Fuel Cell Mobile Lighting

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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

The DOE broadened the scope of its H_2 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

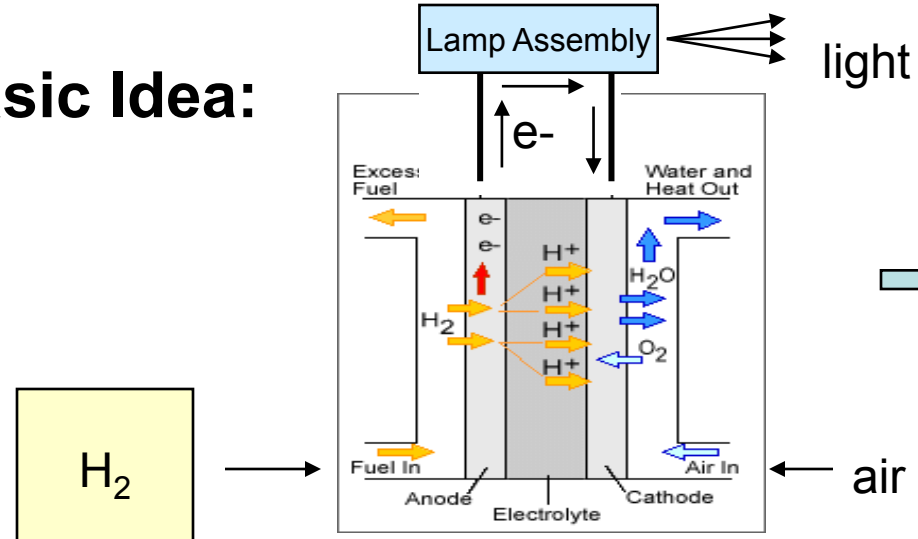
Origin: Boeing Interested in Bringing Fuel Cell Technology to Ground Support Equipment (GSE)

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**

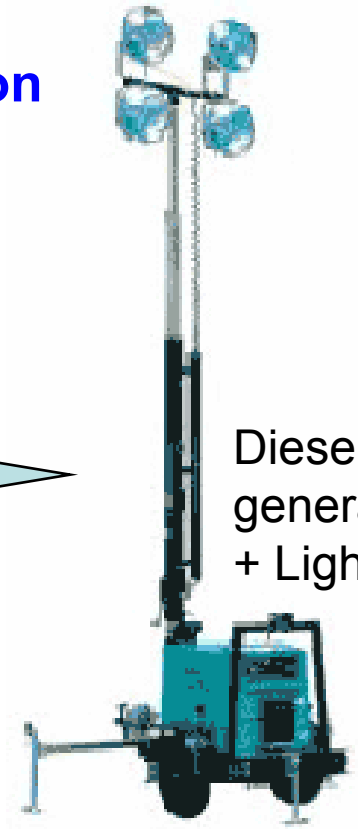
Initial discussions settle on a H_2 fuel cell demonstration for mobile 5 kW aircraft maintenance lighting:

Basic Idea:



Proton Exchange Membrane (PEM) Fuel Cell

replaces….



Diesel generator + Lights

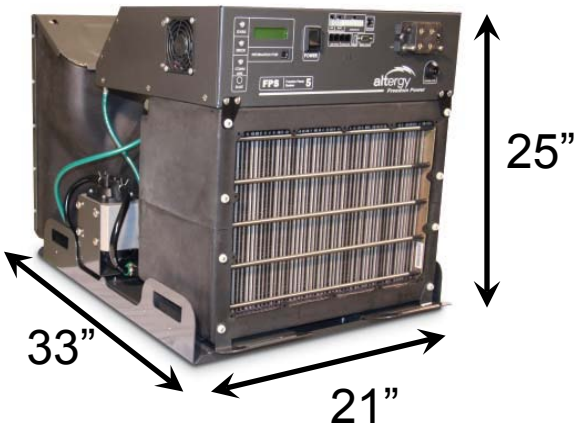
A Strong Development Team is in Place

New Technology Experts + Manufacturing Partners + End Users

Combining Fuel Cell Power with Plasma Lighting

PEM Fuel Cell

Altergy FPS-5 (5kW)

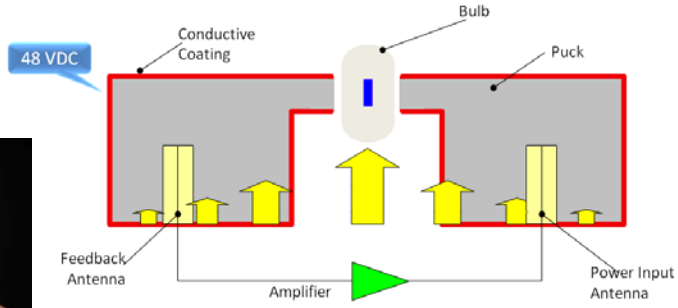


$H_2 + \frac{1}{2}O_2 \longrightarrow H_2O$

- Already in use for cell-tower backup power
- Fast start, excellent durability
- Uses pure H_2 from storage system
- Oxygen obtained from ambient air
- 47% efficiency (diesel lighting ~ 27% efficient)
- No CO_2, NO_x 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_2/Fuel Cell Mobile Light (10/2009)

