X.4 Fuel Cell Combined Heat and Power Industrial Demonstration

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Fiscal Year (FY) 2011 Objectives

The overall objective of this project is:

- To demonstrate combined heat and power fuel cell (CHPFC) systems in small commercial facilities.
- Assess the system performance of the demonstration systems.
- Document market viability of this class of fuel cells for small commercial facilities.

This objective is being accomplished by working with commercial fuel cell manufacturers and their partners to manufacture and install CHPFC systems for application and demonstration at several small industrial facilities.

Technical Barriers

This project aims to address technical and economic issues preventing the full commercialization of fuel cell systems (FCSs). This includes:

- Lack of long-term validated performance data for 5 kilowatt electric (kWe) to 100 kWe FCS
- Energy performance
- Durability
- Reliability
- Installation, operations, and maintenance costs

FY 2011 Accomplishments

We established baseline technical performance models, down-selected the most competitive projects and issued a final contract with ClearEdge Power to provide up to 38 fuel cells at up to 10 partner locations centered primarily in California and Oregon.

- The PNNL team conducted site visits and telephone calls with many FCS manufacturers to gain insight from manufacturers prior to generating the request for proposal (RFP).
- We established an open dialog with manufacturers regarding overall requirements for the RFP through the Fuel Cell and Hydrogen Energy Association.
- PNNL finalized Technical Requirements and Evaluation Criteria documents in which the technical proposal was worth 60 percent of the points, and the cost proposal was worth 40 percent of the points.
- The RFP was released in December, and proposals were due in early February.
- We established models of FCS cost and technical performance which was part of the technical proposal submittal.
- Decision to negotiate award ClearEdge Power from Portland, Oregon in March.
- PNNL and ClearEdge signed a contract in late May, 2011.

Introduction

Research and development progress has paved the way for fuel cells to enter the commercial market in applications including stationary power generation and propulsion for vehicles. Accelerating fuel cell use in these key early markets will create jobs in an industry that needs high volume purchases to ramp up production, decrease costs, support commercialization, and enable a domestic supplier base. Early markets will also greatly expand the growth of green jobs with new opportunities associated with manufacturing fuel cells and related hydrogen technologies, fuel cell maintenance and support systems, and hydrogen production, delivery, and storage. In addition, the success of these early markets will help the fuel cell industry overcome a number of non-technical barriers that also face the broader marketplace, including the lack of practical user operating experience, the lack of user confidence, and the inherent resistance to new technologies.

As stated above, the objective of this project is to demonstrate CHPFC systems in small commercial facilities and assess their performance to help determine and document market viability. This information is important for the DOE, the fuel cell community, and most importantly for small commercial facilities that have power and heat requirements for their operations. PNNL is working with commercial fuel cell manufacturers and their partners to

manufacture and install CHPFC systems for application and demonstration at several small industrial facilities. It is also our objective to work with the fuel cell manufacturers and industrial partners to obtain performance data on these systems over the course of several years. The information that is gathered, analyzed, and documented during these demonstrations will be used to benefit and bolster the domestic supply base, increase user confidence, compete in the market place in terms of value provided, and provide favorable reduced lifecycle cost, energy, and emission savings compared to incumbent technologies (e.g., lead acid batteries, combustion engines, or power/heat generators) without tax incentives and with a reasonable chance of approaching parity through short-term technology or mass production improvements. In addition, it is expected that we will gather and analyze "real-world" data from units "in the customer's hands" to validate performance, durability and reliability; installation, operations, and maintenance costs; and identify remaining barriers to widespread commercialization.

Approach

Our approach to the deployment of CHPFCS at small industrial locations was based upon the notion that the manufacturers of fuel cells know their customers and would propose deployments at locations that would meet the requirements set forth by PNNL. In addition, our approach is to have PNNL monitor and analyze the performance data resulting in the development.

First, we established a baseline model input for cost and technical performance of the fuel cell systems in order to have a common basis in which to evaluation the systems that will eventually be deployed. Several key data packages were included in the input that was categorized into three areas:

- Engineering performance of the installed systems.
- Financial performance of the FCSs including FCS cost, and the breakdown of cost elements.
- Environmental performance of each deployment including feedstock energy source, greenhouse gas emissions, other pollutants, and end-of-life plans (recycle).

Next we set out to acquire the fuel cell systems for demonstration. The acquisition process was conducted through an open competition in which both U.S. and foreign companies were solicited for proposals. While foreign competition was encouraged, all of the deployments were required to occur in the U.S. We required that the manufactures and the end-user demonstration sites would team together for this acquisition. As such, the industrial team would serve as the integrator for each demonstration. Also, as part of the procurement process, we required a minimum 50% cost share from the fuel cell manufacturer and end-user team for each deployment.

After the fuel cell manufacturers and their industrial partners were selected, the fuel cells would be deployed at each of the end-user industrial sites. At that point, we will initiate the continuous monitoring key parameters of the systems. Key parameters that we are planning on remotely monitoring include:

- Instantaneous and cumulative power generation.
- Grid voltage at the inverter.
- Power that is utilized by the facility as well as power that is exported to the grid.
- Internal cabinet temperatures.
- Heating and cooling temperatures of water as well as the flow rates.
- Heat exchanger cooling fan speeds.
- Exhaust temperature.
- Fuel inlet flow rate and cumulative fuel use.
- Heat generation rate and cumulative heat generated.
- Cumulative system time on load.
- System availability.

