2007 DOE Hydrogen Program Review

DOE Hydrogen Program

DMFC Prototype Demonstration for Consumer Electronic Applications

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FCP-36

This presentation does not contain any proprietary or confidential information

Overview

Timeline

- Project start – Aug ’04
- Funding gap – Jan ’06 – Apr ’07
- Restart program – May ‘07
- Anticipated completion – Sep ‘08
- Percent complete – 40

Barriers

- Energy/power density
- Cost
- Codes and regulations

Budget

- Total project funding
  - DOE share - $3.0M
  - Contractor - $3.2M
- Received to date - $1.7M

Partners

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Dupont

Gillette/Duracell

Program Objectives

1. Benchmark system energy density equal to or better than 600 Wh/liter
2. Demonstrate prototypes
3. Develop design and manufacturing pathways to low cost systems for initial market entry
4. Demonstrate continual operation of up to 1,000 hours
5. Accelerate codes and standards activities leading to appropriate regulations that allow shipping and airline passenger cabin usage

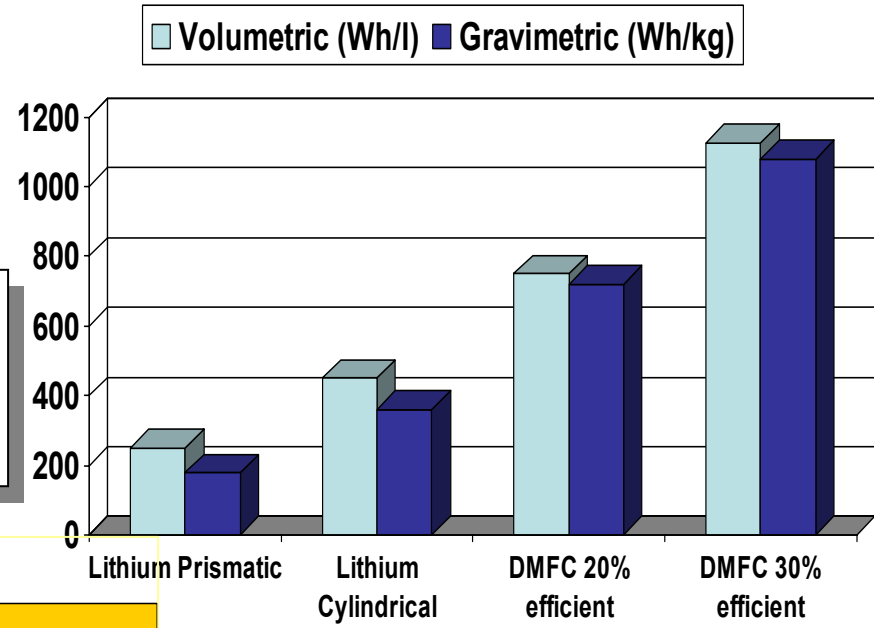
Micro DMFC is an early pathway for the large scale, public introduction to fuel cell benefits

