PLUG POWER FUEL CELL DEMONSTRATION PROJECT
UNITED STATES MILITARY ACADEMY (USMA)
WEST POINT, NY

Initial Project Description Report

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Prepared for

U.S. ARMY CORPS OF ENGINEERS
CONSTRUCTION ENGINEERING RESEARCH LABORATORY (CERL)
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Background and Objectives of the Project

The installation and operation of PEM fuel cells at the United States Military Academy (USMA) – West Point, NY has objectives that further the missions the U.S. Army Corps of Engineers, the USMA and Plug Power. The following points summarize the common high-level objectives for this program:

- Allow assessment of fuel cells in supporting sustainable military installations;
- Increase the Army's ability to more efficiently construct, operate and maintain its installations;
- Assess the role of PEM fuel cells in supporting the Army's training, readiness, mobilization, and sustainability missions;
- Provide a technology demonstration site for military base market;
- Provide operational testing & validation of product to assess installation, grid interconnection, operation of systems in all seasonal conditions, and integration of units into an existing military base environment.
- Provide an understanding of military requirements in applications utilizing CHP and standby capabilities.

Plug Power, a New York State designer and manufacturer of Proton Exchange Membrane (PEM) fuel cells has extensive experience in the design and operation of PEM fuel cell systems since its inception in 1997. Plug's focus on natural gas powered fuel cell systems has resulted in the successful demonstration of systems with increasing reliability, reduced cost, and increasing functionality. Plug Power fuel cells have been sold to, and operated for New York State Energy Research and Development Authority, General Electric, DTE Energy Technologies, and the Long Island Power Authority. In addition, Plug Power has operating experience of integrated fuel cell systems of over 250,000 hours in laboratory, field demonstration, and prototypical environmental applications. Plug Power's initial approach to the marketplace is targeting electric and gas utility customers as well as government customers. This program supports Plug Power's recognition of the Department of Defense as a potentially significant customer for fuel cells in the future, and provides the opportunity for an initial assessment of the use of PEM fuel cells supporting military base infrastructure.

The Equipment Installed

Plug Power Inc. will manufacture, install and operate a total of three (3) of its GenSys™ 5CS - 5kW PEM fuel cell systems for one year at the USMA. The natural gas powered fuel cell systems will provide electricity to the facility and incorporate combined heat and power (CHP) capability that allows waste heat to be recovered from the fuel cell and used to supplement the existing domestic hot water system. Additionally, the fuel cell systems include standby capability that will allow the units to operate during periods of electric utility grid (Grid) outage.

CHP mode:

- Reclaims the waste heat generated by the fuel cell and offers it to the customer
- Can supplement and in some cases replace the heat source for many existing customer systems such as baseboard heat, space heating and potable water

- Results in a cheaper, more efficient overall system.

Standby capability:

- Normal operation - the fuel cell provides base electrical service to the facility and the grid supplements peaks and surges. Unused electricity will flow back to the grid.
- Power outage - the fuel cell continues to provide electricity to critical loads and acts as a back-up generator
- Fuel cell shuts down - electricity to the facility will be provided uninterrupted from the electric grid.

Plug Power Inc. will serve as the service provider and will be responsible for the operation and maintenance of the three-system fleet. A typical installation is shown in Figure 1 and the product specifications for the fuel cell systems are described in Table 1.

Figure 1: Installation of a Fuel Cell

Table 1: Product Specifications

Physical	Size (L X W X H):	74" X 32" X 68 $^1/_4$"
Performance	Power Rating:	5kW$_e$ (9kW$_{th}$) continuous
	Power:	2.5 - 5kW$_e$ (3-9kW$_{th}$)
	Voltage:	120VAC @ 60Hz
	Power Quality:	IEEE 519
	Emissions:	NO_X < 1ppm
		SO_X < 1ppm
		Noise < 65 dBa @ 1meter
Operating Conditions	Temperature:	0°F to 104°F
	Elevation:	0 to 750 feet
	Installation:	Outdoor
	Electrical Connection:	Grid Parallel/Standby
	Fuel:	Natural Gas
Certifications	Power Generation:	CSA International
	Power Conditioning:	UL
	Electromagnetic Compliance:	FCC Class B

Site Information

The United States Military Academy (USMA) in West Point, NY is the home and training ground of the future leaders of the U.S. Army.

