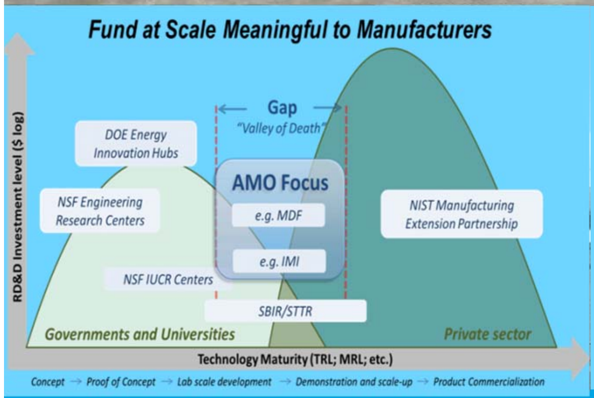
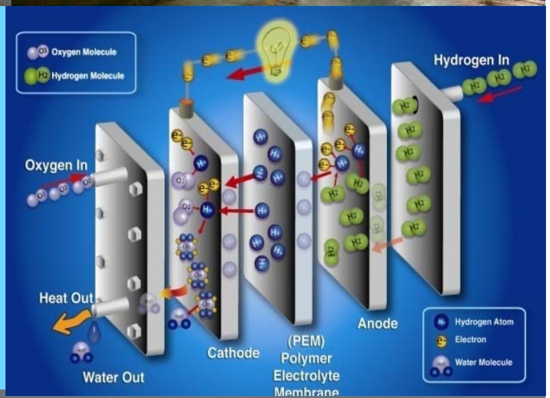
Joint Fuel Cell Technologies and Advanced Manufacturing Office Webinar

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



"The process of converting raw materials, components, or parts into finished goods that meet a customer's expectations or specifications."

– Businessdictionary.com, accessed 4/10/12



Department of Energy
Washington, DC
11/20/2012

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Agenda

- Overview of Fuel Cell Technologies Office and Manufacturing R&D
- Introduction to Advanced Manufacturing Office Activities
  - E.g. Manufacturing Demonstration Facilities
- Potential Opportunities for H_2 and Fuel Cells

Program Mission

The mission of the Fuel Cell Technologies Office is to enable the widespread commercialization of a portfolio of hydrogen and fuel cell technologies through applied research, technology development and demonstration, and diverse efforts to overcome institutional and market challenges.

Key Goals : Develop hydrogen and fuel cell technologies for:

1. Early markets such as stationary power (prime and back up), lift trucks, and portable power in the 2010 – 2012 timeframe,
2. Mid-term markets such as residential combined-heat-and-power systems, auxiliary power units, fleets and buses, in the 2012 to 2015 timeframe, and
3. Long-term markets including mainstream transportation applications with a focus on light duty vehicles, in the 2015 to 2020 timeframe.

Overview
Fuel Cells – An Emerging Global Industry

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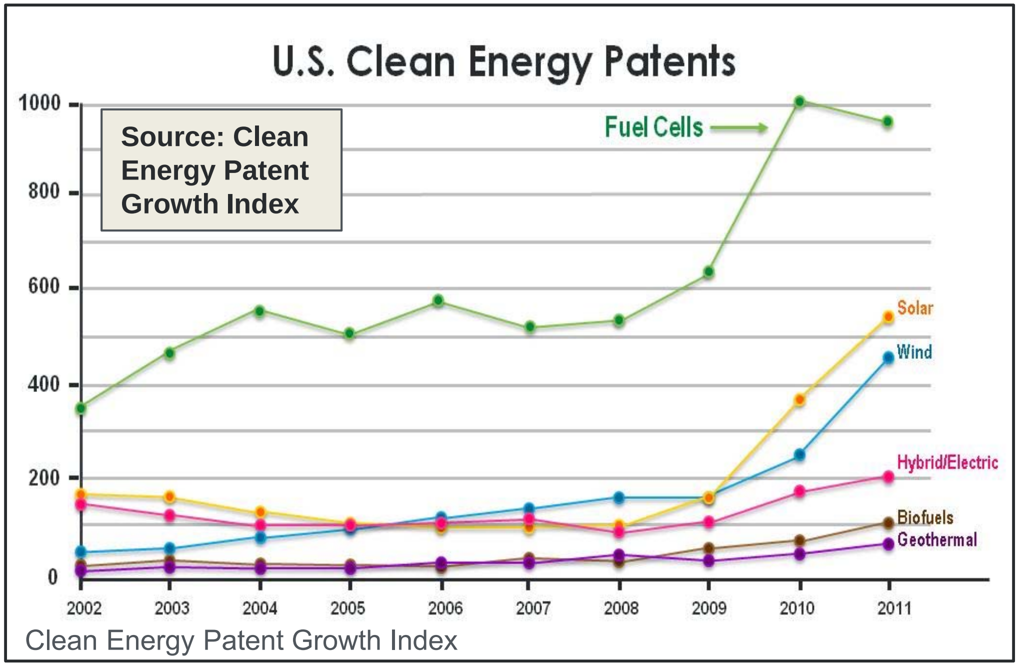

