DACA42-03-C-0024

US State Department International Chancery Conclave PEM Demonstration Project Midterm Report

Proton Exchange Membrane (PEM) Fuel Cell Demonstration
Of Domestically Produced PEM Fuel Cells in Military Facilities

US Army Corps of Engineers
Engineer Research and Development Center
Construction Engineering Research Laboratory
Broad Agency Announcement CERL-BAA-FY02

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September 5, 2006

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Executive Summary

Under terms of its FY'02 DOD PEM Demonstration Contract with ERDC/CERL, LOGANEnergy has installed and operate a Plug Power GenCore 5kWe auxiliary fuel cell power plant (see Appendix section 2) at the State Department Administrative Center of the International Chancery Conclave (ICC) in Washington, DC. The Gencore fuel cell operates on hydrogen fuel and provides +48Vdc back-up power.

This project was initially destined for Ft Belvoir, VA. However, the project POC and former head of the Fort Belvoir Fuel Cell Technology Team of the US Army Communications-Electronics, Research Development and Engineering Command (CERDEC), moved on to another position in June 2004. So, after putting forth a good faith effort for several months to gain new support for the project and still having no good prospects, it was decided to seek a new opportunity at another location. In October 2004 the Department of State (DOS) ICC emerged as a suitable alternative. The ICC is a major real estate development of the DOS to relocate all foreign embassy compounds to one site in order to provide greater security for foreign delegations. The hydrogen powered unit is electrically configured to selected circuits in the administration building in order to simulate support of critical or emergency loads so that the State Department may properly evaluate the PEM backup power technology. No local electrical or mechanical contractors were required to complete the installation tasks. The DOS POC for this project is:

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Proposal – Proton Exchange Membrane (PEM) Fuel Cell Demonstration of Domestically Produced Residential PEM Fuel Cells in Military and Federal Government Facilities

1.0 Descriptive Title

LOGANEnergy Corporation Small Scale PEM Demonstration Project at US DOS International Chancery Conclave Administrative Building located at Van Ness Street, Washington DC. The installed back-up power fuel cell system provides up to 5kW of back-up +48V DC power while operating on hydrogen fuel.

2.0 Name, Address and Related Company Information

LOGANEnergy Corporation

1080 Holcomb Bridge Road
BLDG 100- 175
Roswell, GA 30076
(770) 650- 6388

DUNS 01-562-6211
CAGE Code 09QC3
TIN 58-2292769

LOGANEnergy Corporation is a private Fuel Cell Energy Services company founded in 1994. LOGAN specializes in planning, developing, and maintaining fuel cell projects. In addition, the company works closely with manufacturers to implement their product commercialization strategies. Over the past decade, LOGAN has analyzed hundreds of fuel cell applications. The company has acquired technical skills and expertise by designing, installing and operating over 30 commercial and small-scale fuel cell projects totaling over 8 megawatts of power. These services have been provided to the Department of Defense, fuel cell manufacturers, utilities, and other commercial customers. Presently, LOGAN supports 30 Phosphoric Acid Fuel Cells (PAFC) and PEM fuel cell projects at 21 locations in 12 states, and has recently installed 22 new projects in the US and the UK.

3.0 Production Capability of the Manufacturer

Plug Power manufactures a line of PEM fuel cell products at its production facility in Latham, NY. The facility produces three lines of PEM products including the 5kW GenSys5C natural gas unit, the GenSys5P Liquid Propane Gas (LPG) unit, and the GenCore 5kW standby power system. The current facility has the capability of manufacturing 10,000 units annually. Plug Power will support this project by providing remote monitoring, telephonic field support, overnight parts supply, and customer support. These services are intended to enhance the reliability and performance of the unit and achieve the highest possible customer satisfaction. Vincent Cassala is the Plug Power point of contact for this project. His phone number is 518.782.7700 ex1228, and his email address is vincent_cassala@plugpower.com.

