

# Fuel Cell Mobile Lighting

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*2011 DOE H<sub>2</sub> Program Annual Merit Review  
Crystal City Virginia*

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Project ID #  
MT010

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# Overview

## Timeline

- Project start date: 4/1/2010
- Project end date: 9/30/2011
- Percent complete: 70%

## Budget

- Total project funding
  - DOE share: \$600K

## Barriers

- A. System Weight & Volume
- B. Cost
- C. Efficiency
- D. Durability
- E. Charge/discharge rates

## Partners



# Relevance and Approach

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The DOE broadened the scope of its H<sub>2</sub> program to include early market uses of fuel cells including non-motive equipment for portable power, aviation ground support equipment (GSE), construction, back-up power and other non-vehicle applications. This project funds the design, construction and field testing of 5 hydrogen fuel cell mobile lights, suitable for aviation GSE and general construction. The overall objectives are to produce a field-tested commercially available system, thereby expanding the use of fuel cell equipment in diverse applications.

## General Approach:

1. Combine new technology holders, mass manufacturing partners and end-users into a cohesive team.
2. Design, build and field test 5 prototype units, with all partners (including end-users) participating in the design, with mass manufacturing partners performing the build.
3. Field-test units in real use by end users.
4. Collect feedback, commercialize, introduce to industry via end-users

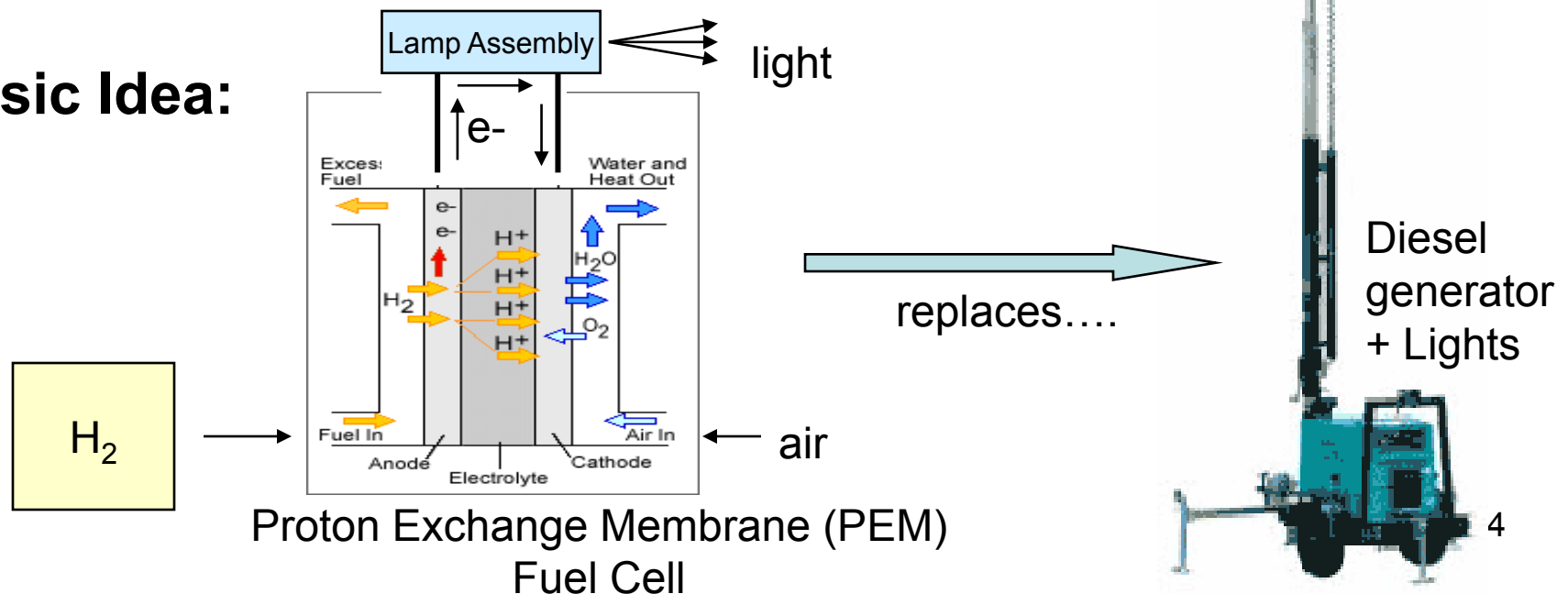
# Origin: Boeing Interested in Bringing Fuel Cell Technology to Ground Support Equipment (GSE)

