2012 Hydrogen and Fuel Cells Program
Annual Merit Review Meeting
Hydrogen Energy Systems as a
Grid Management Tool

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Project: MT008

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Overview

Timeline

✓ Project start date: 30 Sep 10
✓ Project end date: 29 Sep 12
✓ Percent complete: 50%

Budget

✓ Total project funding:  
  ➢ $1,796,515
✓ Funding received in FY11:  
  ➢ $1,500,000 State of Hawaii
  ➢ $600,000 ONR
  ➢ $500,000 US DOE

Barriers

✓ Hydrogen Production  
  ➢ J: Renewable electricity generation integration  
  ➢ Non-technical issues preventing full commercialization of hydrogen

Partners

✓ US DOE: Project Sponsor & Funding
✓ Office of Naval Research: Supplemental funding
✓ Naval Research Laboratory:  
  ➢ Federal Technical Program Manager
✓ HNEI: Implementing Partner, Technical Lead
✓ Puna Geothermal Ventures:  
  ➢ Host site, Power & Water Provider.
✓ County of Hawaii Mass Transit Agency:  
  ➢ Host Site, Bus Operator
✓ HELCO: Potential partner for expanded program
Relevance: High Percentages of As-Available Renewable Resources Creates Problems for Grid Systems

- Significant transmission and distribution issues;
- Substantive difference between peak load vs. base load;
- Small grid systems with no interisland connections;
- These issues lead to curtailment of renewable energy.

- Good renewable resource mix;
- High electricity costs; and
- Grid issues.
- Provide unique opportunity for validation and deployment of new renewable and enabling technologies.
Approach: Energy Roadmapping/Technology Validation

FOUR-STEP PROCESS TO EVOLVE ENERGY SYSTEMS:

Step 1: Develop and validate rigorous analytic models for electricity and transportation

Step 2: Develop and model scenarios for deployment of new energy systems including additional renewables

Step 3: Identify and analyze mitigating technologies (DSM, storage, Smart Grid, advanced controls, forecasting, future gen) to address systems integration (grid stability) and institutional issues.

Step 4: Conduct testing and evaluation to validate potential solutions to facilitate utility acceptance
Approach: HNEI & GE Modeled Electrical Infrastructure

- Transient Performance (PSLF™)
  - Full network model, incorporating generator governors and AGC;
  - Transient Stability Simulation;
  - Long-Term Dynamic Simulation.

- Production Cost (MAPS™)
  - Representation of dispatch and unit commitment rules;
  - Hour-by-hour simulation of grid operations for a full year;
  - Yields cumulative fuel usage, emissions, variable cost.
Approach: Frequency Variability due to Wind Fluctuation used as Initial Test of Model

- 100 to 200 MW w early evening peak
- 30 MW wind
- 30 MW unregulated geothermal
- Significant and growing photovoltaics

Frequency (Hz)

Apollo Wind Farm (MW)
Approach: Models indicate that modest energy storage can mitigate negative effects of high wind penetration.

Significant Wind Fluctuation on May 23rd 2007

Frequency Comparison

- No storage
- Storage (1 MW, 60 seconds)
- Storage (1 MW, infinite)
Approach: Utilize Hydrogen Energy Systems as a Grid Management Tool

- Demonstrate the use of electrolyzers as a grid management tool to mitigate the impacts of intermittent renewable energy;
- Characterize performance/durability of commercially available electrolyzers under dynamic load conditions;
- Provide hydrogen to fuel hydrogen shuttle buses for local community bus service operated by County of Hawaii Mass Transit Agency; and
- Conduct performance/cost analysis to identify benefits of integrated system including grid services & off-grid revenue streams.
Approach

Phase 1
US DOE Funds

Hydro

Geothermal

Wind

Electolyzer

Ramp Up (Loss of Load)

Ramp Down (Loss of Gen)

