Fuel Cells for Portable Power

JoAnn Milliken
Office of Transportation Technologies
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585
202-586-2480
JoAnn.Milliken@ee.doe.gov

January 15-17, 2002
Phoenix, AZ
Presentation Outline

• Why are we here?
• DOE Transportation Fuel Cell Program
• Workshop Objectives
• Guidelines for Workshop Product
• What have past DOE workshops achieved?
**Why are we here?**

**Government:**
Cost - the primary barrier to commercialization of PEMFCs for automobiles

**Industry:**
Business plans include fuel cells or fuel cell powered products

**Industry/Academia/National Labs:**
Funding opportunities for fuel cell research, development, demonstrations
Our goal is to develop highly efficient, low- or zero-emission, cost-competitive automotive fuel cell power system technologies that operate on conventional and alternative fuels.
**Vision:**
Affordable full function cars and trucks are free of foreign oil and harmful emissions, without sacrificing freedom of mobility and freedom of vehicle choice.

**Strategic Approach:**
- Develop technologies to enable mass production of affordable hydrogen-powered fuel cell vehicles and assure the hydrogen infrastructure to support them.
- Continue support for other technologies to dramatically reduce oil consumption and environmental impacts. Adopt policies that stimulate consumer demand for vehicles and fuels that enhance energy security and reduce pollution.
- Instead of single vehicle goals, develop technologies applicable across a wide range of passenger vehicles.

*CAR = Cooperative Automotive Research*
Automotive Fuel Cells

Key Technical Challenges

There are significant technical and economic barriers that will keep fuel cell vehicles from making significant market penetration for 10 years.

- Cost/Affordability (Platinum)
- Start-Up (Gasoline System)
- Durability
- Thermal/Water Management
  - heat rejection
- Air Management
- Hydrogen Storage/Refueling
## Cost of Fuel Cell Systems

### Status versus Targets

<table>
<thead>
<tr>
<th>Projected Manufacturing Cost of Gasoline PEMFC Systems(^1)</th>
<th>Status</th>
<th>$300/kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOE Automotive PEMFC Target(^2)</td>
<td>Targets</td>
<td>$45/kW</td>
</tr>
<tr>
<td>Current manufacturing cost of portable power Li battery(^3)</td>
<td>~ $5,000/kW</td>
<td></td>
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</tbody>
</table>

\(^1\) Today’s cost, based on 500,000 units/year
\(^2\) 2010 target; cost-competitive with, not cost-equivalent to, internal combustion engines
\(^3\) Estimated
Challenges/Strategy for Cost Reduction

Cost Challenges:

- high precious metal loading
- low voltage cells, low power density large number of cells in a stack
- low activity, low durability shift catalysts
- lack of high-volume fabrication processes for MEAs, bipolar plates

R&D Activities:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Projected Cost*</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>High volume fabrication of MEAs with reduced Pt loading - 3M, SwRI/W.L. Gore, IFC, DeNora/DuPont</td>
<td>MEA: $100/kW</td>
<td>$10/kW</td>
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<tr>
<td>New cathode structures to improve cell performance - 3M, IFC, DeNora, SMP,LANL, LBNL, BNL, NRL</td>
<td>WGS: $13/kW</td>
<td>$3/kW</td>
</tr>
<tr>
<td>Manufacturing capability for composite bipolar plates – GTI, Porvair</td>
<td>BP: $10/kW</td>
<td>$10/kW</td>
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<tr>
<td>Manufacturing Capability for Portable Power Fuel Cells.</td>
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</table>

* Based on ADL Cost Study
Workshop Objectives

• Identify and prioritize the technical barriers to commercialization of PEMFCs for portable applications.

• Draft a research, development, and demonstration plan to overcome the barriers.

• Develop a strategy to use the commercialization of portable power fuel cells to facilitate commercialization of automotive PEMFCs.
The Workshop Product will be a RD&D Roadmap:

- **Consumer Electronics**
  - Technical Barriers: 1, 2, 3...
  - RD&D Activities/Milestones: 1a, b, c ... 2a, b, c ... 3...