**3/1/2008:**

“We (Boeing) would like Sandia to lead an effort with us to bring hydrogen fuel cell technology to airport ground support equipment” -- George Roe, Manager Boeing Research and Technology

**Initial discussions settle on a H<sub>2</sub> fuel cell demonstration for mobile 5 kW aircraft maintenance lighting:**

**Basic Idea:**



# A Strong Development Team is in Place

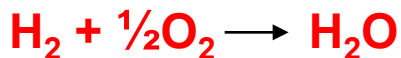
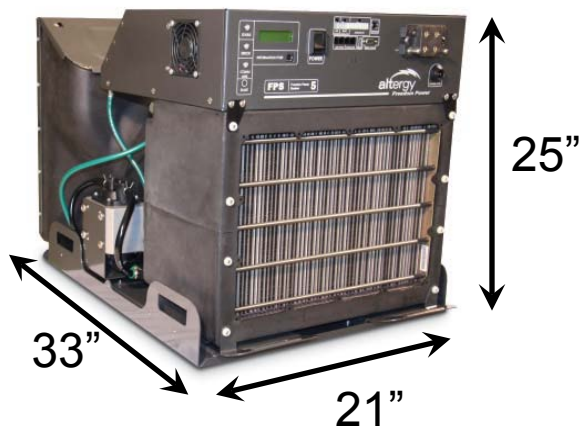


*New Technology Experts + Manufacturing Partners + End Users*

# Combining Fuel Cell Power with Plasma Lighting

## PEM Fuel Cell

### Alteryg FPS-5 (5kW)

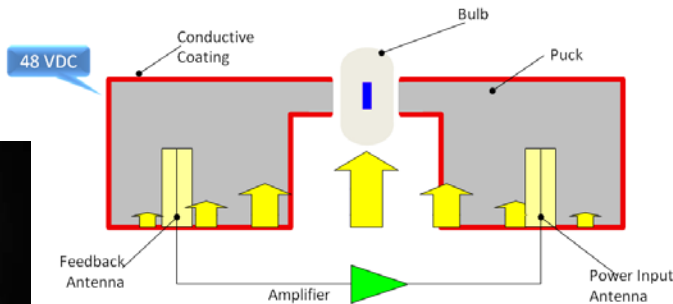


- Already in use for cell-tower backup power
- Fast start, excellent durability
- Uses pure H<sub>2</sub> from storage system
- Oxygen obtained from ambient air
- 47% efficiency (diesel lighting ~ 27% efficient)
- No CO<sub>2</sub>, NO<sub>x</sub> or particulates emitted
- No moving parts, very quiet operation

## Plasma Lighting



plasma light bulb



- 1) Amplifier feedback circuit establishes electric field
- 2) Field ionizes gas and creates plasma ⇒ Purple glow emission
- 3) Plasma vaporizes the salts ⇒ Blue light emission

- High efficiency – 120 lumens/watt
- 50,000 hour lifetime
- Color Rendering up to 96 CRI
- 30 second turn-on time
- Rapid Re-strike
- Compact source (1/4"x1/4")
- No Audible Noise or Flicker
- Programmable
- Indoor and Outdoor Use
- Already in use for arena, street lighting

# “Alpha” H<sub>2</sub>/Fuel Cell Mobile Light (10/2009)

Alpha system built by Multiquip, Alteryg Systems, Luxim, Stray Light



-- funded by Multiquip, Luxim, Stray Light  
Alteryg Systems and Boeing

Employs two 5000 psi tanks of H<sub>2</sub> (4kg)

