X.1 Fuel Cell Mobile Lighting

Lennie Klebanoff
Sandia National Laboratories
7011 East Avenue
Livermore, CA 94568
Phone: (925) 294-3471
E-mail: lekleba@sandia.gov

DOE Manager
HQ: Pete Devlin
Phone: (202) 586-4905
E-mail: Peter.Devlin@ee.doe.gov

Project Start Date: March 15, 2010
Project End Date: September 30, 2011

Fiscal Year (FY) 2011 Objectives

- Design a fuel cell mobile lighting system to replace current diesel-based systems.
- Organize a project development team that includes new technology holders, mass manufacturing partners and end users.
- Build five fuel cell mobile lights, field test with deployment partners.
- Design a commercial system, produce a commercially available product.
- Deploy the technology in high-profile events to increase public awareness of hydrogen fuel cell technology.

Technical Barriers

This project addresses the following technical barriers assigned to this project:

(A) System Weight and Volume
(B) Cost
(C) Efficiency

Technical Targets

- Promote exposure of public to H_2/fuel cells (trade shows, high profile events).
- Promote use of H_2/fuel cells in aviation (use at San Francisco International Airport [SFO], in Boeing manufacturing plant).
- Promote use of H_2/fuel cells in entertainment (use at Paramount Pictures, award shows).
- Promote use of H_2/fuel cells in construction (use with California Department of Transportation [Caltrans]).
- Promote use of H_2/fuel cells in high technology (use at National Aeronautics and Space Administration (NASA) Kennedy Space Center).

FY 2011 Accomplishments

- Designed a fuel cell mobile lighting system combining high pressure (5,000 psi) hydrogen storage, efficient plasma lighting and a 5 kW proton exchange membrane (PEM) fuel cell.
- Designed a hybrid fuel cell mobile light incorporating both high pressure (5,000 psi) hydrogen tankeage and a interstitial metal hydride tank.
- Organized a project development team that includes new technology holders, mass manufacturing and end users. The project team includes Multiquip Inc., Stray Light Optical Technology, SFO, Ovonic Hydrogen Systems, Altergy Systems, Golden State Energy, Caltrans, the California Fuel Cell Partnership (CaFCP), Lumenworks, Boeing, Luxim, and Saunders Electric.
- Built five fuel cell mobile lights, being field tested at Boeing Manufacturing Plant, NASA Kennedy Space Center, Caltrans, Paramount Pictures/Saunders Electric and at SFO.
- Promoted exposure of public to H_2/fuel cells (use of system at 2010 Oscars, 2011 Golden Globes, 2011 Grammy Awards and the 2011 Screen Actors Guild Award Show).
- Achieved a fuel cell mobile light that will run for 66 hours, with a greater than 73% reduction in greenhouse gas emissions (GHG) emissions compared to current technology. System is significantly quieter than current diesel technology
- Designed a commercial fuel cell mobile light system, now commercially available by Multiquip Inc. as the H_2LT system.

Introduction

The vast majority of mobile light-to-medium construction equipment is based on combustion of diesel fuel. Equipment examples include diesel-fueled mobile lighting towers, portable power generators, mobile water pumps and concrete-masonry equipment. Such equipment is commonly used for road maintenance, general construction and other industrial applications. As diesel-based systems, the current equipment technology suffers from well-known problems including release of toxic air contaminants and particles into the air (threatening human health), and also emission of CO_2 and other GHG

(contributing to global climate change). These diesel systems are also comparatively inefficient in their use of energy, as well as distractingly loud, which is a safety issue for those using them. The goal of this project has been to replace diesel-powered mobile lighting systems with clean, energy efficient new technology based on fuel cell power. Our goals in this project are not to perform a demonstration, but rather design, build, test and commercialize a fuel cell-based mobile lighting system that customers can buy to start reducing GHG and other criteria pollutants.

Approach

After an initial design of the fuel cell mobile light, we put together a development team comprised of new technology holders, mass manufacturing and end users. The project team includes the new technology holders Altergy Systems (PEM fuel cells), Luxim, Lumenworks and Stray Light Optical Technologies (plasma lighting), hydrogen systems storage and integration (Sandia) and metal hydride hydrogen storage (Ovonic Hydrogen Systems). The mass manufacturing partners are Multiquip Inc. (the largest manufacturer of rental construction equipment), Altergy Systems (mass manufacturer of PEM fuel cells) and Luxim, Stray Light Optical Technologies and Lumenworks (manufacturers and designers of plasma light technology). End users include the SFO, Caltrans, Boeing and Saunders Electric Inc. Golden State Energy made critical contributions to the development of the project team, and the CaFCP has been an important advisor on hydrogen refueling stations/technology, and on the current codes and standards associated with hydrogen fueling. Special thanks go to Paramount and NASA Kennedy Space Center who will also be deploying the technology.