4.0 Principal Investigator(s)

Name	Samuel Logan, Jr.	Keith Spitznagel
Title	President	Vice President Market Engagement
Company	Logan Energy Corp.	Logan Energy Corp.
Phone	770.650.6388 x 101	860.210.8050
Fax	770.650.7317	770.650.7317
Email	samlogan@loganenergy.com	kspitznagel@loganenergy.com

5.0 Authorized Negotiator(s)

Name	Samuel Logan, Jr.	Keith Spitznagel
Title	President	Vice President Market Engagement
Company	Logan Energy Corp.	Logan Energy Corp.
Phone	770.650.6388 x 101	860.210.8050
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Email	samlogan@loganenergy.com	kspitznagel@loganenergy.com

6.0 Past Relevant Performance Information

a) Contract: PC25 Fuel Cell Service and Maintenance Contract #X1237022

Merck & Company
Ms. Stephanie Chapman
Merck & Company
Bldg 53 Northside
Linden Ave. Gate
Linden, NJ 07036
(732) 594-1686

Four-year PC25 PM Services Maintenance Agreement.
In November 2002 Merck & Company issued a four-year contract to LOGAN to provide fuel cell service, maintenance and operational support for one PC25C fuel cell installed at their Rahway, NJ plant. During the contract period the power plant has operated at 94% availability.

b) Contract: Plug Power Service and Maintenance Agreement to support one 5kWe GenSys 5C and one 5kWe GenSys 5P PEM power plant at NAS Patuxant River, MD.

Plug Power
Mr. Vincent Cassala
968 Albany Shaker Rd.
Latham, NY 12110
(518) 782-7700 ex 1228

c) Contract: A Partners LLC Commercial Fuel Cell Project Design, Installation and 5-year service and maintenance agreement on 600kW UTC PC25 power block.
Contract # A Partners LLC, 12/31/01

Mr. Ron Allison
A Partner LLC
1171 Fulton Mall
Fresno, CA 93721
(559) 233-3262

7.0 Host Facility Information

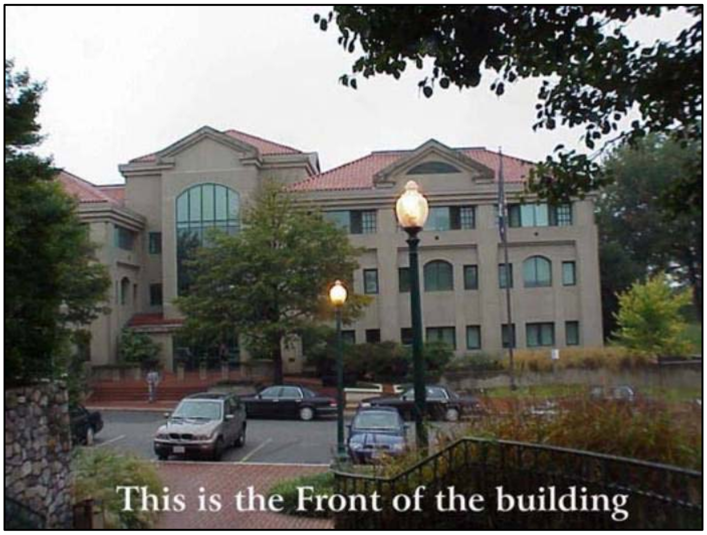

Figure 1 – International Chancery Center

The US Department of State International Chancery Center (ICC) administrative building is located in the Northwest Section of Washington DC. The ICC is an alternative to "Embassy Row" along Massachusetts Avenue. It began developing more than 30 years ago, when Congress set aside former National Bureau of Standards land for international use. Located on either side of Van Ness Street the 47 acre site is home to 18 foreign embassies including Israel, Jordon, Kuwait, Singapore, Austria, Bahrain, Bangladesh, Brunei, Egypt, Ethiopia, Ghana, Malaysia, Nigeria, Pakistan, Singapore, Slovakia, the United Arab Emirates and Morocco. China is about to break ground on a complex designed by I.M. Pei. The ICC administrative is a three story building built in 1990, and houses the DOS Office of Protocol, the US Secret Service, and the DOS Office of Foreign Missions.

8.0 <u>Fuel Cell Installation</u>

The fuel cell was installed adjacent to a ventilation shaft on the northwest corner of the building (Fig. 2). Being near the ventilation shaft facilitated running the conduit to the electrical panels located in the underground parking deck. This location also provided good access for the driver delivering hydrogen cylinders required to refuel the unit. The control panel and test load were installed in a highly visible location near the existing generator room. The fuel cell required two separate conduit runs for power conductors (1 1/2in) and communications (3/4 in). All conduits were of the rigid metallic type (Fig. 3).

