VI.C.1 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 (Figure 1) having stationary fuel cell power and vehicle fueling capability (Figure 2) 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 (3.5.4.2) 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 Technology Validation section of the Hydrogen, Fuel

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

FIGURE 2. Hydrogen Dispenser, 5,000 psig

Cells and Infrastructure Technologies Program Multi-Year RD&D Plan:

Milestone 6: Validate vehicle refueling time of 5 minutes or less (4Q2006)
Fuel cell vehicles are being refueled on a consistent basis at the DTE Energy Hydrogen Technology Park. The average refueling time from January through June 2006 has been less than 5 minutes. Although this refueling time is within the 5 minute target, for consistent, customer friendly operation, a target of less than 3 minutes is desirable, even as filling volumes increase. With new technologies including pre-cooling and proper communication between the dispenser and vehicle, it is expected that this refueling time can be maintained or reduced.

Milestone 11: Validate cost of producing hydrogen in quantity of $3.00/gge untaxed (1Q2006)
The DTE Hydrogen Technology Park generates hydrogen with the use of an electrolyzer powered by electricity from a combination of grid and renewable sources. Economic analysis of the cost of hydrogen produced from off-peak grid power has been performed using the DOE H2A economic model. This analysis was based on 2006 costs with no scaling for the economies expected from high volume manufacturing of equipment.

Milestone 15: Validate co-production system using 50 kW PEM fuel cell; hydrogen produced at $3.60/gge and electricity at 8 cents/kWhr (4Q2005)
The DTE Hydrogen Technology Park generates hydrogen with an electrolyzer powered by electricity from a combination of grid and renewable sources. Over 42 MWhr of electricity has been produced using a bank of 10, 5 kW proton exchange membrane (PEM) fuel cells and 175 kg of high purity hydrogen has been dispensed to vehicles. The operation of the site has been analyzed for optimization opportunities and economic analysis has been performed.

Accomplishments

- Operated an integrated hydrogen co-production facility utilizing:
  - Electrolyzer ($1,500/kWe), output 2.7 kg/hr, at 59% efficiency, 4200 kg produced.
  - PEM fuel cell bank ($5,000/kW), output 50 kW, 44% efficiency, 42 MWhr produced.
  - Vehicle dispenser (5000 psi), 175 kg dispensed.
  - Photovoltaic (PV) panels (27 kW), 46 MWhr total solar output, 394 kg hydrogen production.
- Operated site with no safety recordables.
- Reported technical and operating data to partners and NREL to meet all data reporting requirements.
- Assessed system technical performance and economics.
- Performed fueling interface failure mode effects analysis (FMEA).
- Enhanced public awareness program with special events and tours.
- Replaced TK-15 fueling nozzle (leakage detected) with WEH TK-16 H2 which meets the new SAE J2600 Standard.
- Negotiated with vendor for new electrolyzer.
- Continued codes and standards work with State of Michigan.
- Fully integrated project into the DOE Controlled Hydrogen Fleet and Infrastructure Demonstration program with our project partners BP and DaimlerChrysler.

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 providing meaningful information about 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 360 kWhr/day of on-peak electricity and 15-kg/day of compressed hydrogen gas 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 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

Key milestones and objectives have been reached, resulting in the achievement of the installation, operation and preliminary analysis of an integrated hydrogen co-production facility.

The system is capable of producing 40 kg/day of 99.995% pure hydrogen using a combination of on-site solar and grid power during off-peak hours. In addition, the system is capable of generating 360 kWhr/day of on-peak, emission-free electricity using installed fuel cells and dispensing 15 kg/weekday of compressed hydrogen @ 5,000 psig for vehicle refueling. Hydrogen production thermodynamic efficiency has been measured at 59% and fuel cell thermodynamic efficiency to alternating current power output has been measured at 44%. The site is capable of storing 138 kg of hydrogen and is designed to operate on a continuous weekly cycle.

System operation is performed with a web-based integrated data acquisition, control and safety system. This system is capable of: 1) remotely monitoring 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. In addition, an independent on-site alarm/security/video monitoring system is in 24-hour operation to enable remote observation and insure appropriate response to any un-authorized activity.

A comprehensive data collection, analysis, and economic assessment program is in place with unique, yet complementary, approaches from our academic partners. Lawrence Technological University (LTU) is leading the system data reporting effort and the performance optimization analysis. Sandia National Laboratories is working with LTU to model the system from first engineering/scientific principles. The University of Michigan has completed a master's team project with joint sponsorship from the School of Business and Natural Resources resulting in an economic model and market assessment.

