

**SANDIA NATIONAL LABORATORIES
HYDROGEN AND FUEL CELL TECHNOLOGIES (FCTP) OFFICE
MARKET TRANSFORMATION PROGRAM**

QUARTERLY PROGRESS REPORT FOR JANUARY 1, 2013–MARCH 31, 2013

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CONTENTS

FY 2013 MILESTONES/DELIVERABLES3
FY 2012 MILESTONES/DELIVERABLES3
FY2013, TASK 1: BEVx—FEASIBILITY ANALYSIS AND RETROFIT DESIGN4
 BACKGROUND4
 OBJECTIVE.....4
SUBTASK 1.1: ANALYSIS OF THE HYDROGEN FUEL CELL RANGE
 EXTENDER/RECHARGER, BEVx.....5
 PROJECT STATUS5
 PLANS FOR NEXT QUARTER AND KEY ISSUES5
SUBTASK 1.2: DESIGN OF THE BEVx RETROFIT FOR THE MILES ELECTRIC ZX40ST5
 PROJECT STATUS5
FY2013, TASK 2: FC-AMP EVALUATION AND CONTROLS DEVELOPMENT5
 BACKGROUND5
 OBJECTIVE.....6
SUBTASK 2.1: EVALUATE PEM FUEL CELL SYSTEMS.....6
 PROJECT STATUS6
 PLANS FOR NEXT QUARTER AND KEY ISSUES6
SUBTASK 2.2: DEVELOP CONTROLS FOR MULTIPLE FUEL CELL SYSTEMS.....6
 PROJECT STATUS6
 PLANS FOR NEXT QUARTER AND KEY ISSUES7
 PUBLICATIONS/PRESENTATIONS7



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FY2013, TASK 3: FC-AMP FEASIBILITY ANALYSIS	7
BACKGROUND	7
OBJECTIVE.....	7
SUBTASKS 3.1 AND 3.2: SITE EVALUATIONS AND SELECTION, AND INDUSTRY-	
COLLABORATIVE FEASIBILITY ANALYSIS	8
PROJECT STATUS	8
PLANS FOR NEXT QUARTER AND KEY ISSUES	8
PUBLICATIONS/PRESENTATIONS	8
FY2012, TASK 2: FUEL CELL MOBILE LIGHTING	9
BACKGROUND	9
OBJECTIVE.....	9
PROJECT STATUS	9
PLANS FOR NEXT QUARTER AND KEY ISSUES	10
PUBLICATIONS/PRESENTATIONS	11

FY 2013 MILESTONES/DELIVERABLES

Task/Milestone Description	Planned	Status
Task 1: BEVx—Feasibility Analysis and Retrofit Design		
<i>Subtask 1.1: Analysis of the Hydrogen Fuel Cell Range Extender/Recharger, BEVx</i>		
Presentation of analysis results with go/no-go evaluation for subtask 1.2	12/1/12	To be completed 7-1-2013
<i>Subtask 1.2: Design of the BEVx Retrofit for the Miles Electric ZX40ST</i>		
Presentation of design concept with go/no-go evaluation for subtask 1.3; go decision includes performance goals for subtask 1.3	6/30/13	Task suspended
Task 2: FC-AMP Evaluation and Controls Development		
<i>Subtask 2.1: Evaluate PEM fuel cell systems</i>		
Presentation of results of evaluation for PEM fuel cell systems	3/1/13	Deferred
<i>Subtask 2.2: Develop controls for multiple fuel cell systems</i>		
Presentation of controls development with a go/no-go decision for future project tasks based on CQD targets to be established	8/1/13	Delayed to 9/30/13
Task 3: FC-AMP Feasibility Analysis		
<i>Subtask 3.1: Site Evaluations and Selection</i>		
Subtask 3.1: Conceptual design document that addresses site-specific requirements for the integrated system	12/1/12	Incorporated into Subtask 3.2
<i>Subtask 3.2: Industry-Collaborative Feasibility Analysis</i>		
Subtask 3.2: Summary report of project feasibility with a go/no-go evaluation on future integration and demonstration tasks	9/30/13	Final report issued 1/29/13