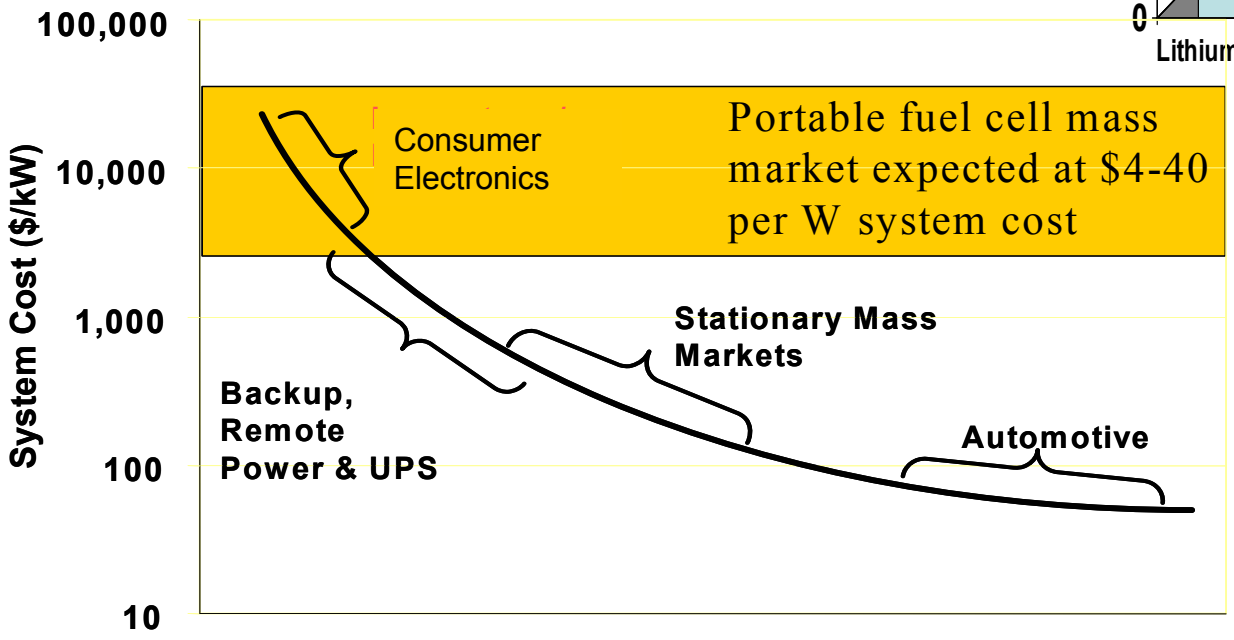
Merits of the DMFC Track

Handheld electronics provide an early opportunity for fuel cells to enter the market

Growing international momentum for small DMFC product platforms

Product capability, and low cost, high volume manufacturing is critical for market entry





DMFC Advantages

- Energy density beats batteries
- Fuel logistics
  - High energy density
  - Simple fueling systems
- Regulatory acceptance

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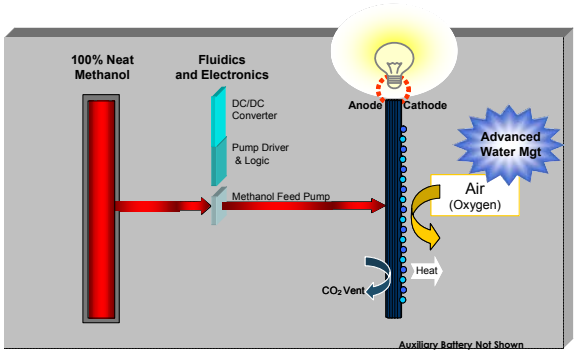
Approach

- Use non-dilute methanol fuel to maximize energy density
- Develop system designs that reduces complexity, size and number of components
- Develop supply chain and apply high volume manufacturing technology to reduce costs
- Work with OEM's to prepare product introduction strategy
- Pursue early product codes and standard to clear path to market



