2011 DOE Hydrogen and Fuel Cells Program Review

Hydrogen Energy Systems as a Grid Management Tool

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Project: MT008

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Overview

Timeline

✓ Project start date: 1 Sep 10
✓ Project end date: 30 Sep 12
✓ Percent complete: 25%

Budget

✓ Total project funding:
  ➢ DOE: $1,833,015
✓ Funding received in FY10:
  ➢ DOE: $915,515

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.
Energy Roadmapping/Technology Validation

Ongoing DOE/Industry funded effort to identify economically viable technologies to transform island energy infrastructures.

APPROACH: 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
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 (MAPSTM)
  - 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.
Frequency Variability due to Wind Fluctuation used as Initial Test of Model (Big Island)

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

Apollo Wind Farm (MW)

Frequency (Hz)
Models indicate that modest energy storage can mitigate negative effects of high wind penetration.
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 2 Ford E450 IC 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.
Project Site

PGV Site
✓ Greenfield with nearby access to critical utilities;
✓ Project site is rectangular, 43,000 sq ft;
✓ Access to the lot is via an asphalt road from the main county road shown at the top of the drawing.
Project Schedule


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

Task #3: Select Supplier for Hydrogen System for delivery August 2011: Completed

Task #4: Complete PGV and MTA Site Infrastructure, Sep 2011

Task #5: Install & Commission Hydrogen System, Sep 2011

Task #6: Procure Ford Shuttle Buses, Sep 2011

Task #7: Operate Hydrogen System, through Sept 2012

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

- Develop legally binding agreements from all parties before making major financial commitments;
- **Puna Geothermal Venture:**
  - Confirm power free: **Confirmed**
  - Confirm host site availability: **Confirmed**
- **Ford Motor Company:**
  - Finalize terms & conditions for supply of buses including insurance & liability requirements: **Underway**
- **County of Hawaii Mass Transit Agency:**
  - Confirm MTA host site availability, agree upon bus operations, develop maintenance commitments: **Confirmed**
- **Hydrogen Production System Operator** – preliminary negotiations underway for third party operation of hydrogen/fueling plant.
Task #2: Hydrogen System Requirements

- 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
Hydrogen Supply

Hydrogen Dispensing under Grid Management Program (MT008)

Hydrogen Delivery Trailer

Hydrogen Dispensing under Power Park Program (TV009)

Geothermal Powered Hydrogen Production (MT008)
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: Selected
  ✓ Supplier to offer complete product liability and indemnification insurance coverage. Completed

• Task 4: Install Site Infrastructure
  ✓ HNEI to issue contract for site infrastructure upon award of hydrogen system; and
  ✓ 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 2 Ford Buses

✓ Ford and Hawaii County MTA execute MOA prior to ordering buses;
  ➢ Ford insurance requirements;
  ➢ MTA must take Ford training courses;
  ➢ Need to ensure that MTA maintenance facility properly set up in accordance with Ford requirements.

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

✓ Timing of lease - coordinate arrival of buses with commissioning of hydrogen system so 1-year lease coincides with on-site H2 production system acceptance.
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 Ford buses
  ➢ Meet bus requirements;
  ➢ Conduct hydrogen delivery and fueling operations.

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

✓ Developed system requirements;
✓ Developed concept system design;
✓ Prepared & issued RFP for supply of the hydrogen system;
✓ Conducted bidders conference;
✓ Bids received and evaluated;
✓ Supplier selected; and
✓ Developing site design with infrastructure contractor.
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;
✓ **The Gas Company**: Interested system operator.
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 2 Ford buses E-450 shuttle buses;
✓ 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.