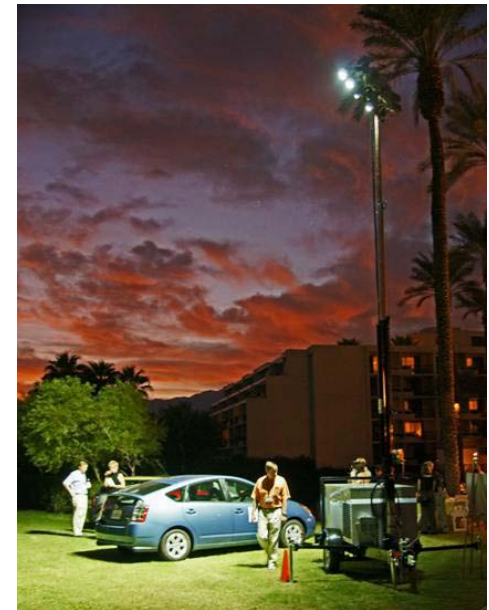
Alteryg 5kW PEM fuel cell

8 Luxim Plasma Lights (~2.1 kW total)

Multiquip Trailer

~ 30 hour duration

*The Alpha system  
provided critical  
early learning and  
allowed Multiquip to  
gain familiarity with  
the technology.*



at the 2009 AASHTO Meeting

# Alpha System Introduced To Entertainment Industry at Paramount Pictures on 1/14/2010

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Mark Bauserman and Russ Saunders (pointing) discuss the Alpha Fuel Cell Light



The project team was invited to deploy Fuel Cell Mobile Lighting at the Academy Awards event in Hollywood on March 7, 2010.



# Use of Fuel Cell Light at Entertainment Events



**2010 Academy Awards**

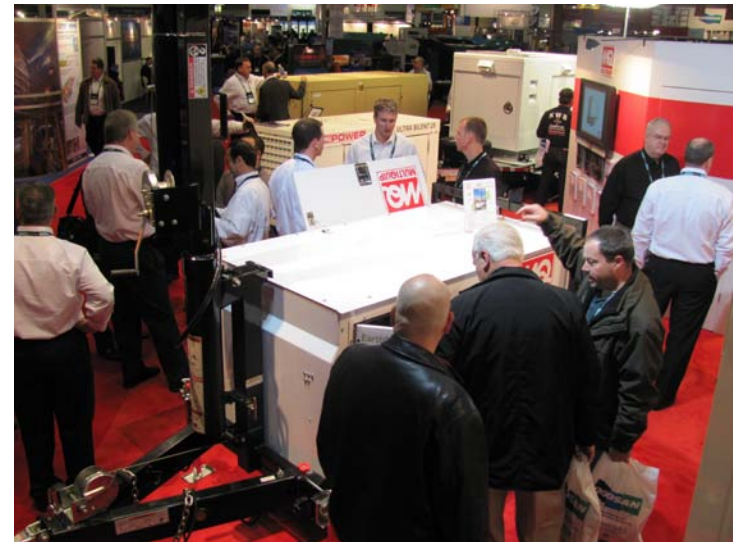


**2011 Golden Globes**

Alpha Fuel Cell Mobile Light was also used on the Red Carpet at the 2011 Screen Actors Guild (SAG) Awards, and at the 2011 Grammys

Introduction of the technology to these industries, through use by Saunders Electric and entertainment construction personnel, will naturally lead to the development of the entertainment early market.

