Fuel Cell Mobile Light Project

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NASA TEERM-ITB Inc. & Sandia National Laboratories

Advances in Hydrogen Energy Technologies
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A Strong Development Team is in Place

New Technology Experts + Manufacturing Partners + 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 H₂ fuel cell demonstration for mobile 5 kW aircraft maintenance lighting:

**Basic Idea:**

![Diagram of Proton Exchange Membrane (PEM) Fuel Cell]

- **H₂**
  - Fuel In
  - Air In
  - Proton Exchange Membrane (PEM)
  - Fuel Cell

- **Lamp Assembly**
  - Light

- **Excess Fuel**
  - Water and Heat Out

- **Anode**
  - **H₂**

- **Electrolyte**
  - **H⁺**

- **Cathode**
  - **O₂**
  - **H₂O**

- **Diesel generator + Lights**
  - Replaces...
Combining Fuel Cell Power with Plasma Lighting

**PEM Fuel Cell**

Altergy FPS-5 (5kW)

- Already in use for cell-tower backup power
- Fast start, excellent durability
- Uses pure H₂ from storage system
- Oxygen obtained from ambient air
- 47% efficiency (diesel lighting ~ 27% efficient)
- No CO₂, NOₓ or particulates emitted
- No moving parts, very quiet operation

\[ H₂ + \frac{1}{2}O₂ \rightarrow H₂O \]

**Plasma Lighting**

- 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” H₂/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 H₂ (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
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.
First Beta Unit Constructed 1/2011

**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

World of Concrete Show
January 2011
Fuel Cell Mobile Light Capabilities

• ~66 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
H₂LT 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 H₂

So, the questions are:

- How much CO₂ (equivalent) is released in making and burning 30 gallons of diesel fuel in a conventional light tower?

- How much CO₂ is released in making 7.5 kg of 5,000 psi H₂ from Natural Gas (NG) and using it in the Fuel Cell Mobile Light?

Using the GREET Model, the total CO₂ (equiv.) emission associated with making (65kg CO₂) and burning (295kg CO₂) 30 gallons of diesel is 65 + 295 = 360 kg CO₂.

For b) If you make 7.5 kg of 5,000 psi hydrogen from NG, GREET indicates that you release 98 kg of CO₂ equivalent. Zero CO₂ is released at point of H₂ use.

GHG decrease = 98 kg/360 kg = 0.27... ∴ 73% GHG savings -- Greater decrease if H₂ 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
Kennedy Space Center (Florida), exposure to heat, humidity, salt air
Boeing (Washington State), exposure to sleet, ice, rain and fog
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

Evaluation Topics:

Lighting Efficacy: (Illumination uniformity, glare, visibility, coverage area)
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
Caltrans, UC Davis

Delivered: 4/14/11, Training 4/19/11, Characterization Ongoing
The System for SFO will combine HP tanks and Metal Hydride (MH) Storage of Hydrogen

H₂ stored in “reversible” AB₂H₃ 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 H₂ 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
Andrew Socha (Sandia) performing design
Fuel Cell Mobile Light In Support of Last Shuttle Launch

Fuel Cell Mobile Light Team with Shuttle Astronaut George Zamka
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Questions?