Maritime Fuel Cell Generator Project

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Sandia National Laboratories
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We have built and deployed a containerized hydrogen fuel cell generator for reefer power on land and sea.


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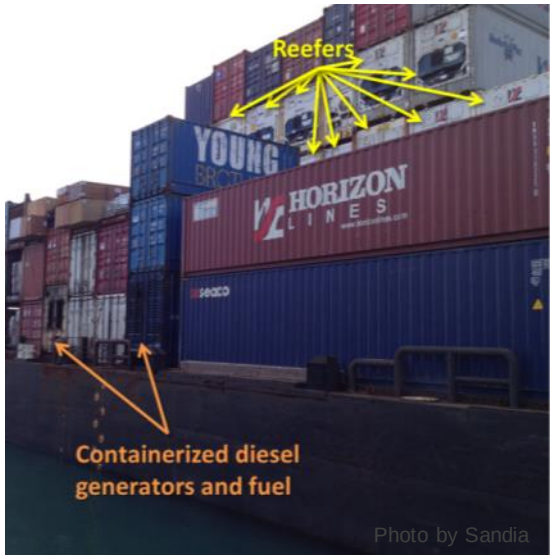

Photo by Sandia


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Project Concept

Fuel cell unit replaces diesel generators, reducing fuel cost and emissions.

Project Scope (2013-present)

Design, build, and deploy a containerized fuel cell system to supply portable power for refrigerated containers ("reefers").

- **100 kW (net) fuel cell and H_2 storage inside a 20-foot container, ~ 4kW B.O.P.**
- **9-month deployment on land and over the ocean. (Honolulu-Kahului)**
- **Strategic set of project partners, encompassing both the H_2-fuel cell and maritime communities.**
- **Upgrade the MarFC, find a post-Hawaii (June 2017) deployment site and re-deploy.**

Project Overview

Timeline:

- Start: July 2016
- End: December 2019
- 80% complete

Budget:

- Total: $1.429M
  - DOE FY16: $258K
  - DOE FY17: $279K
  - DOE FY19: $150K
  - DOT/MARAD* FY17: $211K
  - DOT/MARAD* FY18: $329K
  - Contractor FY2017: $202K

MT Barriers Addressed:

- A: Inadequate standards
- E: Financing mechanisms (Lack of cost and performance data)
- F: Inadequate user experience

Partners:

- Sandia *(project manager)*
- Scripps Institution of Oceanography (SIO)
- Hydrogenics *(sub w/ cost share)*

*DOT/MARAD: US Department of Transportation, Maritime Administration

Relevance – Overall Project 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*)

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- ✓ **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*)

Approach: July 2018 - Present

- Engaged with Curtin Maritime (Long Beach, CA) for use of MarFC.
- Reviewed compatibility of the Curtin Maritime site for H_2 refueling with the Port of Long Beach, Linde, Hydrogenics.
- Modify Project Team to Support Deployment at SIO* for Shore Power.
- Review SIO site with Air Liquide, Air Products for regs. compliance.
- Engage with SIO to Secure Legal Agreement for Deployment.
- Upgrade the MarFC generator for 480 VAC operation.
- Engaging with H_2 suppliers for availability of H_2 and quote.

* SIO = Scripps Institution of Oceanography, San Diego CA

Accomplishments and Progress: Approached Curtin Maritime to Assess Interest

Recommended by Christine Houston, Port of Long Beach

CURTIN MARITIME

Capt. Martin Curtin, owner

Offering a range of services including:

Ocean Towing, Barge Charter Tugboat Charter, Ship Assist, Marine Construction, Dredging, Crane Service, Environmental Remediation and Restoration, Naval Fabrication, Offshore Projects

Curtin Maritime was interested in using the MarFC to provide 480 VAC shoreside power initially for their offices and construction/repair building, and then if all went well, would consider it for other types of service.

CURTIN MARITIME

June 26, 2018 First Meeting

July 20 2018: Approval Mtg.