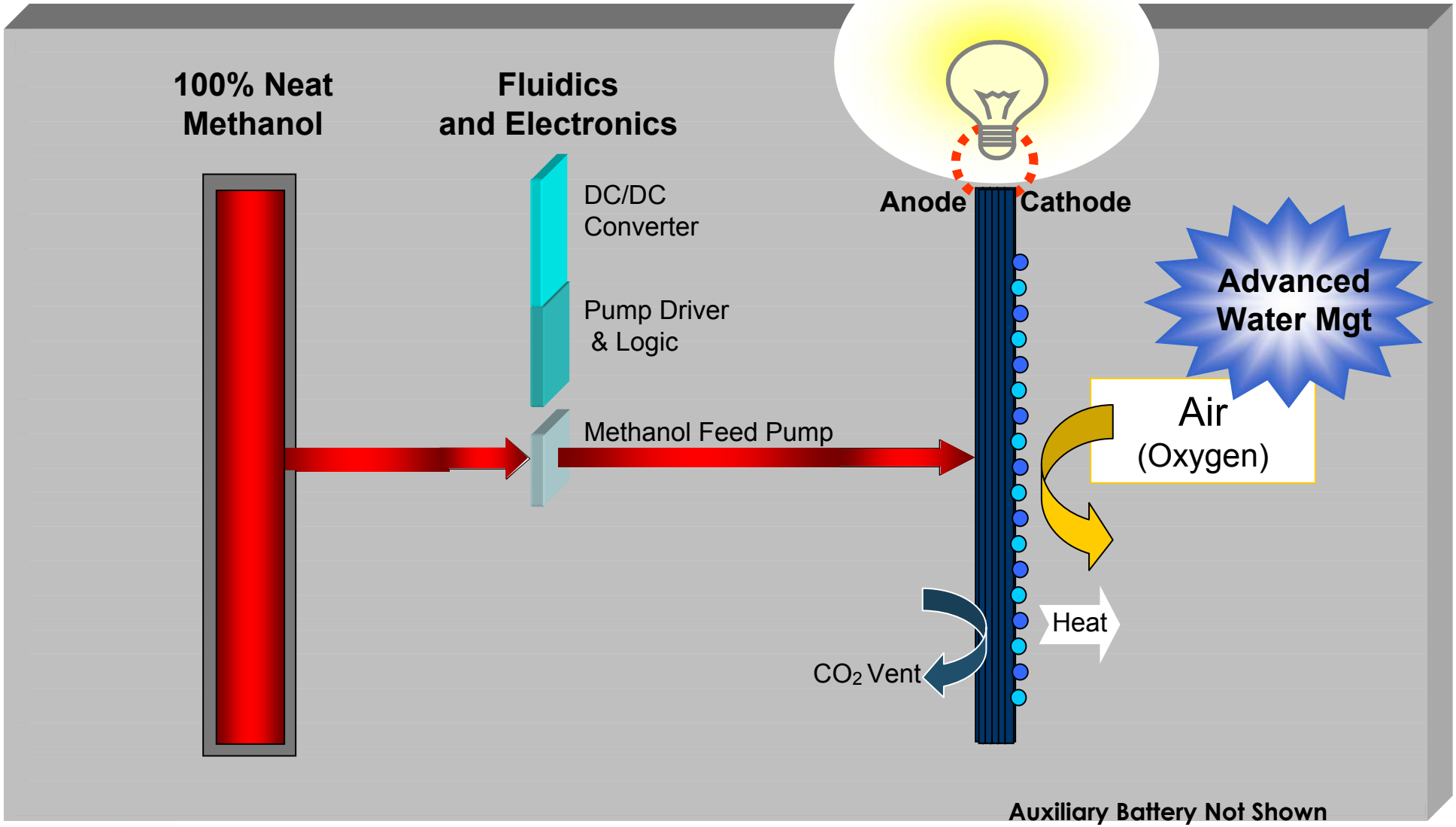
Concept

2005 Brassboard

Product

2006 Prototype

Mobion System Approach
Reduced Complexity



Product Integration Approach

Generation 1	Generation 2	Generation 3
External Accessory	Base Accessory	Embedded
		