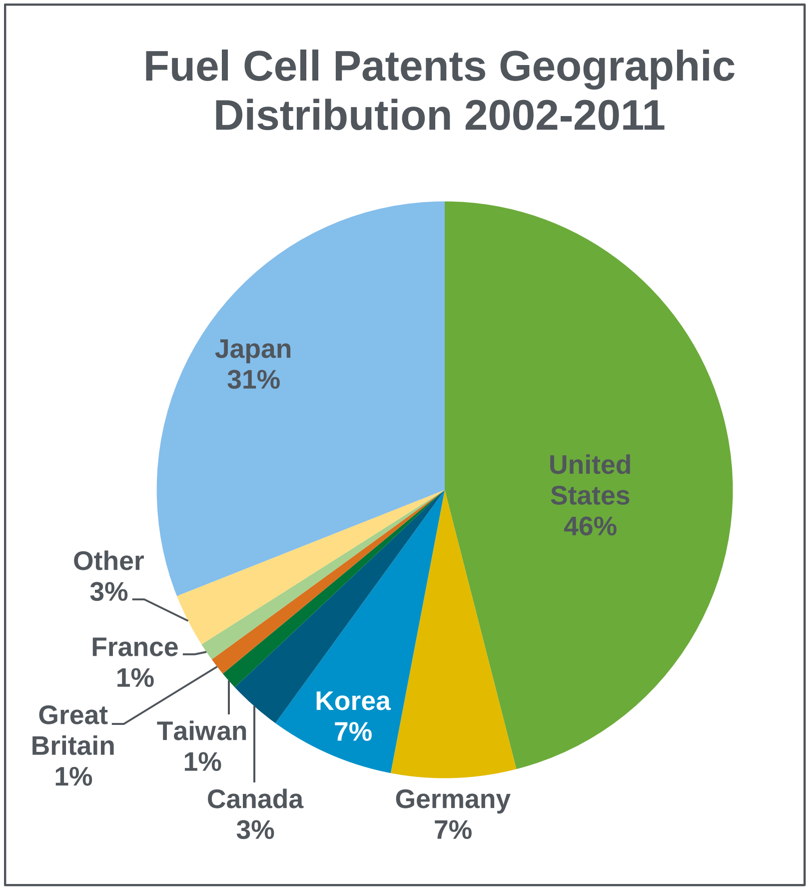

Top 10 companies: GM, Honda, Samsung, Toyota, UTC Power, Nissan, Ballard, Plug Power, Panasonic, Delphi Technologies

Clean Energy Patent Growth Index[1] shows that fuel cell patents lead in the clean energy field with over 950 fuel cell patents issued in 2011.

- Nearly double the second place holder, solar, which has ~540 patents.

[1} 2010 Year in Review from http://cepgi.typepad.com/heslin_rothenberg_farley_/ http://cepgi.typepad.com/files/cepgi-4th-quarter-2011-1.pdf

DOE Program Overview

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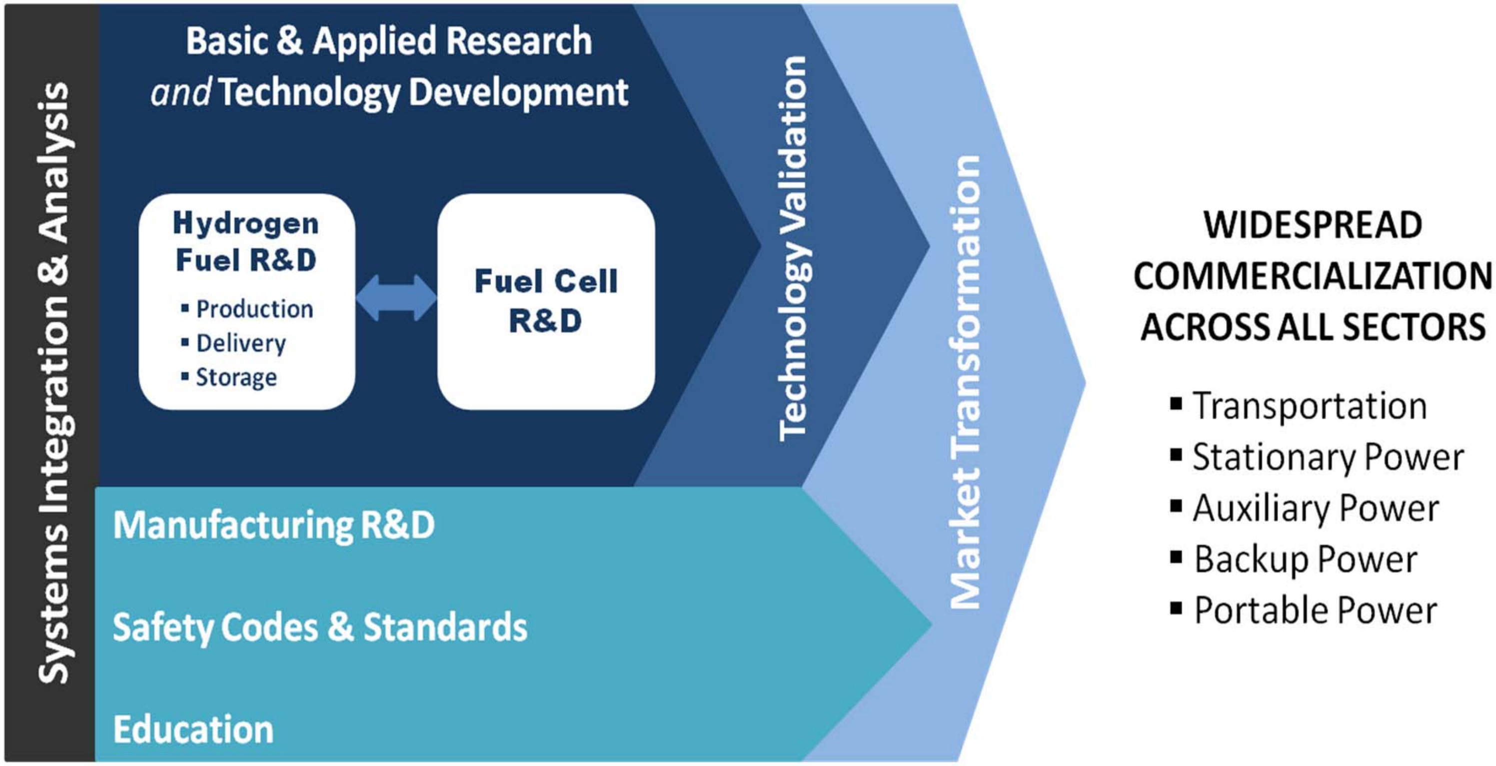
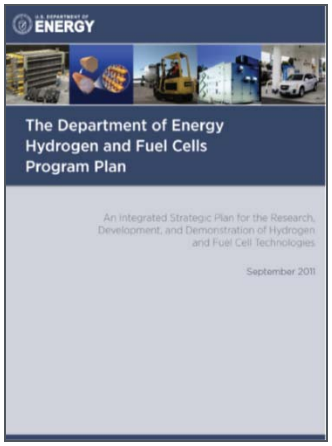
The Program is an integrated effort, structured to address all the key challenges and obstacles facing widespread commercialization.