- **Portable Power**
  - Technical Barriers: 1, 2, 3...
  - RD&D Activities/Milestones: 1a, b, c ... 2a, b, c ... 3...

- **Fuels**
  - Technical Barriers: 1, 2, 3...
  - RD&D Activities/Milestones: 1a, b, c ... 2a, b, c ... 3...

- **Transition Strategy**
  - Issues: 1, 2, 3...
  - RD&D Activities/Milestones: 1a, b, c ... 2a, b, c ... 3...
And a Demonstration Plan with Transition Strategy

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>2001</th>
<th>Feasibility Demonstration</th>
<th>2004</th>
<th>Phase 2</th>
<th>Controlled Fleet Demonstrations</th>
<th>2008</th>
<th>Phase 3</th>
<th>Commercial Fleet Demonstrations</th>
<th>2012</th>
<th>Commercialization Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehcles</td>
<td>Objective</td>
<td>Test FC vehicle performance and feasibility</td>
<td></td>
<td></td>
<td>Demonstrate use of FC vehicles under real-world conditions.</td>
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<td>Demonstrate commercial viability of FC fleet vehicles.</td>
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<tr>
<td>Sites</td>
<td>Number of Vehicles</td>
<td>1(CaFCP)</td>
<td>5-8; varying climates</td>
<td>~500</td>
<td></td>
<td></td>
<td>2-3 states (networked sites)</td>
<td>~5000</td>
<td>Investment for 25-50% of all stations H₂ capable</td>
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<tr>
<td>Infrastructure</td>
<td>Objective</td>
<td>Demonstrate H₂ fueling station</td>
<td>Onsite generation from multiple feedstocks</td>
<td>Renewables and fossil fuels</td>
<td>Most cost effective sources</td>
<td>20-30</td>
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<tr>
<td>Hydrogen Source</td>
<td>Number of stations</td>
<td>Primarily trucked-in liquid H₂</td>
<td>3</td>
<td>5-10</td>
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<tr>
<td>Government Role</td>
<td></td>
<td>Share management responsibilities</td>
<td>Purchase Vehicles</td>
<td>Cost share &amp; operate H₂ fueling stations</td>
<td>Data collection &amp; dissemination</td>
<td>Coordination of international codes &amp; standards</td>
<td>Education</td>
<td>Vehicle subsidy</td>
<td>Cost shared infrastructure Education</td>
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<td></td>
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<td>Fuel Chain Analyses</td>
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<td>Education</td>
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<tr>
<td>Industry Role</td>
<td></td>
<td>Operate Vehicles and H₂ stations</td>
<td>Vehicle design, engineering &amp; integ.</td>
<td>Cost share fueling stations</td>
<td>Identify service requirements</td>
<td>Complete Codes &amp; standards</td>
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<td>Primary Funding</td>
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| Success Criteria [achieved through parallel technology development] | \begin{align*}
\text{Fuel Cell} & : \$325/kW \\
\text{Durability} & : 1000 \text{ hrs} \\
\text{Onboard H₂ Storage} & : \$125/kW \\
\text{Cost (/kWh)} & : 2000 \text{ hrs} \\
\text{Energy Density} & : \$45/kW \\
\text{Specific Energy} & : 5000 \text{ hrs} \\
\text{Hydrogen Infrastructure} & : \$5/kWh \\
\text{Cost} & : 2000 \text{ Wh/kg} \\
\text{Greenhouse Gases} & : \$21/GJ \\
\text{Specific Energy} & : 1100 \text{ Wh/L} \\
\text{Cost} & : \$12/GJ \\
\text{Greenhouse Gases} & : 98 \text{ g/kg} \\
\end{align*} | | | | | | | | |

Given the high risk nature of the accelerated timeline, careful decision criteria prior to each phase need to be jointly established by Industry and Government.
Previous DOE Workshops/Outcomes

Basic and Applied Research Needs for PEMFCs

• Established a high-temperature membrane (HTM) R&D program
  ➢ LANL, multiple universities
  ➢ Industry projects w/ 3M, UTC Fuel Cells, DeNora/DuPont
  ➢ HTM Working Group

