Fuel Cells for Transportation Applications

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Fuel Cells for Transportation Program
Office of Transportation Technologies
Office of Energy Efficiency and Renewable Energy

Solid State Energy Conversion Alliance Workshop
March 21, 2002
OTT Mission

...support the development and use of advanced transportation vehicles and fuels which will reduce energy demand, particularly for petroleum; reduce greenhouse gas emissions; and enable United States transportation to sustain a strong competitive position in domestic and world markets.
The “Oil Gap” is Growing

Highway Carbon Emissions
(million metric tons)

1990  2000  2010  2020
325    384     455    507

Domestic Oil Production

Millions of Barrels per Day

0  2  4  6  8  10  12  14

Heavy Trucks
Light Trucks
Automobiles
Commercial Vehicles

Passenger Vehicles

Transportation Emissions Remain an International Concern

- Transportation produces:
  • 79% of carbon monoxide,
  • 50% of nitrogen oxides,
  • 36% of volatile organics, and
  • 42% of carbon dioxide emissions
- Over 100 million people live in areas not meeting National Ambient Air Quality Standard (EPA, Oct. 1995)
Closing the Oil Gap

✓ Increase the Supply of Oil
✓ Reduce the Demand for Oil

-- Improve the Fuel Economy of Vehicles & other Oil Using Equipment
-- Replace Oil with Alternative Fuels (& Feedstocks)
Energy Security – Reducing Petroleum Imports to 50%
21st Century Truck Partnership

Industry Participants

Allison Transmission
BAE SYSTEMS Controls
Caterpillar
Cummins
DaimlerChrysler
Detroit Diesel
Eaton Corporation
Freightliner

General Motors
Honeywell
International Truck and Engine
Mack Trucks
NovaBUS
Oshkosh Truck
PACCAR
Volvo Trucks North America

Department of Energy
DOE/EE/OTT
Heavy Vehicle Technologies R&D

Department of Defense
Army/TACOM
NAC Military Vehicle R&D

Intelligent Vehicle and Highway Safety R&D

Department of Transportation
Vehicle Emissions Regulations

Environmental Protection Agency

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Fuel Cells For Transportation Program Goal

More MPG

Develop highly efficient, low- or zero-emission, cost-competitive automotive fuel cell power system technologies that operate on conventional & alternative fuels.
Hydrogen can be stored and supplied directly to the fuel cell: *Storage and Infrastructure Issues*

- Hydrogen can be derived on-board from fuels such as ethanol, methanol, natural gas, gasoline or FT fuels: *Complexity, Cost, and Start-up Issues*
Program is Focused on Critical Technical Challenges

Significant technical and economic challenges will keep fuel cell vehicles from making significant market penetration for up to 10 years.

Major Challenges for Automotive PEM Fuel Cells:

- Cost
- Performance (Durability, Efficiency)
- Air Management (Compressor Technology)
- Startup (Fuel Processor Thermal Mass)
- Thermal/Water Management
Project Areas and Funding
Total Fiscal Year 2002 Budget: $41.9M
2003 Budget Request: $50M

Systems
- Benchmark 50 kW fuel cell power systems
- 50 kW stack subsystems
- system modeling
- thermal/water management
- sensors

Fuel Processing
- 50 kWe fuel processor subsystem
- emissions testing
- advanced fuel processing catalysts
- fuel stream clean-up devices

Stack Subsystem Components
- low-cost bipolar plates
- low-cost membrane electrode assemblies
- air management systems (compressor, expander, motor, controller)
- gas diffusion layers
- advanced fuel cell catalysts
- high temperature membranes

Total Fiscal Year 2002 Budget: $41.9M
2003 Budget Request: $50M
DOE is a Member of the CALIFORNIA FUEL CELL PARTNERSHIP

Goals
- Demonstrate vehicle technology
- Demonstrate the viability of alternative fuel infrastructure technology
- Explore the path to commercialization
- Increase public awareness

