IX.5 Maritime Fuel Cell Generator Project

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Project Start Date: September 15, 2013
Project End Date: December 31, 2015

Overall Objectives

- Lower the technology risk of future port fuel cell deployments by providing performance data of hydrogen proton exchange membrane (PEM) fuel cell technology in this environment.
- Lower the investment risk by providing a validated business case assessment for this and future potential projects.
- Enable easier permitting and acceptance of hydrogen fuel cell technology in maritime applications by assisting U.S. Coast Guard (USCG) and the American Bureau of Shipping (ABS) develop hydrogen and fuel cell codes and standards.
- Act as a stepping stone for more widespread shipboard fuel cell auxiliary power unit (APU) deployments.
- Reduce port emissions with this and future deployments.

Fiscal Year (FY) 2014 Objectives

- Familiarize maritime code and safety offices with the project and concept of hydrogen fuel cells in maritime applications.
- Produce preliminary prototype design and review with ABS, USCG, and the Hydrogen Safety Panel.
- Produce data collection and analysis plan.
- Develop hydrogen supply plan in close coordination with existing resources

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:

(A) Inadequate standards and complex and expensive permitting procedures

(E) A lack of flexible, simple, and proven financing mechanisms

(F) Inadequate user experience for many hydrogen and fuel cell applications

Technical Targets

No specific technical targets have been set.

FY 2014 Accomplishments

- Established partnership team and held project kick-off
- Collaboratively determined prototype functional specifications
- Made progress towards hydrogen supply arrangements
- Engaged maritime code and safety authorities and defined requirements
- Engaged Hydrogen Safety Panel to ensure safety is integrated into the project
- Produced preliminary prototype design and received design basis approval from USCG

INTRODUCTION

Fuel costs and emissions in maritime ports are an opportunity for transportation energy efficiency and emissions reduction efforts. For example, a 2004 study showed the Port of Los Angeles had average daily emissions exceeding that of 500,000 vehicles [1]. Diesel fuel costs continue to rise as low-sulfur limits are imposed, making power generation more expensive for fleets. Hydrogen fuel cells have the potential meet the electrical demands of vessels in the port as well as supply power for other port uses such as yard trucks, forklifts and other material handling specialty equipment. Validation of the commercial value proposition of both the application and the hydrogen supply infrastructure is the next step towards widespread use of hydrogen fuel cells in the maritime environment, and is determined by meeting

necessary equipment and operating costs and customer expectations such as reliability, form, and function.

Sandia National Laboratories' recent report, "Vessel Cold-Ironing Using a Barge Mounted PEM Fuel Cell: Project Scoping and Feasibility," identified several opportunities for demonstrating technical and commercial viability of a fuel cell in the maritime environment [2]. One identified opportunity is in Honolulu Harbor at the Young Brothers Ltd. (YB) wharf. YB provides barge transport of goods between Oahu and the Hawaiian neighbor islands and is an ideal demonstration location because of their high fuel costs and corporate interest in low-emission, low-environmental impact solutions. YB uses refrigerated containers ("reefers") which are kept cold while on the dock and on the barge by using dedicated diesel generators mounted inside mobile 20-foot containers. Sandia's report concluded that it is technically feasible to build a containerized hydrogen fuel cell generator to replace the diesel generator in YB operations.

APPROACH

This project develops and demonstrates a nominally, 100-kW, integrated fuel cell prototype for marine applications. This project brings together industry partners in this prototype development as a first step towards eventual commercialization of the technology. To be successful, 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. Project costs will be shared by the primary stakeholders in the form of funds, in-kind contribution, and material/equipment either loaned or donated to the project. Funding provided by the Department of Transportation, Maritime Administration (MARAD) is used to provide assistance with the integrated system and packaging designs, data collection and assistance during the demonstration period, and technical assistance and project management throughout the project. In addition some MARAD funds will be used to purchase specialized equipment needed to construct the prototype. DOE funds will be used to provide overall project management, technical design assistance, and deployment facilitation, and used via subcontract to the prototype manufacturer for the design, build, and testing of the final product.

The project has four phases:

1. Establishment and specification (Sept. 2013-Dec. 2013)
2. Detailed design and engineering (Jan. 2014-June 2014)
3. Prototype fabrication/site construction (July 2014-March 2015)
4. Deployment (on-site demonstration) and analysis (April 2015-December 2015)

RESULTS

The Maritime Fuel Cell Project team consists of eleven partners, and their roles are shown in Table 1.