O2 Storage

Oxygen

Hydrogen

H2 Storage

Controllable Variable Load

Electrolyzers
- PEM
- Alkaline

- Ramp Up
- Steady State
- Ramp Down

Provides 2 Services
- Down Regulation
- Up Regulation

Different Characteristics lead to different Service

Battery

Fast Response
- Fuel Cell
  - Depends on type
- Reserve

Medium Response
- Steam Turbine
  - Reserve

Slower Response
- ICE Gen
  - Reserve

Vehicles
- Value Add
- Large Medium-Term Market

NH3 Fertilizer
- Value Add
- Large Near-Term Market

Emergency B/U FC
- Value Add
- Large Near-Term Market

HNEI
Harvesting New Energy Institute
University of Hawaii at Mānoa
Project Site

PGV Site
✓ Greenfield with access to critical utilities;
✓ 1 acre site
Updated Project Schedule

Task #1: Develop Memorandum of Agreement & Contracts with Key partners (PGV, MTA): April 2012.  
Took longer than planned. Has delayed other tasks.

Task #2: Define System Requirements: Dec 2010.  Completed

Task #3: Select Supplier for Hydrogen System for delivery August 2012:  Contract Issued February 2012. Took longer than planned.

Task #4: Complete PGV and MTA Site Infrastructure, Sep 2012

Task #5: Install & Commission Hydrogen System, Sep 2012

Task #6: Procure Shuttle Bus, Sep 2012

Task #7: Operate Hydrogen System, start October 2012

Task #8: Outreach & Education: Ongoing
Task #1 Develop MOAs and Contracts
80% complete

✓ Develop legally binding agreements from all parties before making major financial commitments;

✓ Puna Geothermal Venture:
  ➢ Confirm power free: Confirmed
  ➢ Confirm host site availability: Confirmed
  ➢ Develop MOA – 95% complete. Took longer than planned.

✓ County of Hawaii Mass Transit Agency:
  ➢ Confirm MTA host site availability, agree upon bus operations, develop maintenance commitments: Confirmed

✓ Hydrogen Production System Operator – final negotiations underway for third party operation of hydrogen/fueling plant. 80% complete.

✓ Complete Environmental Assessment. This is a State of Hawaii requirement if utilizing state $$. Underway.
Task #2: Hydrogen System Requirements Completed

✓ Fully automated for remote monitoring, data acquisition, and control;
✓ Redundant fail-safe safety systems;
✓ Category 4 earthquake resistance;
✓ Highly corrosive salt air coastal environment;
✓ Hydrogen Production:
  - PEM or alkaline electrolysis with minimum 60 kg/day operated continuously at full capacity;
  - High purity hydrogen (SAE J2719) for engine and fuel cell use;
  - Dynamic Operation (frequent cycles up to 30% capacity, intermittent (2 per day) up to 80% capacity, one minute ramp rate;
  - Ability to control cycling directly or via grid frequency;
  - Lightweight hydrogen tube trailers for easy transport on narrow roads. Permanent on-site storage utilizing “spoolable” plastic pipe (subject to funding);
  - Compression consistent with maximum pressure of selected light-weight tube trailers (i.e. 350 bar or less).
✓ Mobile fueling station incorporating fueling dispenser & compressor.
Task #2: Hydrogen System Concept Design Completed
Approach: Hydrogen Supply

- Geothermal Powered Hydrogen Production
- Hydrogen Dispensing under Grid Management Program
- Hydrogen Delivery Trailer uses unique cascade fill process that required no onsite compressor
- H2-fueled shuttle buses
- Hydrogen Dispensing under Hawaii Power Park Program
- Geothermal Powered Hydrogen Production
Tasks 3 and 4

• Task 3: Procure H2 Production/Delivery/Dispensing
  ✓ RFP for turn-key integrated system including dispenser to insure system compatibility: Completed
  ✓ Select vendor for August delivery: Contract Awarded
  ✓ Supplier to offer complete product liability and indemnification insurance coverage. Completed
  ✓ Additional Hydrogen Delivery Trailers: Contract Awarded