Lennie Klebanoff (Sandia)

Christine Houston (Port of Long Beach)

Martin Curtin (Curtin Maritime)

Boomer Sisneros (Curtin Maritime)

Marley Schroepfer (Curtin Maritime)

Will Cook (Hydrogenics)

Jeff Earl (Linde)

Jim Lohan (Linde)

Site Requirements for MarFC Deployment

All H_2 providers have requirements for refueling or H_2 storage that must satisfy NFPA 2 (Hydrogen Technologies Code), NFPA 55-2016 Compressed Gases and Cryogenic Fluids Code (2016) and their own requirements.

Considerations Include Distances to:

Lot Lines
Overhead Power Lines
Intakes (HVAC, compressors)
Wall Openings (operable and inoperable)
Other Flammable Gas Storage
Parked Vehicles
Ignition Sources (welding)
Others.....

The current Curtin Maritime site could not accommodate the lot line and overhead power line distance requirements for this H_2 project.

The Scripps Institution of Oceanography

Project Team Visited SIO on 8/17/2018

R/V Robert Gordon Sproul docked at Nimitz Marine Facility

Paul Mauricio, Chief Engineer, SIO

1. SIO wants to use the MarFC unit to provide shore power for the Research Vessel (R/V) Robert Gordon Sproul when in port at the Nimitz Marine Facility, San Diego CA.

2. "The Sproul" is typically in Port for 1 week, goes out for 2-3 days, and then comes back.

3. While in Port, the Sproul requires 480 VAC 3-phase shore power 24 hours per day.

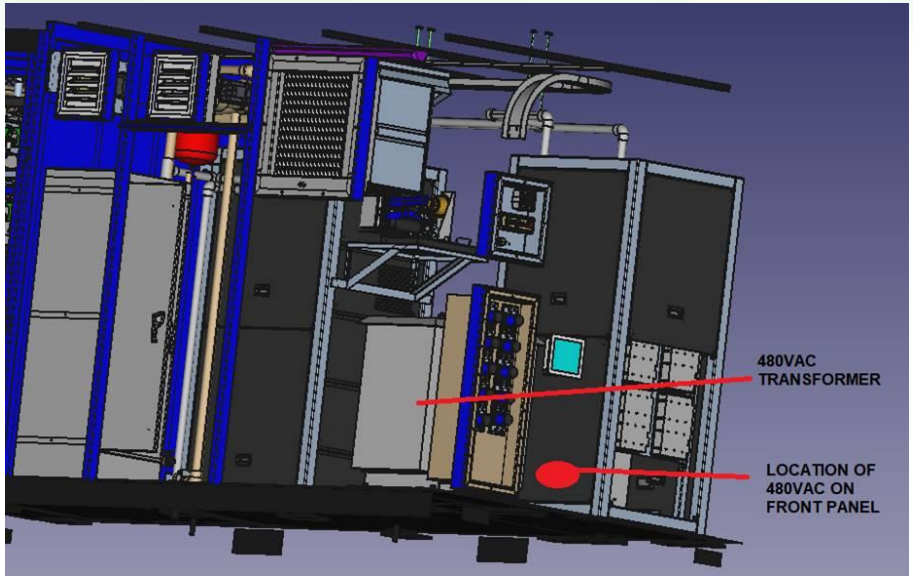
4. Average power ~ 30 kW. During the day, the power can peak to ~ 50 kW, during the evening, the power load ~ 15 kW. These are within the 100 kW MarFC capability to provide (once the MarFC unit is upgraded to provide 480 VAC).

The SIO Nimitz Marine Facility location is in full compliance with relevant NFPA and H_2 supplier requirements for H_2 storage and delivery. ✓

Also satisfied Scripps terms and conditions. ✓

Deployment scheduled for 6-15-19 through 12-31-19.