Figure 2 – Fuel Cell Location

Figure 3 – Ventilation Shaft

The fuel cell and chemical energy storage module (CESM) were initially installed adjacent to each other using pre-cast concrete slabs. In this arrangement, the CESM is approximately six inches from the fuel cell. The fuel cell and CESM were anchored to the slabs using standard concrete anchors. This is the arrangement recommended by the manufacturer. The CESM and fuel cell were connected using the factory supplied stainless steel hose assembly and wiring harness. There was also a field installed grounding conductor that must be connected between the units.

Figure 4 – CESM & Pavers

Once the fuel cell was installed, an issue was raised by the local hydrogen representative at Airgas. He was unhappy with the location and cited safety concerns with having to transport the hydrogen cylinders across an unpaved area, not having a job safety assessment (JSA), and having to conduct specific employee training regarding the cylinder replacement procedure. He also indicated that a level, hard surface was required adjacent to the unit for staging cylinders during refueling. After several discussions involving Airgas and Plug Power, it was suggested that temporarily installing concrete pavers during the project might be adequate to satisfy the safety concerns of the hydrogen vendor. The pavers were installed near the end of June 2005 (Fig. 4).

Once the pavers were installed the local Airgas representatives returned to the site to perform a JSA. The JSA determined that the pavers were an improvement, but still inadequate for regular use. The gas supplier recommended a paved walkway or other similar access.

Due to the temporary nature of the demonstration and site cosmetics, it was not feasible to construct a paved walkway. Therefore, it was necessary to relocate the CESM so that it was adjacent to the paved area behind the Chancery Center. This area is normally used for temporary storage and delivery vehicles. In the new location, the CESM was located on a poured 4ft x 6ft concrete slab. The slab included bollards that serve to protect the CESM from incidental contact (Fig. 5). In the new location, the fuel cell was approximately 35 feet from the Chemical Energy Storage Module. This required trenching from the fuel cell to the hydrogen storage cabinet in order to install the extended fuel supply line and electrical connections. Once the CESM was installed in the new location, Airgas agreed to provide the refueling service for the demonstration.

Figure 5 – Relocated CESM

In order to simulate a DC bus application, a Sorenson 48VDC power supply was installed in conjunction with a 1.8kW resistance heater. The installation also includes a timer that cycles power to the rectifier in order to simulate a grid outage. The fuel cell is designed to detect and respond to drops in bus voltage should there be a problem with the grid or customer equipment. This test panel was assembled off site and installed on the wall just outside the existing electrical room. Figure 6 outlines the layout of the fuel cell, CESM, and test panel.

Upon completion of the equipment installation, it was necessary to commission the fuel cell. This involved removing factory installed coverings from all fuel cell openings, installing hydrogen cylinders in the CESM, and performing the initial startup. During the startup, additional checks were performed including fuel pressure check, leak check, and overall system operation. Several problems were encountered with the fuel cell during start up. These included a faulty excess flow valve in the CESM, a software issue with the low bus monitoring, an improperly installed pressure gauge, and a short in the electrical connector between the fuel cell and CESM. All of these issues were reported to the manufacture and corrected through component replacement or software upgrades.