FY 2012 MILESTONES/DELIVERABLES

Task/Milestone Description	Planned	Status
Task 2: Fuel Cell Mobile Lighting		
<i>Subtask 2.1: Program management</i>		
Final project report	9/30/2011	9/30/2013

FY2013, TASK 1: BEVx—FEASIBILITY ANALYSIS AND RETROFIT DESIGN

Point of contact: Lennie Klebanoff

BACKGROUND

The U.S. Department of Energy is interested in developing and demonstrating a fuel-cell-based range extender/recharger for battery electric vehicles, a technology abbreviated BEVx. The range extender/recharger would consist of a fuel cell power system (both fuel storage and fuel cell) coupled directly to the battery of the battery electric vehicle (BEV). The purpose of the range extender is to introduce a power system on the BEV that has a higher gravimetric and volumetric energy density than the battery itself, thereby allowing the vehicle to drive further without recharging the battery from a grid power system. Working together, the battery/fuel cell combination would combine the fast transient electrical response of the battery with the high energy density of the fuel cell technology, resulting in a superior overall vehicle performance while maintaining zero-emissions. In addition, the onboard fuel-cell-based range extender could act as an auxiliary power unit, allowing the range-extended BEVx vehicle to serve as a mobile auxiliary power system.

OBJECTIVE

The original purpose of this project was to design, build, and demonstrate a BEVx range extension system, mate it to an existing electric vehicle platform, and demonstrate the technology in collaboration with the City of Santa Monica, making use of its municipal hydrogen station. The vehicle chosen for this work was the Miles Electric ZX40ST work truck, shown in Figure 1. Currently, 15 Miles Electric ZX40ST trucks are in use in Santa Monica, used for maintenance of the city parks and upkeep of the municipal promenades. Santa Monica is an ideal deployment site, located only 33 miles from the corporate headquarters of Miles Electric. However, during the quarter, Miles announced that it would no longer be building new electric vehicles, and instead would be providing parts and services to the existing fleet. Miles would provide a commercial BEVx unit as a retrofit to its existing fleet. However, this news prompted DOE to direct Sandia to finish the analysis part of the project, but not pursue the other planned activities such as detailed BEVx design and construction of a prototype.



Figure 1. Miles Electric model ZX40ST battery electric work truck used by the City of Santa Monica.

SUBTASK 1.1: ANALYSIS OF THE HYDROGEN FUEL CELL RANGE EXTENDER/RECHARGER, BEVx

PROJECT STATUS

During the past quarter, Sandia developed a synthetic drive profile for the existing ZX40ST battery electric truck, based on data collected for the vehicle by Miles Electric. The profile gives an example of truck use given the boundary conditions of 8-hour battery duration, and driving on both flat and hilly terrain. Altery Systems and Sandia examined the synthetic drive profile with an eye towards doubling the range of the vehicle in the profile derived using a BEVx fuel cell.

A key requirement of the analysis is to understand the efficiency and rate at which the existing on-board lead acid batteries can accept charge from the fuel cell. The existing battery provider (Full River Batteries) could not provide this information, so instead we consulted with the current designer of the Miles Electric Battery Recharging system, a company named Delta-Q. A teleconference with Delta-Q engineers described the type of battery recharging information we needed, and that information is currently being gathered by Delta-Q staff. With that information hand, the analysis can proceed.

PLANS FOR NEXT QUARTER AND KEY ISSUES

With the information from Delta-Q, the analysis of the BEVx system will proceed, including specifications of desired fuel cell size, required hydrogen storage, and expected improvements to vehicle range.

SUBTASK 1.2: DESIGN OF THE BEVx RETROFIT FOR THE MILES ELECTRIC ZX40ST

PROJECT STATUS

Task suspended.