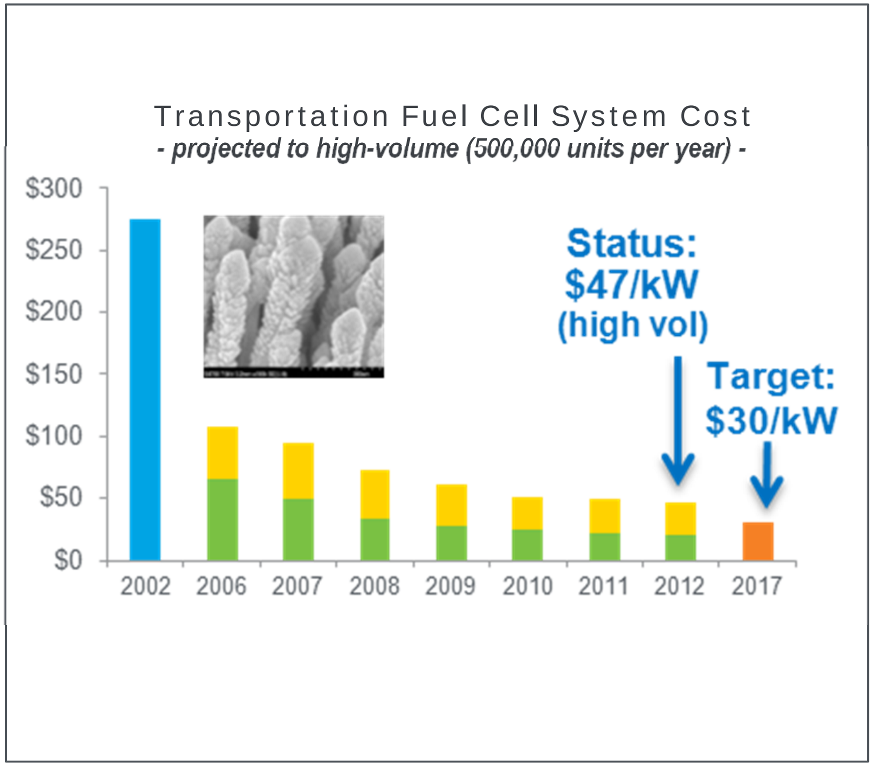




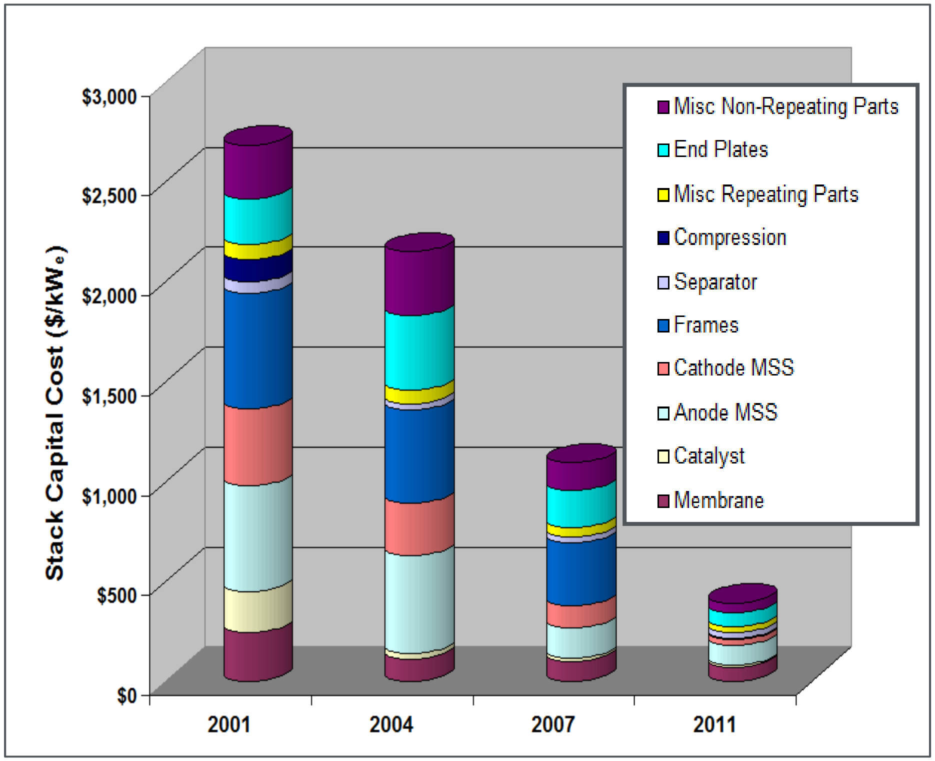
DOE Hydrogen and Fuel Cells Program Plan (revised 2011)
Includes Four DOE Offices EERE, FE, NE and Science