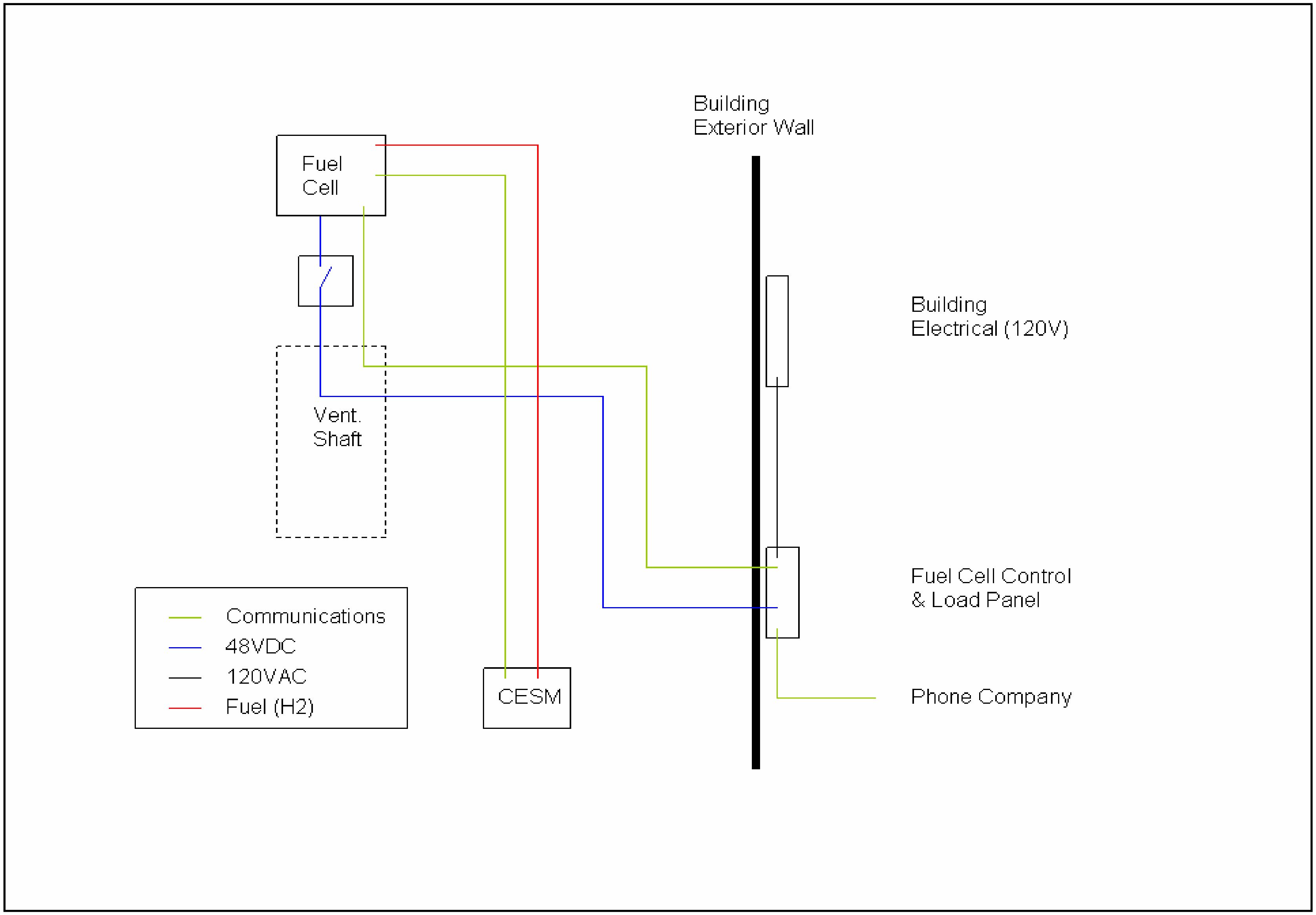

Figure 6 – ICC Conduit and Mechanical Layout

9.0 Electrical System

The Plug Power Gencore fuel cell is designed for use in the telecommunications industry. It is designed for direct current (DC) applications and is normally installed in parallel with a DC rectifier and accompanying lead-acid battery bank. By design, the Gencore is always connected to the customer's bus and continually monitors the voltage of the primary supply. If the customer's bus voltage drops below a user defined setpoint, the Gencore will start automatically and provide reliable back up power for the customer's application. When running, the Gencore matches its current output to the required load and runs at a voltage slightly below (0.5V) the customer setpoint. Once the customer DC bus returns, the fuel cell senses the corresponding voltage rise and returns to standby mode. The available runtime depends on the average output power. The Gencore is capable of providing twelve hours of runtime at 5.0 kW using a bank of six industry standard hydrogen cylinders.

