U.S. DEPARTMENT OF ENERGY

Fuel Cells

Nancy Garland

Acting Team Leader

2007 DOE Hydrogen Program
Merit Review and Peer Evaluation Meeting

May 15, 2007

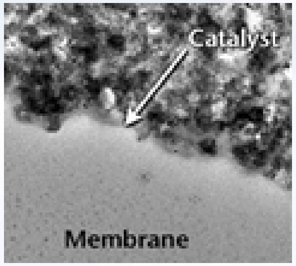
Challenges

- **Durability**
- **Cost**
- **Electrode Performance**
- **Water Transport Within the Stack**
- **Thermal, Air and Water Management**
- **Start-up Time and Energy**

Cost and durability present two of the more significant barriers to the achievement of clean, reliable, cost-effective systems.

Strategy

- Primary focus is on fuel cells for transportation applications
- R&D is focused on components rather than systems



Membranes

Bipolar Plates

Electrodes

Seals

Membrane Electrode Assemblies

Balance-of-plant Components

Gas Diffusion Layers

Innovative Concepts

Analysis, Characterization and Benchmarking

Strategy

Secondary focus is on stationary and other early market fuel cells to establish the manufacturing base

Distributed Power

- Improve system durability
- Improve stack performance w/ reformate
- Improve fuel processor performance
- Increase system electrical efficiency

APUs

- Develop diesel fuel processor
- Develop FC that operates on reformate
- Design, build, & test under real-world conditions

Portable Power

- Develop membranes to reduce methanol crossover
- Design, build, & test under real-world conditions

Key Targets

Integrated Transportation Fuel Cell Power System (80 kW_e) Operating on Direct Hydrogen
➢ **\$45/kW by 2010**
➢ **\$30/kW by 2015**
➢ **5,000 hours durability by 2010 (80^{O}C)**

Other Key Targets

Distributed Energy (PEMFC)

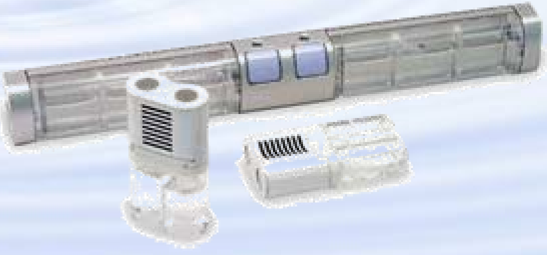
- $750/kW by 2011
- 40,000 hours durability by 2011
- 40% electrical efficiency

Auxiliary Power Units (SOFC)

- Specific power of 100 W/kg by 2010
- Power density of 100 W/L by 2010

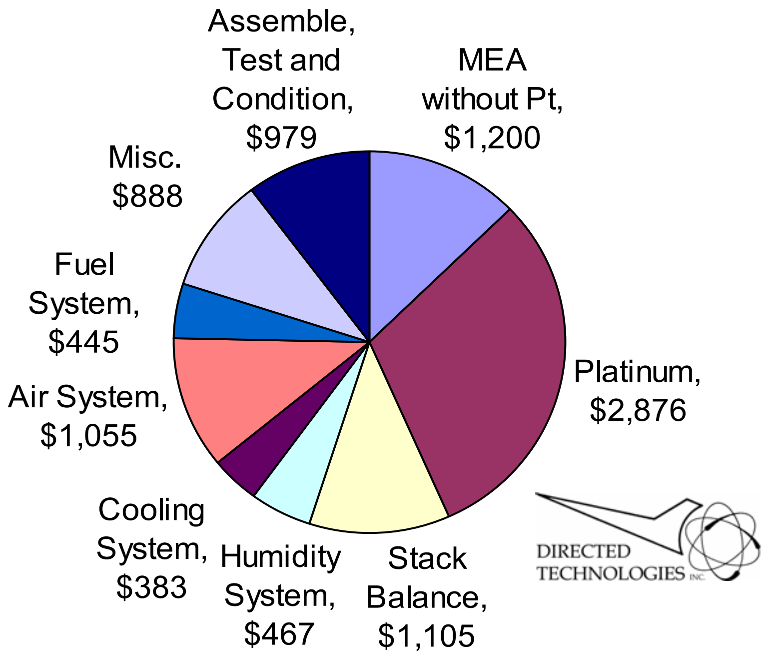
Consumer Electronics (DMFC)