FY2013, TASK 2: FC-AMP EVALUATION AND CONTROLS DEVELOPMENT

Point of contact: Aaron Harris

BACKGROUND

This task involves asset transfer, evaluation, and redeployment of an 8-kW (nominal) battery replacement fuel cell system from material-handling applications funded under the American Recovery and Reinvestment Act (ARRA). The project included equipment from Joint Base Lewis McChord and others. The task, which fits together with Task 3, includes evaluation of the fuel cell systems and development of a laboratory-scale system (16–24 kW) for the purpose of validating control system designs. Task 2 conducts critical engineering design of control systems

and evaluates the units for redeployment. Task 3 surveys the potential market transformation activities to determine areas in which a demonstration prototype might encourage a new market or markets to develop.

OBJECTIVE

Perform necessary engineering test and hardware development in a laboratory setting to support prototype deployment.

SUBTASK 2.1: EVALUATE PEM FUEL CELL SYSTEMS

PROJECT STATUS

The major objectives of this task are suspended pending the outcome of demonstration project planning and acquisition of commercial partners.

The work performed under this task supported the follow-on activities as a result of the Task 3 deliverable, SAND Report “Vessel Cold-Ironing Using a Barge Mounted PEM Fuel Cell: Project Scoping and Feasibility.”

A meeting with Hawaii Tug and Barge (HTB) was coordinated and several teleconferences with HTB and US Department of Transportation (DOT) representatives have been held to discuss the options of a demonstration project at HTB’s Honolulu facility.

PLANS FOR NEXT QUARTER AND KEY ISSUES

We plan to acquire commercial partners and begin working on detailed engineering designs for a demonstration system.

SUBTASK 2.2: DEVELOP CONTROLS FOR MULTIPLE FUEL CELL SYSTEMS

PROJECT STATUS

The intent of this project is to identify and develop necessary power conditioning and fuel cell system controls in support of a future demonstration prototype. The demonstration prototype will combine multiple 8-kW systems, which were originally designed to operate independently and with a direct current application, into a single power source for an alternating current application. This project will conduct experiments at a laboratory scale: 16 to 24 kW.

Test facility planning and development is underway. The laboratory space must be cleared and electronic loads acquired and installed to accommodate the operation of the units.

Included in this task is a more permanent storage solution for the units, which will not be used in this laboratory-scale testing.

PLANS FOR NEXT QUARTER AND KEY ISSUES

Task suspended pending outcome of Task 2.1.

PUBLICATIONS/PRESENTATIONS

Prepared presentation, “Comparison of Part-Load Operation of Diesel Gensets and PEM Fuel Cells,” and presented it via telecon to Hawaii Tug and Barge/Young Brothers, Ltd.

Prepared presentation, “Maritime Fuel Cells: Emissions and Cost Comparisons of Diesel and Hydrogen Fuel Cell Generators,” for use by DOE to present to DOT-MARAD (Maritime Administration).

FY2013, TASK 3: FC-AMP FEASIBILITY ANALYSIS

Point of contact: Joe Pratt

BACKGROUND

The fuel use of and emissions from maritime port sources can be significant. For example, a 2004 study showed the Port of Los Angeles (POLA) had average daily emissions exceeding that of 500,000 vehicles. Efforts have been underway to reduce these emissions from all sources, but vessels are still major contributors to air pollution and greenhouse gas emissions in and around ports. Approximately one-third to one-half of emissions attributed to ocean-going vessels comes from their auxiliary diesel engines, which are run while the vessel is at berth (docked) and requires electrical power for everything from lighting to loading/discharging equipment.

One recent effort to reduce vessel port emissions involves the practice referred to as cold-ironing, where a vessel at berth connects to a source of electricity on the shore. It has been proposed that a cold-ironing power supply be based on a hydrogen-fueled proton exchange membrane (PEM) fuel cell that is mounted on a floating barge. The PEM fuel cell produces zero emissions and the barge provides flexibility and an alternative to installation of electrical infrastructure.