In order to test the operation of the unit, LOGANEnergy installed a test panel to simulate the DC bus. This panel consists of a 48 VDC Sorenson power supply, an Intermatic programmable cycle timer, two relays, and a 1.8 kW DC resistance heater. During the test cycle, the timer simulates a DC bus failure by disabling the output of the power supply (relay 1). At the same time, the timer closes the load relay (relay 2) and energizes the resistance heater. Once the voltage drops below the predefined set point, the fuel cell starts and runs the load for a specified time. In this demonstration, the timer is programmed to initiate two test cycles a day for a period of twenty minutes each. Figure 7 shows a detail of the test panel. Figure 8 shows the panel as installed at the Chancery Center.

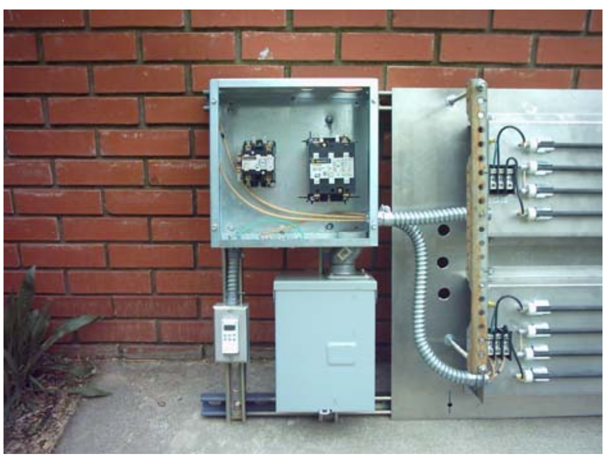

Figure 7 – Test Panel Detail

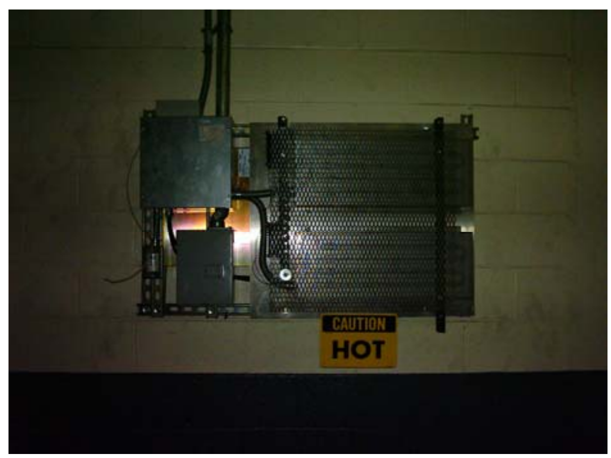

Figure 8 – Test Panel as Installed

10.0 <u>Thermal Recovery</u>

Not applicable.

11.0 Data Acquisition System

The GenCore controller will record and store operating data including the number of automatic starts, fuel cell operating hours, and kWh provided to the DC load. The Gencore also receives input from pressure transducers inside the CESM Storage Module. These pressure transducers allow daily fuel consumption to be monitored remotely using the fuel cell modem. Required data will be downloaded regularly and compiled into readable format in order to maintain an operating record of the test site. In addition, a Dent Instruments data-logger has been installed to verify test panel operation and provide limited alarming capability.

12.0 Fuel Supply System

Fuel is supplied to the Gencore via standard industrial hydrogen cylinders. At the International Chancery Center the local vendor is Airgas. The optional CESM hydrogen storage module that is offered by Plug Power accepts six, industry standard, 200 SCF hydrogen cylinders. The cylinders are divided into two banks of three, and either bank can be replenished without interrupting the operation of the system. The CESM comes equipped with an automatic changeover valve that automatically switches cylinder banks once one is depleted. The CESM includes analog pressure transducers that allow the Gencore to track fuel level. Fuel usage is calculated manually using the physical relationship between pressure, temperature, and volume.