Nearly 300 projects currently funded
at companies, national labs, and universities/institutes

Reduced high-volume cost of fuel cells 35% since 2008, 83% since 2002



Reduced cost of electrolyzer stacks 60% since 2007



FCT Manufacturing R&D—Overview and Highlights

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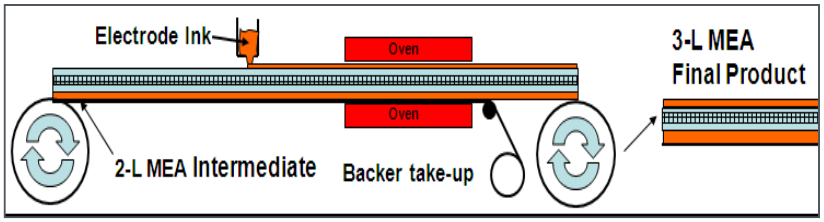
Goal: Research and develop technologies and processes that reduce the cost of manufacturing hydrogen production, delivery, storage, and fuel cell systems.*

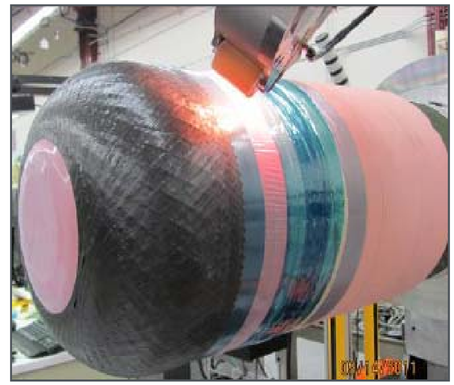
*http://www1.eere.energy.gov/hydrogenandfuelcells/mypp/pdfs/manufacturing.pdf

Roll-to-Roll MEA Processing at W.L. Gore



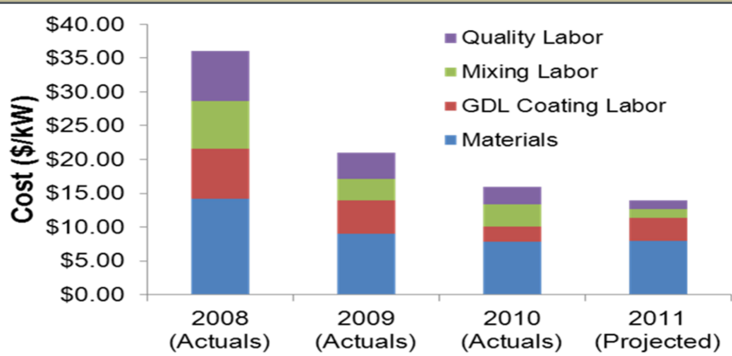
- Increase MEA performance
- Eliminate intermediate backing material
- Reduce number of coating passes
- Direct coating of catalyst onto ionomer

Tank Manufacturing at Quantum Technologies



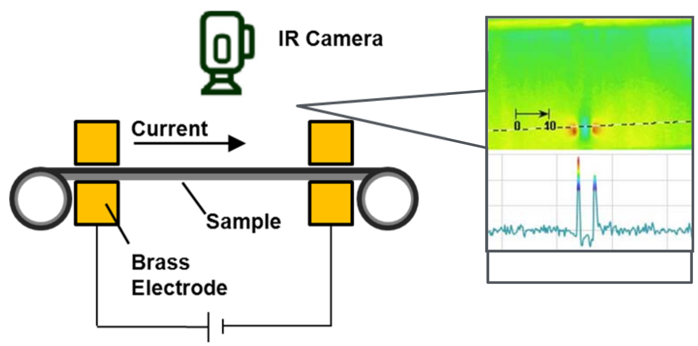
- Reduced carbon fiber use while maintaining structural integrity
- Integrate new, low-cost, composite fiber
- Increase manufacturing efficiency

Optimized Fabrication of GDLs at Ballard



- Demonstrated 4x increase in production capacity and >50% decrease in GDL cost
- Improved production yields and efficiency
- Move to full width production

In-Line Diagnostics Techniques at NREL



- Developing in-line diagnostic techniques for MEA component quality control
- Investigating effects of manufacturing defects on MEA performance

DOE/NREL Hydrogen and Fuel Cells Manufacturing R&D Workshop

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- Held 8/11 in Washington, D.C. with reps from industry, academia, lab, and government
- Identified and prioritized needs and barriers to manufacturing
- Outputs support potential FY13 FOA for H_2 & FC Manufacturing R&D

