



The Case for Fuel Cell Powered Material Handling Equipment

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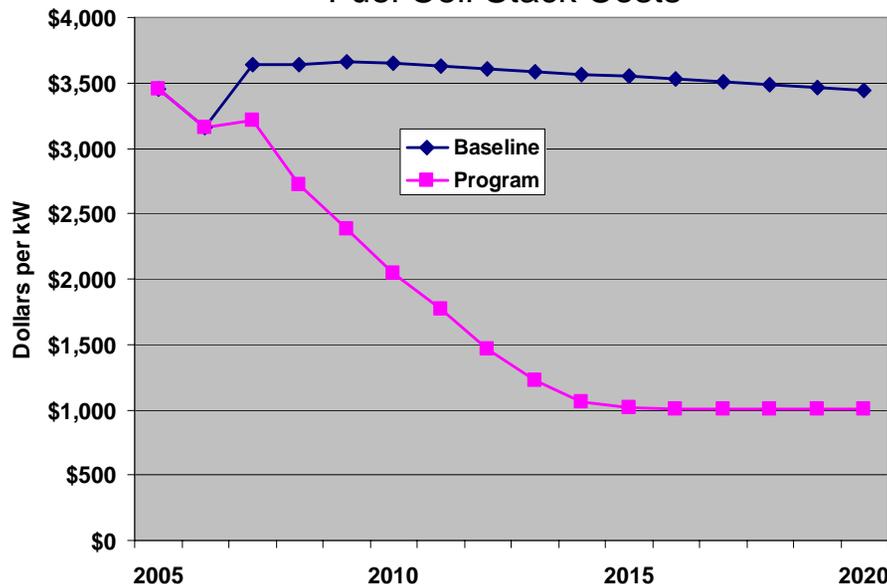
DOE Hydrogen Program Market Transformation

GOAL: Eliminate non-technical barriers to facilitate hydrogen and fuel cell technology commercialization

- Assist Federal agencies in using hydrogen and fuel cells to meet the requirements of:
 - EPCACT 2005 Sec. 782 and 783
 - Executive Order 13423
- Increase volume of fuel cell purchases to achieve economies of scale
- Support national infrastructure and domestic supplier base development
- Improve user confidence in fuel cell reliability by collecting operations data

Government acquisition – even at a relatively modest level – appears to be enough to drive down fuel cell costs

Estimated Effect of Government Acquisitions on Fuel Cell Stack Costs



Source: David Greene, ORNL; K.G. Duleep, Energy and Environmental Analysis, Inc.



Fuel Cells – Early Market Opportunities

Fuel Cells for Backup Power ...

- Provide longer continuous run-time, greater durability than batteries
- Require less maintenance than batteries or generators
- *May provide substantial cost-savings over batteries and generators*



A 1-kW fuel cell system has been providing power for this FAA radio tower near Chicago for more than three years. (Photo courtesy of ReliOn)

Fuel Cells for Material Handling Equipment ...

- **Allow for rapid refueling — much faster than changing-out or recharging batteries**
- **Provide constant power without voltage drop**
- **Eliminate need for space for battery storage and chargers**
- *May provide substantial cost-savings over battery-powered forklifts*



Photo courtesy of Hydrogenics

Fuel Cells for Data Centers ...

- Provide high-quality, reliable, grid-independent on-site critical load power
- Improve the effectiveness of data center power use by 40%, with combined heat-and-power (for cooling and heating)
- Produce no emissions
- Have low O&M requirements
- Can be remotely monitored





Fuel Cells and Battery Replacement

Positive value generated by:

- ✓ Labor savings
- ✓ Productivity improvements
- ✓ Reduced maintenance
- ✓ Battery waste elimination

Offset by:

- ✓ Higher initial capital costs compared to batteries and chargers
- ✓ Higher maintenance costs versus batteries
- ✓ Higher energy costs of using hydrogen vs. electricity

Compelling economic case can be made in many market segments

- ✓ High throughput distribution centers (Ace Hardware, Wal-Mart, Target, Kroger, etc.)
- ✓ Manufacturing plants (Toyota, Nissan, Bridgestone, etc.)
- ✓ Military supply logistics (Defense distribution depots)