• Task 4: Install Site Infrastructure
  ✓ HNEI to issue contract for site infrastructure upon award of hydrogen system; Started
  ✓ Permitting not expected to be issue at site.
Task #5: Install & Commission Hydrogen System

✓ HNEI will provide coordination between infrastructure contractor and hydrogen system supplier;
✓ Hydrogen systems modular & containerized for ease of installation; and
✓ Acceptance testing included in hydrogen system award.
Task #6: Procure Shuttle Bus

✔ Ford buses not available within project timeline.
  ➢ Leveraging HAVO FCEV hybrid buses based on El Dorado 19 passenger bus
  ➢ Bus conversion by HCATT. NRE by Air Force Research Laboratory ~ $750k savings to project.
  ➢ State of Hawaii Barrel Tax funds ($500k) used to pay for conversion.
  ➢ Reduced to 1 bus.

✔ Develop a “wrap” (graphics package) in accordance with DOE guidance.
  ➢ MTA, NRL & ONR need to be included to ensure recognition.

✔ First bus being converted by HCATT.

✔ This represents a significant project improvement by replacing H2 ICE bus with FCEV bus
Task #7: Operate PGV System

- Prepare test protocols:
  - Dynamic response;
  - Liaise with project partners, DOE, and NRL;
  - Invite HELCO to participate.

- Operate PGV system in accordance with protocols for 12 months.
  - Operation beyond 12 months depends on availability of funding and buses.

- Operate FCEV buses
  - Meet bus requirements;
  - Conduct hydrogen delivery and fueling operations.

- Collect & analyze data;
- Develop alternate uses for hydrogen;
- Prepare reports.
Technical Accomplishments & Progress

- Awarded contract to Powertech to supply Hydrogen Equipment;
- Started Environmental Assessment;
- Developed MOA with PGV;
- Awarded contract to Powertech for additional hydrogen delivery trailers;
- Developing site design with infrastructure contractor;
- Replaced Ford H2 ICE buses with El Dorado FCEV bus. Additional funding from State.
- Procured additional $1 million from State H2 Fund for site infrastructure;
- Procured additional $600k from ONR for overall project support including additional hydrogen delivery trailers.
Collaborations

✔ US Department of Energy: Project Sponsor & Funding;
✔ Office of Naval Research: Supplemental Funding;
✔ State of Hawaii: Cost Share;
✔ Naval Research Laboratory: Federal Technical Program Manager;
✔ Hawaii Natural Energy Institute: Implementing Partner, Technical Lead;
✔ Puna Geothermal Venture: Host Site, Provide Power and Water (Cost Shared);
✔ County of Hawaii Mass Transit Agency: Host Site, Bus Operator (Cost Shared);
✔ HELCO: Interested Observer, Potential Partner for Grid Analysis;
✔ HCATT: Conversion of shuttle bus.
Proposed Future Work

✓ Install hydrogen production infrastructure at PGV site;
✓ Install fueling infrastructure at MTA site;
✓ Install & commission hydrogen systems at PGV & MTA sites;
✓ Procure 1 El Dorado shuttle bus;
✓ Operate systems;
✓ Collect & analyze data;
✓ Prepare performance reports;
✓ If results show promise, apply for a phase 2 follow-on project that increases the size of electrolyzers.
Summary

✓ 5MW of electrolysis would produce approximately 600,000 kg hydrogen per year, ~1% total Hawaii gasoline usage, ~ 10% Big Island gasoline usage;

✓ Electrolysis of water to produce hydrogen could contribute significantly to Hawaii fuel usage while providing significant support for renewable intermittency;

✓ Performance & durability of electrolyzer under sustained cyclic operation needs to be validated;

✓ Detailed grid behavior with significant electrolysis needs to be validated via models; and

✓ Costs required to justify large scale electrolysis for fuel need to be determined.