

Market Transformation

- Session Introduction -

Pete Devlin

Goals and Objectives

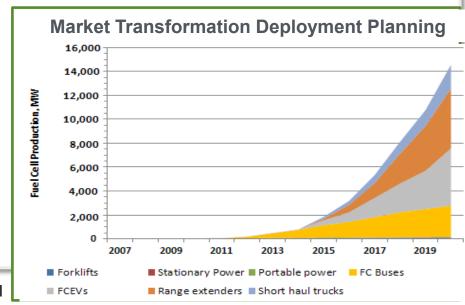


GOALS

- Ensure continued technology utilization growth for domestically produced hydrogen and fuel cell systems
- Lower life cycle costs of fuel cell power by identifying and reducing deployment barriers

OBJECTIVES

- Catalyze key implementation projects and partnerships with state and local governments and other stakeholders
- Increase domestic market penetration by standardizing and stimulating institutional and financial market practices
- Increase data analysis associated with siting and deployment (e.g., insurance, permitting, and installation)

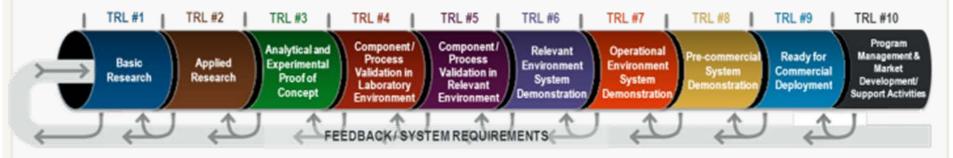


Data stems from research conducted by the California Fuel Cell Partnership and Pike Research

Challenges



• To test emerging applications at the Technology Readiness Level (TRLs) 7-9 level to expand user and servicing expertise



 To test new technology applications in user operating conditions to establish baseline energy efficiency and reliability performance and determine commercial viability

Examples:



A 1-kW fuel cell system providing power for this FAA radio tower near Chicago

(Photo courtesy of ReliOn)

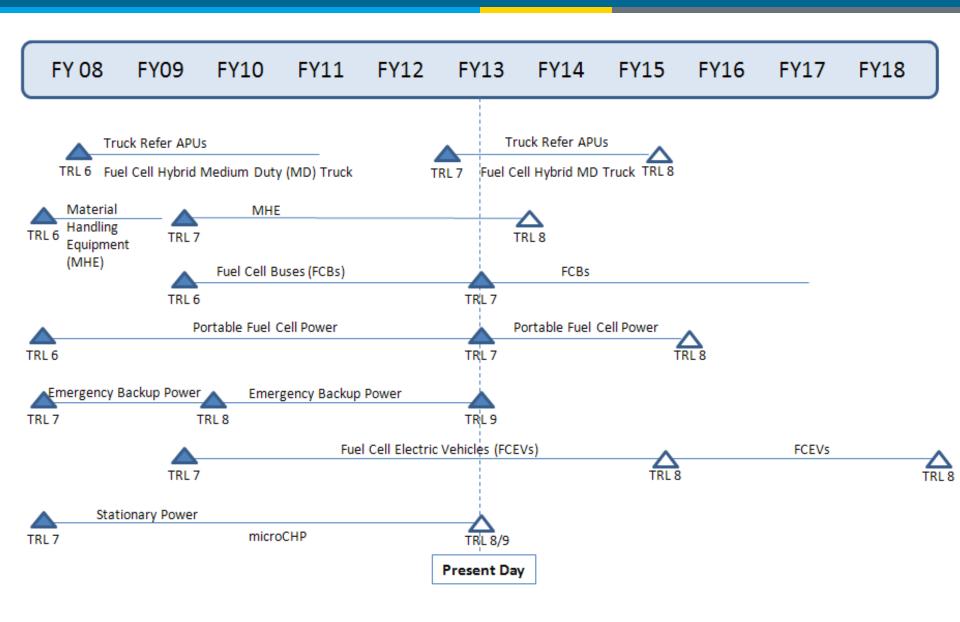


Material Handling Equipment at work in U.S. airports

(Photo courtesy of Hydrogenics)