**Multiquip Inc. introduces the Fuel Cell Mobile Light as the first of their “EarthSmart” Product Line at PowerGen 2010**



Upgraded Alpha System at PowerGen 2010  
December 14, Orlando Florida

# First Beta Unit Constructed 1/2011

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World of Concrete Show  
January 2011

***Beta is a near-commercial unit***

Employs four 5000 psi tanks of H<sub>2</sub> (~8kg)



One Alteryg 5kW PEM fuel cell

8 Luxim Plasma Lights (~2.1 kW draw)

Multiquip Trailer

Fully integrated controls for fuel cell, lights

# Fuel Cell Mobile Light Capabilities



*Beta Fuel Cell Mobile Light  
Running at World of Concrete 2011*



- ~63 hour duration (lighting)
- Indoor or outdoor use
- Area of illumination: 50 yds x 75 yds  
(at 3.5 foot candles)
- ~ 3 kW of AC power as option
- Easily moved
- Quiet: 43 dB noise level at 23 feet  
← ( --- and can be reduced)
- 30 foot tower height, fully rotatable

*Alpha Fuel Cell Mobile Light at the 2009 AASHTO Meeting*

# H<sub>2</sub>LT Gives > 73% Reduction in GHG Emissions

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Current Diesel Light Towers: 4000W lights, 48 hour run time on 30 gallons of diesel

Fuel Cell Mobile Light: Same light output, same duration time, on 7.5 kg of H<sub>2</sub>

*--efficiencies from fuel cell AND lighting*

So, the questions are:

- How much CO<sub>2</sub> (equivalent) is released in making and burning 30 gallons of diesel fuel in a conventional light tower?
- How much CO<sub>2</sub> is released in making 7.5 kg of 5,000 psi H<sub>2</sub> from Natural Gas (NG) and using it in the Fuel Cell Mobile Light?

Using the GREET Model, the total CO<sub>2</sub> (equiv.) emission associated with making (65kg) and burning (295kg) 30 gallons of diesel is  $65 + 295 = 360$  kg.

For b) If you make 7.5 kg of 5,000 psi hydrogen from NG, GREET indicates that you release **98 kg** of CO<sub>2</sub> equivalent. Zero CO<sub>2</sub> is released at point of H<sub>2</sub> use.

**GHG decrease =  $98 \text{ kg} / 360 \text{ kg} = 0.27\dots \therefore 73\%$  GHG savings  
-- Greater decrease if H<sub>2</sub> is made from low-C sources.**

# Deployment Partners

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***With DOE funding, we are deploying 5 units to gather testing data and to reduce diesel use at these sites:***

**Caltrans (Sacramento)**, exposure to heat, snow, cold, road work

**Boeing (Washington State)**, exposure to sleet, ice, rain and fog

**Kennedy Space Center (Florida)**, exposure to heat, humidity, salt air

**Paramount Pictures (LA)**, performance for noise reduction

**San Francisco International Airport (SFO)**, performance of Hybrid system

***Note: One unit is being devoted to display and demonstration at equipment trade shows.***

# Caltrans/UC Davis to Perform Formal System Eval.

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-- A joint activity between Sandia, Caltrans, The California Highway Patrol, and the U.C. Davis Advanced Highway Maintenance and Construction Technology Research Center (AHMCT)