- Energy density of 1,000 W-h/L by 2010

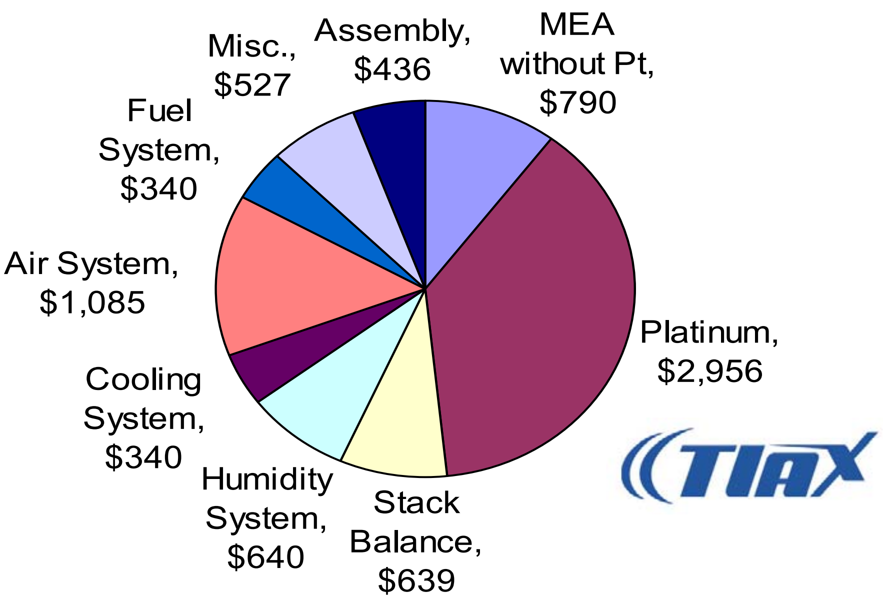


Recent High-volume Cost Analyses (500,000 units/year)

DTI Fuel Cell System 80 kW Direct H_2
Cost = $118/kW (net), $9412



TIAX Fuel Cell System 80 kW Direct H_2
Cost = $97/kW (net), $7760



- The *major difference* between the DTI and TIAX estimates is the cost of the MEA and the seals in stack balance. DTI included Test & Conditioning.

Fuel Cell Program Budget

Budget Activity	Funding ($ in thousands)		
	FY 2006 Appropriation	FY 2007 Appropriation	FY 2008 Request
Fuel Cell Stack Component R&D	30,710	38,082	44,000
Transportation Fuel Cell Systems	1,050	7,518	8,000
Distributed Energy Fuel Cell Systems	939	7,419	7,700
Fuel Processor R&D	637	4,056	3,000

Research Partners

Membranes
3M, Arkema (2), DuPont, Plug Power, LBNL, Colorado School of Mines, Penn State, Virginia Tech, Giner (1 + 1 SBIR), U of Tenn, Case Western Reserve U (2), FuelCell Energy, Clemson U, GE Global Research, Arizona State U, U of Central Florida, Farasis (SBIR)

MEAs
UTC Fuel Cells, 3M, LANL

Catalysts and Supports
Ballard, U. of South Carolina, 3M (2), UTC, LANL, ANL, PNNL, Farasis Energy (SBIR), BASF, Ion Power

Bipolar Plates
Graftech, ORNL

BOP Components
Honeywell (2), Advanced Fluids Tech. (SBIR), UTC

Characterization and Analysis
NIST, ORNL, LANL, ANL, TIAX, DTI, Battelle

Impurities
LANL, Clemson U, U of CT

Innovative Concepts
Plug Power, Case Western Reserve U, PNNL, ANL

Stationary and other Early Market Fuel Cells
IdaTech, UTC Fuel Cells, Plug Power (3), Nuvera, Texaco, Delphi, Cummins, PolyFuel, MTI Micro, Intelligent Energy