MarFC Being Modified to 480 VAC Operation



The old 208 VAC transformer will be removed, with the new 480 VAC transformer installed in the same location within the MarFC shipping container.

transformer wt. = 1257 lbs

MarFC Being Modified to 480 VAC Operation

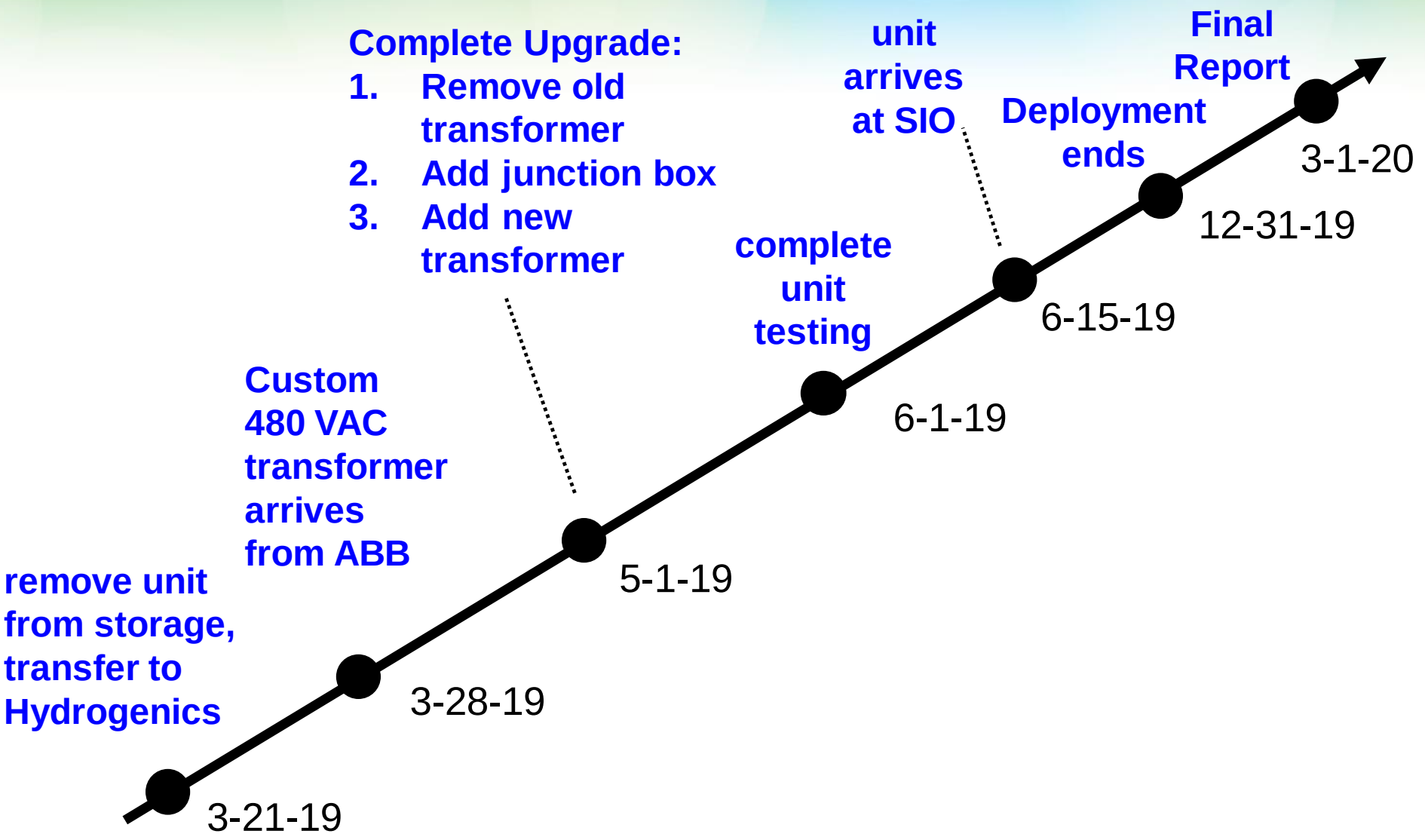
Old 208 VAC transformer to be kept at SNL for possible future use with “reefers.”