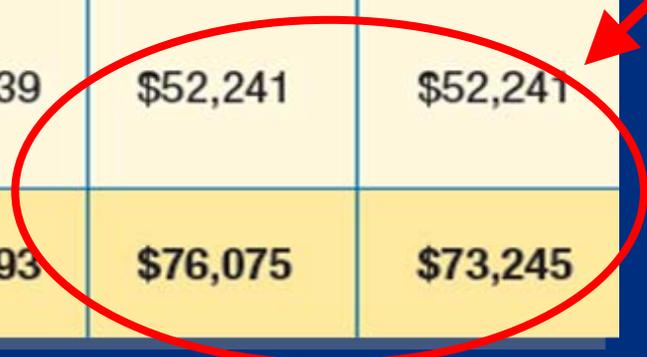
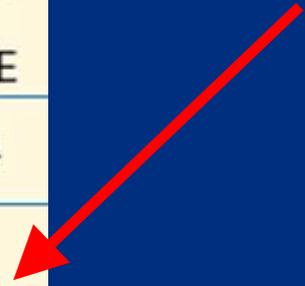




PEM Fuel Cells Can Be Cost-Competitive Today

	3kW PEM FUEL CELL PAIRED WITH INTEGRAL NiMH BATTERY, FOR PALLET TRUCKS*		
	BATTERY-POWERED (2 batteries per truck)	PEM FUEL CELL-POWERED, WITHOUT INCENTIVE	PEM FUEL CELL-POWERED, WITH INCENTIVE
Net Present Value of Capital Costs	\$17,654	\$23,835	\$21,004
Net Present Value of O&M Costs (including the cost of fuel)	\$127,539	\$52,241	\$52,241
Net Present Value of Total Costs of System	\$145,193	\$76,075	\$73,245

Low-cost option for forklifts



Source: Identification and Characterization of Near-term Direct Hydrogen Proton Exchange Membrane Fuel Cell Markets, Battells Memorial Institute (April 2007)

* **Assumptions:** Operate 7 hours/shift, 3 shifts/day, 7 days/week; batteries changed out every shift, taking ~30 minutes; operator cost \$15/hour; PEM forklift uses 3kW stacks with NiMH batteries; PEM fuel cell stack replaced every 5 years at \$3,000/kW; batteries replaced every 5 years at \$1,800; PEM fuel cell forklift refueled once every shift, refueling time 1 minute; no disposal costs were assumed for any of the technologies.



Case Study: Defense Logistics Agency (DLA)

DLA is the DoD's largest combat support agency

- Provides logistical support for everything from food to fuel
- 21,000 employees
- 5.2 million stock items managed – 54,000 requisitions/day
- Operates a network of 26 distribution centers worldwide

DLA is the DoD's fuel and energy supplier

- Conducts R&D to improve operations and long term war fighting capabilities



DLA HQ, Ft. Belvoir, VA

DLA seeks to be an early adopter and principal demonstrator

- Foster competition in the marketplace and provide market demand
- Exercise the supply chain
- Test under real world conditions, provide feedback to manufacturers
- Highlight the business case for fuel cells
- Nurture market momentum toward a tipping point for commercial acceptance



Case Study: Defense Logistics Agency (DLA)

Defense Depot Susquehanna, PA – Ribbon Cutting August 2008

- Add 20 new fuel cell forklifts and retrofit 20 forklifts with fuel cells
- Indoor dispensing system for hydrogen
- NREL to collect and analyze operational data

Defense Depot Warner Robins, GA – Kick-off July 2008

- Expand to include on-site reformation and mobile refueling
- Retrofit 20+ forklifts with fuel cells
- Hydrogen reformed on site from natural gas
- Teaming with Air Force Advanced Power Technology Office (APTO)



Case Study: Defense Logistics Agency (DLA)

Fort Lewis, WA

- 19 new or retrofitted forklifts
- Expand to explore hydrogen production from biogas from a waste water treatment plant; tri-generation from waste digester gas – heat, power, and hydrogen
- Mobile refueler for dispersed activities
- First articles anticipated – January 2009

Defense Depot San Joaquin, CA

- Replace 20 propane forklifts
- Hydrogen generated on site using solar energy for electrolysis
- Mobile refueler for dispersed activities
- Award anticipated in January 2009



Private Sector Examples

Many companies are also looking to fuel cell powered material handling equipment to support their operations. Examples include –

User

Ace Hardware

Nissan

Bridgestone

Wal-Mart

East Penn Manufacturing

Location

Rocklin, California

Smyrna, Tennessee

Aiken County, South Carolina

Washington Court House, Ohio

Lyon Station, Pennsylvania



Funding Opportunity

DOE Hydrogen Program Funding Opportunity Announcement

“Research, Development, and Demonstration of
Fuel Cell Technologies for Automotive, Stationary,
and Portable Power Applications”

- Issued May 27, 2008
- Closes August 27, 2008
- Topic 7B: Fuel Cell Powered Material Handling Equipment
- www.hydrogenandfuelcells.energy.gov/advanced_fc_technology.html



Questions?

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