Issue	Votes
PEM Fuel Cells/Electrolyzers BOP: Facilitate a manufacturing group for DOE to expand supply chain.	21
Electrodes: How to apply ink directly to membrane; dual direct coating of CCM; *membrane dimensional change with deposition of current inks (Fuel cell R&D)*	20
PEM Fuel Cells/Electrolyzers BOP: *Develop low cost manufacturing of natural gas reformers (Fuel cell R&D)*	18
Stack Assembly: High volume stack assembly processes: reduced labor, improved automation	15
Quality/Inspection/Process Control: Develop methods of identifying coating defects on a moving web, then rejecting single pieces downstream; defect detection after MEA assembly when defect may no longer be visible; ability to separate materials with defects from rolled goods with minimum production of scrap	15
SOFC: Multi-layer/component sintering	14

http://www1.eere.energy.gov/hydrogenandfuelcells/wkshp_h2_fc_manufacturing.html

PEMFC and SOFC Manufacturing: Status vs. Needs—Examples

PEM Fuel Cells

Current MEA
- Large batch mixing
- Roll-to-roll processes for membrane, electrode, and GDL fabrication
- Decal transfer of electrode to membrane
- Manual assembly of MEA with seals
- Hot pressing

Advancements
- Continuous mixing
- Robotic or roll-to-roll assembly of MEAs with seals
- Direct coating of electrode on membrane
- Hot-roll lamination or improved pressing

Current Stack
- Manual assembly
- Manual leak/performance test

Advancements
- Automated assembly
- Automatic leak/performance test

Current BOP
- Lean manufacturing cells and flow
- Unique components

Advancements
- Standardized designs
- Robotic BOP/system assembly line

Solid Oxide Fuel Cells

Current Cell
- Large batch mixing of powders and slurries
- Single layer tape casting with lamination of layers (planar)
- Batch pressing or extrusion of tubes (tubular)
- Semi-automated coating of electrolyte and cathode (tubular)
- Batch heat treatment and sintering
- Manual assembly of cells with seals
- Manual winding of interconnect wire

Advancements
- Continuous mixing
- Multi-layer tape casting (planar)
- Continuous pressing or extrusion of tubes (tubular)
- Continuous firing and sintering
- Robotic assembly of cells with seals
- Automated winding of interconnect wire

Current Stack
- Manual assembly
- Manual shaping of insulation
- Manual leak/performance test

Advancements
- Automated assembly
- Net-shape or other methods for insulation
- Automatic leak/performance test

Current BOP
- Manual assembly
- Unique components

- Lean manufacturing cells and flow

Advancements
- Standardized designs
- Robotic BOP/system assembly line

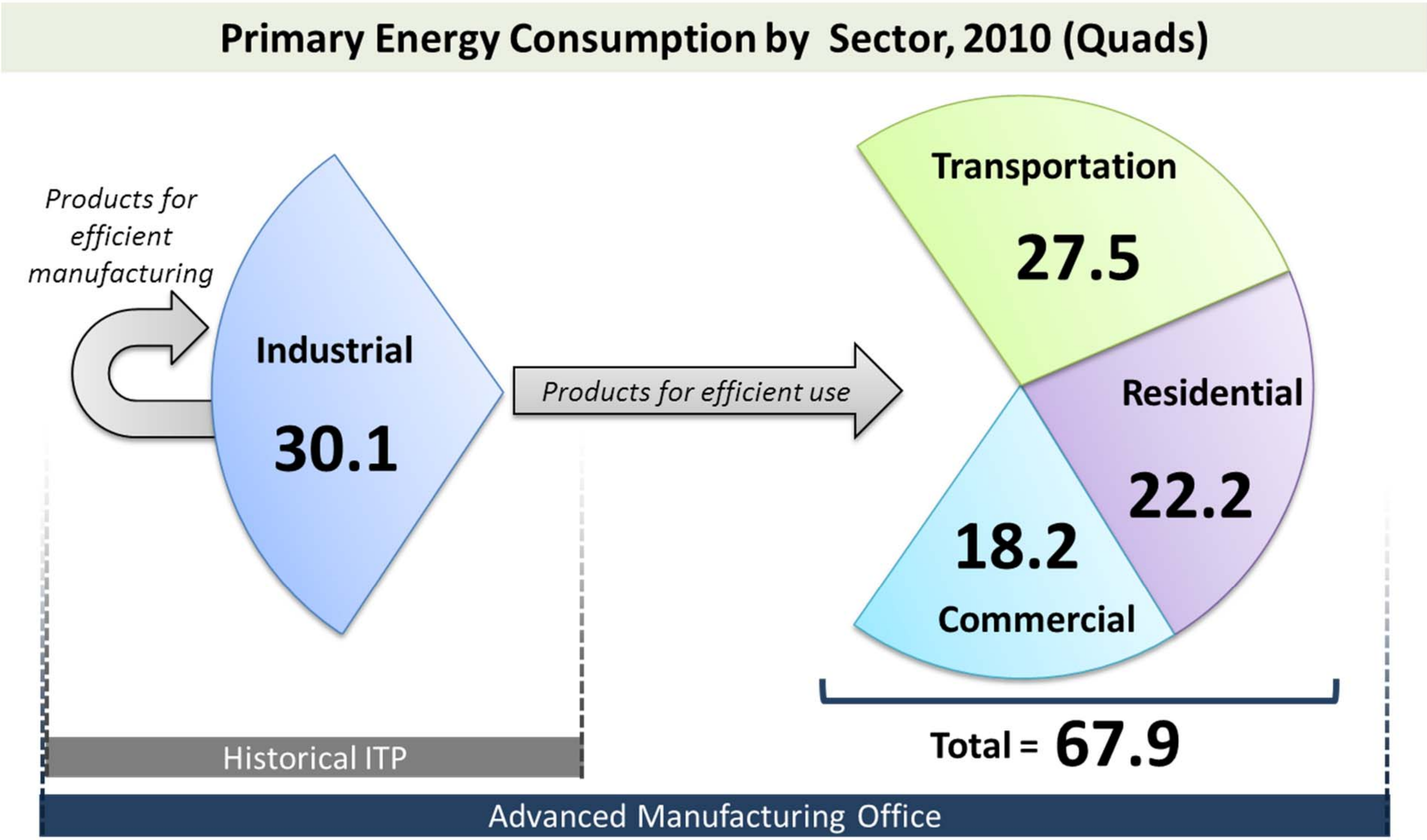
Products for Efficient Manufacturing (Industry) → **Products for Efficient Use (Life Cycle Impact)**