Commercial Industry Fuel Cell Deployments (preliminary assessment)

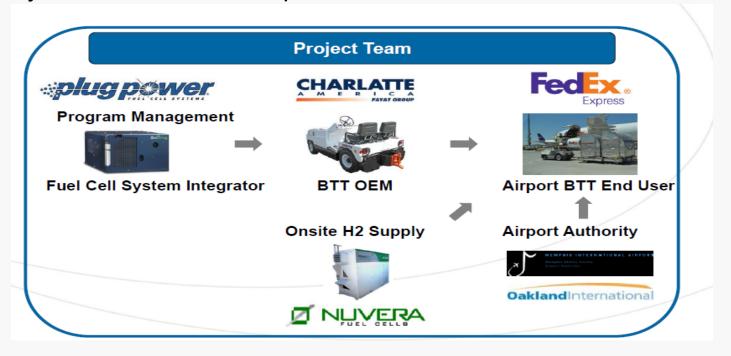




Challenges



 To develop strategies to mitigate commercial risks and develop new approaches to ensure high hydrogen and system utilization and reliability under mass market penetration scenarios

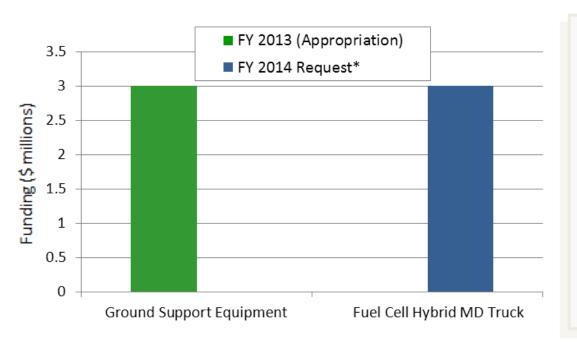


 To obtain data from operating experience and develop replicable business cases

Market Transformation Budget



FY 2013 Appropriation = \$3M FY 2014 Request = \$3M



^{*} Subject to appropriations and project go/no go decisions

EMPHASIS

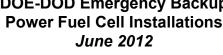
- ➤ New Ground Support Equipment
 Awards were made in January 2013
- Planning multiple FOAs over the next few FYs to enhance leveraging of deployments with DOE offices and other agencies
- Continue developing models, tools and templates for early markets

Market Transformation Fact Sheets



DOE-DOD Emergency Backup Power Fuel Cell Installations June 2012





ENERGY Beneralis Energy

As of May 2012, six that call units have en installed at Aberdeen Providing round and Fort Hood. In a first-of-a-kind servy duty use application, a 10 kW fluid cell at Fort Hood provides backup power to a 20mp air compressor. Additionally, a eployment coordination team made up of sees fael cell and users meets quarterly to provide first hand experiences and importa-

These projects, managed by the U.S. Army Corps of Engineers' Construction Engineering Research Laboratory, are accelerating the deployment of this important clean energy technology at DOD facilities and providing valuable data that below identify future research great for field cells. Continued R&D efforts enable further reductions in final cell costs, and as they con times to come down, that cells are becincreasingly competitive in the commercial

Emergency Back Fuel cells are a viable op gency backup power, par mission critical operatio outages employ butteries

lysco Foods, Fedlix Foo Vegmans, Coca- Cola, K

and Whole Foods), and I

conhined, these project wer 1.2 million hours o

DOE-supported MITE p

led to more than 1,500 as cell lift truck installation

industry without any D

Imost 200,000 ref

exication systems using fael cells for beckup power in the United Status.³ Fuel cells can offer significant cost advantage capability of three days or less is suf-ficient. In a study for the DOH, Statelle

Market Transformation

Model Transferration is hased or the concept that rederal support can catalyze a market to achieve economic and environmental benefits that can reduce costs through aconomies of scale. Adoption of fluor calls in emorging markets expands the growth of groon jobs, with new opportunities in manufacturing, fuel cell maintenance and support systems, and domestic hydrogen fuel production and delivery. By providing reliable field operations data and increasing user confidence, early market deninaments bein overcome non-technical challenges cooks and standards and reducing high insurance costs.