External Fuel Cell Charger	Base Fuel Cell Charger	Embedded Fuel Cell

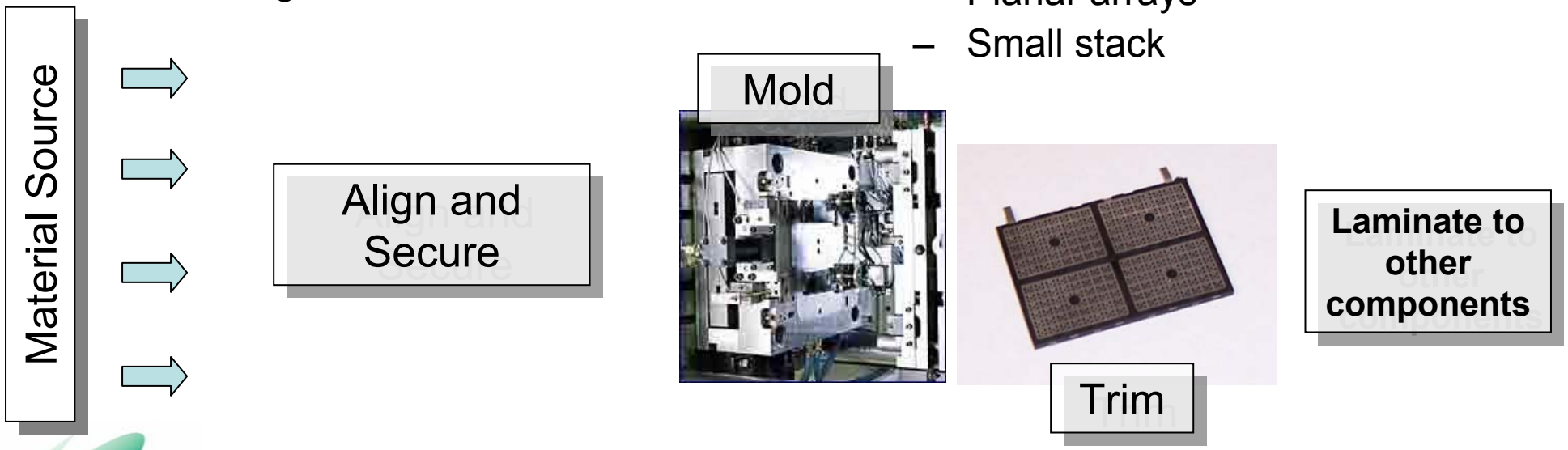
Manufacturing Development Progress

Program Activities

- Current collector lead frame fabrication
- MEA production development
  - Work with multiple manufacturers
- Molding process development
  - With no MEA damage
- High volume process evaluation
  - Lead frames
  - molding

Impact to Industry

- Current collector lead frame capabilities will enhanced planar PEM array manufacturing
- MEA component production process will support PEM
- Molding development can support a number of micro PEM options
  - Planar arrays
  - Small stack



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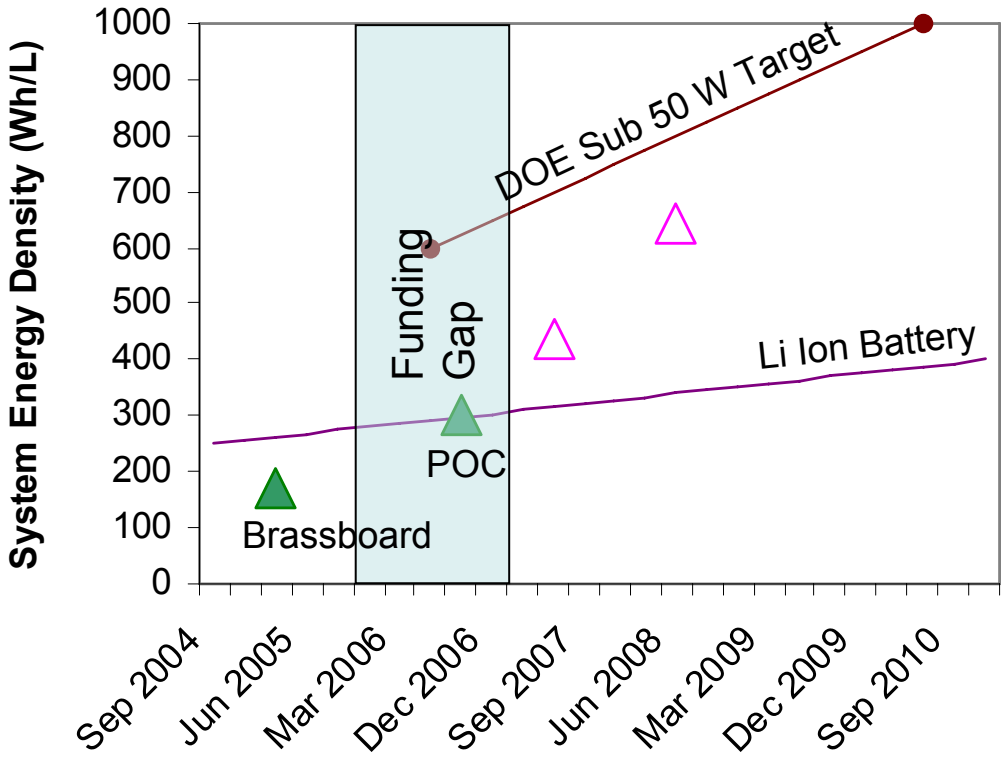
BOP Component Miniaturization Progress

