Hawaii Hydrogen Power Park

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Objectives

- Demonstrate an integrated hydrogen power park comprised of the following:
  - Electrolyzer powered by a renewable energy source,
  - Hydrogen storage and distribution system,
  - Proton exchange membrane (PEM) fuel cell connected to the grid & building, and
  - Optional hydrogen-fueled vehicle dispensing system;
- Demonstrate hydrogen as an energy carrier;
- Investigate interface issues with grid and buildings;
- Identify codes & standards required to site a power park;
- Identify barriers to a hydrogen infrastructure;
- Educate local authorities on hydrogen technologies;
- Prepare an economic analysis of hydrogen infrastructure development;
- Generate public interest and support.

Technical Barriers

This project addresses the following technical barriers from the following sections of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year R,D&D Plan:

<u>Hydrogen Production</u>

- T. Renewable Integration

<u>Off-Board Hydrogen Storage</u>

- U. Codes and Standards
- V. Life Cycle and Efficiency Analysis

<u>Technology Validation</u>

- B. Hydrogen Storage
- C. Hydrogen Refueling Infrastructure
- E. Codes and Standards

- H. Hydrogen from Renewable Resources
- I. Hydrogen and Electricity Co-production

Education

- A. Lack of Awareness
- B. Lack of Demonstrations or Examples of Real World Use
- C. Institutional Barriers and Access to Audiences

Approach

Sequence of steps used to conduct the research:

Phase 1

- Design the Hawaii Power Park System proceeding from conceptual design, to detailed design, to final design;
- Map out the permitting processes and develop a permitting plan;
- Educate the local permitting authorities and prepare a community outreach plan;
- Procure and test the individual system components at the Hawaii Fuel Cell Test Facility ("FCTF") located in Honolulu, including use of a UTC single-cell PEM fuel cell;
- Procure initial fuel cell module;
- Procure and install the data acquisition system;
- Develop the Power Park systems model.

Phase 2

- Procure additional fuel cell power system modules;
- Obtain all necessary permits to relocate to the Natural Energy Laboratory Hawaii Authority (NELHA) Distributed Energy Resources (DER) Center;
- Complete necessary site improvements to receive equipment;
- Ship system from FCTF to NELHA DER Center;
- Interface the system with the commercial building and the utility grid;
- Add new systems, high pressure storage, renewable electrolyzer systems as funding allows;
- Conduct community education & outreach program;
- Conduct initial engineering cost & performance analysis.

Phase 3

- Prepare test plans & procedures;
- Conduct experiments, analyze the data and prepare reports;
- Develop a business case for hydrogen;
- Prepare an overall project Final Report.

Accomplishments

- Permits for FCTF system development site issued;
- Electrolyzer delivered, installed and commissioned at the Hawaii FCTF;
- Prototype hydrogen gas distribution panels designed, installed and operated;
- Candidate site selected subject to negotiation of a satisfactory lease agreement;

- Negotiations initiated for procurement of first 5-kW PEM fuel cell module from UTCFC;
- Interactive project management web site developed.

Future Directions

- Continue in accordance with the project plan;
- Seek new partners to expand test bed capabilities for hydrogen technologies.

Introduction

Distributed power generation is increasingly viewed as an important component of the future electrical energy supply in the United States. A "Hydrogen Power Park" is a distributed power system comprised of locally available energy sources such as natural gas or renewable electricity generated by wind, geothermal or solar. The natural gas is reformed to produce hydrogen. The renewable electricity powers an electrolyzer to produce hydrogen. The hydrogen is stored and then used in a fuel cell or an environmentally acceptable hydrogen or hydrogen/natural gas internal combustion engine (ICE) to generate electricity to power a building complex or industrial facility. The hydrogen could also be used to fuel automobiles equipped with fuel cells or hydrogen internal combustion engines. As hydrogen technologies become competitive with conventional energy technologies, the "Hydrogen Power Park" concept is considered by the DOE to be an important step towards developing the viability of using hydrogen as an "energy carrier" in distributed power generation applications.

In addition to the technical barriers being addressed through RD&D in laboratories for specific components of a hydrogen system, there are obstacles to successful implementation of fuel cells and the corresponding hydrogen infrastructure that can only be addressed by integrating the components into complete systems. To have confidence in these technologies, they must work as designed in "real world" systems. Power Park projects are part of the validation process. They are comprised of the most current technologies and operated in a real-world environment. A by-product of this approach to technology validation is that technical and system problems are revealed, and component requirements can be better evaluated.

Approach

Our project approach was to first assemble a very strong public/private team whose members support the Power Park's objectives and have relevant hydrogen expertise to bring to the project.