Strategies Market Transformation's primary goal is

to accelerate the expansion of hydrogen and fael cell use by lowering the life cycle costs of hydrogen and fael cell schoologies and identifying and reducing the barriers impeding full technology commercialization. The strategy is to

Use government as a test bed for early adoption of hydrogen and fael cells

of hydrogen and finel cells through collection and analysis of perform and cost data

Develop models, tools, and template for users to provide best practices in

ut the country. These partners include echnology project developers, vehicle naturfacturers, federal, state and local

ENERGY Energy Efficiency & FUEL CELL TECHNOLOGIES OFFICE

final cell users in industry. The collabora-tions have resulted in the deployment of thousands of final cells that are now demonstrating the use of these clean energy

Material Handling Equipment

Many leading American businesse are choosing fuel cells to power their restorial handling equipment (MHI) because of the productivity gains, lower cost, and performance advantages of fael cell-powered lift trucks. When compared o typical bettery-powered units, fuel cell lift tracks provide 80% lower reflecting labor costs and require 75% less facility space for reflecting, based on preliminary data collection and analysis by the National Renewable Reergy Laboratory Paul cell-powered lift tracks offer longer markines, constant power between

refueling, rapid refueling time, and the in high-throughput, multiple shift MHE. operations, fael cells can lower the total post of ownership and provide a positive

Fael cell-powered MHE is alread being used at dozens of warshouses distribution centers, and manufactur

DOE-DOD Compared with diesel generation, which

Emergency Backup Power Fuel Cell Installations

Energy (DOE) announced that, as part of thingy (IAAI) amonated that, as part or an interagency perturation with the U.S. Department of Definite (DOD) to strengthe American energy security and develop new clear energy technologies, DOE and DOD will collaborate on a project to install and operate 18 faul cell backup power systems ar eight defense installations across the country. The Departments will tust how the fael cells perform in real world operations. identify any improvements manufacturery could make to enhance the value proposi tion, and highlight the benefits of find cells for energency backup power applications.

The shared vision of the Department of Energy and the Department of Delives for a safe, secure energy finance provides as with a strong fundation to work together on specific technologies," said Unergy Secretary Steven Chn. "Projects like these fael cell systems will help reduce found fool

FUEL CELL TECHNOLOGIES PROGRAM Proving Ground

are often used for hadcup power, fuel cells use no petroleum, are quieter, and produce far fewer air emissions. Peel cells used in mergency hackup power applications wit natural gas reduce the emission of outron dicaside by 10% and nitrogen could by o either generators or hatteries, and can easily

available find cells is the higher first cost power systems that we being installed under the DOE-DOD partnership, will increase the scale of deployment and help improve the economics of the technology, which could ead to more widespread adoption and use.

The eight DOD installations were chose based on responses from a joint DOD-DOR project proposal request. LDOAN Energy of Roswell, Georgia, is the prime contractor for the project and is installing fuel cells. Spolome, Washington, Altergy Energy systems of Follows, California; Matech J.C of Bead, Oregon; and Hydroge Corroration of Oregon, Canada.



ester for monitoring the skies and space Forth American Aerospace Definese Command (NORAD) and the U.S. Space Command. The fast cell backup power at the VII Call Center is used to ensure the uring utility grid outages.

