XII.7 Highly Efficient, 5-kW CHP Fuel Cells Demonstrating Durability and Economic Value in Residential and Light Commercial Applications

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Vendor:
ClearEdge Power, Hillsboro, OR

Project Start Date: October 1, 2009
Project End Date: September 15, 2013

Objectives

- Quantify the durability of proton exchange membrane (PEM) fuel cell systems in residential and light commercial combined heat and power (CHP) applications in California.
- Optimize system performance though testing of multiple high-temperature units through collection of field data.
- Demonstrate that GenSys Blue product is a technology that is commercially ready for the marketplace.
- The goal of the project is to demonstrate in the real-world that high-temperature PEM technology can offer reliable heat without additional equipment and to refine the product design and subcomponent performance related to polybenzimidazole (PBI) technology, stacks, advanced controls and fuel reforming.

Relevance to the American Recovery and Reinvestment Act (ARRA) of 2009 Goals

- Near-term: The expenses of the project sustained jobs for the companies involved through work on the installation of the fuel cell-powered systems, the engineering work to sustain system performance, and all third parties involved in building sub-components, shipping parts to on-site locations and managing/coordinating the project.
- Long-term: Advances were made to prove the durability and efficiency of fuel cell technologies for CHP that will help power and fuel the long-term economic health of our nation.
- This project used six fuel cell-powered CHP systems that were built, installed and maintained by commercial entities. The fuel cell manufacturer gained valuable reliability data/experience that will advance their ability to meet customer expectations in order to be a viable competitor to traditional technologies.

Technical Barriers

- Ability to match the durability and reliability of traditional energy sources.
- Produce adequate heat to meet consumer comfort requirements.
- Prove supply vendors can deliver the quality and timely delivery of sub-components.

Technical Targets and Milestones

- Met heat availability target of >99%
- Met electricity efficiency target of >30%
- Did not meet the target of 8,760 hours per year. Performance was 3,000 hours.

Accomplishments

- Installation of six systems in Latham, NY and three systems and the University of California Irvine.
- Logged system performance for over two years resulting in over 34,000 run hours that produced:
  - 57,000 kWh of electricity and 780,000 kWh of thermal.
  - A startup reliability level of 56% and a thermal availability of 100%.
- Manufacturing build time reduced from >120 to <50 hr
- Direct material cost reduction: ~$90k to $53k in volumes <20

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Introduction

The partners of this project operated or leased a total of 11 fuel cell-powered CHP systems in order to prove the durability and reliability of fuel cell-powered CHP systems. The CHP systems operated for over two years and were operational for over 34,000 hours, as shown in Table 1. Each system was installed, operated, repaired and analyzed by technical staff with the results reported to the DOE.

The fuel cell CHP systems were high-temperature and the project achieved 100% availability for heat production. This is a significant achievement for advancing fuel cells to become competitive or advantaged over traditional technologies. Through development of fuel cell products that run on hydrogen and can meet or exceed customer expectations, fuel cells will enable a hydrogen economy.

Approach

To collect the necessary data that would prove our goals around availability, reliability and durability, we needed to keep the systems running. We trained technical staff available to trouble-shoot and fix the system or sub-component issues. Several engineers, along with the trained technical staff, reviewed the system performance through site visits or through the transfer of data, to determine the corrective actions.

There was extensive documentation of failures and corrections that allowed us to replace the responsible failed components. All site preparation and grid interconnection was performed with a safety first attitude. During site visits and trouble-shooting/find and fix events, safety was a primary concern.

Results

The high-temperature systems that were in service met a major piece of our objectives but not all. Issues with our membrane electrode assembly (MEA) supply and quality led the majority of systems to run in heat-only mode, significantly decreasing the availability performance metrics of the CHP system as a whole. A significant amount of time was spent diagnosing the CHP sub-component issues and communicating them with the supplier, to resolve the issue. See Table 1 for quantitative support.

In addition to the uneven performance of the power versus the heat, we have seen a decrease in reliability of the power output (Figure 1). The main cause of this decrease in reliability has been the MEA quality and performance. We experienced a significant degree of variation in beginning of life stacks and unfortunately, the decision to switch to a previous version of the MEA that has a thinner cross-section took much time. The deliberation and engineering review pushed us further back in our supplier's production queue.

