

X.4 Hydrogen Energy Systems as a Grid Management Tool

Richard (Rick) E. Rocheleau (Principal Investigator),
Mitch Ewan (Primary Contact)

Hawaii Natural Energy Institute (HNEI)
School of Ocean and Earth Science and Technology
University of Hawaii at Manoa
1680 East-West Road, POST 109
Honolulu, HI 96822
Phone: (808)956-2337; (808) 956-8346
Email: ewan@hawaii.edu; rochelea@hawaii.edu

DOE Manager

Pete Devlin
Phone: (202) 586-4905
Email: Peter.Devlin@ee.doe.gov

Technical Advisor

Karen Swider-Lyons
Naval Research Laboratory
Phone: (202) 404-3314
Email: karen.lyons@nrl.navy.mil

Contract Number: DE-EE0002811

Project Start Date: September 30, 2010

Project End Date: September 29, 2015

- Execute a Facility Use Agreement (lease) with NELHA for the test site
- Install site improvements and utilities at NELHA to support the operation of the hydrogen system
- Conduct a hydrogen site safety review utilizing an independent third party consultant
- Install, commission, and operate the hydrogen system at NELHA
- Install a 350 bar hydrogen fuel dispenser at NELHA to fuel the MTA fuel cell shuttle bus
- Develop electrolyzer system cycling test protocols based on operational data collected from a 1 MW battery energy storage system installed on the HELCO grid for frequency regulation
- Characterize performance/durability of the electrolyzer system under dynamic load conditions at Powertech Labs facilities in Vancouver, Canada, prior to shipping equipment to Hawaii
- Conduct performance/cost analysis to identify benefits of integrated systems including grid services and off-grid revenue streams

Overall Objectives

- Demonstrate the use of electrolyzers to mitigate the impacts of intermittent renewable energy by regulating grid frequency
- Characterize performance/durability of commercially available electrolyzers under dynamic load conditions
- Supply hydrogen to fuel cell shuttle buses operated by County of Hawaii Mass Transit Agency (MTA), and Hawaii Volcanoes National Park (HAVO)
- Conduct performance/cost analysis to identify benefits of integrated system including grid ancillary services and off-grid revenue streams
- Evaluate effect on reducing overall hydrogen costs offset by value-added revenue streams

Fiscal Year (FY) 2015 Objectives

- Relocate the project from the Puna Geothermal Venture (PGV) power plant to the Natural Energy Laboratory Hawaii Authority (NELHA) site at Kailua-Kona on the Island of Hawaii

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:

Section 3.9.5 – Market Transformation Barriers

- (A) Inadequate standards and complex and expensive permitting procedures
- (B) High hydrogen infrastructure capital costs for Polymer Electrolyte Membrane (PEM) fuel cell applications
- (C) Inadequate private sector resources available for infrastructure development
- (F) Inadequate user experience for many hydrogen and fuel cell applications
- (G) Lack of knowledge regarding the use of hydrogen inhibits siting
- (H) Utility and other stakeholders lack awareness of potential renewable hydrogen storage application

Technical Targets

No specific technical targets have been set.

FY 2015 Accomplishments

- Relocated the project from the PGV geothermal power plant to the NELHA site at Kailua-Kona on the Island of Hawaii
- Executed a Facility Use Agreement (lease) with NELHA for the test site
- Designed site improvements and utilities at NELHA to support the operation of the hydrogen system; prepared construction bid package for installation of the site improvements
- Conducted a NELHA hydrogen site safety review utilizing Boyd Hydrogen
- Developed electrolyzer system cycling test protocols based on operational data collected from a 1 MW battery energy storage system installed on the Hawaii Electric Light Company grid for frequency regulation
- Designed, fabricated and installed a programmable logic controller (PLC) and power monitoring system for control of the electrolyzer system
- Commissioned the electrolyzer system and characterized performance/durability under dynamic load conditions at Powertech Labs facilities in Vancouver, Canada
- Conducted five months of testing at Powertech Labs supervised by on-site HNEI staff