ENERGY Bermanite Francy FUEL CELL TECHNOLOGIES OFFICE

Story

The Fountain Willey energy

1Cod Airborne Division, the U.S. A. Special Operations Command, and the Sanitation District's waste halding to support computers and li-

Rickenbacker Air Natio Guard Base

a one of the Arroy's oldest on

U.S. Army Fort Bragg



is home to the Air Force 121st Air Marine Coms Reserve, Two 20 kW had cell avaterus will be installed at Troop Command and the Civil Sup-

Tri-Generation Success

World's First Tri-Gen Energy Station- Fountain The Fountain Valley energy station, supported in part by a \$2.2 million grant from the Energy Department, is the world's first tri-generation hydrogen

energy and electrical power station to provide transportation field to the publi and electric power to an industrial facility. Located at the Orange Count plant in Fountain Valley, California, the unit is a combined heat, hydrogen, and power (CHHP) system that co-produce power (citati') system that or produce hydrogen in addition to electricity and heat, making it a tri-generation system. The hydrogen produced by the system supplies a hydrogen faeling station that

emissions. In addition, since the nower is open to the public and can autoport een 25 and 50 feel cell ele shicle fills per day. The fael cell also reduces approximately 250 kW of pov

cell and hydrogen energy station uses

uses a molten carbonate feel cell

for its high efficiency and the ca

integrated with a hydrogen puri

Gas or Blogas

Highlights from DOE's Fuel Cell Recovery Act Projects May 2012



FUEL CELL TECHNOLOGIES PROGRAM

ENERGY Beneral France

February 17, 2009. The Recovery Act was an unpreceden

lobs, and put a down payment on addressing long-neglect-

ed challenges so our country can thrive in the twenty-first

the commercialization and deployment of fuel cells; and to

build a robust fuel cell manufacturing industry in the United

States, with accompanying jobs in fuel cell manufacturing.

were awarded to develop and deploy a variety of fuel cell

Installation, maintenance, and support services. Grants

technologies including polymer electrolyte, solid oxide

and direct-methanoi fuel coils in stationary, portable, and

castury On April 15, 2009, the Fromy Department on.

(Recovery Act) was stoned into law by President Obama on specialty vehicle applications (i.e., lift trucks). This fund ing has supported the deployment of over 1,000 fuel cell effort to lumpstart our economy, create or save millions of systems. These efforts are accelerating the potential of tue cells to provide power in stationary, portable, and specialty which applications and to cut carbon emissions create lobs, and broaden our nation's clean energy technology nounced \$41.6 million in Recovery Act funding to accelerate



Three projects were awarded \$18.5M in Recovery Act fixed

at AT&T and Pacific Clas & Electric sites) and Sprint Neutel are demonst KRIUL DZ. ing the technical and economic viability 27.5 Holis Briss of deploying 1 kW to 10 kW polymer provide backup power for critical cellular lower sites and utility networks. As of April 2012, over 650 fuel cells have been deduc France female retailed and are operational at over 300 sites nationwide. Data collected from the National Renewable Energy Laboratory LINE, O'R. PERSON Plug Power (MA) (NRIL) has already shown over 99.7% reliability of the fuel cells. Since the

World's First Tri-Gen Energy Station - Fountain Valley March 2013

Market Transformation Program Fact Sheet April 2013

Go to: http://www1.eere.energy.gov/hydrogenandfuelcells/pubs_educational.html

Project Progress



- Collected ~172,000 hour data DMFCpowered lift truck operations in 4 locations reducing unscheduled maintenance by 36% (NREL)
- Developed and installed electrolyzer system for geothermal renewable hydrogen (RH2) fuel demo (HNEI)
- Developed and installed LFG gas clean for industry RH2 fuel cell lift truck demo (SCRA/BMW)
- Installed and collected data on 15 Micro-CHP systems for light commercial facilities with availability of 93.4% (PNNL)



5 kW MicroCHP



DMFC Powered Lift Truck



Other FY12-13 Accomplishments



- Initiated new IWG committee (Advanced Vehicles) and identified a Fed Fleet strategy
- Awarded HDV Electric Transportation Technology Projects with VTO
- Awarded Ground Support Equipment Project (Plug Power)
- Started 2 Refer APU projects (PNNL)
- Identified 4 MW of projects through a government wide procurement process
- Started Site Study with GSA and FEMP for refueling station
- Completed model and simulation analysis for on board recharging of eMDVs and eLDVs



C3-6 Delivery Truck

C8 Drayage Truck

Accomplishments: Backup Power Operation Summary 2009 Q1 – 2012 Q4



1.86
Installed capacity in MW

Systems are operating reliably in 19 states. Reasons for unsuccessful starts include an estop signal, no fuel, and other system failures. BACKUP POWER