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

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

Employs two 5000 psi tanks of H_2 (4kg)

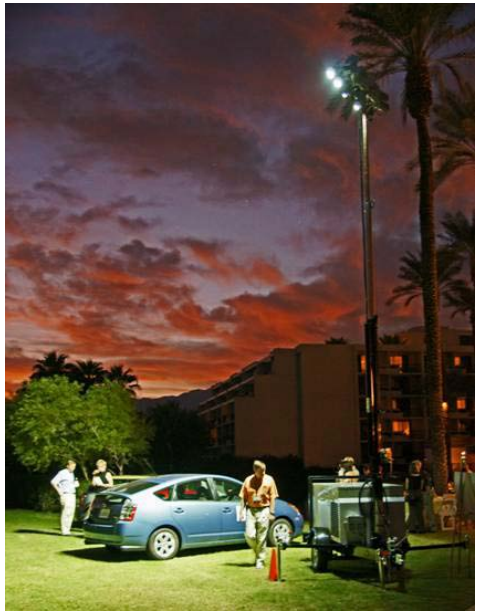
Altergy 5kW PEM fuel cell

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

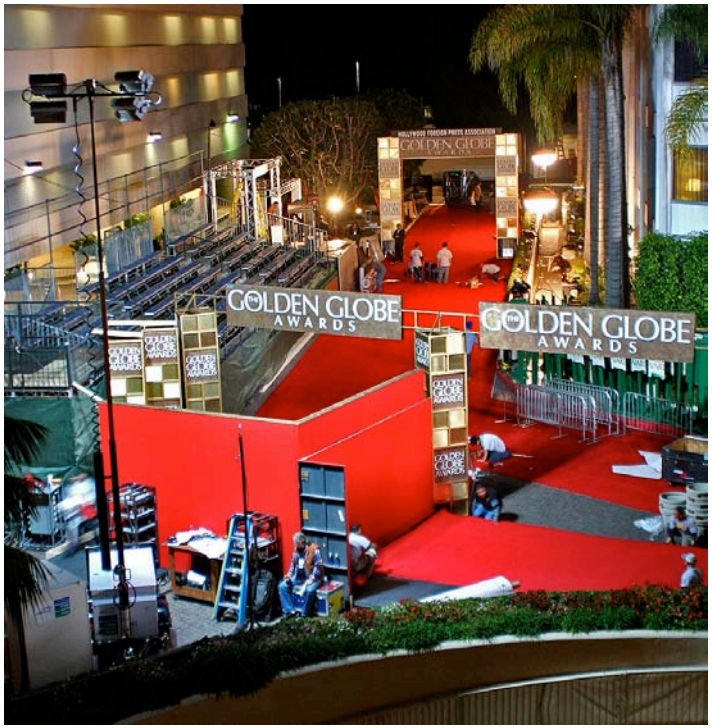
Alpha System Introduced To Entertainment Industry at Paramount Pictures on 1/14/2010

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

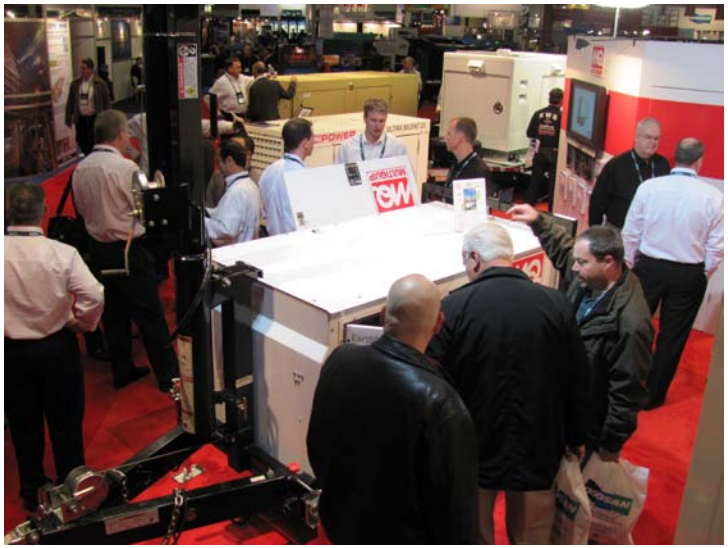
Alpha Fuel Cell Mobile Light was also used on the Red Carpet at the 2011 Screen Actors Guild (SAG) Awards, and at the 2011 Grammys

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

EarthSmart

H2LT



Upgraded Alpha System at PowerGen 2010
December 14, Orlando Florida

First Beta Unit Constructed 1/2011

World of Concrete Show
January 2011

Beta is a near-commercial unit

Employs four 5000 psi tanks of H_2 (~8kg)

One Altergy 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_2LT Gives > 73% Reduction in GHG Emissions

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_2

--efficiencies from fuel cell AND lighting

So, the questions are:

a. How much CO_2 (equivalent) is released in making and burning 30 gallons of diesel fuel in a conventional light tower?

b. How much CO_2 is released in making 7.5 kg of 5,000 psi H_2 from Natural Gas (NG) and using it in the Fuel Cell Mobile Light?

