commercially viable production facility
 - Builds facilities
 - Guarantee military customer
 - Ensures production meets demand
- Enhance domestic production capabilities
- Title III will assist **manufacturing scale up** to ensure industry can meet growing military demand
 - TRL
 - From 4/5 to 8/9
 - MRL
 - From 3 to 6-8
- Prepares manufacturing to meet subsequent growth in commercial demand

Can we do this for hydrogen and fuel cells?

Fuel Cells for Stationary Power, Auxiliary Power, and Specialty Vehicles

The largest markets for fuel cells today are in stationary power, portable power, auxiliary power units, and forklifts.

~75,000 fuel cells have been shipped worldwide.

>15,000 fuel cells shipped in 2009 (> 40% increase over 2008).

Fuel cells can be a cost-competitive option for critical-load facilities, backup power, and forklifts.



Production & Delivery of Hydrogen

In the U.S., there are currently:

~9 million metric tons of H₂ produced annually

> 1200 miles of H₂ pipelines

Source: US DOE 09/2010



Fuel Cells for Transportation

In the U.S., there are currently:

> 200 fuel cell vehicles

~ 20 active fuel cell buses

~ 60 fueling stations

Sept. 2009: Auto manufacturers from around the world signed a letter of understanding supporting fuel cell vehicles in anticipation of widespread commercialization, beginning in 2015.