Members
- State of California (CARB/CEC/SCAQMD)
- Auto Manufacturers (DaimlerChrysler/Ford/Honda/Hyundai/Nissan/Volkswagen/General Motors/Toyota)
- Energy Providers (BP/Shell Hydrogen/Texaco/ExxonMobil)
- Fuel Cell Companies (Ballard/IFC/XCELLSiS)
- Associates (Air Products/Methanex/Praxair/Hydrogen Burner/Pacific G&E
- Proton Energy/Stuart Energy/AC Transit/SunLine)
- Federal agencies (DOE/DOT)
SECA-Related R&D

OTT is developing fuel cells for auxiliary power units (APUs) in diesel trucks, and addressing the related technical challenges:

- **Diesel Reforming**
  - eliminate carbon formation
  - remove sulfur and/or develop sulfur tolerant catalysts

- **Solid Oxide Fuel Cells**
  - develop rugged, low cost cell materials
  - reduce startup time

Current R&D efforts are being carried by LANL, NETL, and ANL under the Transportation Fuel Cell Program. Small businesses and universities will carry out R&D through the Cooperative Automotive Research for Advanced Technology (CARAT) Program. Analyses of APUs for light and heavy vehicle applications being conducted.
The President’s Plan directs us to explore the possibility of a hydrogen economy….”

Spencer Abraham, Secretary of Energy
The CAR in FreedomCAR is for Cooperative Automotive Research

The Partners are:
- U.S. Department of Energy
- U.S. Council for Automotive Research

(USCAR is a cooperative endeavor of DaimlerChrysler, Ford and General Motors to conduct pre-competitive research)
Energy Security Through FreedomCAR Technology

America’s Transportation Freedoms

- Freedom from dependence on foreign petroleum
- Freedom from pollutant emissions
- Freedom to choose the vehicle you want
- Freedom to drive where you want, when you want
- Freedom to obtain fuel affordably and conveniently
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 hybrid technologies and advanced materials that can dramatically reduce oil consumption and environmental impacts in the nearer term.

- Develop technologies applicable across a wide range of passenger vehicles.
Goals

- Develop reliable systems for future fuel cell powertrains with costs and performance comparable to conventional internal combustion engine/automatic transmission systems.

- Enable clean, energy-efficient vehicles operating on clean, hydrocarbon-based fuels powered by either internal combustion powertrains or fuel cells.

- Enable reliable hybrid electric vehicles that are durable and affordable.
Goals

- Enable the transition to a hydrogen economy, ensure widespread availability of hydrogen fuels while retaining the functional characteristics of current vehicles.

- Develop material manufacturing technologies for light weight, high volume production vehicles.
## 2010 FreedomCAR Technology Specific Goals

<table>
<thead>
<tr>
<th>Fuel Cell System</th>
<th>Efficiency</th>
<th>Power</th>
<th>Energy</th>
<th>Cost**</th>
<th>Life</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60% (hydrogen)</td>
<td>325 W/kg</td>
<td>$45/kW (2010)</td>
<td>15 years</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>45% (w/ reformer)</td>
<td>220 W/L</td>
<td>$30kW (2015)</td>
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<tr>
<td>Hydrogen Fuel/ Storage/ Infrastructure</td>
<td>70% well to pump</td>
<td>2 kW-h/kg</td>
<td>$5/kW-h</td>
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<tr>
<td></td>
<td>≥55 kW 18 s</td>
<td>1.1 kW-h/L</td>
<td>$1.25/gal (gas equiv.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric Propulsion</td>
<td>≥55 kW 18 s</td>
<td>30 kW cont.</td>
<td>$12/kW peak</td>
<td>15 years</td>
<td></td>
<td></td>
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<tr>
<td>Electric Energy Storage</td>
<td>25 kW 18 s</td>
<td>300 W-h</td>
<td>$20/kW</td>
<td>15 years</td>
<td></td>
<td></td>
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<tr>
<td>Materials</td>
<td>45% peak</td>
<td></td>
<td>$30/kW</td>
<td>15 years</td>
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<td></td>
</tr>
</tbody>
</table>

* Meets or exceeds emissions standards.
** Cost references based on CY2001 dollar values.
Executive Steering Committee
USCAR Vice Presidents of R&D
DOE EERE Assistant Secretary, OSTP Associate Director for Technology
Designated Observers -- OVP, OMB

FreedomCAR Operations Group
USCAR Director and Industry FreedomCAR Directors
DOE FreedomCAR Partnership Director, OAAT & Hydrogen Program Office Directors

Consultations:
Gov’t Agencies, Energy Industry, Suppliers, Etc.

