FuelCell Energy
World Leader in Ultra-Clean Power

Demonstration of a Fuel Cell Power Plant for Co-production of Electricity and Hydrogen

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Project Sponsors: DOE-EERE and Air Products and Chemicals, Inc.

Period of Performance: 2005-2009

Introduction

One of the immediate challenges in the development of hydrogen as a transportation fuel is finding the optimal means to roll out a hydrogen-fueling infrastructure concurrent with the deployment of hydrogen vehicles. To meet this challenge, distributed generation of hydrogen has been proposed as a potential sourcing solution. However, the low-volume hydrogen requirements in the early years of fuel cell vehicle deployment and the sporadic nature of vehicle fueling make the economic viability of stand-alone, distributed hydrogen generators particularly challenging. One significant challenge for fueling station developers will be minimizing the financial risk associated with stranded capital assets. A potential solution to this "stranded asset" problem is the use of hydrogen energy stations that produce electricity in addition to hydrogen. One such station concept that shows promise, as concluded by APCI and DOE, is the use of high-temperature fuel cells to co-produce hydrogen and electricity. This concept has the potential to meet the DOE hydrogen cost targets, while producing power for less than $0.10/kW. To validate this conclusion, a DFC-300 modified to allow for the separation and purification of hydrogen from the fuel cell anode exhaust using an Air Products-designed hydrogen purification system will be demonstrated. In addition to natural gas as a fuel, renewable digester gas fuel will be used for this demonstration for hydrogen co-production.

Objectives

Demonstrate the technical and economic viability of a hydrogen energy station using a high-temperature fuel cell designed to produce power and hydrogen from natural gas.

- Complete a technical assessment and economic analysis on the use of high-temperature fuel cells (HTFCs), including solid oxide fuel cells (SOFCs) and molten carbonate fuel cells (MCFCs), for the co-production of power and hydrogen from natural gas (energy park).
- Determine the applicability of HTFC co-production for the existing merchant hydrogen market and for the emerging hydrogen economy.
- Demonstrate the concept at a suitable site with demand for both hydrogen and electricity using natural gas and digester gas as fuels.

- Obtain adequate operational data to provide the basis for future commercial activities, including hydrogen-fueling stations.

Technical Targets

The overall objective is to demonstrate the use of a DFC-300 to produce power and electricity for a minimum of 6 months. This project will contribute to the achievement of key DOE technology validation milestones to demonstrate a prototype energy station for 6 months with a projected durability >40,000 hours, electrical energy efficiency >40% and an availability >80%. Current process projections put the electrical efficiency at 49%. Based on actual field performance data, both the durability and availability of the technologies selected for demonstration are expected to exceed the milestone values.

Results

Performance projections based on the design and component testing,as shown in Table 1, exceed APCI's preliminary estimates and supports the economic viability of the co-production system. Through innovative cycle design work and the selection of the optimal adsorbents, PSA recovery was improved to over 85% at 150-psig pressure. Achieving a higher recovery with less compression power significantly improves the economics of the co-production system.

	Units	Phase I	Phase II
Overall Efficiency (Net Power + Hydrogen Product) / (Fuel)	LHV	60% ⇨	66%
Power Efficiency Net Power / (Total Fuel – Hydrogen Product)	LHV	49%	49%
Hydrogen Efficiency (Hydrogen Product – Purification Power) / Hydrogen Product	LHV	68% ⇨	77%
Hydrogen Product	Nm3/hr	~ 40 ⇨	~ 80
Net Power w/o & w Hydrogen	kW	~ 247 / 207	~ 300 / 243
Natural Gas Flow	Nm3/hr	~ 55	~ 74

Table 1. Overall Performance Projection

A plot plan was developed using the preliminary process design and equipment specifications. A 3-D rendering of the proposed co-production system can be seen in

Figure 2. The footprint is approximately 50 ft x 50 ft. The entire system consists of skidded modules for ease of transportation, installation and maintenance.

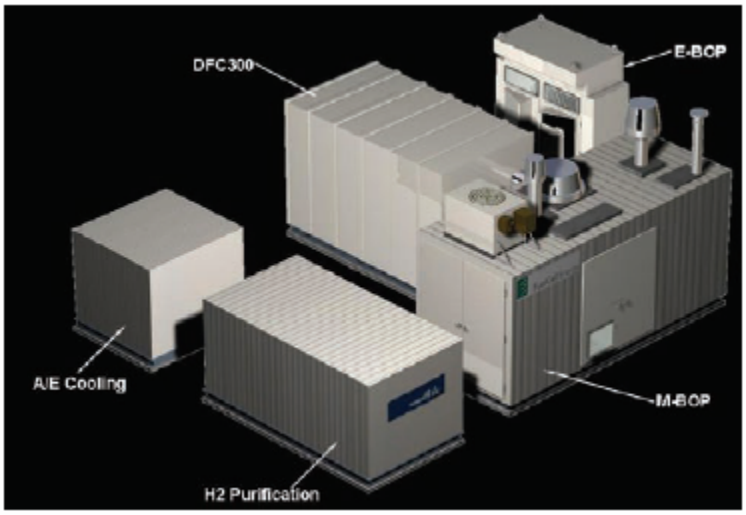

Figure 2. Energy Station Rendition

Detailed bottom-up cost estimates were completed for co-production systems using both the FuelCell Energy DFC-300 and DFC-1500 product lines. Costs for the major pieces of equipment and costs for fabrication are based on actual vendor quotes. The Air Products Construction group developed installation estimates. To match the fueling station criteria in DOE's Multi-Year program
Plan, two DFC-1500s would be required. In this configuration a total of 1,400 kg/day of hydrogen would be produced with a net power production from the fuel cell of 2.4 MW. Using H2A criteria with the Solid State Energy Conversion Alliance (SECA) capital cost targets for the fuel cell resulted in a hydrogen price of $1.63/kg. In this scenario power is being sold for 8 cents/kWh. It is important to

Figure 3. APCI Hydrogen Filling Station Rendition

note that the hydrogen price does not include the fueling station equipment. A graphical rendering of a Hydrogen Filling Station incorporating a DFC Co-production system is

shown in Figure 3. The expected electricity and hydrogen generation capacity using DFC power plants is given in Table 2.

DFC Power Plant	Electrical Output [kW]	Hydrogen Produced [lbs/Day]	Fuel Cell Fleet Vehicles Serviced [approx.]
DFC-300	250 kW	300	~300
DFC-1500	1000 kW	1,200	~1,200

* DOE-Air Products' Study

Table 1. Co-production of Hydrogen and Electricity Using DFC Power Plants

Publications/Presentations

1. Tyndall, D., "Validation of an Integrated Hydrogen Energy Station" DOE Hydrogen Program Review Meeting, Washington, DC, May 2007.
2. Keenan, G. R., and Patel, P., "Hydrogen Co-production from a Molten Carbonate Fuel Cell," 2005 Fuel Cell Seminar, November 2005, Palm Springs, CA.