Maritime Fuel Cell Generator Project

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DOE Manager: *(will be supplied – no input required)*

Contract Number: *(National Laboratory projects do not include this line)*

Subcontractors:

Hydrogenics, 220 Admiral Boulevard, Mississauga, Ontario, Canada L5T 2N6

IGX Group, 1619 Shattuck Avenue, Berkeley CA 94709 USA

Project Start Date: October 1, 2013
Project End Date: Project continuation and direction determined annually by DOE.

Overall Objectives

- Lower the technology risk of future port fuel cell deployments by providing performance data of H_2-PEMFC technology in this environment. (Barrier: E)
- Lower the investment risk by providing a validated economic assessment for this and future potential projects. (Barrier: E)
- Enable easier permitting and acceptance of H_2-FC technology in maritime applications by assisting USCG and ABS develop H_2+FC codes and standards. (Barrier: A)
- Engage potential adopters/end users of hydrogen fuel cells to enable more widespread acceptance of the technology. (Barrier: F)

Fiscal Year (FY) 2019 Objectives

- Find a suitable maritime deployment site for the MarFC unit that is consistent with hydrogen regulations, would effectively utilize the MarFC capabilities, test the unit and reduce emissions.
- Engage with next deployment site to secure legal/insurance agreements for deployment.
- Upgrade the MarFC unit to correct issues from the last deployment and ensure compatibility with the next deployment site.
- Secure agreement with an H_2 supplier to provide hydrogen for the unit at the next deployment site.
- Review the deployment site chosen gas supplier to ensure safe refueling operations compliant with applicable codes and standards.

Technical Barriers

This project addresses the following technical barriers from the Market Transformation section of the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan:

- Inadequate standards
- Financing mechanisms (Lack of cost and performance data)
- Inadequate user experience

Contribution to Achievement of DOE Milestones

This project will contribute to achievement of the following DOE milestones from the Market Transformation section of the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan:

- 1.17: Enable economics of scale to achieve cost-competitiveness (4Q, 2020). The MarFC deployment at SIO will consume approximately 200 kg of hydrogen per week, generating significant hydrogen demand to introduce economies of scale.
- 2.8: Develop a case study for hydrogen infrastructure that services the MHE and other emerging fuel cell application markets (4Q,2014). The MarFC use at SIO involves providing vessels in port with clean zero-emission power, an attractive new market for fuel cell applications.

FY 2019 Accomplishments

- Engaged with the Scripps Institution of Oceanography (SIO, San Diego, CA) for use of the MarFC to power the research vessel *R/V Robert Gordon Sproul* while in port at the Nimitz Marine Facility. The site was determined to be a good use of the unit and compatible with the applicable hydrogen regulations.
- Secured legal/insurance agreements between Sandia and U.C. San Diego (university home of SIO) for the deployment of the MarFC.
- Secured refueling agreement with IGX Group to provide 350 bar hydrogen refueling for the SIO deployment.
- Upgraded the MarFC unit (transformer, connections) to provide 480VAC operation as required by the *R/V Robert Gordon Sproul*, and to provide the proper electrical interface box as required by the vessel.
- Conducted start-stop and endurance performance testing of the MarFC electrical upgrades in preparation for the SIO deployment.

Introduction

The objective of this project is the demonstration, and validation of hydrogen fuel cells in the marine environment. The prototype generator can be used to guide commercial development of a fuel cell generator product. Work includes assessment and validation of the commercial value proposition of both the application and the hydrogen supply infrastructure through third-party hosted deployment as the next step towards widespread use of hydrogen fuel cells in the maritime environment.

Approach

H_2 fuel cells have the potential to meet the electrical demands of vessels in a port as well as supply power for other port uses, such as yard trucks, forklifts and other material handling specialty equipment. H_2 fuel cells produce zero pollutant emissions and no greenhouse gases at the point of use and can reduce the overall amount of diesel or other maritime fuel used. This project involves the demonstration of a nominally 100 kW, integrated and containerized fuel cell prototype for marine applications. This project brings together industry partners in this prototype development as a first step towards eventual product commercialization. For success, the project incorporates interested industry and regulatory stakeholders: an end user, technology supplier and product integrator, and land and maritime-based safety and code authorities such as the U.S. Coast Guard.

Results

The final legal/insurance discussions were completed between Sandia and SIO (U.C. San Diego) regarding the use of the SIO Pier and issues of risk assumption. These necessary agreements cleared the path for the MarFC unit to be deployed at SIO. A telephonic project meeting (Sandia, Hydrogenics, SIO) was held to review the power requirements for the *R/V Robert Gordon Sproul*, to check that the 100 kW MarFC unit could supply the needed power. In addition, the configuration of the new junction box on the MarFC was designed to ensure compatibility with existing electrical cabling for the *R/V Robert Gordon Sproul.*

In order to provide shore power for the SIO research vessel *R/V Robert Gordon Sproul*, the MarFC unit had to be converted from 208VAC to 480VAC operation. In discussions with the Chief Engineer of the *R/V Robert Gordon* Sproul (Paul Mauricio), Sandia and Hydrogenics successfully completed specification of the MarFC modification required for Hydrogenics to upgrade the MarFC for 480VAC operation. This includes replacing the existing power transformer with a new transformer of 480VAC 3 phase (120kVA) operation, changing the user power connector interface on the MarFC unit to a new connection terminal and defining support equipment such as coolant pumps to operate with the new voltage.

