Proton Exchange Membrane (PEM) Fuel Cells for Transportation

Energy Efficiency and Renewable Energy
Office of Transportation Technologies

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Solid State Energy Conversion Alliance Workshop

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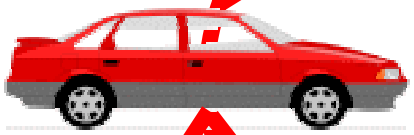
EERE PEM Fuel Cell Development Efforts Benefit Multiple Applications

Medium & Heavy Duty Vehicles

Buildings

Automotive Program



Distributed Power

Portable and Premium Power

Projected Fuel Cell Vehicle Performance (PNGV-Class Series Hybrid)

Projected Mileage, MPG

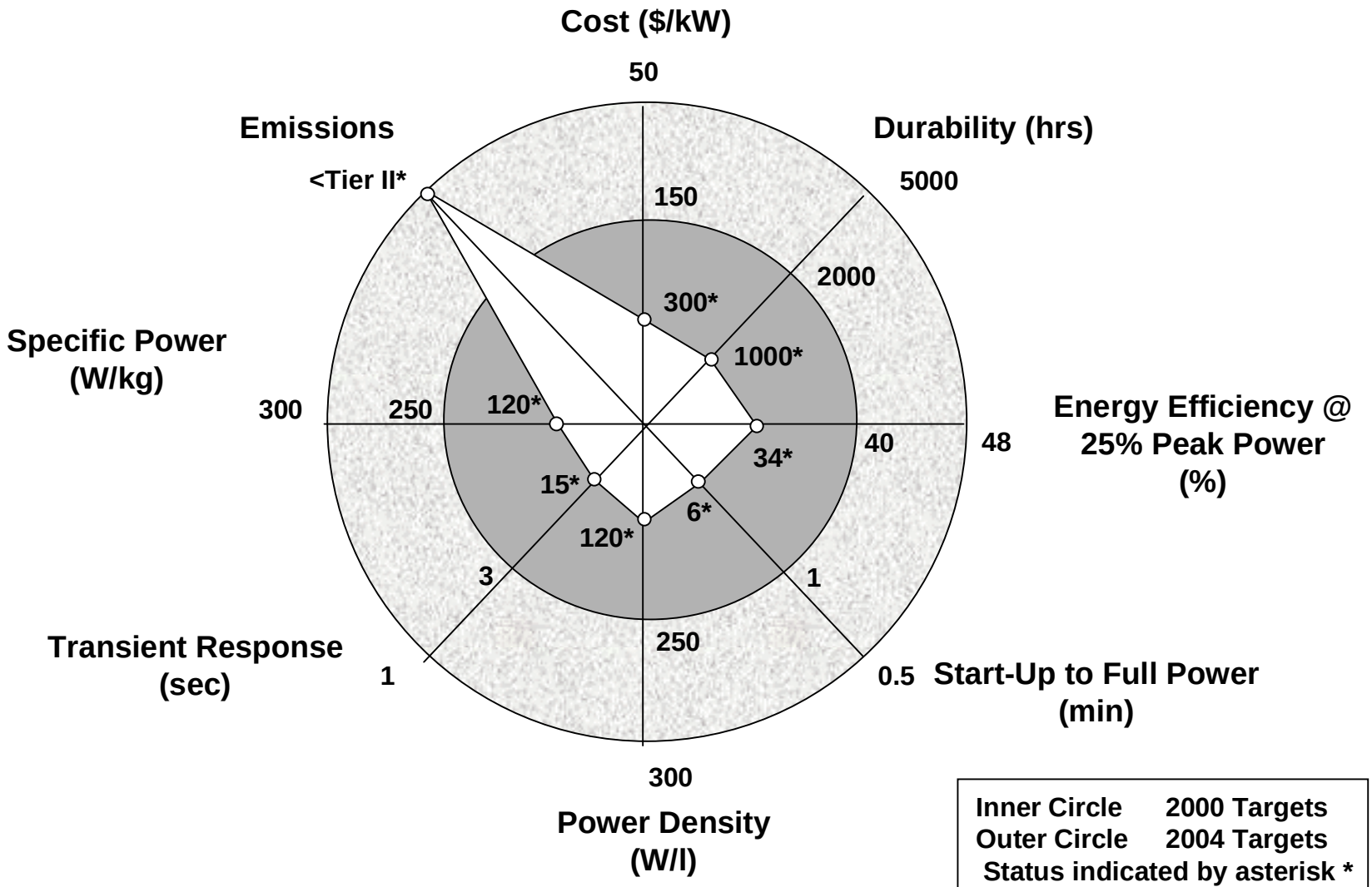
	Gasoline Fueled	Hydrogen Fueled
Urban Fuel Economy	79	101
Highway Fuel Economy	97	128
Combined	**86**	***111***

Note: Based on NREL/ADVISOR system modeling using target fuel cell efficiencies.