OBJECTIVE

This task examines the feasibility of a hydrogen-fueled PEM fuel cell barge to provide electrical power to vessels at anchorage or at berth. This study includes both a determination of the technical feasibility of the idea as well as an analysis that informs the selection of potential deployment efforts.

SUBTASKS 3.1 AND 3.2: SITE EVALUATIONS AND SELECTION, AND INDUSTRY-COLLABORATIVE FEASIBILITY ANALYSIS

PROJECT STATUS

At the beginning of FY13 Q2 we presented our findings at DOE HQ. We also revised our report and issued it under number SAND2013-0501, which is now on the DOE website. Major findings in the report include the following:

- Environmental concerns, regulatory compliance, and rising fuel cost are driving increased support for cold-ironing.
- Vessel power and energy needs determine technical feasibility.
- Infrastructure requirements, fuel cost, regulatory environment, and stakeholder buy-in determines commercial feasibility.
- Container ship power is the large-scale application that can be both technically and commercially viable.
- Smaller vessels such as tugs, and on-board power generation are other viable applications.
- Several other opportunities exist for maritime environment demonstrations.

We have continued to support project development in this area on an as-needed basis under both Task 2 and Task 3. We performed more detailed project scoping for the Hawaiian Tug and Barge project, cost comparisons with other options, and emissions comparisons. In addition, we are supporting potential project development at the Ports of Tacoma and/or Seattle.

PLANS FOR NEXT QUARTER AND KEY ISSUES

Continue developing project plans and analysis as needed.

PUBLICATIONS/PRESENTATIONS

SAND2013-0501, "Vessel Cold-Ironing Using a Barge Mounted PEM Fuel Cell: Project Scoping and Feasibility," by J. W. Pratt and A. P. Harris, issued February 2013 and published on the DOE website:

http://www1.eere.energy.gov/hydrogenandfuelcells/fc_publications.html#fc_aux

FY2012, TASK 2: FUEL CELL MOBILE LIGHTING

Point of contact: Lennie Klebanoff

BACKGROUND

The fuel cell mobile light project aims to design, build, field test, and then commercialize a fuel-cell-based mobile lighting system. The system consists of a 5-kW PEM fuel cell from Alteryg Systems, 8.4 kg of hydrogen stored in 5,000-psi tanks, and advanced lighting. These light towers are commonly used by road construction crews, on movie sets, or at other locations where temporary, outdoor, artificial lighting is needed. An additional benefit of the system is the virtually silent operation, a feature not shared by traditional diesel generator systems. The unit is in the process of being commercialized by Multiquip, Inc.

The task this year will continue to (1) support early market field-tests of the prototype systems, and (2) assist Multiquip with gathering technical information needed for product commercialization.

OBJECTIVE

Support 2013 field-testing deployments with Saunders Electric in the entertainment industry (Oscars, Golden Globes, SAG Awards), at the San Francisco Airport, and with the Connecticut Department of Transportation.

PROJECT STATUS

This past quarter, the Fuel Cell Mobile Light Beta unit (4 hydrogen tanks) was used for Red Capet construction and take-down at the 2013 Screen Actors Guild Awards in Los Angeles; at the 2013 Golden Globe Awards in Beverly Hills, CA; and at the 2013 Oscars (formerly called the Academy Awards Show) in Hollywood, CA; as provided by Saunders Electric. The Alpha system also being used by Saunders was used at the 2013 Screen Actors Guild Awards, but thereafter experienced a maintenance problem precluding its use at the Golden Globes and Oscars. Hydrogen for these deployments was provided free of charge by the Santa Monica Hydrogen Station under the direction of Mr. Rick Sikes.