13.0 Project Cost

US State Department International Chancery Conclave - Gencore Demonstration

Project Utility Rates						
1) Water (per 1,000 gallons)			N/A			
2) Utility (per KWH)			N/A			
3) Bottled Hydrogen (per SCF)			$ 0.145			
First Cost				**Budgeted**	**Actual**	**Variance**
Plug Power 5 kW Gencore				$ 15,000	$ 14,915	**$ (85)**
Product Training - Gencore				$ 2,500	$ 2,500	**$ -**
Shipping				$ 1,800	$ 1,312	**$ (488)**
Installation electrical				$ 1,500	$ 3,106	**$ 1,606**
Installation mechanical & thermal				$ 1,500	$ 2,854	**$ 1,354**
Instrumentation, Data Package				$ 1,170	$ 1,559	**$ 389**
Site Prep, labor materials				$ 650	$ 1,075	**$ 425**
Technical Supervision/Start-up				$ 6,500	$ 6,500	**$ -**
Total				**$ 30,620**	**$ 33,821**	**$ 3,201**
Annual Operating Expenses	**Budgeted**	**Actual**	**$/Min**	**Budgeted**	**Actual**	**Variance**
Bottled Hydrogen, Scf/min @ 1.8kW	0.8480	1.0250	$ 0.123	$ 1,790	$ 2,164	$ 374
Hydrogen Cost/kWh			**$ 4.10**			

Economic Summary	**Budgeted**	**Actual**	**Variance**
Forecast Annual kWH	437	437	0
Annual Cost of Operating Power Plant kWH	$ 4.10	$ 4.95	$ 0.86
Credit Annual Thermal Recovery kWH	N/A	N/A	N/A
Project Net Operating Cost kWH	$ 4.10	$ 4.95	$ 0.86
Displaced Utility cost kWH	N/A	N/A	N/A
Energy Savings (Increase)	N/A	N/A	N/A
Annual Energy Savings (Increase)	N/A	N/A	N/A

14.0 Acceptance Test

The acceptance test included verifying all operational and safety aspects of the installation. In general, the test included observing the operation of the Gencore through several automatic test cycles. The test included successful completion of the following events:

1) – the Gencore detected a drop in the DC bus voltage
2) – the Gencore initiated a "Low Bus Start"
3) – the bus voltage stabilized and remained at the bus set-point with the load applied
4) – when the bus returned the Gencore should detect the availability of the bus
5) – the fuel cell began a controlled shutdown
6) – the system reinitialized to the "System Ready" state

During the initial acceptance test, there were two major issues with the Gencore. The initial problem involved the excess flow valve inside of the CESM storage module. This valve is designed to isolate the hydrogen should there be a significant hydrogen leak downstream of the valve. In our test, the valve was overly sensitive and nuisance trips would occur even when there was no fuel leak. This was corrected by recalibrating the valve in the field. The second issue was that the fuel cell did not reinitialize properly after an automatic run cycle. This problem required a software revision from Plug Power. Once the new software was received, it was installed by the field technician. With the new software, the fuel cell was able to successfully complete the acceptance test.

On July 27, 2005 the fuel cell completed acceptance testing.

15.0 Appendix

1.0 Gencore Product Specification Sheet

plug power

Rugged, reliable design.

Flexible

Proton Exchange Membrane (PEM) Fuel Cell Stack – proprietary fuel cell design delivers efficient, clean, quiet DC power. Integrated cell voltage monitoring provides continuous feedback for optimal fuel cell performance.

DC Power Conditioning – GenCore systems offer either -48Vdc or +48Vdc power conditioning to meet the needs of wireless and wireline providers.

Reliable

Electrical Energy Storage – maintenance-free system provides immediate response to power interruptions.

Fuel Storage System – available in a variety of forms, hydrogen fuel storage is scalable to meet site and provider specific needs.

Robust

Thermal Management System – freeze-tolerant design is compliant with Telcordia NEBS standards, including operation from -40C to 46C.

Insulated Cabinet – rugged design is finished with a high-quality paint process that protects the exterior finish.

GenCore.

PRODUCT CHARACTERISTICS		GENCORE 5B
Performance	Rated Net Output[1]	0 to 5,000 W
	Adjustable Voltage	+46 to -56 Vdc (+48)
	Operating Voltage Range	+42 to +60 Vdc
	Operating Current Range	0 to 109 Amps
Fuel	Gaseous Hydrogen	99.95% Dry
	Supply Pressure	80 psig
	Fuel Consumption	40 slm at 3,000 W
		75 slm at 5,000 W
Operation	Ambient Temperature	-40 C to 46 C
	Relative Humidity	0% to 95% Non condensing
	Altitude	-197 ft to 6,000 ft
Physical[2]	Dimensions	44" H x 26" W x 24" D
	Weight	500 Lbs
Safety	Compliance	FCC Class A
		ANSI Z21.83
		UL Listed
		Telcordia GR 63, 78, 487, 1089
Emissions	Water	Maximum 1.75 Liters per hour
	CO, CO2, NOx, SO2	<1 ppm
	Audible Noise	60 dba @ 1m
Sensors[3]	Gas Hazard Detection	Standard
Control	Microprocessor	Standard
	2 LED Panel	Standard
	Low Fuel Alarm	Standard
	Communications[4]	RS-232
		Digital Interface

