DOE/Boeing Sponsored Projects in Aviation Fuel Cell Technology at Sandia

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DOE-DOD Workshop on Uses of Fuel Cells in Aviation

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Sandia is a government-owned/contractor operated (GOCO) facility. Sandia Corporation, a Lockheed Martin company, manages Sandia for the U.S. Department of Energy's National Nuclear Security Administration.

- ~ 8,300 employees
- ~ 1,500 PhDs; ~2800 MS/MA
- ~ 700 on-site contractors

Annual Budget ~ $2.2 Billion
($1.3 Billion DOE, $0.9 Billion work for others)

Website: www.sandia.gov
Origin: Boeing Interested in Bringing Fuel Cell Technology to Ground Support Equipment (GSE)

Initial discussions settle on a H₂ fuel cell demonstration for mobile 5 kW aircraft maintenance lighting:

**Basic Idea:**

- **H₂**
- Diesel generator + Lights
- Proton Exchange Membrane (PEM) Fuel Cell
- Lamp Assembly
- Light
- Air

**Benefits:**
- Quiet, no emission of particulates, NOₓ, CO₂
- Better energy efficiency
- Lots of uses (airports, road work, film industry)
Fuel Cell Mobile Light Development Team

New Technology Experts + Manufacturing Partners + End Users
Alteryg FPS-5 (5kW)

- High power density with low weight and volume
- Fast start, excellent durability
- Uses pure H₂ from storage system
- Oxygen obtained from ambient air
- 43% efficiency (diesel lighting ~ 27% efficient)
- No CO₂, NOₓ or particulates emitted
- No moving parts, very quiet operation

H₂ + ½O₂ → H₂O

Plasma Lighting

- High efficiency – 120 lumens/watt
- 50,000 hour lifetime
- Color Rendering up to 96 CRI
- Instant On, Dimmable to 20%
- Rapid Re-strike
- Compact source (1/4”x1/4”)
- No Audible Noise or Flicker
- Programmable
- Indoor and Outdoor Use
Fuel Cell Mobile Light Capabilities

- 40 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 available
- Easily moved
- Quiet: 43 dB noise level at 23 feet (--- and can be reduced)
- 30 foot tower height

Fuel Cell Mobile Light used at the 2010 Academy Awards
The DOE/Boeing will fund the build and field-test of 6 units for the purpose of duration and environmental testing:

Caltrans (Sacramento), exposure to snow, cold (upgrade of Alpha System)
SFO (Hybrid Unit), performance of Hybrid system
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
Disneyworld (TBD), exposure to gummy bears and cotton candy

We have an offer from the State of Connecticut Dept. of Transportation to cold test one of these units in the winter.

Our end goal is to get the necessary testing in to allow Multiquip to offer a commercial Fuel Cell Mobile Light by the end of the 2010
Low-Temperature Fuel Cell Systems for Commercial Airplane Auxiliary Power

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Sandia National Laboratories
September 30, 2010
Here we briefly describe our ongoing study of fuel cell systems on-board a commercial airplane.

Scope

Method

\[ R = \frac{\alpha M C_L}{C_T} \ln \frac{W_1}{W_2} \]

Preliminary Findings
Sandia’s current project is focused on PEM fuel cells applied to specific on-board electrical power needs. (Preliminary results are based on IFE study)
We want to understand how having a fuel cell on an airplane would affect overall performance.
The fuel required to accomplish a mission is used to quantify the performance.

**Empty Mass**

**Drag**

**Lift**

**Range**

**Velocity**

**TSFC**

*TSFC: Thrust-Specific Fuel Consumption*
Our analysis shows the differences between the base airplane and the airplane with the fuel cell.

*Base Airplane and Mission: 787-8 derivative, 5 hr flight, 20 kW IFE load*
There are many ways of designing a system, depending on what you do with the waste heat.

“Water cooled,” “hot water,” “water recovery”
A system that requires ram air cooling has a large mass penalty due to increased drag.

Data for: 5 hr flight, 20 kW (net) PEM for IFE, H₂ in 5,000 psi composite tanks
The bottom-line impact can be expressed as additional fuel required to complete the mission.
Early results suggest PEM fuel cells can be used on airplanes with manageable performance impact if heat is rejected properly.

- Fuel cell generates heat
- On-board uses may not fully absorb waste heat
- Cooling system has large drag penalty
- Reject through fuel system
For PEMs on aircraft, we are continuing to perform:

- **Thermodynamic analysis** (investigate configurations)
  - [Diagram of thermodynamic system]

- **Integrated electrical design** (with dynamic modeling of the micro grid)
  - [Diagram of integrated electrical design]

- **Hardware assessment** (performance, weight, and volume)
  - [Diagram of hardware assessment]

- **Galley and peaker application**
  - [Diagram of galley and peaker application]

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