99.6%

Successful starts

806
Systems in operation*

4-6

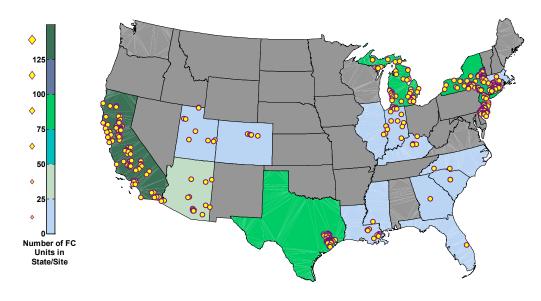
Average site capacity in kW

1,796Start attempts

65

Continuous run hours demonstrated

1,153Operation hours



*Not all systems have detailed data reporting to NREL

Accomplishments: MHE Operation Summary 2009 Q4 – 2012 Q4



Validation of MHE is based on real-world operation data from high-use facilities.

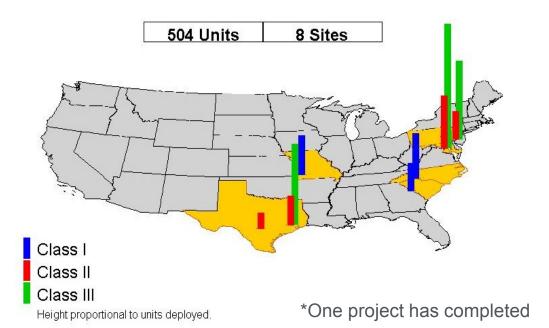
1,445,558Operation hours

246,997Hydrogen fills

490Units in operation*

4.6
Average operation hours between fills

187,426
Hydrogen dispensed in kg



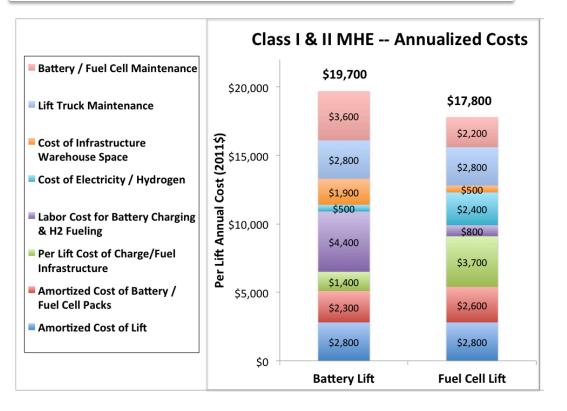
0.6
Average fill amount in kg

2.3
Average fill time in minutes

Accomplishments: Completed MHE Cost of Ownership Report*



Cost advantage per unit is ~\$2,000/year for the average high-use facility with Class I and II fuel cell lift trucks analyzed by NREL.



Key Findings

- Cost advantages dependent on deployment size and use (i.e., multi-shift operation per day)
- H₂ fuel cell cost advantages in maintenance, warehouse infrastructure space, and refueling labor cost
- H₂ fuel cell cost disadvantages in infrastructure and fuel cell cost and hydrogen cost