Reducing energy intensity *within the Industrial sector* is a necessary but insufficient charter for federal investments in manufacturing

Design and manufacturing choices within the Industrial sector affect the energy performance of *products in other sectors* in the economy

Products from advanced manufacturing have **lifecycle impacts**

Aim for economy-wide lifecycle impacts



Source: US EIA Annual Energy Review 2010, Table 2.1a. http://205.254.135.24/totalenergy/data/annual/pdf/sec2_3.pdf

Program Overview

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- The **mission** of the Advanced Manufacturing Office (AMO) is to co-invest with private and public partners to improve U.S. competitiveness, save energy, create high-quality domestic manufacturing jobs and ensure global leadership in advanced manufacturing and clean energy technologies.

- Main Goals:
  - Reduce the **life-cycle** energy consumption of manufactured goods by 50 percent over 10 years for AMO supported technologies
  - Encourage a culture of continuous improvement in corporate energy management
  - Support achievement of 40 GW of new combined heat and power by 2020

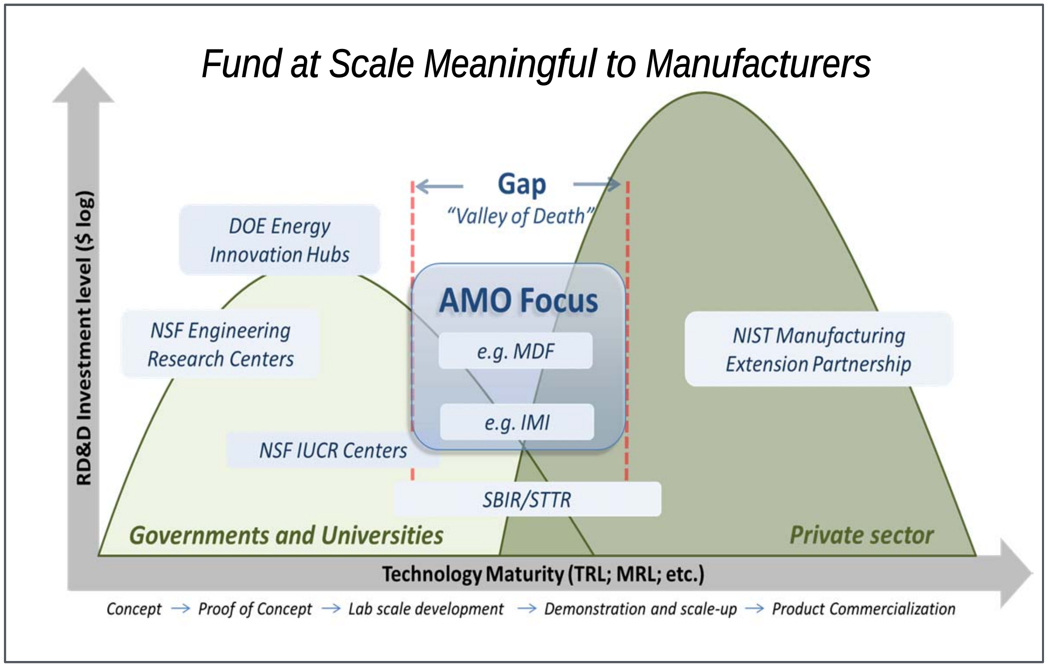
AMO *portfolio* management criteria:

1. ***High Impact*** — high marginal returns and leveraged investments
2. ***Project Diversity*** — spread risk and increase chances for big wins
3. ***Nationally Important Projects at the Critical Phase*** – provide only the minimal marginal investment required to encourage a larger private sector investment
4. ***Invest in Energy Impacts*** — enable better energy systems throughout the economy

*"Report to the President on Capturing Domestic Competitive Advantage in Advanced Manufacturing" PCAST , July 2012.
http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_amp_steering_committee_report_final_july_27_2012.pdf