Plug Power and USMA personnel have identified three (3) residential sites within the campus for the fuel cell installation– specifically:

- 221A Lee Rd, Lee Housing Area – LTC Boettner
- 290B Lee Rd, Lee Housing Area – LTC Massie
- 76A Schofield Place, Lusk housing area.– COL Nygren

The locations were selected utilizing criteria based on location, environmental impact, security, staffing, and access. The site selection process attempts to match as closely as possible the fuel cell output and average demand of the facility being served. Because this is based on monthly averages, there will be times at which demand is greater or less than the system electrical and CHP output. The local grid within the USMA grounds will consume electricity unused by the site. The USMA complex is supplied electricity from Orange and Rockland Utilities (O&RU) and has a primary metered service classification where only the main feed to the complex is metered.

Each site will have one (1) fuel cell system:

- The systems will be configured for standby power generation mode where the systems will continue to power the residence in the event of a power (grid) outage. Each tenant will be allowed to select five circuits in their existing panel that they would like to keep powered. These circuits will be switched over to a new critical load panel that will be installed for each site.
- Thermally, the fuel cells will be integrated to support/supplement the existing domestic and hot water heating needs of the sites. BTU meters will be installed at each site in order to measure the amount of heat transferred from the fuel cell into the site host's hot water system. In addition, space-heating elements (baseboard heat) will be installed and monitored in order to study the effectiveness and efficiency of the CHP loop for this type of application.

The similarity and consistency of all the sites will provide a solid basis for assessing CHP System performance in a military, residential environment.

Figures 2 through 6 are site photos and Figures 7 & 8 are installation schematics typical for all three sites.

Figure 2: 221A Lee Rd.

Figure 3: 221A Lee Rd.

Figure 4: 290B Lee Rd.

Figure 5: 290B Lee Rd.

Figure 6: 76A Schofield Place

Program Initial Economic Analysis

This program consists of the planning, installation, and operation of 3 Plug Power fuel cell systems at various locations supporting operations at the United States Military Academy (USMA) – West Point, NY.

The USMA Department of Housing and Public Works (DHPW) provided the utility rates below as averages for FY2002.

- Electrical = $0.08/kW-hr
- Natural Gas = $7.24/decatherm

The system gas usage rate is based upon the nominal Plug Power Lower Heating Value for natural gas of 804 kJ/mol and an average beginning of life (BOL) electrical efficiency of 24.8%. This efficiency is calculated using a weighted average of the system efficiencies at the different set points.

- System natural gas usage rate = 0.138 therm/kW-hr

The program run hours is based on 3 systems operating with a total availability of 90% for the one-year life of the program:

- Program run hours = 24 hrs X 365 days X 0.90 X 3 = 23,652 hrs.

The program number of kilowatt-hours (electrical) produced is based on a system power set point of 2.5 kW for the program run hours above:

- Program kW-hrs$_e$ = 2.5 kW X 23,652 hrs. = 59,130 kW-hrs$_e$

The program number of therms claimed by the customer is based on a system power set point of 2.5 kW for the program run hours above and an overall system efficiency of 50%. Since overall efficiency is based on utilizing the "waste" heat from the fuel cell, the therms claimed by the customer will vary depending on hot water demand:

- Program therms = 2.5 kW / 0.248 X [0.5 – 0.248] X 23,652 hrs X 0.03412 therms/kW-hr = 2,050.1therms

The program number of therms of natural gas consumed by the fuel cells is based on the usage rate multiplied by the number of program kW-hrs above:

- Program therms consumed = 59,130 kW-hrs X 0.138 therm/kW-hr = 8,159.9 therms

The program total cost of natural gas is based on the number of therms consumed multiplied by the cost per therm:

- NG cost = 8,159.9 therms X $0.724/therm = $5,907.77

The equivalent cost of the fuel cell electricity and heat if purchased from Niagara Mohawk is based on the number of kilowatt-hours and therms produced by the systems multiplied by Niagara Mohawk's rate:

- Electrical cost = 59,130 kW-hrs$_e$ X $0.08/kW-hr = $4,730.40
- Thermal cost = 2,050.1 Therms X $0.724/therm = $1,484.27

The projected total energy savings for the program by using system-generated electricity and heat instead of purchasing it from Niagara Mohawk is:

- Avoided cost = $4,730.40 + $1,484.27 – $5,907.77 = **$306.90**
- Avoided cost per residence = $306.90 / 3 = $102.30

The USMA benefits from unusually low electric and natural gas rates when compared to the average for New York State. The state averages for 2001-2002 were approximately $0.14/kWh electric and $1.16/Therm natural gas. The chart below shows the effect of various electric rates when compared to a fixed gas rate. In this example, you can see that with the USMA gas rate and the NYS average electric rate of $0.14/kWh the avoided cost for the demonstration would be roughly $3,800 (more than a factor of ten higher). Also evident is the fact that the same demonstration at a more conventional residence (non-military facility) with the state average rates would realize cost-savings of near $1,250 or four times what is seen at the USMA.

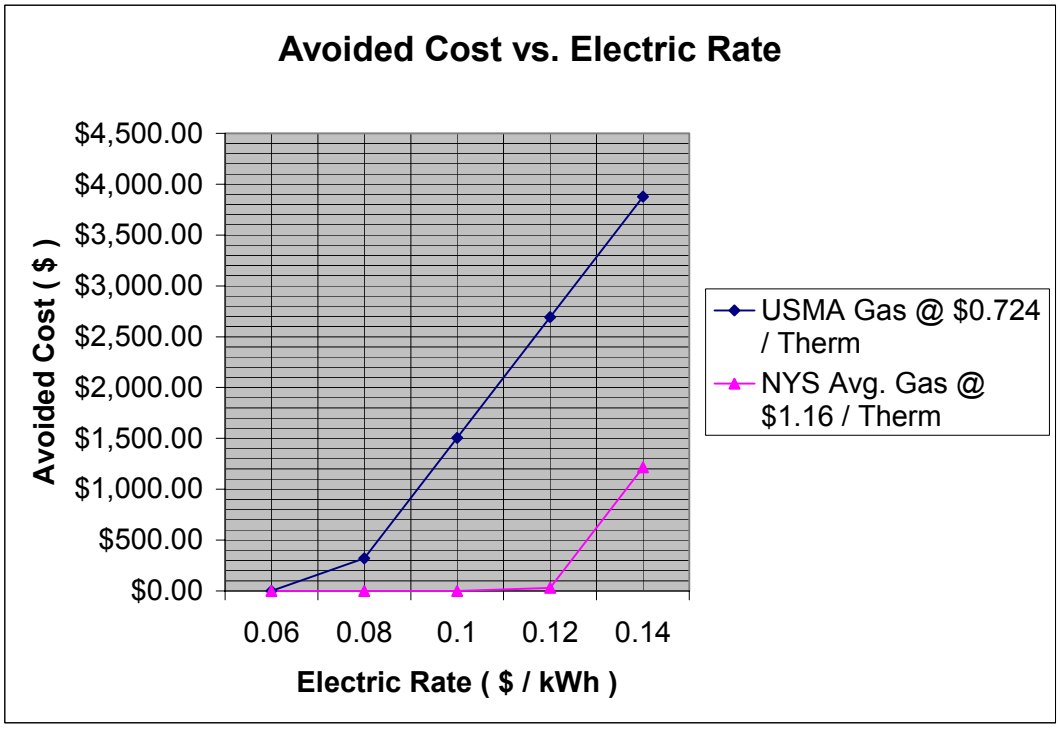

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Figure 7: Proposed Mechanical Schematic (Typical)