- Advanced insulation packages have produced impressive thermal isolation
- Fuel pumps are now less than 1 cc
- Fuel feed is tightly integrated to arrays
- Water management system is less than 10 cc
- Power processing and control electronics are small and highly integrated
- Thermal management components are tightly integrated and serving dual functions

System Performance Summary

- Brassboard system benchmark in first year of program
- Interim proof of concept (POC) during funding gap used large internal fuel tank
  - Competitive with lithium ion battery energy density
- Sep ’07 projection uses small internal fuel tank with energy density based on multiple refills
- Jun ’08 projection based on energy density with multiple cartridges



POC Prototype

2007 Prototype

Future Component and System Development Work

(Program refunded in May 2007)

FY2007

- Advance the MEA performance, reduce cost and characterize performance life
- Develop fuel cell array (FCA) design and manufacturing processes to reduce cost
- Integrate FCA and all BOP components, and test system prototype

FY2008

- Continue to reduce component costs
- Finalize system design
- Complete MEA, FCA and system life testing
- Assemble and test final system prototypes

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Codes and Standards Progress

- UL/CSA developed 2265A standard for fuel cells and for shipping methanol cartridges
- United Nations established new Shipping & Packaging for “Fuel Cell Cartridges with Flammable Liquid”
- International Electrotechnical Commission (IEC) has now approved a publicly available specification (PAS) for a number of fuel cell technologies including DMFC and PEM micro fuel cells
  - Provides product safety requirements
- International Civil Aviation Organization (ICAO) enacted the international shipping regulations for fuel cell cartridges
- US enacted shipping regulations
- ICAO enacted regulations for methanol, butane and formic acid fuel cell use in airline passenger cabin

Goal: Clear regulatory pathway to fuel cartridges available in every store and accepted in every airline passenger cabin

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Future Codes and Standard Work

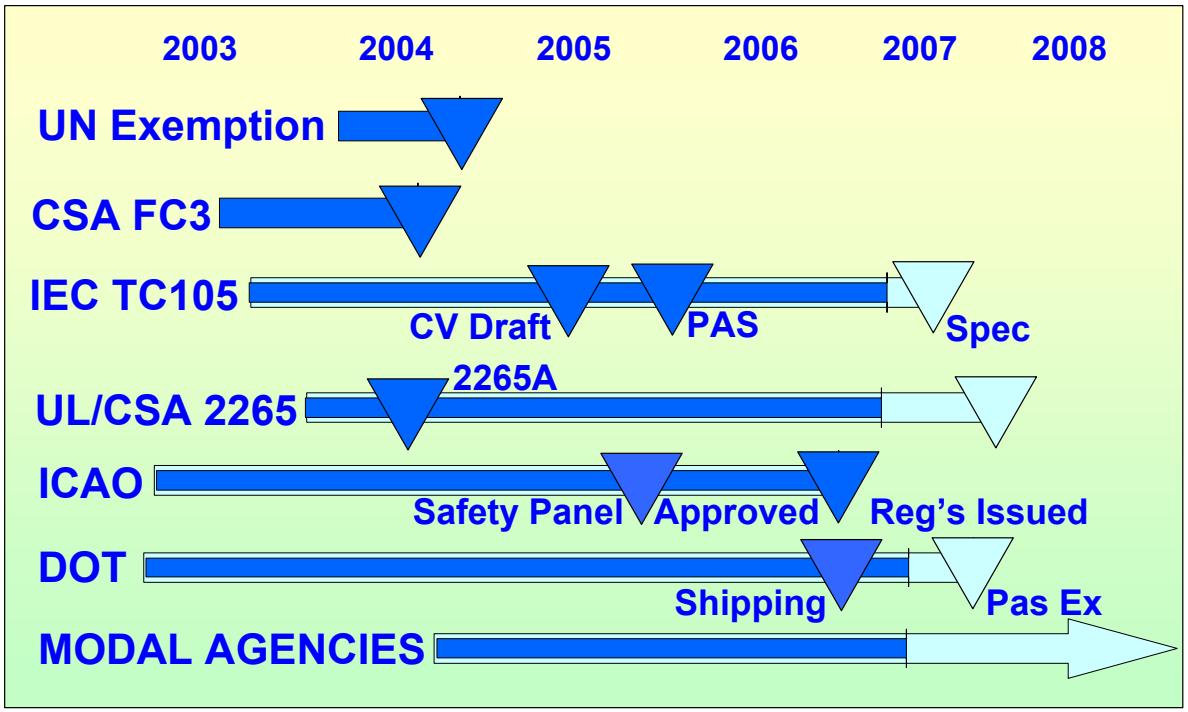
- IEC will continue to evolve the 62282-6-1 standard
- IEC will develop a common interface standard between fuel cell and cartridge
- DOT will complete US regulations around UN and ICAO model regulations