Our service calls were reduced by running in heat-only mode, which is prone to less failure and downtime. Recent calls relate to our combustion monitors, oil pump failures and control board diagnostics. See Figure 2 for a breakdown of our failures and service calls over the project.

See Figure 3 for a breakdown of our failure-modes as of June 1, 2012.

Conclusions and Future Directions

A contract with ClearEdge was executed on June 15, 2012. Two ClearEdge units that are being leased will run for one year as part of this demonstration. One unit will run in the laboratory at the University of California at Irvine. The second unit is part of a commercial demonstration and will run at a Taco Bell in San Juan Capistrano, California. The electricity will be used to power a portion of the power needs while the heat will be used for steam in food preparation and storage.

TABLE 1. Cumulative Run-Time by Operational Mode

HT GenSys Reliability Fleet Stats Through 6/1/2012 0:00

System S/N	Commissioned Date	System Runtime (Hours)	Current Stack Runtime	Burner Runtime	Electrical kWh	Thermal kWh	Startup Reliability	Heat Operational A(t)	CHP Operational A(t)
EpsilonPlus8	1/8/2010 14:50	7823	6058	14401	15247	141427	0.56	1.00	0.60
EpsilonPlus9	1/11/2010 15:14	4381	3802	12400	7349	123059	0.68	1.00	0.34
EpsilonPlus10	4/9/2010 8:55	1777	1777	11695	2520	124008	0.56	0.99	0.44
Foxtrot2	1/8/2010 14:59	11884	4558	10883	19072	151272	0.59	1.00	0.73
Foxtrot3	3/2/2010 10:47	5011	3098	13549	6679	140065	0.53	1.00	0.45
Foxtrot4	6/11/2010 14:45	3249	3249	10368	6002	98676	0.47	0.99	0.40
Totals	-	34126	22542	73295	56868	778506	-		-
Average	-	5688	3757	12216	9478	129751	0.56	1.00	0.49