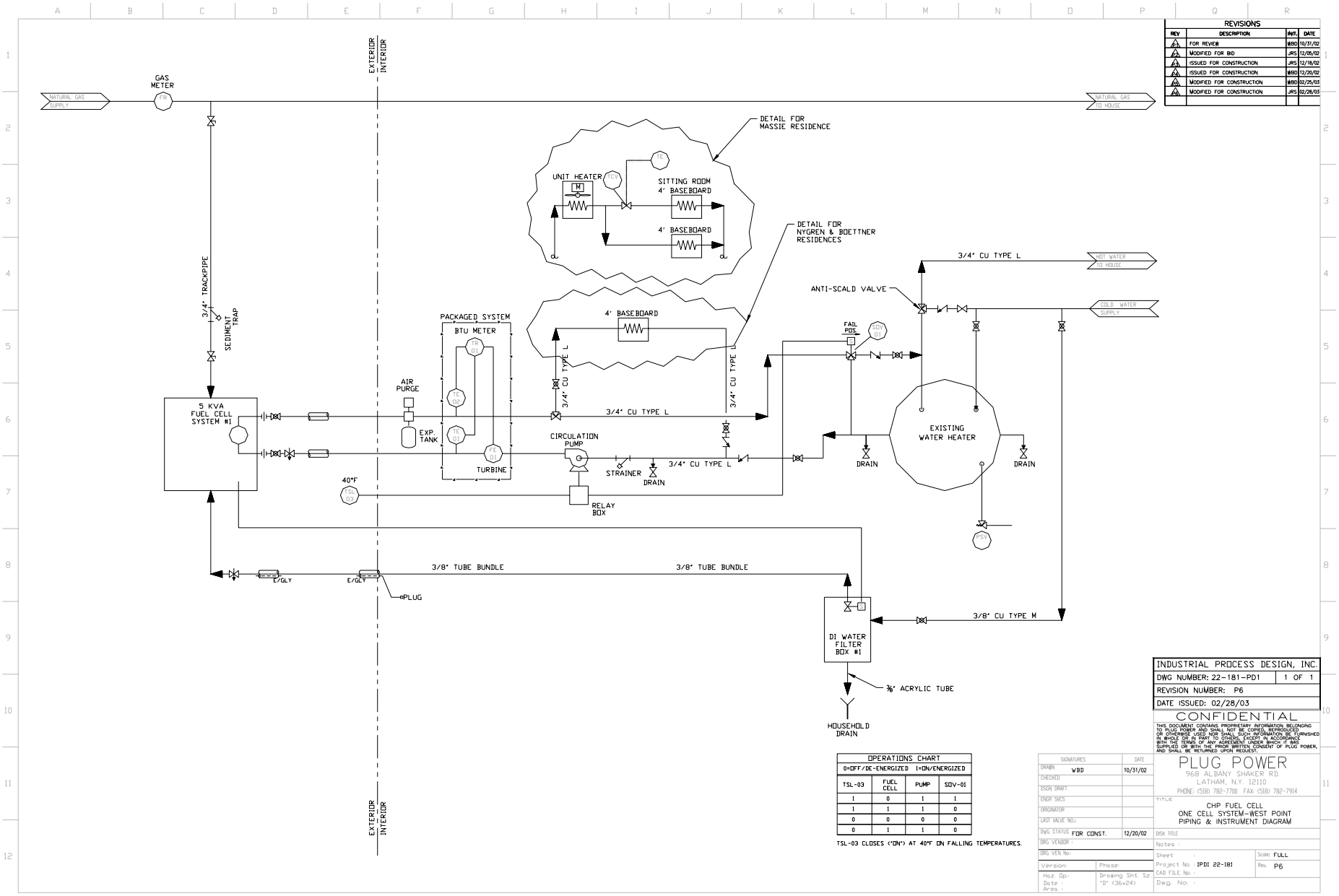

Figure 8: Proposed Electrical Schematic (Typical)