Milestones for 2007

- US DOT will implement airline passenger exception
- IEC will issue next round of IEC Standard 62282-6-1
- TSA will develop security procedures for fuel cells

Milestones for 2008

- DOT and TSA evaluation of MTI prototypes
- CSA/UL evaluations



DMFC leading the way for micro PEM fuel cells

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Status Against Objectives

- Energy density greater than 600 Wh/cc
  - Proof of concept prototype demonstrated 250 Wh/cc
  - 2007 and 2008 prototypes projected to reach 400 and 650 Wh/cc, respectively
- Demonstrate prototypes
  - First brassdboard benchmarked in 2005, prior to funding gap
  - Two more rounds of prototypes in 2007 and 2008
- Accelerate codes and standards
  - All international standards for shipping and airline passenger transport were in place at start of 2007
  - USDOT enacted the shipping regulations for 2007, but is delayed on airline passenger exception due to TSA concerns over liquids. Still expect completion later this year.
- Demonstrate continual operation to 1000 hours
  - Candidate materials for long life still in selection – some candidates have reached 1000 hours in test cells (results will be prepared as program activities resume)
- Design and manufacturing pathway to $5
  - Fuel cell markets for handhelds can be entered at costs significantly above this target – need to modify target for sub-Watt systems

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Micro-DMFC Technology Supports US Fuel Cell Programs

- Provides early public exposure and acceptance of fuel cells
  - Numerous early applications in handheld consumer electronics
  - DMFC/methanol has minimal technical barriers
- Prepares regulatory environment for other fuel cell technologies
  - A number of technologies benefit from methanol's early entry
- Maintains important US leadership in portable power
  - Formidable foreign DMFC competition
    - Japan\Korea taking DMFC fast-track
  - US leadership benefits US economy and military

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Micro-DMFC Technology Supports US Fuel Cell Programs

- Component suppliers are looking for near term markets to justify technology development
  - MTI's platform targeted at near term markets
- Suppliers in all the following areas have expressed interest in DMFC as a path to the hydrogen market
  - Catalyst
  - Membranes
  - GDL
  - MEA
  - CC Plates
  - Molded frames
  - Filters
  - BOP
    - Pumps
    - Water management
    - Heat rejection

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Summary

Relevance: Open the door to broad public exposure to fuel cells AND develop supplier and large scale manufacturing infrastructure to advance hydrogen fuel cells.

Approach: Develop and miniaturize DMFC technology, while finding pathways for low cost manufacturing and demonstrating early prototype capabilities. This "DMFC path" is validated by the growing international activities in DMFC product and regulatory development.

Technical Accomplishments: Demonstrated prototype energy density on path to system targets. Excellent success on regulatory road map. Accomplishments will accelerate now that funding is restored.

Technology Transfer: Continue to develop a broad range of MEA, flow field, current collector and BOP component vendors. DMFC related activities at key MEA companies, for example, are providing important leverage for hydrogen technology.

Propose Future Research: Produce next round of compact fuel cell arrays and test system prototypes. Performance improvements and component miniaturization will continue with increased effort on manufacturing cost reductions and performance durability.