*-- Funded by Caltrans*



## Evaluation Topics:

**Lighting Efficacy:** (Illumination uniformity, glare, visibility)

**Emissions:** (compare with diesel system, assess H<sub>2</sub>LT)

**Refueling Efficacy:** (refueling time, ease of operation, costs)

**Design Robustness:** (engineering analysis of performance, other testing)

**Performance Evaluation and Recommendations**

# The System for SFO will combine HP tanks and Metal Hydride (MH) Storage of Hydrogen

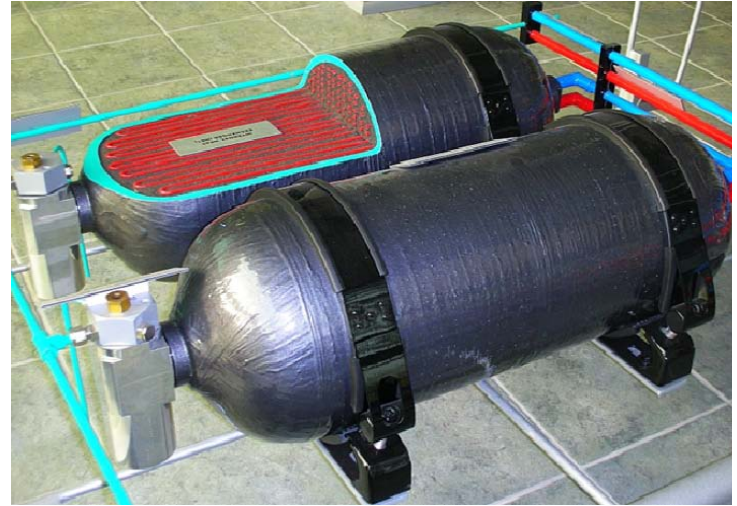
H<sub>2</sub> stored in “reversible” AB<sub>2</sub>H<sub>3</sub> MH from Ovonic Hydrogen Systems

A = Ti, Zr ; B = V, Cr, Mn

## Advantages:

- Smaller volume needed for storage
- Storage at low pressure (~200 psi)
- Fueling from low pressure sources (< 1000 psi)

Disadvantages: heavier tanks, more complex system



For SFO we are going to build a “Hybrid” system, combining 2 High Pressure H<sub>2</sub> tanks with one MH Tank (funded by DOE and Boeing).

## Advantages of the Hybrid Approach:

Allows Multiquip to get learning on MH technology

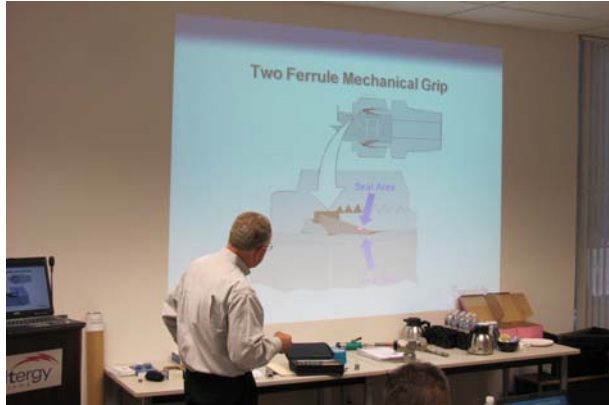
Allows system to be filled at SFO station which requires HP tankage

Minimizes cost, while permits learning



# Alteryg, Swagelok Train Multiquip, Caltrans in the Ways of H<sub>2</sub> Technology (11/15/10)

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Connector Basics



Construction techniques



High-pressure testing



Fuel Cell Fundamentals

# Fuel Cell Mobile Light Promotes H<sub>2</sub> Infrastructure

- H<sub>2</sub> Fueling Stations

The Fuel Cell Mobile Light in Hollywood is making use of the Burbank Hydrogen Station



Fuel Cell Mobile Light at Burbank H<sub>2</sub> Station

- Mobile H<sub>2</sub> Refueling Stations

Our deployment at the 2010 Academy Awards employed an Air Products Mobile H<sub>2</sub> Station



Saunders Electric Staff Refueling Fuel Cell Mobile Light with Mobile H<sub>2</sub> Station for Oscars

- Refueling from H<sub>2</sub> Cylinders

The unit can be filled to ~1800 psi using readily available hydrogen cylinders from local gas suppliers



Airgas Locations

# Engaging Early Markets for the Fuel Cell Light

Have been engaging the DOT and Aviation GSE communities on the availability and details of the hydrogen fuel cell mobile light technology



Telecon on May 11, 2010 with Rick Hanley. Caltrans and ConnDOT will share a Beta Unit in FY11, with fueling at a Proton Energy H<sub>2</sub> station



New York State  
Department of Transportation

Telecon on February 1, 2011 with NYDOT. System capabilities and refueling logistics under discussion



Randy Woolley (Caltrans, L) and Rick Hanley (ConnDOT, R) at a fuel cell workshop at Sandia



Greg Moreland and Lennie Klebanoff gave presentations on DOE FCT program and the Fuel Cell Mobile Light to airport GSE community on Feb. 23, 2011