[1] Rating applies for altitudes up to 1,000 ft. Beyond this, total power available will decrease 1.5% per 1,000 ft.
[2] Excludes fuel storage. Optional fuel module (shown above) is 44" H x 26" W x 24" D.
[3] Optional sensors are available to detect: Pad shear, water intrusion and tampering.
[4] Optional communications include modem or ethernet.

Specifications subject to change without notice.

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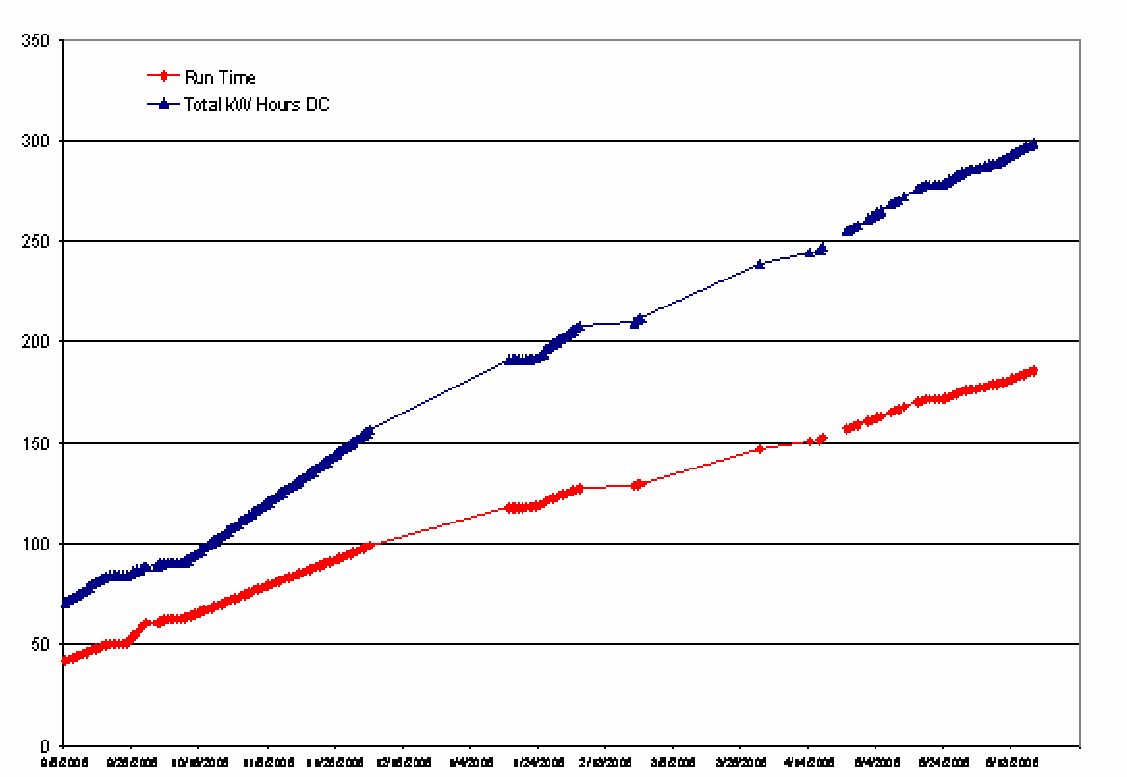
Fax: +1.518.782.9060
www.plugpower.com

2.0 Operating Data as of June 2006

- Runtime = 10.5 months
- kWh generated = 299
- Requested starts = 2,880
- Actual starts = 2,333
- Calc. availability = 81.0%
- Calc. H_2 consumption = 29 slm



3.0 Failure Pareto Chart as of June 2006