• Initiated projects to improve cathode
  ➢ LANL, LBNL, Superior MicroPowders, other industry

• Expanded projects to reduce Pt content
  ➢ NRL, BNL

Sensor Needs for PEM Fuel Cells and DI Engines

• Initiated a Sensor R&D Program
  ➢ National Labs – LANL, LLNL
  ➢ Industry – UTRC, Honeywell
For Further Information

DOE Fuel Cells for Transportation Program:

Pat Davis: 202-586-8061, patrick.davis@ee.doe.gov
Nancy Garland: 202-586-5673, nancy.garland@ee.doe.gov
Donna Ho: 202-586-8000, donna.ho@ee.doe.gov
Peter Devlin, 202-586-4905, peter.devlin@ee.doe.gov

Office of Transportation Technologies: www.ott.doe.gov
Additional Information
Program Activities – Fuel Cells

FY 2002 Budget = $41.9M

**Fuel Cell Stack Subsystem**
- Catalyst R&D
- High Temperature Membrane R&D
- MEA/Bipolar Plate Manufacturing Processes
- Cost Reduction R&D
- Durability Studies
- Direct Methanol Fuel Cells

**Fuel Processing/Storage Subsystem**
- Catalyst R&D
- Fuel Processor R&D
- Fuel Effects/Durability Studies
- Microchannel Components
- CO & Sulfur Management
- Hydrogen Storage R&D

**Systems**
- System Validation
- System Modeling
- Ancillary Components (Compressors, Sensors)
- Cost Analyses
- Emissions Testing
**Program Addresses Technical Challenges**

through cost-shared R&D with industry and applied research at national labs and universities

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Current R&amp;D Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>ADL/DTI – Cost Analyses&lt;br&gt;3M, SWRI/W.L. Gore – High Volume, Low Pt MEA Fabrication&lt;br&gt;GTI, ORNL, Porvair – Bipolar Plates&lt;br&gt;ANL, UMich, NexTech - Improved FP, WGS Catalysts&lt;br&gt;LANL, NRL, BNL – Low Pt Electrodes</td>
</tr>
<tr>
<td>Durability</td>
<td>LANL, many industry projects are now addressing durability.</td>
</tr>
<tr>
<td>Air Management</td>
<td>IFC, ADL, Honeywell, Mechanology, Meruit – Compressors</td>
</tr>
<tr>
<td><strong>Start-Up</strong>&lt;br&gt;(Fuel Processing)</td>
<td>Nuvera, McDermott, Catalytic - fuel processing system/components&lt;br&gt;ANL, UMich, NexTech - Improved FP, WGS Catalysts&lt;br&gt;PNNL – Microchannel Fuel Processing</td>
</tr>
<tr>
<td>Thermal/Water Management</td>
<td>3M, IFC, DeNora/DuPont, LANL/Universities → High temperature membranes&lt;br&gt;ORNL – Carbon foams for radiators, humidifiers</td>
</tr>
<tr>
<td><strong>H₂ Storage,</strong>&lt;br&gt;Refueling</td>
<td>UTRC, SwRI – H₂ Storage R&amp;D, Testing&lt;br&gt;Air Products, GE – Refueling technologies</td>
</tr>
</tbody>
</table>


Fuel Cell Program Implementation

USCAR
- System Requirements
- System Analyses
- Technology Goals
- Technical Reviews
- R&D Priorities

US DOE
- Program Management
- Procurement
- Budgeting & Resource Allocation
- Technology/Program Assessment

ADVISORS/STAKEHOLDERS
- Fuel Providers
- Federal/State Govt
- Stationary/Building

NAT’L LABS/Univ.
- R&D on most critical technical barriers
- Assist Suppliers
- Independent T&E
- Advanced Concepts Analysis & Modeling

SUPPLIERS
- PEM fuel cell system development
- Fuel-flexible fuel processor development
- Materials/Component development

AUTOMAKERS
- EV Powertrain Design
- Vehicle Engineering/ Packaging Design Vehicles

User Customer

Technology Development Flow