Our work has been focused on designing, building, and deploying a fuel cell mobile light system to replace existing diesel-powered lighting towers commonly seen along highways in road maintenance work. After deploying the mobile light, the fuel cell technology is being proliferated into a newly created Multiquip Inc. fuel-cell-based product line called EarthSmart™.

Results

The first result was the design of a near-commercial "Beta" unit that improved the operating characteristics beyond the "Alpha" system that was built prior to DOE funding of the project. The Beta unit utilizes four commercially available 5,000 psi composite hydrogen tanks, along with eight plasma light fixtures (from Luxim, Stray Light Optical Technologies and Lumenworks). The 5 kW PEM fuel cell (Altergy) was incorporated, along with full "near-commercial" integration of the electronics for the fuel cell and lighting controls. The Beta system was designed by Sandia, Multiquip, Altergy and Stray Light Optical Technologies, with the system integrated by Multiquip in its Boise, Idaho manufacturing facility. It is worth noting that Multiquip had no prior manufacturing experience with high-pressure gas, fuel cells or hydrogen systems in general. Early on, a training class in high-pressure systems design, hydrogen safety, and hydrogen and fuel cell technology took place at Altergy Systems on November 14, 2010. Attendees included Multiquip manufacturing management and staff, along with other project partners.

Sandia felt that it was important for the project partners (especially Multiquip) to have some experience with metal hydride hydrogen storage technology. As a result, Sandia designed a hybrid fuel cell mobile light system that combines high-pressure storage with one metal hydride tank (from Ovonic). The design incorporates and accommodates thermal management issues that arise with metal hydride technology, namely heat needing to be supplied to the metal hydride material from fuel cell waste heat, and heat needing to be removed from the material when the metal hydride material is recharged with hydrogen. Construction of a hybrid unit will be complete by Sandia and Multiquip in August of 2011.

The first construction activity was an upgrade of the Alpha system that had been built prior to DOE funding. The upgrade of the system included a more commercial looking cabinet, and the introduction of weatherproof lighting housings. This upgrading allowed the Alpha system to be a field-deployable unit from which early learning could be gathered. The Alpha system was deployed at the NASA Kennedy Space Center in support of the last two shuttle launches. A picture of the Alpha system at the Kennedy Space Center is shown in Figure 1. Eventually the Alpha system at the NASA Kennedy Space Center will be replaced by a Beta system which has twice the endurance of the Alpha system, and more commercial integration of the fuel cell and lighting controls.

Endurance data on the Alpha system was collected by Sandia at its Livermore, California facility. Monitoring the power consumed by the lighting, hydrogen pressure, and the system endurance, results indicated that a commercial fuel cell mobile light using plasma light technology could last 66 hours on a single fueling. This is somewhat longer than the typically 50-hour duration of diesel-based systems. Using the test data, a PEM fuel cell efficiency of 47% was observed.

The first Beta fuel cell mobile light system was used to introduce the H_2 fuel cell mobile light to the power generation community at PowerGen 2010 in Orlando, Florida on December 13, 2010. The response was excellent from the power generation community particularly with regard to its quiet operation, and ability to be used indoors. The Beta system was also shown to the realm of construction equipment at the World of Concrete Show in Las Vegas, Nevada on January 17, 2011. At this show, the Beta fuel cell mobile light, now termed H_2LT (hydrogen light tower) as an official Multiquip product, received the prestigious 2011 Most Innovative Product Award, World of Concrete Editors Choice Award for General Tools and Equipment. A picture of the Beta unit from the World of Concrete Show is shown in Figure 2.

(Photo courtesy of Lennie Klebanoff Productions)

FIGURE 1. Deployment of Alpha Fuel Cell Mobile Light at the NASA Kennedy Space Center, 4/21/2011, Cape Canaveral Florida

(Photo Courtesy of Lennie Klebanoff Productions)

FIGURE 2. The Beta Fuel Cell Mobile Light at the World of Concrete Show, January 17, 2011, Las Vegas, Nevada

The second Beta unit was constructed and delivered to Caltrans on April 19, 2011. Caltrans, using its own internal resources, is having the H_2LT tested in a comprehensive series of tests conducted by the University of California, Davis (UC Davis) Advanced Highway Maintenance and Construction Technology Research Center. The California Highway Patrol is also participating in this characterization project. The UC Davis team is characterizing the performance of the H_2LT with regard to lighting efficacy (illumination uniformity, glare, and visibility), emissions (compared with diesel system), refueling efficacy (refueling time, ease of operation, costs) and design robustness (engineering analysis of performance, other testing). Caltrans will use its Beta system in its road construction work, graffiti removal work, as well as at a snow-chain checkpoint in the Sierra Mountains of Northern California to test its use in cold weather.