2006 Congressionally Directed
UTC, Chemsultants, U of S. Mississippi, Kettering U, U of Akron, Bloom Energy

Water Transport
RIT, LANL, Nuvera, CFD

Agenda

Tuesday, May 15, 2007		
1:15	Fuel Cells Sub-Program Overview	Nancy Garland, DOE
1:30	FC 1 — Fuel Cell Systems Analysis	Rajesh Ahluwalia, ANL
2:00	FC 2 — Neutron Imaging Study of the Water Transport in Operating	Muhammad Arif, NIST
2:30	FC 3 — Microstructural Characterization of PEM Fuel Cell MEAs	Karren More, ORNL
3:00	FC 4 — Novel Approach to Non-Precious Metal Catalysts	Radoslav Atanasoski, 3M
3:30	Break	
3:50	FC 5 – Novel Non-Precious Metals for PEMFC: Catalyst Selection Through Molecular Modeling and Durability Studies	Branko N. Popov, U of So. Carolina
4:20	FC 6 – Development of transition metal/ chalcogen based cathode catalysts for PEM fuel cells	Stephen Campbell, Ballard
4:50	FC 7 – Applied Science for Electrode Performance, Cost, and Durability	Bryan Pivovar, LANL
5:20	Adjourn	

Agenda

Wednesday, May 16, 2007		
8:00	FC 8 — Development of Polybenzimidazole-based High Temperature Membrane and Electrode Assemblies for Stationary Applications	John Vogel, Plug Power
8:30	FC 9 — Development of a Low-cost, Durable Membrane and MEA for Stationary and Mobile Fuel Cell Applications	Scott Gaboury, Arkema Chemicals
9:00	FC 10 — MEA and Stack Durability for PEM Fuel Cells	Mike Yandrasits, 3M
9:30	FC 11 — Improved Membrane Materials for PEM Fuel Cell Applications	Robert Moore, Univ. of South Mississippi
10:00	Break	
10:30	FC 12 — Poly(p-phenylene Sulfonic Acid)s with Frozen-in Free Volume for use in High Temperature Fuel Cells	Morton Litt, Case Western Reserve University
10:50	FC 13 – Poly(cyclohexadiene)-Based Polymer Electrolyte Membranes for Fuel Cell Applications	Jimmy Mays, U of Tennessee
11:10	FC 25 – NanoCapillary Network Proton Conducting Membranes for High Temperature Hydrogen/Air Fuel Cells	Peter Pintauro, Case Western Reserve University
11:30	FC 15 – Lead Research and Development Activity for High Temperature, Low Relative Humidity Membrane Program	James Fenton, Univ. of Central Florida
12:00	Lunch	

Agenda

Wednesday, May 16, 2007		
1:15	FC 16 — Protic Salt Polymer Membranes: High-Temperature Water-Free Proton-Conducting Membranes	Dominic Gervasio, Arizona State
1:35	FC 17 — Novel Approaches to Immobilized Heteropoly Acid (HPA) Systems for High Temperature, Low Relative Humidity Polymer-Type Membranes	Andrew Herring, Colorado School of Mines
1:55	FC 18 — High Temperature Membrane With Humidification-Independent cluster Structure	Ludwig Lipp, FuelCell Energy, Inc.
2:15	FC 19 — Design and Development of High-Performance Polymer Fuel Cell Membranes	Ryo Tamaki, General Electric
2:35	FC 20 — Fluoroalkylphosphonic-acid-based proton conductors	Stephen Creager, Clemson
3:15	Break	
3:30	FC 21 – Dimensionally Stable High Temperature Membranes	Cortney Mittelsteadt, Giner
3:50	FC 22 – New Proton Conductive Composite Materials with Co-continuous Phases Using Functionalized and Crosslinkable	Serguei Lvov, Penn State
4:10	FC 23 – Advanced Materials for Proton Exchange Membranes	James McGrath, Virginia Tech
4:30	FC 24 – Dimensionally Stable High Performance Membrane	Han Liu, Giner
4:50	FC 14 – Center for Intelligent Fuel Cell Materials Design Phase 1	Denise Katona, Chemsultants International

Agenda

Friday, May 18, 2007		
9:00	FC 26 — Economic Analysis of Polymer Electrolyte Membrane Fuel Cell Systems	Harry J. Stone, Battelle
9:30	FC 27 — Direct Hydrogen PEMFC Manufacturing Cost Estimation for Automotive Applications	Stephen Lasher, TIAX
10:00	Break	
10:30	FC 28 — Mass Production Cost Estimation for Direct H_2 PEM Fuel Cell System for Automotive Applications	Brian James, DTI
11:00	FC 29 – Platinum Recycling Technology Development	Stephen Grot, Ion Power, Inc.
11:30	FC 30 – Platinum Group Metal Recycling Technology Development	Larry Shore, BASF

For More Information

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