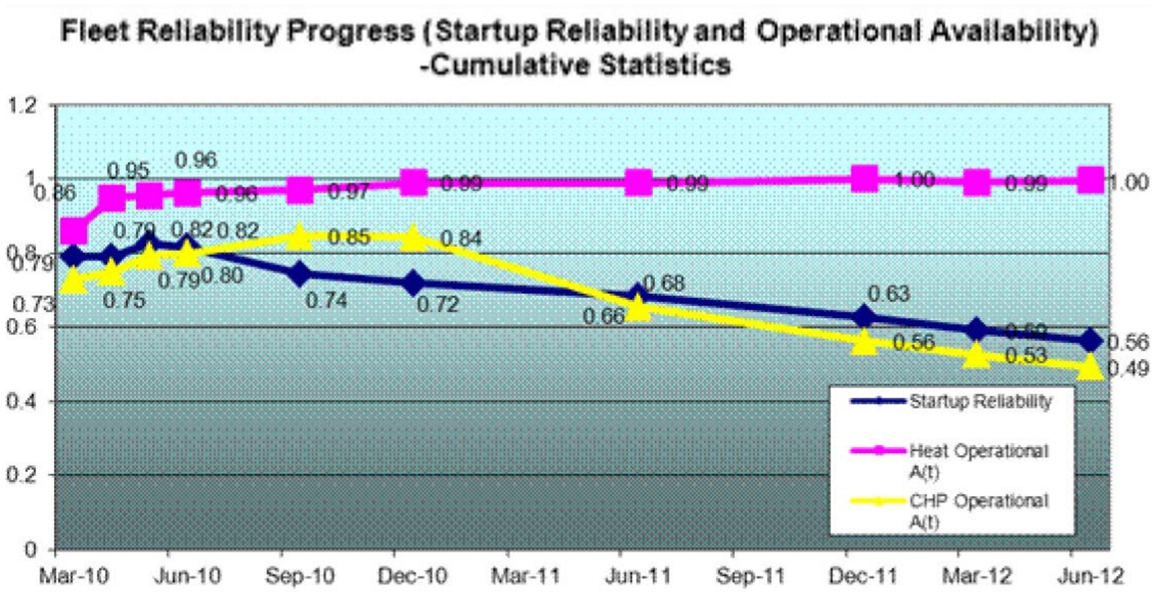


FIGURE 1. CHP Reliability by Mode

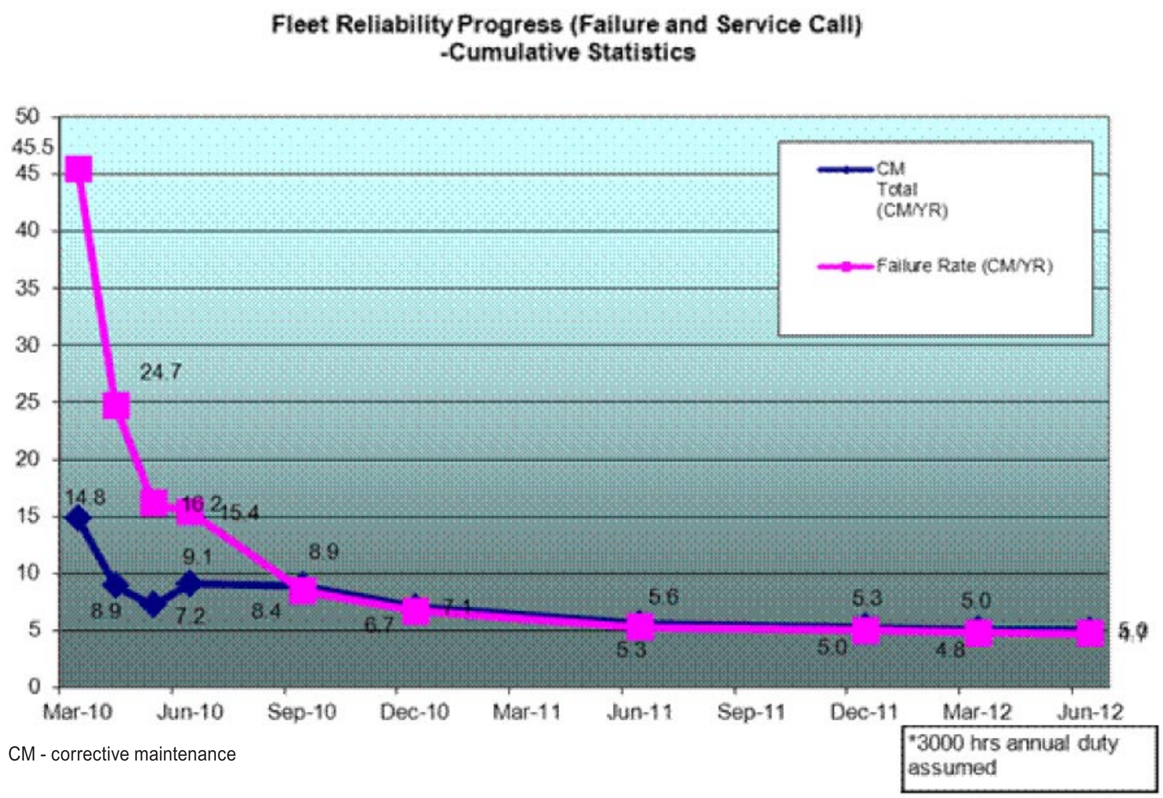
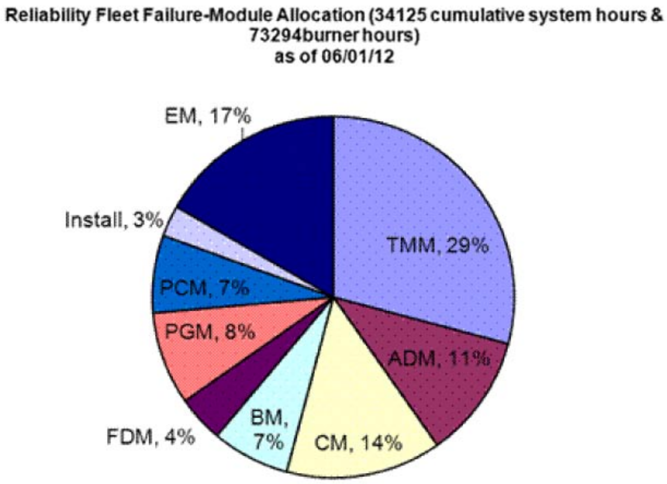


FIGURE 2. Service Calls and Failures



TMM - Thermal Management Module; ADM - Air Delivery Module;
CM - Control Module; BM - Burner Module; FDM - Fuel Delivery Module;
PGM - Power Generation Module; PCM - Power Control Module;
Install - Installation; EM - Electronics Module

FIGURE 3. Failure Mode Breakdown