Boeing received its Beta unit in late July of 2011. The unit will be used at Boeing's Paine Field operations, as well as inside its aircraft manufacturing facility in Everett, Washington. The Paine Field operations will allow the unit to be tested against rain, sleet, and cold foggy conditions which are present at that location in the winter months. Similarly, the Hybrid Unit which will be deployed at SFO will be severely tested against the rain, wind, and fog present at that facility which often leads to very early rusting of equipment in use on the airfield. The Beta system which will be eventually deployed at the NASA Kennedy Space Center will be exposed to extreme heat, humidity and salty air at the Cape Canaveral Florida location. Finally, testing of the fuel cell mobile light with Saunders Electric and Paramount Pictures will assess its usefulness in the entertainment industry. In particular use of the unit for remote Paramount film shoots will allow Multiquip to assess the sound conditioning which is really required for the unit. Up until this point, units have not been sound conditioned in any way, yet the response from potential customers has been that the naturally quiet fuel cell technology is already remarkably better than noise from diesel-based systems. The project may attempt to sound condition a unit to see just how low the noise can be brought on the H_2LT technology.

The Alpha version of the fuel cell mobile light was used at the 2010 Academy Awards on March 7, 2010, at the invitation of Saunders Electric Inc. who provides all the portable power for the Oscars. For this event, the unit was used in the construction of the red carpet by construction

(Photo courtesy of the Academy of Motion Picture Arts and Sciences)

FIGURE 3. Use of the Alpha Fuel Cell Mobile Light at the 2010 Academy Awards, Red Carpet Construction, 3/6/2010

(Photo courtesy of Ron Roy Productions)

FIGURE 4. Use of the Alpha Fuel Cell Mobile Light at the 2011 Golden Globe Awards, Red Carpet Construction, January 16, 2011

crews of the Academy of Motion Picture Arts and Sciences, and used the day of the event to provide lighting and power at a security entrance to the red carpet. A picture from the Academy Awards red carpet preparations is shown in Figure 3. The upgraded Alpha was also used at the 2011 Golden Globe awards in Los Angeles California on January 16, 2011 for the red carpet construction, as shown in Figure 4. Saunders Electric also deployed the technology at the 2011 Screen Actors Guild Award show on January 30, 2011, and at the 2011 Grammy Awards on February 13, 2011.

Conclusions and Future Directions

The fuel cell mobile light project has allowed the design, construction, deployment and commercialization of the first fuel cell technology used in the construction equipment realm. The response from the construction, entertainment and power community has been excellent, with recognition of the project from a number of sources and use of the technology in a number of high-profile events. The H_2LT system is the first product in a newly formed EarthSmart™ product line from Multiquip Inc. Future directions for could involve the construction of fuel cell versions of other construction equipment, for example portable power generators, and air compressors used in construction.

Special Recognitions

1. 2011 DOE Hydrogen and Fuel Cells Program R&D Award, "In recognition of outstanding contributions to Fuel Cell Market Transformation Activities," for Fuel Cell Mobile Light Project, presented to Lennie Klebanoff, Sandia National Laboratories, May 11, 2011.

2. U.S. Congress Certificate of Special Recognition, 2011 Dream Makers and Risk Takers Award Winner, presented to Lennie Klebanoff and Terry Johnson (Sandia) "in recognition of outstanding and invaluable service to the community," for Fuel Cell Mobile Light Project, issued by John Garamendi, Member of U.S. Congress, March 29, 2011.

3. 2011 Dreamers and Risk Takers Technology Award, Livermore CA Chamber of Commerce, presented to Lennie Klebanoff and Terry Johnson (Sandia) for Fuel Cell Mobile Light Project, March 29 2011.

4. 2011 Most Innovative Product Award, World of Concrete Editors Choice Award for General Tools and Equipment, Fuel Cell Mobile Light (H_2LT), presented to Multiquip Inc.

5. 2010 Federal Laboratory Consortium Award "Mid-Continent Region" for "Notable Technological Achievement", Sandia National Laboratories, Fuel Cell Mobile Light Project, September 2010, presented to Lennie Klebanoff.

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.