Our project team organization is illustrated in Figure 1. Our project partners include those companies that are responsible for supporting infrastructure for conventional fuels, electricity, and utility gas. Their participation will ensure that issues critical to integrating hydrogen systems within the existing fuels and electricity delivery infrastructure are considered. The roles and interests of the team members are as follows:

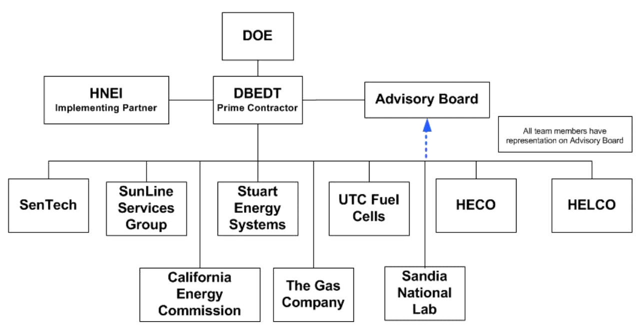

Figure 1. Project Team & Organization

State of Hawaii - Hawaii Department of Business, Economic Development and Tourism (DBEDT):

- DBEDT provides state leadership to the introduction of a hydrogen infrastructure in the State of Hawaii and to bringing hydrogen systems into the marketplace. Through the implementation of this project, the state envisions the creation of a "living laboratory" that will allow the state to address a number of issues to overcome impediments for the utilization of DER systems and hydrogen development.

- DBEDT is the Prime Contractor.
- DBEDT provides overall program coordination and is a cost share partner.

Hawaii Natural Energy Institute, University of Hawaii (HNEI):

- HNEI, a research unit within the School of Ocean & Earth Science & Technology (SOEST) at the University of Hawaii Manoa, has been an active participant in DOE's Hydrogen Program since 1986 and, in 1996, was named a DOE Center of Excellence for Hydrogen Research & Education.
- HNEI is the Implementing Partner to execute the project on behalf of DBEDT.

Sentech:

- SenTech is a Washington DC consulting company that provides technical and economic analysis, education and outreach, and project management support to the DOE Hydrogen, Fuel Cells and Infrastructure Technologies Program.

UTC Fuel Cells (UTCFC):

- UTCFC has a long history of commercializing fuel cells and is considered by many to be the premier U.S. fuel cell company in both stationary and transportation applications.
- UTCFC will supply fuel cell systems and engineering support for installation and evaluation.

Stuart Energy Systems:

- Stuart is a major developer and supplier of electrolyzers and has an extensive program to develop electrolyzers powered by renewable energy sources. This project provides a venue for testing and demonstrating their products in a real world environment.
- Stuart is providing significant cost share.

Hawaii Electric Light Company (HELCO):

- HELCO is the electric utility on the Big Island. HELCO is a subsidiary of HEI, which is the holding company for the electric utilities on Oahu, Maui and the Big Island.
- HELCO shall provide engineering and staff expertise in the permitting process and design of the interconnections between the grid, the electrolyzer, the fuel cell power system and the commercial test building.
- HELCO shall utilize the existing utility consumer education programs to provide an outreach medium for the Power Park project.

Hawaiian Electric Company (HECO):

- HECO is the electric utility for the island of Oahu and is the largest of the Hawaiian electric utilities.
- As part of its ongoing interest in and support of renewable energy projects, HECO has agreed to participate in the Power Park project and is providing engineering and staff time to review system designs on a cost share basis.

The Gas Company (GasCo):

- GasCo is the gas utility for Hawaii. It supplies Synthetic Natural Gas (SNG) to parts of Oahu and propane to the remainder of Oahu and the neighbor islands;
- GasCo is supplying low pressure hydrogen storage tanks and related engineering and permitting expertise.

SunLine Services:

- SunLine is providing engineering and staff time to transfer its expertise in the permitting process, community outreach programs, and design of a hydrogen infrastructure.
- Participation in design review meetings to be conducted on the Big Island to provide valuable "Lessons Learned" and technology transfer from the SunLine experience.

California Energy Commission (CEC):

- CEC has an interest in supporting the introduction of hydrogen infrastructure and DER in California. The Hydrogen Power

Park provides the opportunity to leverage CEC resources in a dedicated test bed that is available to conduct projects of specific interest to CEC and California utilities at a fraction of the cost of establishing a similar facility.

Sandia National Laboratory Livermore (SNLL):

- SNLL is a recent addition to the Hawaii Hydrogen Power Park team.
- SNLL is developing flexible systems that can be quickly adapted to provide engineering analysis of advanced power parks for production of both hydrogen and electricity.