All prior 208 VAC connections to be kept.

12” Waterproof Display of FC Status

Location of new 480 VAC connection box.

MarFC Upgrade Schedule and Shipping to SIO



Summary

- Engaged with Curtin Maritime for use of MarFC.
- Reviewed compatibility of the Curtin Maritime site for H_2 refueling, found the current site could not meet H_2 regulations.
- Identified SIO as a good deployment option.
- Reviewed SIO site with Air Products, Air Liquide, found compliance.
- Secured legal/insurance agreement with SIO for deployment.
- Upgrading the MarFC generator for 480 VAC operation.
- Engaging with H_2 suppliers for availability of H_2 and quotes.

Responses to Previous Year Reviewers' Comments

"The project team may have overcome or will overcome most barriers but appears utterly stymied by one barrier: location....the project needs a home somewhere."

--The unit will be deployed at SIO, which satisfies all the regulatory and legal requirements for deployment of the MarFC.

"It would be good to document "lessons learned" for the benefit of the Program and its partners and contractors."

-- The lessons learned from the project will be documented in the final report. Some of the lessons learned regarding site requirements have been included in this presentation.

"It is unfortunate that this (finding new deployment sites) could not have been done in parallel with the upgrade/test timing."

-- new potential deployment sites and partners for FY2020 are being sought as the unit is undergoing modification for the SIO deployment.

Remaining Project Challenges and Barriers

- To find another deployment site after SIO that does not require indemnification and satisfies NFPA 2, NFPA 55 and H_2 supplier requirements.
- To find a deployment site that does not require liability insurance beyond the current Sandia limit of $3,000,000.
- Cost of delivered hydrogen is still currently high (> $40/kg).

("Any proposed future work is subject to change based on funding levels")

Proposed Future Work

- More data is needed to complete technical and economic evaluation.
- Sandia, FCTO, and MARAD are actively engaged in identifying a subsequent demonstration project.

Photo by Sandia

- Future evaluations and operating experiences will enable answering the question of whether this technology will be able to compete with incumbent technology in the future, and how.

("Any proposed future work is subject to change based on funding levels")

Collaboration and Coordination

Thanks to our partners and colleagues:

- Scripps Institution of Oceanography: Bruce Appelgate, Paul Mauricio, Andrea Lupu
- Hydrogenics: Ryan Sookhoo, Nader Zaag, Will Cook
- Air Liquide: Dwight Zuck, Jorge Lopez
- Air Products: Chris Kretz
- Linde: Jeff Earl, James Lohan
- Curtin Maritime: Martin Curtin, Boomer Sisneros, Marley Schroepfer
- Port of Long Beach: Christine Houston
- Sandia National Laboratories: Lennie Klebanoff, Madelynne Farber, Jon Zimmerman

Thank You!

Photo by author

Publications and Presentations

- No publications were produced from the work.
- "H_2 Maritime Webinar," Department of Transportation/MARAD, Department of Energy FCTO, California Air Resources Board, California Energy Commission and Bay Area Air Quality Management District Joint Webinar, August 23, 2018.
- "Maritime Fuel Cell Generator Project," DOE H_2 Program Annual Merit Review, Washington D.C., April 30, 2019.

Critical Assumptions and Issues

1. We need to find a deployment site that does not require indemnification.

   SIO satisfies this requirement.

2. Cost of delivered hydrogen is still currently high (> $50/kg), which is a burden on the deployment site.

   We are working with the H_2 suppliers to provide hydrogen within the existing project funding.

Data Management Plan (DMP)

- All data will be posted to the Sandia Hydrogen Fuel Cell Maritime public website: maritime.sandia.gov. Data will also be shared by publication when a publication results from the project.
- The data coming from the project, as well as test data during modification of the fuel cell unit will be posted to the public Sandia Hydrogen Fuel Cell Maritime public website: maritime.sandia.gov
- Costs for the data sharing are supplied by Sandia National Laboratories overhead.

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