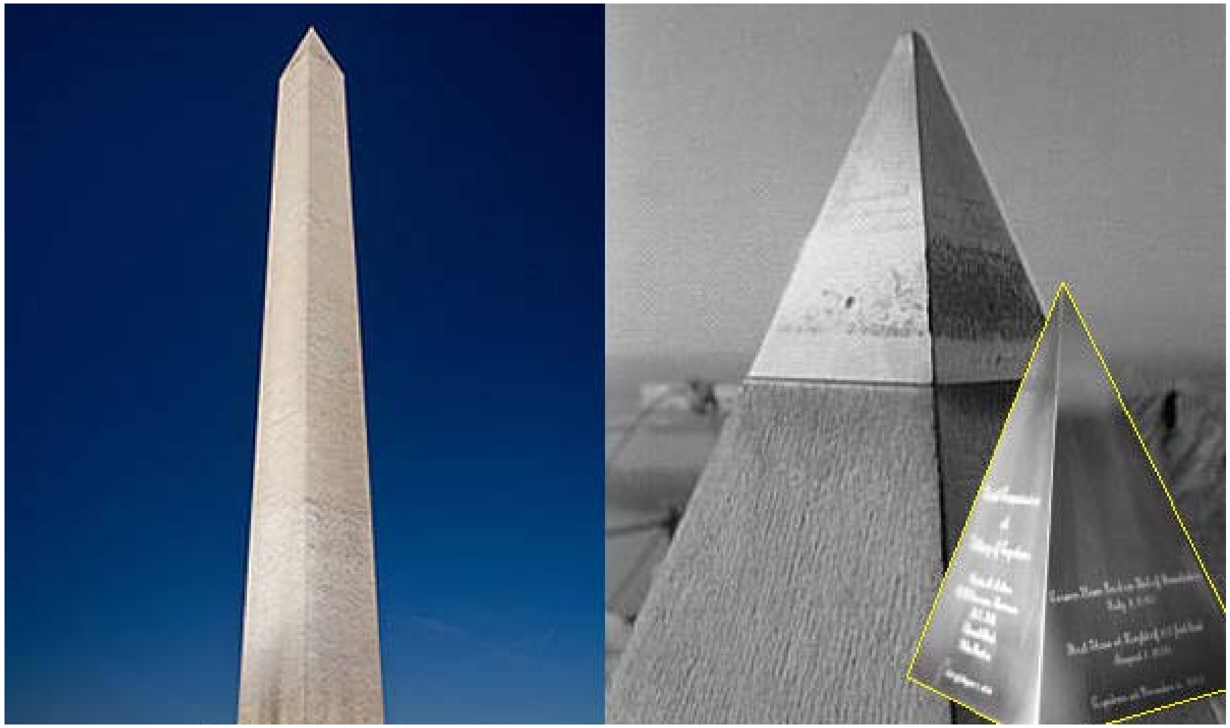
Program Overview

- Strategy/Approach
  - **Manufacturing Processes and Materials**: Support timely, high-impact, *foundational* manufacturing technologies with the potential to transform energy use and accelerate introduction into the US economy
    - 50% life-cycle energy savings over 10 years for supported projects



  - Industrial Technical Assistance: Help manufacturers across the supply chain reduce energy costs and get the most out of existing manufacturing facilities by providing unbiased information, technical assistance, and AMO resources.
    - Reduce manufacturing energy intensity by 25% over ten years
    - Support the achievement of 40 GW of new, cost-effective combined heat and power by 2020.

What are “foundational” technologies?
Why invest in them?



1884:

The price of aluminum was \$1/oz and the price of gold was \$20/oz.

The highest skilled craftsman working on the Washington Monument was paid \$2/day.

Today:

The price of Al ~ 6¢/ oz and the price Au ~ \$1776/oz.

Reason:

Innovative process for extraction of Al from ore

"…the fixation of Nitrogen is vital to the progress of civilized humanity" - William Crookes (1898)
Royal Academy

Gunpowder

Fertilizer

1898:

Ammonia was the critical material of 1898; key to fertilizer and gunpowder
Global population on track to exceed 2,000,000,000
Food production (wheat) in concentrated locations (US)

Today:

Ammonia costs fractions of a cent/mole

Reason:

Innovative process for the production of ammonia

Haber

Bosch

$$N_2 + 3H_2 \rightarrow 2NH_3$$

- What is the organizational impact of the technology?
  - What can the technology currently be used for and/or what could it be used for?
  - What new suppliers/companies/jobs can the technology create?
  - Does the technology apply to many different markets/industries that would sustain the technology?
  - How much could the market for the technology grow over the next ten years?
- What is the magnitude of the impact?
  - How much product lifecycle energy savings and total energy/GHG reduction could be achieved?
  - What U.S. market value growth is possible with the adoption of the technology? *(impact to GDP)*
  - How much cumulative energy could be saved per Federal dollar invested?
  - What is the increase in U.S. GDP per Federal Investment dollar?
- Risk Assessment and Project Management
  - What are the cost targets needed to achieve the market penetration predicted?
  - What are the technical performance targets needed to achieve market penetration predicted?
  - What are the hurdles to achieve the cost and technical targets?
  - How will the Federal investment assist in overcoming the cost and technical targets?

Potential *foundational* technology areas:

- Wide band gap semiconductor materials
- Low Cost Carbon fiber composites
- In-situ metrology and process controls
- Membranes for lower energy separations
- Bio-manufacturing (sustainable nano-manufacturing)
- Joining of disparate materials
- Catalysis
- Low cost, lower energy, high performance metals;
- Low temperature processing, directed self assembly, high magnetic field processing, electrolytic

Foundational Technology: A technology whose capability to *transform* techno-economic systems is disproportionate to the *effort of transformation* relative to other technologies (with a threshold at 10X $ factor and >10TBTU/yr)

Transformation: Significant change in the life-cycle impact (energetic or economic) of manufactured products due to changes in the *organization* and *magnitude* of transactions in product supply chains.

