VIII.B.2 DTE Energy Hydrogen Technology Park

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Projected End Date: July 31, 2006

Objectives

Discover and document whether the power park concept is technically and economically viable as a clean energy system, and if so, under what operating and market conditions. Specific objectives include:

- Develop and test a hydrogen co-production facility having stationary fuel cell power and vehicle fueling capability using renewable and non-renewable resources
- Employ representative commercial units under real-world operating conditions
- Based on performance data, project experiences, and market assessments, evaluate the technical and economic viability of the power park system
- Contribute to development of relevant safety standards and codes required for commercialization of hydrogen-based energy systems
- Identify system optimization and cost reduction opportunities including design footprint, co-production, and peak-shaving applications
- Increase public awareness and acceptance of hydrogen-based energy systems

Technical Barriers

This project addresses the following technical barriers from the Technology Validation section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration (RD&D) Plan:

- C. Hydrogen Refueling Infrastructure
- E. Codes and Standards
- H. Hydrogen from Renewable Resources
- I. Hydrogen and Electricity Coproduction

Contribution to Achievement of DOE Technology Validation Milestones

This project will contribute to achievement of the following DOE technology validation milestones from the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year RD&D Plan:

- By 2008, validate an electrolyzer with capital cost of $600/kWe and efficiency of 68% (including compression to 5,000 psig), when built in quantities of 1000;
- By 2008, develop a distributed generation proton exchange membrane (PEM) fuel cell system that achieves 32% electrical efficiency and 20,000 hours durability at $1500/kW.

Approach

- Design, install, and operate an integrated hydrogen co-production facility utilizing electrolytic hydrogen production, on-site gas storage, stationary fuel cell power generation, vehicle dispensing, on-site renewable solar energy and grid-connected biomass energy.
- Collect, analyze, and report system performance data and lessons learned for an integrated co-production facility operating under real-world conditions.
- Evaluate opportunities to reduce system costs and optimize performance through methods like peak shaving and the integration of power and transportation applications into a common infrastructure.
- Evaluate commercialization opportunities for an advanced Power Park facility.

Accomplishments

- Installed system and commenced operations
- Developed and conducted site acceptance tests (SATs)
- Employed representative commercial units operating under real world conditions
- Implemented remote monitoring and control system
- Commenced data collection, analysis, and reporting activities
- Began assessment of system technical performance and economics
- Enhanced the public awareness program with special events, tours, and project video
- Integrated the site into the DOE Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project (FY05-FY08)

Future Directions

- Complete system commissioning
- Operate system to support data collection and analysis, system optimization, and achievement of DOE program milestones
- Continue education and outreach activities
- Continue hydrogen codes and standards efforts
- Assess system performance and develop technical report
- Assess system economics and business case
- Transfer project to DOE Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project (FY05-FY08)

Introduction

Given the potential for the commercialization of hydrogen as a replacement energy carrier for fossil fuels, this demonstration project, which models an end-to-end renewable hydrogen energy system, is intended to provide meaningful information into the technical and economic challenges of realizing a hydrogen-based economy.

Approach

This project develops, installs, and operates a hydrogen co-production facility capable of delivering

500 kWh/day of on-site electricity and 15-kg/day of compressed hydrogen for vehicle refueling. The integrated system approach provides opportunities to reduce costs and optimize performance, including the integration of power generation and transportation applications into a common infrastructure. By incorporating the most commercially representative units into a complete system operating under real world conditions, this approach is designed to validate system and component technical targets and provide feedback to the Department of Energy as to the commercial viability of hydrogen energy systems.

Results

A number of key milestones were reached over the last year, resulting in the achievement of a primary project objective: installation and operation of an integrated hydrogen co-production facility (Figure 1).

During initial and follow-on system testing, several problems with vendor-supplied equipment were identified that required correction before system commissioning could be accomplished. These included: 1) hardwired safety system (HWSS) not supplied as control reliable; 2) diaphragm compressor mounting unsound; 3) electrolyzer control system code not reliable; and 4) electrolyzer heat management systems not properly engineered.

As a consequence of these and other problems, equipment and system modifications were made that resulted in the need for developing new, comprehensive SATs. Subsequently, SATs were completed for major systems and components including: 1) system integrity and pressure testing; 2) HWSS validation; 3) system equipment (excluding the electrolyzer); and 4) site support systems (Figure 2). Electrolyzer testing has been partially completed, with final testing scheduled for October 2005 once heat management issues are resolved.

System acceptance testing notwithstanding, full system functionality per project objectives and statement of work has been demonstrated. The system is capable of producing 60 kg/day of 99.995% pure hydrogen using a combination of on-site solar and grid power. In addition, the system is capable of generating 500 kWh/day of emission-free electricity using installed fuel cell generators and dispensing 15 kg/day of compressed hydrogen @ 5000 psig for vehicle refueling. Early performance data has been encouraging, with the project already achieving 37.6% measured efficiency on the stationary fuel cells, exceeding the 2008 efficiency target of 32%.