Consultations With DOE Offices
Fossil Energy, Office of Science, Etc.

Technical Team
Technical Team
Technical Team
Technical Team

* Number & Composition of Technical Teams TBD
FreedomCAR FY03 Budget Request Reflects Fuel Cell and Hydrogen Priorities

Adv. Combustion Engine 14,076
Hybrid Vehicle Comp. 38,500
Electric Vehicle 3,500
Small Business Universities 2,000
Materials 10,800
Fuels 5,600
Trans-Related Hydrogen 25,820
Fuel Cells 50,000

Totals = $150,296

($K)
FreedomCAR encompasses support for technologies with the potential to dramatically reduce oil consumption and environmental impacts in the period prior to the introduction of affordable fuel-cell vehicles.

- Hybrid Electric Drivetrains
- Advanced Internal Combustion Engines
- On-Board Fuel Processors for Fuel Cells
- Lightweight Materials, Energy Storage, Electronic Components
FreedomCAR Partnership

A Long-Term Effort to Achieve
Clean Energy-Efficient Automotive Transportation
Based on Hydrogen-Powered Fuel-Cell Vehicles

With

✓ Intermediate Goals and Metrics
to Ensure Measurable Progress

While

✓ Ensuring America’s Transportation Freedoms
Fuel Cell  
Report to Congress

FY02 Interior Appropriations Bill

“The Department should report to the House and Senate Committees on Appropriations, within twelve months of the date of enactment of this Act, on the technical and economic barriers to the use of fuel cells in transportation, portable power, stationary, and distributed generation applications. The report should include recommendations on program adjustments based on an assessment of the technical, economic, and infrastructure requirements needed for the commercial use of fuel cells for stationary and transportation applications by 2012.”
House/Senate Conference Report:

*Interim Report*: “Within six months of the date of enactment of this Act, the Department should also provide an interim assessment that describes preliminary findings about the need for public and private cooperative programs to demonstrate the use of fuel cells in commercial scale applications.”
Reorganization of Energy Efficiency and Renewable Energy
Current Organization (Fuel Cell Related)

Energy Efficiency and Renewable Energy
David Garman, Assistant Secretary

Office of Transportation Technology
Thomas J. Gross, Deputy Assistant Secretary

Fuels Development
John Ferrell

Heavy Vehicle Technologies
James Eberhardt

Advanced Automotive Technologies
Robert Kirk

Technology Utilization
David Rodgers

Office of Power Technology
Dr. Robert K. Dixon, Deputy Assistant Secretary

Distributed Energy Resources
Patricia Hoffman

Hydrogen & Superconductivity Technologies
James Daley

Other EERE Offices
Reorganization of Energy Efficiency and Renewable Energy
New Program Office for Hydrogen and Infrastructure

- Within EE, accomplishes NEP goal of “integrating current programs regarding hydrogen, fuel cells, and distribution”.


- No information available about staffing of this organization, but will be determined in the next week. Staff are expected to be drawn from existing programs.
Summary

- DOE’s Office of Transportation Technologies is addressing the key technical challenges in the development of fuel-efficient vehicles for both light duty and heavy duty applications.

- Government-Industry partnerships are critical to the success of OTT’s Vehicle Technology Programs.

- OTT’s Fuel Cell Program has made tremendous progress; however, major technical challenges remain which prevent the introduction of fuel cell vehicles today.

- The new structure of transportation programs under Energy Efficiency and Renewable Energy will consolidate fuel cell and hydrogen related work.

For more information, visit the OTT Web Site: www.ott.doe.gov