Effort of Transformation: The investment needed to develop the technology to overcome economic and technical hurdles that prevent adoption of the technology. The Government investment is the portion of the total development cost for a technology that is not accounted for by private funding and is focused on reducing the risk in pervasive and widely applicable domains.

Example: Out of autoclave composites

Large components assembled and heated in autoclave

Autoclave for 787 fuselage sections produced at Vought with inside working diameter of 30 ft.

No autoclave required

DARPA demonstration of a 68-foot, out-of-the autoclave composite wing.

Goal: Demonstrate 10X reduction in energy intensity and 3X reduction in cost

Source: DARPA

Mechanisms for identifying need

Technical workshops,

EERE Manufacturing Competitiveness Analysis,

PCAST and AMP recommendations,

and other interagency collaboration

What are Manufacturing Demonstration Facilities?

User facilities for manufacturing

Manufacturing Demonstration Facilities (MDFs)

Barriers addressed:

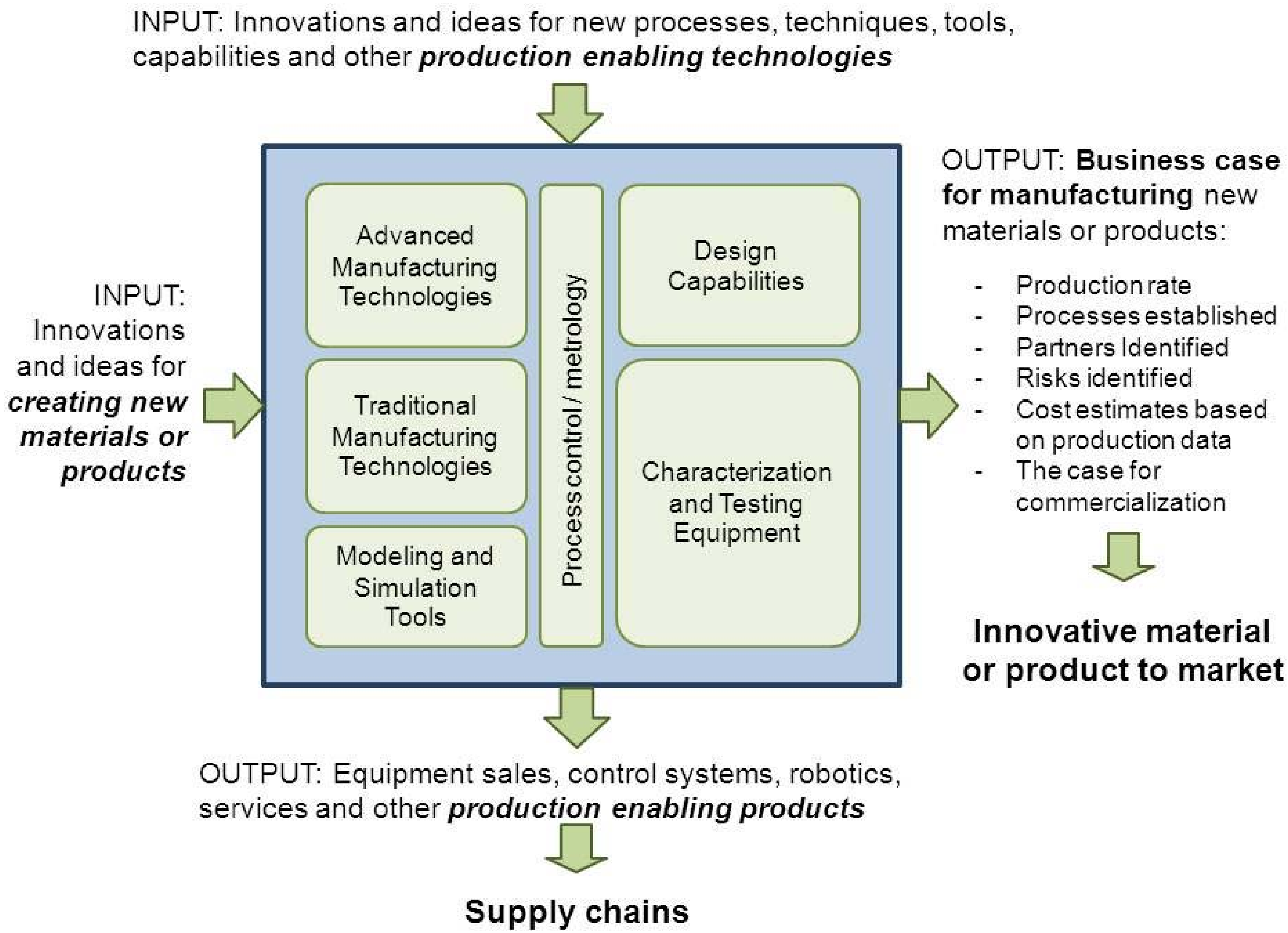
- Access to expensive technologies and capabilities
- Sharing overhead costs - more efficient use of capital
- Increases visibility of unknown process options
- Accelerates partnership development and supplier relationships

Effect on U.S. competitiveness:

- Increased pool of domestic competitors, especially SMEs
- Increased rate of new product development
- Positive feedback between production and research/design accelerates both

Manufacturing Demonstration Facilities (MDFs)

Two pathways through the MDF that stimulate each other at the cross-roads



Thank You

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