The complete Power Park Project spans three years and is divided roughly into three 1-year phases which closely match the expected cash flow. The design of the system shall provide the flexibility to add components and new technologies as desired by existing and new partners. The "Hawaii Hydrogen Power Park" conceptual design is illustrated in Figure 2. The diagram shows an optional wind hydrogen system, an optional reformer system and an optional fuel dispensing system for transportation systems. While the initial project called for the testing of a PEM fuel cell system, an internal combustion engine running on hydrogen or a hydrogen rich mixture is an option of interest to the CEC and GasCo. The optional systems are subject to the availability of additional project funding.

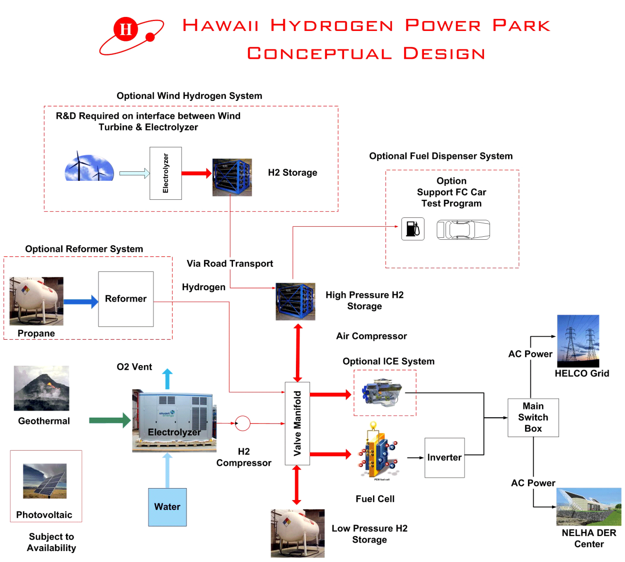

Figure 2. Hawaii Power Park Conceptual Design

Project Implementation. Due to funding cash flow availability, Phase 1 was subdivided into two phases 1A & 1B. Phase 1A constitutes the design phase of the project and extends until October 2003. Phase 1B constitutes the procurement and assembly of the hydrogen production and storage systems and the first fuel cell module. Phase 1B extends until approximately June 2004 and overlaps with Phase 1A. In Phase 1A, the overall Power Park system shall be designed, starting with a conceptual design and going through progressively more detailed iterations resulting in a final design. The hydrogen production and storage system required to support the fuel cell and systems testing will be assembled and tested in Phase 1B at the Hawaii Fuel Cell Test Facility (FCTF) site in Honolulu. The hydrogen during this initial phase will be produced from a grid-connected Stuart Energy Systems electrolyzer. The first fuel cell module will also be procured and integrated into the hydrogen system at the FCTF site during Phase 1B. Identifying and resolving safety and permitting issues are also critical Phase 1 tasks. Analytical tasks in Phase I will focus on defining the power requirements for the Power Park and calculating the costs of hydrogen from the various primary energy options (solar, wind, geothermal etc.).

In Phase 2, the primary emphasis will be on installing and demonstrating the hydrogen and fuel cell systems at the Gateway Center facility. Funding permitting, we will expand and diversify the hydrogen production technologies by adding a second electrolyzer connected directly to a wind turbine at a Big Island wind farm and transport the hydrogen by means of high pressure tanks to the Power Park site. The system will be modular (trailer or skid-mounted) and portable so that it can be moved to other renewable energy source sites on the Big Island and to other Hawaiian islands.

Phase 3 will consist of a series of system experiments for system optimization, market development activities and an expansion of the education and outreach program. A series of studies and analyses will be performed to evaluate system

Figure 3. Stuart Energy Systems Electrolyzer at the FCTF

design differences between automotive and stationary applications.

Results

The project is in the early stages of designing and assembling the system. To date we have prepared a conceptual design of the Power Park and are working on the detailed design. The electrolyzer, a long lead item, has been delivered to the FCTF and has been commissioned. The electrolyzer is pictured in Figure 3. We have also gone through the process of permitting the FCTF site and have received the permits. This experience will help in the permitting process required by the County of Hawaii on the Big Island. We have assembled a high pressure gas storage system and connected the electrolyzer hydrogen output. Negotiations are currently underway for the supply of the first PEM fuel cell module, which will be tested at the FCTF.

Conclusions

- This project is in the formative stage and no conclusions can be drawn at this time.

FY 2003 Publications/Presentations

1. Poster presentation at the 2003 Hydrogen & Fuel Cells Merit Review Meeting - 19-22 May 2003 at Berkeley California