The problem with the Alpha unit was that one of the manual valves on the hydrogen tanks became stuck in the open position. The tank in question was vented by Saunders staff (under Sandia direction), and the unit was shipped to the composite tank manufacturer (Structural Composites Industries) to have the valve replaced and leak checked. Installation of the new valve required re-orienting of the tank with respect to the existing manifolding. This was accomplished by Multiquip service personnel in Carson, CA. The Multiquip staff rotated the tank, reconnected the 6,500-psi rated Swagelok manifolding to the tank valve, and leak checked the unit (using hydrogen from the other system tanks) for system integrity. This repair represents the first field service of a H₂LT unit by Multiquip service staff. The Alpha unit was then returned to Saunders

Electric for use—unfortunately, too late for use at the 2013 Oscars. The defective tank valve is in the possession of Sandia for possible future failure analysis.

On February 27, 2013, an H₂LT unit was formally delivered to the San Francisco International Airport (SFO) equipment staff. Mickey Oros (Altery Systems), Chris Radley (formerly of Altery Systems), Jennifer Hamilton (California Fuel Cells Partnership [CAFCP]), Tom Damberger (Golden State Energy) and Lennie Klebanoff (Sandia) participated, along with 25 representatives from the SFO Fire Department (including two fire chiefs), SFO Fleet Services and Maintenance Staff, and the SFO Environmental Services and Sustainability department. Klebanoff gave an overview presentation of the Fuel Cell Mobile Light project, including its goals, history, funding, and field tests. Klebanoff also gave a description of the H₂LT itself and its capabilities (power output, light production, hydrogen storage, overall design, duration). After the project presentation, Chris Radley (with assistance from Mickey Oros, Jenn Hamilton, and Tom Damberger) reviewed H₂ physical properties in comparison to other common fuels (NG, gasoline), H₂ safety, the nature of the composite tanks, fuel cell safety features, and refueling options. After these presentations, the group went to the equipment yard where Mickey Oros led a hands-on tour/review of the H₂LT features and operation.

The unit has been in use at SFO for lighting runway repair operations and providing general maintenance lighting.

On March 12, the SFO H₂LT unit was brought over to the Emeryville, CA, hydrogen station to familiarize Linde and A.C. transit staff with the unit, and to conduct a test fill using the station's J2601 fueling protocol. The unit was outfitted with thermocouples on the fueling manifold, as the J2601 performs fueling with pre-cooled (-20 °C) hydrogen. The unit filled from 1,000 psi to 5,100 psi in approximately 5 minutes, and the temperatures stayed within the temperature ratings for the fueling manifold Swagelok hardware. The unit was thus deemed “acceptable” for possible future fillings of the SFO unit at Emeryville. The A.C. Transit operational authority is working on refueling agreements, particularly statements of responsibility. These will be distributed for Sandia and SFO legal review when they are available.

Preparations continued for bringing an H₂LT to the Connecticut Department of Transportation. An H₂LT was outfitted with another LED lighting option of interest to Multiquip, manufactured by VisionX. A set of 8 VisionX LED light fixtures was mounted on the “Caltrans” H₂LT, and in-place endurance testing (~ 1 week of operation with cycling) was performed by U.C. Davis Advanced Highway Maintenance and Construction Technology (AHMCT) Research Center personnel. The efficiency (lumens/watt) of the VisionX lights is nearly twice that of the original plasma lights, and is also superior to the Trilliant LED lights on the SFO unit. After testing, the unit was deemed to be in a satisfactory state for shipping to CT DOT.

PLANS FOR NEXT QUARTER AND KEY ISSUES

In the next quarter we will support SFO in its field-testing of their unit, and establish supplements to the CAFCP for refueling the unit. Such alternatives include filling from a tube trailer, or refueling at the nearby Emeryville H₂ station. We will perform a side-by-side test of

the two H₂LT units bearing the different LED technologies at SFO. We will ship the Connecticut DOT unit to their facility in Wethersfield, CT, support (by telephone) their “kickoff meeting,” travel to CT to support its arrival, and provide hands-on introduction and training to CT DOT personnel.

PUBLICATIONS/PRESENTATIONS

None this quarter.