The 480 VAC transformer from ABB was ordered and arrived at the Hydrogenics facility in Mississauga, Ontario, Canada and was installed. The old 208VAC transformer is being kept should the need for power at that voltage arise in the future. Beyond the installation of the transformer, the MarFC unit was modified to incorporate a new junction box that will allow connection to the existing electrical cabling for the *R/V Robert Gordon Sproul.* This junction box work was performed so that the electric connections are recessed, preserving the unit qualification as a "shipping container."

After installation of the new transformer, the unit was tested for a 2-week period in which power output was stopped and started, and the unit was run for endurance testing. The unit testing is completed, and the MarFC meets all performance requirements. To provide continuous support of the unit, weekly checking and rapid response in the event of MarFC system problems, Sandia completed a service agreement with Hydrogenics, to commence when the unit arrives at SIO.

Sandia engaged several hydrogen fuel suppliers to provide quotes for hydrogen fueling. IGX Group was able to provide refueling from a 350-bar trailer that was well suited for the MarFC unit. The IGX Group contract for fueling was established and fueling will commence in November 2019 when the unit has been successfully delivered to SIO and has passed a post-delivery checkout of the unit.

The modifications to the MarFC unit are documented below and include the new 480VAC transformer (Figure 1) the nameplate for the new transformer (Figure 2), and the new recessed Panel Box (Figure 3) that maintains the "container" classification of the unit while conforming to the SIO request for 3 wire connection to the *R/V Robert Gordon Sproul.* Logos for the unit were also updated to include SIO (Figure 4). Figure 5 shows the unit during the post-upgrade performance testing.

Figure 1: New transformer installed

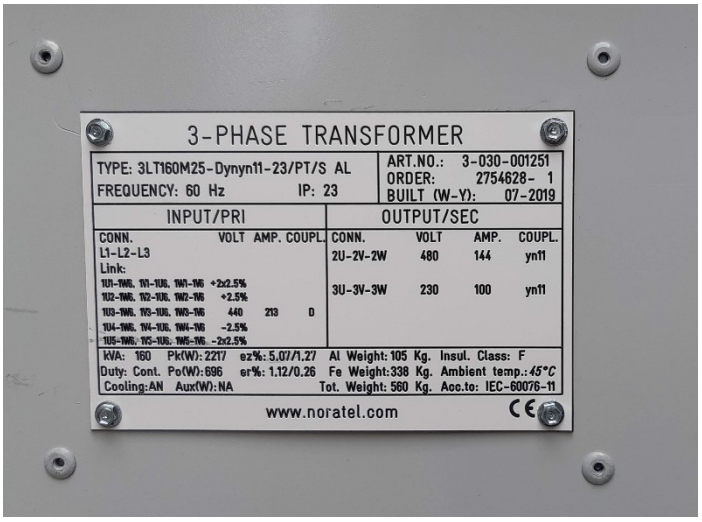

Figure 2: Nameplate of new transformer.

Figure 3: New recessed connector panel/box mounted on the MarFC unit.

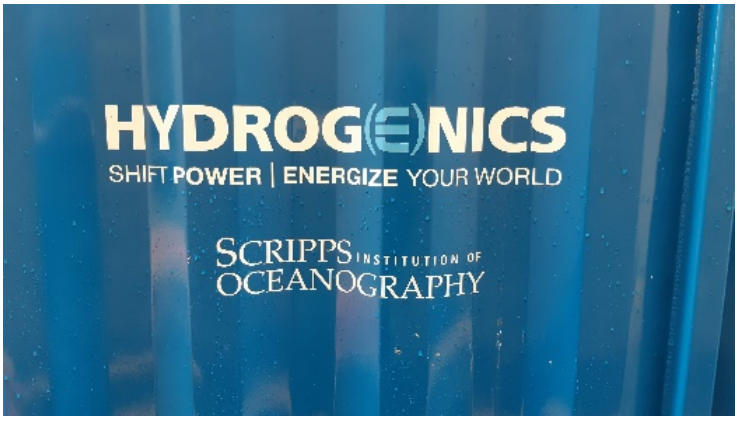

Figure 4: Addition of the SIO logo on the 100 kW MarFC unit.

Figure 5: The 100 kW MarFC unit in place for electrical testing at Hydrogenics.

Conclusions and Upcoming Activities[1]

The unit was successfully upgraded to provide zero-emissions 480VAC shore power for *the R/V Robert Gordon Sproul*. In November 2019, a 6 month deployment at SIO will commence. The unit's performance (electrical output and stability) will be monitored in real time by Hydrogenics, and the mobile refueling of the unit (by IGX Group) will be conducted for the first time. After the 6 month deployment, a data report will be written describing the observed performance of the unit, the fuel cell thermal efficiency, the number of refueling operations, operations and maintenance (O&M) costs and feedback from the SIO community that used the unit.

FY 2019 Publications/Presentations

L.E. Klebanoff, "Maritime Fuel Cell Generator Project," DOE H_2 Program Annual Merit Review, Washington D.C., April 30, 2019.

L.E. Klebanoff, "Development of a Containerized 100 kW Fuel Cell System for Maritime Applications," H2@Ports DOE Workshop, San Francisco, CA September 11, 2019.

Acronyms

ABS: American Bureau of Shipping; FC: Fuel Cell; MarFC: Maritime Fuel Cell Unit; O&M: Operations and Maintenance, PEMFC: Proton Exchange Membrane Fuel Cell; SIO: Scripps Institution of Oceanography; USCG: United States Coast Guard

[1] Projects that are awarded by FCTO through competitive Funding Opportunity Announcement (FOA) selections are fully funded for the project's full period of performance (subject to go/no-go decisions) in the year the project is awarded. Future direct-funded work at the national laboratories is subject to change based on annual appropriations.