Using the GREET Model, the total CO_2 (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_2 equivalent. Zero CO_2 is released at point of H_2 use.

GHG decrease = 98 kg/360 kg = 0.27… ∴ 73% GHG savings
-- Greater decrease if H_2 is made from low-C sources.

Deployment Partners

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.

-- 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

<u>Evaluation Topics:</u>

Lighting Efficacy: (Illumination uniformity, glare, visibility)

Emissions: (compare with diesel system, assess H_2LT)

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

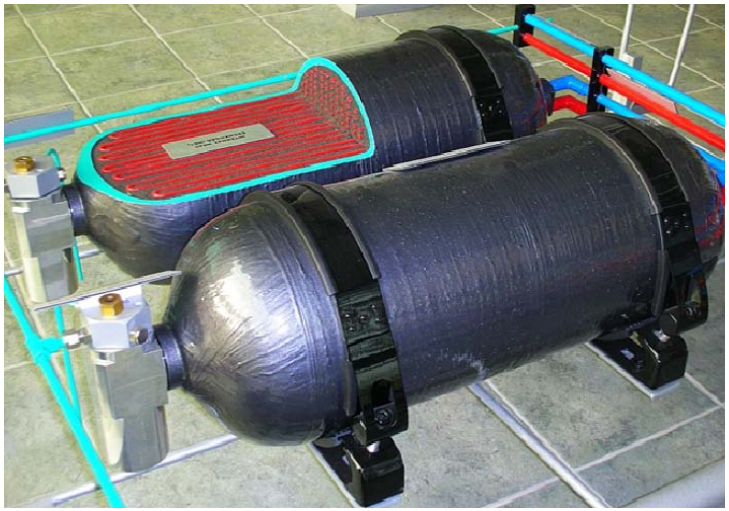
Design Robustness: (engineering analysis of performance, other testing)

Performance Evaluation and Recommendations

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

H_2 stored in "reversible" AB_2H_3 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)**

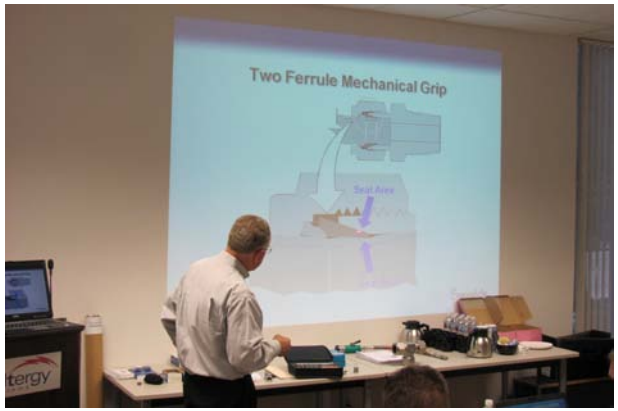
Disadvantages: **heavier tanks, more complex system**

For SFO we are going to build a "Hybrid" system, combining 2 High Pressure H_2 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

Altergy, Swagelok Train Multiquip, Caltrans in the Ways of H_2 Technology (11/15/10)



Connector Basics

Construction techniques

High-pressure testing

Fuel Cell Fundamentals

Fuel Cell Mobile Light Promotes H_2 Infrastructure

- H_2 Fueling Stations

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

Fuel Cell Mobile Light at Burbank H_2 Station

- Mobile H_2 Refueling Stations

Our deployment at the 2010 Academy Awards employed an Air Products Mobile H_2 Station

Saunders Electric Staff Refueling Fuel Cell Mobile Light with Mobile H_2 Station for Oscars

- Refueling from H_2 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_2 station

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

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

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

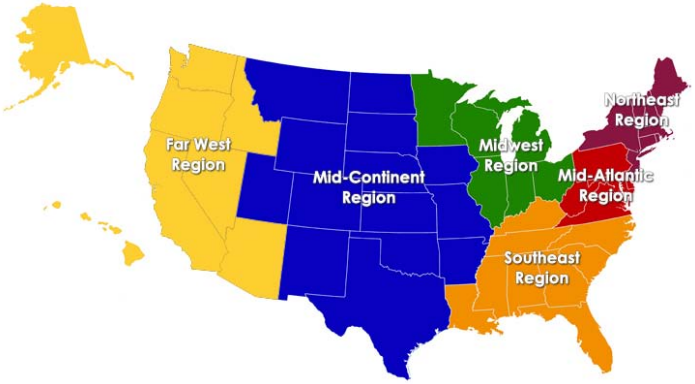
Awards for the Fuel Cell Mobile Light

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

FEDERAL LABORATORY CONSORTIUM
FLC
FOR TECHNOLOGY TRANSFER



Remaining Project Schedule

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

- 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_2 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
Altergy 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