The functional specifications of the unit were decided upon by all partners, considering technical capabilities, and focused on operational requirements and end-user needs. These include:

TABLE 1. Project Partners and Roles

Partner		Project Roles
U.S. DEPARTMENT OF ENERGY	**DOE**	Sponsorship, steering, H_2 supply coordination
	DOT/MARAD	Sponsorship, steering, and facilitation of maritime relationships
YOUNG BROTHERS Your Neighbor Island Partner FOSS	**Young Bros. & Foss Maritime**	Site preparations, prototype operation and routine maintenance
HYDROGENICS SHIFT POWER | ENERGIZE YOUR WORLD	**Hydrogenics *(sub w/ cost share)***	Design, engineer, build, commission, and support prototype unit
HNEI Hawai'i Natural Energy Institute University of Hawai'i at Mānoa	**HNEI**	Hydrogen supply logistics facilitation
ABS	**ABS**	Prototype design to maritime product standards
SECTOR HONOLULU	**US Coast Guard**	Review and acceptance of prototype design and operation
Pacific Northwest NATIONAL LABORATORY	**PNNL H_2 Safety Program**	Prototype and project safety review by HSP; hydrogen emergency response training for first responders
Sandia National Laboratories	**Sandia**	Management and coordination, H_2 materials and systems expertise, tech/business data collection and analysis

- Performance
  - 240 volt alternating current, 3-phase power, at least 100 kW continuous at the plugs
  - Hybrid battery/ultracap for inrush current
  - 10-12 hrs/day on the dock and at least 28 hr on the barge
  - 60-90 kg of H_2 stored at 5,000 psi
- Size and Weight
  - 20-foot hi-cube shipping container; 81,000 lb max weight
- Environmental
  - Ambient temperature +2°C to +40°C
  - Tolerate rain, wave wash, salt water intrusion during operation
  - Tolerate side-to-side movement in 20-foot seas during operation
  - Handled as ordinary container (not operating when moved)

Hydrogen supply arrangements are being made. Current options include utilizing current hydrogen production and dispensing assets on Oahu that will need to be relocated, importing liquid or gaseous hydrogen from the mainland, or installation of new generation and dispensing equipment at or near the deployment site.

The USCG has reviewed the conceptual design of the prototype and will issue a design basis letter which notes that they agree with the concepts, codes, and standards proposed and allows the project team to proceed with detailed design. Because neither USCG nor ABS have existing codes, standards, or rules regarding the use of hydrogen onboard vessels, the project is assisting them with their development.

PNNL's Hydrogen Safety Program is participating in the project in two ways. First, the Hydrogen Safety Panel has reviewed the conceptual design twice and provided valuable feedback for the project team to consider during the design phase. Second, DOE is also working to provide hydrogen safety training to all Young Bros. operations personnel in Oahu, Molokai, and Lanai, the local Hawaii fire station in Oahu (where the unit will be operating on the dock and refueled), and first responders at sea.

CONCLUSIONS AND FUTURE DIRECTIONS

The Maritime Fuel Cell Project is a wholly collaborative effort with early and continuous stakeholders feedback that is breaking down non-technical barriers to hydrogen and fuel cell use. Future work includes:

- Finalize hydrogen supply arrangements
- Finalize data collection and analysis plan
- Begin prototype build
- Finish prototype build, factory test, on-site commissioning, and training
- Finish site preparations and conduct on-site hydrogen safety training
- Begin deployment testing and collect operational and cost data
- Continue to use the leverage for education and outreach both in Hawaii and in the worldwide maritime/port community

FY 2014 PUBLICATIONS/PRESENTATIONS

1. D. Dedrick, "Reducing Emissions at Ports and Advancing Hydrogen Fuel Infrastructure," presented at the California Fuel Cell Partnership Executive Board Meeting, April 15, 2014.

2. J. Pratt, "Fuel Cell Power for Refrigerated Containers: Towards Cleaner and Cheaper Maritime Power," presented at the Ship Operations Cooperative Program Spring Summit, Galveston, TX, May 13–14, 2014.

3. J. Pratt, "Applying Hydrogen and Fuel Cells to Maritime Ports," presented at the California Hydrogen Business Council Spring Summit, Long Beach, CA, May 5, 2014.

4. J. Pratt, "Maritime Fuel Cell Generator Project," presented at the DOE Annual Merit Review, Washington, DC, June 16–20, 2014.

REFERENCES

1. D. Bailey, T. Plenys, G.M. Solomon, T.R. Campbell, G.R. Feuer, J. Masters, and B. Tonkonogy, "Harboring Pollution - Strategies to Clean Up U.S. Ports," National Resources Defense Council, NY, August, 2004.

2. J.W. Pratt and A.P. Harris, "Vessel Cold Ironing Using a Barge Mounted PEM Fuel Cell: Project Scoping and Feasibility," Sandia National Laboratories, Report SAND2013-0501, available at http://energy.gov/eere/fuelcells/downloads/vessel-cold-ironing-using-barge-mounted-pem-fuel-cell-project-scoping-and.