To the extent possible, representative commercial units have been employed. However, the components, and system as a whole, should be considered prototypical vs. commercial, as indicated by the need for significant modifications/re-engineering once on-site to support the intended use.

System implementation included development, validation, and testing of a web-based integrated data acquisition, control and safety system (Figure 3). This system is capable of: 1) remotely monitoring

Figure 1. DTE Energy Hydrogen Technology Park, Southfield, MI

Figure 2. Dispenser Hose Breakaway Release Site Acceptance Test

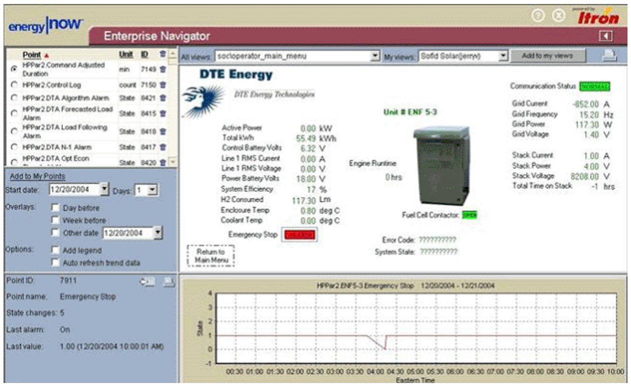

Figure 3. Web-Based Data Acquisition, Control and Safety System

and recording all relevant system parameters including equipment runtimes, power consumption, hydrogen mass produced and consumed, component and system efficiencies, and alarms and warnings; 2) remotely starting and stopping individual system components; and 3) initiating automatic emergency shutdowns should certain system conditions occur.

A comprehensive data collection, analysis, and economic assessment project was begun with unique, yet complementary, approaches for our academic partners. Lawrence Technological University (LTU) is leading system performance and optimization analysis; a University of Michigan master's project team is leading the market assessment and economic modeling work; and Sandia National Laboratories is working with LTU to model the system from first engineering/scientific principles.

Extensive safety reviews were also conducted. In addition to FMEA and HAZOP reviews for vendor-supplied equipment, a Hazard Identification and Quantitative Risk Assessment were conducted, sponsored by our project partner BP. This involved a site level review of the system to identify potential hazards, followed by quantitative modeling of those hazards considered most significant. Key lessons learned from all reviews were shared with the DOE Safety Panel during its recent visit.

Over the last year, there was a concerted effort to increase public awareness of the activities DTE Energy and its partners have undertaken in this area. In June 2004, a groundbreaking event was held, with coverage from local media and speeches from DTE Energy's CEO and the mayor of Southfield, MI. In October 2004, a site dedication event was held,

Figure 4. DOE Controlled Hydrogen Fleet and Infrastructure Demonstration Project

which was attended by approximately 100 guests and featured Acting Undersecretary David Garman as the keynote speaker. Also, a 25-minute project video meant for general audiences was developed. The video provides a background on the evolution and use of energy, leading to the current interest in hydrogen as an energy carrier.

The project has now been integrated into the DOE Controlled Hydrogen Fleet and Infrastructure Demonstration project with our new project partners BP and DaimlerChrysler (Figure 4). A dedicated site customer has been secured and regular fueling begun. In addition, coordinated emergency response plans have been developed and safety reviews conducted. Infrastructure data templates and technical reports are being submitted quarterly per project plan (including safely incidents).

Conclusions

The project has already achieved four of six main project objectives and has made excellent progress on the remaining two. In the coming year, planned activities include:

- Complete system commissioning
- Operate system to support data collection and analysis, system optimization, and achievement of DOE program milestones
- Continue education and outreach activities
- Continue hydrogen codes and standards efforts
- Assess system performance and develop technical report
- Assess system economics and business case

- Transfer project to DOE Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project (FY05-FY08)

With the integration of this project into the DOE Controlled Hydrogen Fleet Demonstration Project (FY05-FY08), the project will continue its work toward achieving the 2008 DOE milestones noted earlier. At this point, we expect that all original project objectives will be achieved, including the primary objective of discovering and documenting whether the power park concept is technically and economically viable as a clean energy system, and if so, under what operating and market conditions.

FY2005 Presentations

1. R. Regan, "DTE Energy Hydrogen Technology Park," SAE Government/Industry Meeting, Washington, DC (May 2005)
2. R. Regan, "DTE Energy Hydrogen Technology Park," Alternative Energy Symposium (St. Clair County Community College), Port Huron, MI (April 2005)
3. R. Regan, "DTE Energy Hydrogen Technology Park," Rochester Institute of Technology, Rochester, NY (April 2005)
4. R. Regan, "DTE Energy Hydrogen Technology Park," University of Michigan Concentration in Environmental Sustainability Program, Ann Arbor, MI (April 2005)
5. R. Regan, "DTE Energy Hydrogen Technology Park," 2004 Waste Reduction & Energy Efficiency Conference, Livonia, MI (October 2004)
6. R. Regan, "DTE Energy Hydrogen Technology Park," DOE Electrolysis-Utility Integration Workshop, Broomfield, CO (September 2004)