108 mpg

Status vs Technical Targets

50-kW Gasoline-Fueled Fuel Cell System



Inner Circle	2000 Targets
Outer Circle	2004 Targets
Status indicated by asterisk *	

DOE Transportation Fuel Cell Program Fuel Strategy

Simultaneously pursue parallel paths for near- and long-term

Near-term: Fuel flexible fuel processor

Primary focus ⇨ Advanced petroleum-based fuel

⇨ Methanol, Ethanol, Natural Gas

Long-term: Renewable hydrogen

Primary focus ⇨ On-board vehicle storage

Advanced fuel is "gasoline-like," facilitates on-board processing, and is compatible with existing infrastructure. Gas-to-liquids, methanol, and ethanol may be used as blending constituents.

Structure of DOE Transportation Fuel Cell Program

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

Universities/LABS
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
Component development

AUTOMAKERS
EV Powertrain Design
Vehicle Engineering/ Packaging Design
Vehicles

User Customer

Technology Development Flow

Program is Focused on Technical Barriers

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

- **Technical Barriers**
  - **Platinum Usage**
  - **Durability**
  - **Air Systems**
  - **Start-up**
  - **Fuel Infrastructure**
  - **Cost**
- **Economic Barriers**
  - **Competition from other technologies**
  - **Fuel Cell Cost**
  - **Economics of fuel introduction**
  - **Cost of fuel**

Projects and Funding by Budget Category

Systems

- Plug Power/Epyx
- IFC
- Energy Partners, AlliedSignal
- ANL

FY00: $6.0M

Fuel Processing

- NUVERA
- Hydrogen Burner
- McDermott
- Plug Power/UOP
- AlliedSignal
- Arcadis
- ANL, LANL, PNNL

FY00: $17.0M

Stack Subsystem Components

- Energy Partners, AlliedSignal, IFC, Plug Power
- IGT, Electrochem
- 3M, SwRI/Gore, Foster-Miller
- Vairex, A.D. Little, AlliedSignal, Meruit
- Spectracorp
- LANL, LBNL

FY00: $14.0M

Accomplishments

Systems

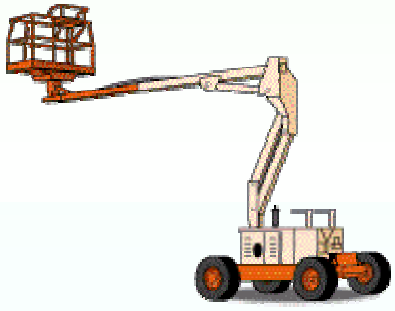
- Demonstration of first gasoline to PEM experiment (1997), first 10kW gasoline system (1999).
- IFC Hydrogen Sys.
- MeOH (GM) system led to Zafira demonstration

Fuel Processing

- Epyx gasoline fuel processors - 50kW
- PNNL microchannel steam reformer
- ANL autothermal catalyst development
- GM MeOH steam reforming.
- Los Alamos PROX.

Stack Subsystem Components

- Los Alamos low platinum electrode, reconfigured anode.
- Inst. Of Gas Tech. $10/KW bipolar plate.
- Sensors and controls
- AlliedSignal stack demonstrated in JLG boomlift.



Office of Transportation Technologies Interest in Solid Oxide Fuel Cell Technology

- **Applications of interest in transportation**
  - **Auxiliary Power for Heavy or Light Duty**
  - **Propulsion for Heavy Duty**
- **Recently completed study by Parsons Infrastructure and Technology indicates auxiliary power application particularly of interest.**
- **OTT will continue to investigate application of solid-oxide fuel cell technology to transportation and support R&D where appropriate.**

Barriers to transportation applications:

Heavy Duty - Cost, Maturity, Durability/Robustness
Light Duty - Cost, Maturity, Start-up, Thermal Cycling

Summary

- **PEM fuel cell technology leverages multiple applications to achieve significant benefits in energy efficiency.**
- **Major technical barriers exist that prevent the introduction of PEM technology into today's light duty transportation options.**
- **The Office of Transportation Technology Fuel Cell for Transportation program is addressing critical technical barriers.**
- **Solid Oxide technology may find a role in transportation applications, but, like PEM, has significant technical and economic barriers to overcome.**