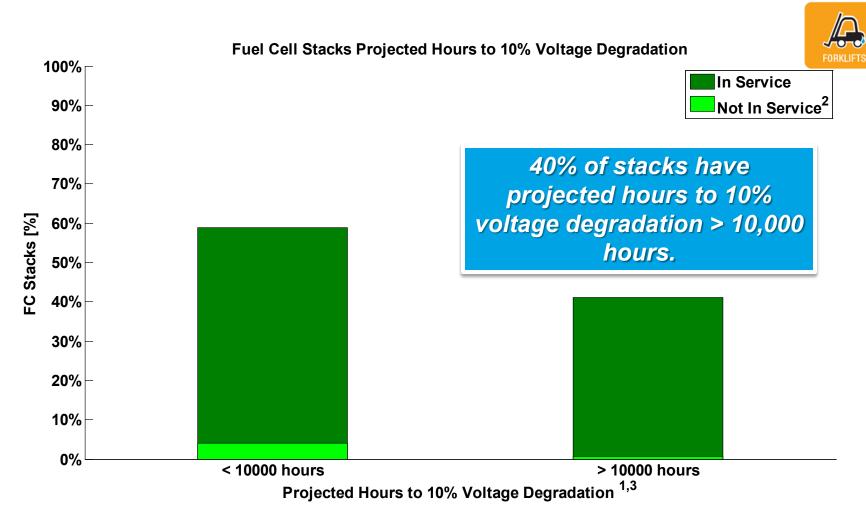
Report Sections

- Inputs, assumptions, and results for Class I/II and Class III
- Sensitivity study
- Intensive deployment scenario

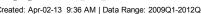
^{*}Publication expected 04/2013

Accomplishments: Study of FC Voltage **Degradation Against 10,000 Hours**





- 1) Projection using field data, calculated at high stack current, from operation hour 0. Projected hours may differ from an OEM's end-of-life criterion and does not address "catastrophic" failure modes.
- 2) Indicates stacks that are no longer accumulating hours either a) temporarily or b) have been retired for non-stack performance related issues or c) removed from DOE program.
- 3) Projected hours limited based on demonstrated hours.



NREL cdp_mhe_97

Summary



Key milestones and future plans

FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016 - 2020
Complete multi-site backup power award with DOD, NASA, and NPS	Complete Government Facilities Procurement Guide Complete 3 DOD-DOE Workshops Complete MYRD&D Plan	Installed and tested Renewable H ₂ Plant (Hawaii) Awarded with VTO¹ ETT Projects Awarded GSE Project Started eHDVx Demos with VTO	Complete MicroCHP Business Case Analysis Data Collection & Assessment of DMFC Powered Lift Trucks Publish MHE and Backup Power Business Cases Award eMDVx demo project (s)	GSE Deployment and Business Case Analysis eHDVx - Business Case Analysis MHE Refueling Case Study	Deploy Test and Business Case for BEVx Financing Methods Test for Mobile Power / Lighting	Deployment and Finance Test for 1st Gen FCEVs Deployment Test for LDVs in Fed fleets Deployment Test for Renewable H ₂ Refueling
¹ Vehicle Tech Office						

Participating Organizations



Industry:

- Plug Power
- Gas Technology Institute
- Clear Edge
- Oorja Protonics
- BMW
- Nuvera

Laboratory:

- Pacific Northwest National Laboratory
- National Renewable Energy Laboratory
- Lawrence Livermore National Laboratory
- Sandia National Laboratory
- Argonne National Lab
- Los Alamos National Laboratory

Government:

- Office of Naval Research
- Army CERL
- SCRA
- DOT
- FAA
- NASA
- NPS
- CCAT
- GSA

University:

 Hawaii Natural Energy Institute

For More Information



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Session Instructions



- This is a review, not a conference.
- Presentations will begin precisely at scheduled times.
- Talks will be 20 minutes and Q&A 10 minutes.
- Reviewers have priority for questions over the general audience.
- Reviewers should be seated in front of the room for convenient access by the microphone attendants during the Q&A.
- Please mute all cell phones and other portable devices.
- Photography and audio and video recording are not permitted.

Reviewer Reminders



- Deadline to submit your reviews is Friday,
 May 24th at 5:00 pm EDT.
- ORISE personnel are available on-site for assistance.
 - Reviewer Lab Hours:
 - Monday, 5:00 pm 8:00 pm (Gateway ONLY)
 - Tuesday Wednesday, 7:00 am 8:00 pm (Gateway)
 - Thursday, 7:00 am 6:00 pm (Gateway)
 - Tuesday Thursday, 7:00 am 6:00 pm (City)
 - Reviewer Lab Locations:
 - Crystal Gateway Hotel—Rosslyn Room (downstairs, on Lobby level)
 - Crystal City Hotel—Roosevelt Boardroom (next to Salon A)