# Awards for the Fuel Cell Mobile Light

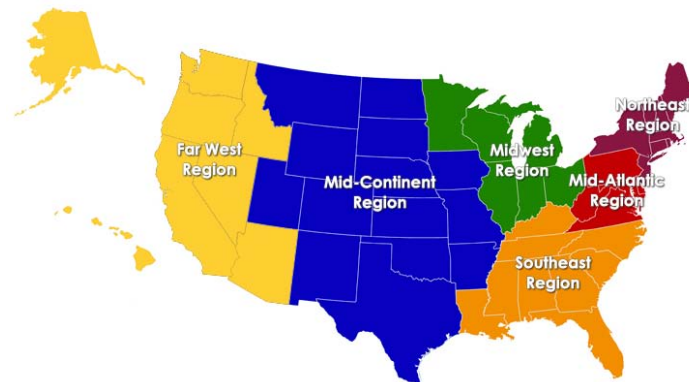
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1. Fuel Cell Mobile Light Awarded 2011 “Editors Choice Award” for Most Innovative New Product in “General Equipment” – World of Concrete 2011  
- February 15, 2011

<http://www.worldofconcrete.com/attendee/show-floor/most-innovative-products-mip.aspx>



2. The Fuel Cell Mobile Light Project awarded a Federal Laboratory Consortium (FLC) Mid-Continent Technology Transfer Award for “Notable Technology Development”. – August 4, 2010



# Remaining Project Schedule

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## **March - April, 2011**

Complete Remaining Beta Units (Total of 4), test and deliver to deployment sites  
Design Hybrid Fuel Cell Mobile Light

## **May, 2011**

Begin Deployments at NASA, Boeing, Caltrans, Paramount,  
Begin construction of Hybrid Fuel Cell Mobile Light

## **June – July, 2011**

Complete construction of Hybrid System  
Monitor Deployments, collect performance data (with UC Davis AHMCT)  
Engage DOTs, Entertainment Industry

## **August 2011**

Test performance of Hybrid System, deliver to SFO  
Monitor Deployments, collect data  
Continue Early Market Engagement

## **September 2011**

Initiate deployment at SFO, continue to monitor all deployments

# Mandatory Summary Slide

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- **A strong Fuel Cell Mobile Light team is in place**
- **The technology has been advanced from prototype Alpha to very near commercial Beta**
- **Alpha system used to engage entertainment industry**
- **4 Beta systems will be completed by April 15, 2011**
- **Hybrid System will be completed by August 2011**
- **End users and Multiquip trained in high-pressure H<sub>2</sub> technology**
- **State DOTs and Aviation GSE end users engaged.**
- **Deployments ongoing**

# Acknowledgements– Fuel Cell Mobile Light

**DOE (EERE):** Pete Devlin, Nancy Garland,  
Greg Moreland (SRA)

**Boeing:** Joe Breit, George Roe, Ty Larsen

**Sandia-CA:** Jay Keller, Terry Johnson,  
Marcina Moreno



## Other Fuel Cell Mobile Light Project Partners:

**Caltrans:** Larry Orcutt, Steve Prey, Randy Woolley

**California FC Partnership:** Bill Elrick, Nico Bouwkamp, Jen Hamilton, Jordan McRobie

**Altery Systems:** Mickey Oros, Chris Radley, Paul Schuttinger, Terry Carlone

**Multiquip Inc.:** Torsten Erbel, Steve Wingert, Jonathan Cuppett, Bruce Coleman

**Ovonic Hydrogen Systems:** Mike Zelinsky, Ben Chao

**San Francisco International Airport:** Roger Hooson, Derek Fliess

**Golden State Energy:** Tom Damberger

**Stray Light Optical Technologies:** Gerald Rea

**Luxim:** Geoff Brown

**Lumenworks:** Thomas Skradski

**Saunders Electric Inc.:** Russ Saunders and Candace Saunders