The DOE H2A economic model has been employed to evaluate the cost of hydrogen production for a broad range of production volumes (Figure 3). This analysis utilized 2006 costs without the advantage of high volume manufacturing economies. The DOE goal of $4.75/kg may be achievable with lower equipment costs resulting from high volume manufacturing. Economics of the basic design and operating assumptions regarding off-peak hydrogen production have been examined utilizing real world electric rates. This analysis was performed by calculating the cost of hydrogen production for 24 hour operation versus the cost of hydrogen production for 16 hour per weekday, off-peak operation. The off-peak production scenario which lowers the overall energy cost required modeling higher capacity electrolysis equipment and more on site storage to meet daily utilization (hydrogen dispensing and consumption) requirements. The results of this analysis representing the calculated differential cost between 24 hour (continuous production), versus off-peak hour production are shown in Figure 4. This analysis shows that for high volumes a 50 cent per kilogram savings is achievable for limiting production to off-peak hours despite the increased costs for storage and electrolyzer capacity.

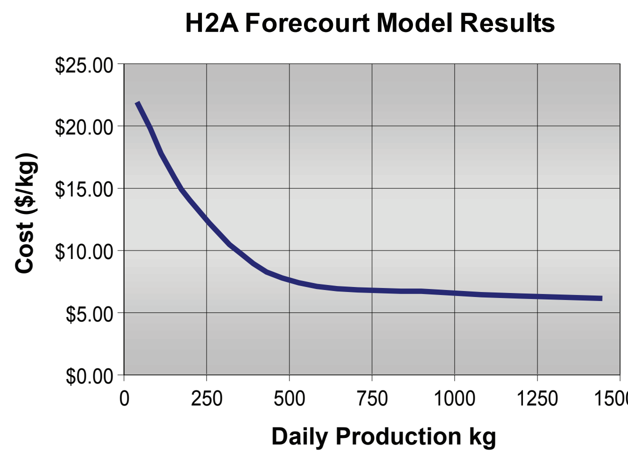

FIGURE 3. Cost of Hydrogen Production

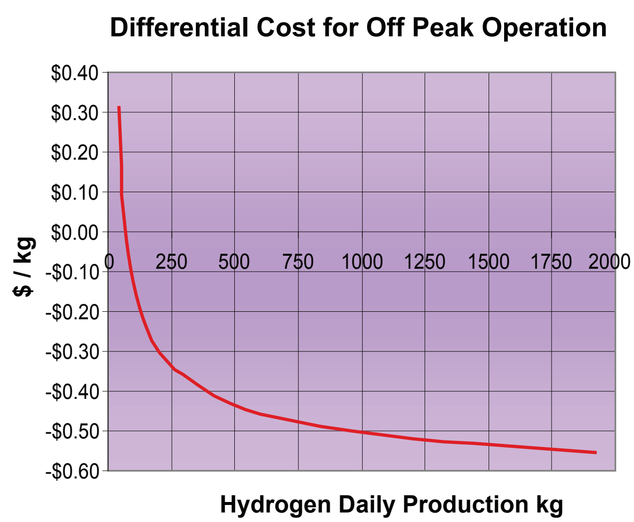

FIGURE 4. Cost Savings for Off-Peak Hydrogen Production

Extensive safety reviews have been conducted. In addition to previous FMEA and hazard and operability analysis (HAZOP) reviews for vendor-supplied equipment, and a Hazard Identification and Quantitative Risk Assessment, this year a FMEA of the hydrogen vehicle fueling interface was conducted. Key lessons learned from all reviews have been shared with partners and resulted in certain implementation plans. The project has been fully integrated into the DOE Controlled Hydrogen Fleet and Infrastructure Demonstration program with our project partners BP and DaimlerChrysler.

Conclusions and Future Direction

The project has already achieved or made significant progress toward all six main project objectives. In the coming year, planned activities include:

- Continue to operate system to support data collection and analysis, system optimization, and achievement DOE program milestones.
- Install replacement electrolyzer.
- Resurface fueling pad area.
- Continue education and outreach activities.
- Continue hydrogen codes and standards efforts.
- Continue to assess system performance.
- Develop technical report.
- Further analyze system economics and business case.
- Evaluate commercialization opportunities for an advanced power park facility.

It is expected 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. With the full integration of this project into the DOE Controlled Hydrogen Fleet Demonstration Project, the project will continue its work toward achieving the DOE milestones.

FY 2006 Presentations

1. R. Bacyinski, "DTE Energy Hydrogen Technology Park," Educators Workshop, DTE Energy, Ypsilanti, MI (August 2005).

2. R. Bacyinski, "DTE Energy Hydrogen Technology Park," Detroit Clean Cities Workshop for Michigan Fleets, Detroit, MI (March 2006).

3. R. Bacyinski, B. Whitney, "DTE Energy Hydrogen Technology Park," DOE Hydrogen RD&D Program Merit Review Meeting, Washington, DC (May 2006).

4. B. Whitney, "DTE Energy Hydrogen Technology Park," Institute of Science and Technology Meeting, West Bloomfield, MI (June 2006).