The last step in our approach is to analyze and document the performance data collected over at least a two-year period of each fuel cell system deployed. These analyses will include recommendations on the technical performance, economic performance, and the environmental performance. Based upon this information, a case will be presented on the viability of this class of fuel cells for light industrial applications.

Results

At this early point in the project, a contract has been signed with ClearEdge Power in Hillsboro, Oregon to manufacture and deploy fuel cells in Southern California, Northern California, and Oregon. The process of fielding these systems is occurring during the third and fourth quarter of FY 2011, and when the systems are commissioned, data collection and analysis will be initiated. At the time of this report, there are no technical results of real time monitoring available, nor has any analysis been conducted.

Publications/Presentations

1. Colella, WG, RJ Timme. "Thermodynamic and Chemical Engineering Models of Combined Cooling, Heating, and Electric Power (CCHP) Fuel Cell Systems (FCSs) using Absorption Chillers." American Society of Mechanical Engineers (ASME) Journal of Fuel Cell Science and Technology, expected 2011.

2. Colella, WG, RJ Timme., "Chemical Engineering Models of Combined Cooling, Heating, and Electric Power (CCHP) Fuel Cell Systems (FCSs): Part B – Electric Chillers." ASME Journal of Fuel Cell Science and Technology, expected 2011.

3. Colella, WG, RJ Timme, J Brouwer, NS Sammes. "Fuel Cell Efficiency can Exceed 50% at Peak Power." Journal of Power

Sources, 2011, in print, manuscript can be seen at http://dx.doi.org/10.1016/j.jpowsour.2011.02.061.

4. Colella, WG, SH Schneider, DM Kammen, A Jhunjhunwala, N Teo. 2010. "Optimizing the Design and Deployment of Stationary Combined Heat And Power (CHP) Fuel Cell Systems (FCS) for Minimum Costs and Emissions – Model Design (Part I of II)." ASME Journal of Fuel Cell Science and Technology 8(2), DOI:10.1115/1.4001756. Available online at http://tinyurl.com/4l3bwto.

5. Colella, WG, SH Schneider, DM Kammen, A Jhunjhunwala, N Teo. 2010. "Optimizing the Design and Deployment of Stationary Combined Heat And Power (CHP) Fuel Cell Systems (FCS) for Minimum Costs and Emissions – Model Results (Part II of II)." ASME Journal of Fuel Cell Science and Technology 8(2), DOI:10.1115/1.4001757. Available online at http://tinyurl.com/4akey74.

Oral Conference Presentations

1. Colella WG, R Timme, M Rinker. 2011. "Fuel Cells for Commercial Buildings." European Fuel Cell Forum, Lucerne, Switzerland, July 1st, 2011.

2. Colella, WG, R Timme, M Rinker. 2011. "Deployment and Independent Monitoring of Stationary Combined Heat and Power (CHP) Fuel Cell Systems (FCSs) in Light Commercial Buildings." ASME 9th Fuel Cell Science, Engineering, and Technology Conference, Washington D.C., Aug. 7th-10th, 2011.

3. Colella, WG, R Timme, M Rinker. 2011. "Independent Testing of Micro-Combined Heat and Power (CHP) Fuel Cell Systems (FCSs)." ASME 2011 Energy Sustainability Conference, Washington D.C., Aug. 7th-10th, 2011.

4. Colella, WG, R Timme, M Rinker. 2011. "Fuel Cell Combined Heat and Power Industrial Demonstration." U.S. DOE Hydrogen and Fuel Cells Program and Vehicle Technologies Program Annual Merit Review and Peer Evaluation Meeting, May 10th, 2011.

Invited Presentations

1. Colella, WG., Timme, R., Rinker, M., Independent Monitoring and Analysis of Stationary Combined Heat and Power (CHP) Fuel Cell Systems (FCSs) Deployed in Light Commercial Buildings, École Polytechnique Fédérale de Lausanne (EPFL) Seminar, EPFL, Laboratoire d'énergétique industrielle, Lausanne, Switzerland, June 27th, 2011.

2. Colella, WG., Timme, R., Rinker, M., Deployment of Micro-Cogeneration Fuel Cell Systems (FCSs) in Commercial Buildings, E4Tech Seminar, E4Tech, Lausanne, Switzerland, July 4th, 2011.

3. Colella, WG, M Rinker, J Holladay, C Baker, Carl. 2010. Combined Heat and Power (CHP) and Combined Cooling Heating and Electric Power (CCHP) Fuel Cell Systems (FCSs) for Light Commercial Applications. ClearEdge Inc., Portland, OR, Nov. 23rd, 2010.

4. Colella, WG, M Rinker, J Holladay, C Baker. 2010. Fuel Cells for Commercial Buildings. Webinar-linked presentation between Pacific Northwest National Laboratory, Richland, WA and the Fuel Cell and Hydrogen Energy Association Power Generation Working Group, Nov. 16th, 2010.