INTRODUCTION

While solar and wind resources offer a major opportunity for supplying energy for electrical grid electricity production and delivery systems, their variability and intermittency can raise challenges for the cost effective and high reliability integration of these renewable sources on electrical grids. In Hawaii, the curtailment and grid management-related challenges experienced by these renewable sources are a challenge at today’s level of generation capacity, and these costs will hinder the substantive additional penetration of electricity generation supplied by these renewable resources. Hydrogen production through electrolysis may provide an opportunity to mitigate curtailment and grid management costs by serving as a controllable load allowing real-time control in response to changes in electricity production. The renewable hydrogen product can also create new and incremental revenue streams to the power producers through the sale of hydrogen products to customers outside of the electricity delivery system. Accordingly, hydrogen energy production at a utility scale offers the potential for increasing the levels of variable renewable energy that can be harnessed by the power producers or systems operators.

APPROACH

This project evaluates the value proposition of using utility-scale electrolyzers to both regulate the grid and using the product hydrogen for transportation applications. An electrolyzer system will be installed at NELHA on the Big Island. The electrolyzer will be ramped up and down to provide frequency regulation. Data will be collected to analyze the optimum electrolyzer ramp rates and determine its durability and performance under dynamic operating conditions. The hydrogen produced by the system will be used to fuel three hydrogen-fueled buses. It is planned to deliver hydrogen to HAVO as per the original plan to support two HAVO buses. The third bus will be operated from Kona instead of Hilo. A schematic of the project concept is shown in Figure 1.

RESULTS

Due to a lava flow that threatened to cut off access to the original project site, the decision was made to move the project from Puna to NELHA located on the West Coast of the Big Island as shown in Figure 1. A lease was executed with NELHA and a new infrastructure design was developed and reviewed by a third party hydrogen safety consultant (Boyd Hydrogen). A construction bid package was prepared and will go out to public tender. In parallel to the site work, HNEI developed electrolyzer system cycling test protocols based on operational data collected from a 1 MW battery energy storage system installed on the



FIGURE 1. Hydrogen Production and Delivery System

HELCO grid for frequency regulation. A PLC and power monitoring system for control of the electrolyzer system was designed and installed on the electrolyzer system to facilitate implementation of the electrolyzer testing protocols, and support data collection. The electrolyzer system was commissioned at Powertech Labs facilities in Vancouver, Canada, in January/February 2015 and on-site HNEI staff conducted a testing program. The electrolyzer system has been characterized and performance and durability testing is being conducted in accordance with the test plan. Several technical issues were identified in the course of operations at Powertech and are being rectified as they are discovered. The electrolyzer has presented many technical challenges. This six-month test phase at the manufacturer's facility is proving to be very beneficial and will result in a true "plug and play" when the system is installed at NELHA with most of the bugs resolved.

CONCLUSIONS AND FUTURE DIRECTIONS

The Hydrogen Energy Systems as a Grid Management Tool project has coordinated the efforts of a diverse group of stakeholders to provide a technology solution to facilitate integration of intermittent renewable energy sources on an electrical grid while producing hydrogen for transportation. The project has identified and provided valuable solutions to the many nontechnical barriers associated with introducing

hydrogen technology into a community for the first time. Lessons learned from this project will make the way easier for projects that follow. Future work includes the following:

- Installing and operating hydrogen production systems and dispensing infrastructure at the NELHA site. It is projected the site will be operational in February 2016.
- Operating the 26-passenger fuel cell electric vehicle (FCEV) bus based at the NELHA site.
- Transporting hydrogen in hydrogen transport trailers from the production site to dispensing HAVO to support the two park service FCEV buses.
- Collecting and analyzing hydrogen system and FCEV bus performance data.
- Preparing performance reports and sharing it with project sponsors and industry.
- Conducting outreach activities with the public to inform them about hydrogen technologies.

FY 2015 PUBLICATIONS/PRESENTATIONS

1. Ewan M., Rocheleau, R., Oral presentation at US DOE Annual Merit Review, "Hydrogen Energy Systems as a Grid Management Tool," Washington, DC, June 10, 2015.