PLUG POWER FUEL CELL DEMONSTRATION PROJECT
SARATOGA SPRINGS NAVAL SUPPORT UNIT
QUIET HARBOR COMPLEX

Initial Project Description Report

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Prepared for

NAVAL AIR WEAPONS STATION
CHINA LAKE, CALIFORNIA

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Background and Objectives of the Project

The installation and operation of PEM fuel cells at the Saratoga Springs Naval Support Unit (NSU) – Quiet Harbor Complex has objectives that further the missions of both the U.S. Naval Air Weapons Station 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 Navy's ability to more efficiently construct, operate and maintain its installations;
- Assess the role of PEM fuel cells in supporting the Navy'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 eight (8) of its GenSys™ 5CS - 5kW PEM fuel cell systems for one year at the NSU - Quiet Harbor housing complex. 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 eight-system fleet. A typical installation of multiple fuel cells is shown in Figure 1 and the product specifications for the fuel cell systems are described in Table 1.

Figure 1: Multiple Unit Installation of Fuel Cells

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 NSU - Quiet Harbor complex provides logistic and base operating support, comptroller duties and supply services (not directly related to training) to the Naval Nuclear Power Training Unit, Ballston Spa, New York. The NSU also provides administrative, morale, welfare and recreation and personal property and housing services for the Department of Defense activities and related personnel. The Quiet Harbor community includes twenty-five (25) four (4) unit townhouse style buildings containing a total of one hundred (100) units. Each group of four units has a common mechanical room and is served by forced hot air heat and an eighty- (80) gallon natural gas fired hot water heater.

Plug Power and NSU personnel have identified four (4) sites within the complex for the fuel cell installation. 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 similarity and consistency of all the sites will provide a solid basis for assessing system performance and CHP integration. To this end, an extensive data monitoring and LAN setup has been installed to maximize the data logged during the demonstration. A high-speed internet connection will transmit detailed system data with a resolution equivalent to that in the Plug Power laboratory. See figure 2 for typical site photos.

Each site will contain two (2) fuel cell systems:

- The upstairs apartments (C & D) at each site will be electrically fed by one fuel cell system.
- Thermally, the fuel cells will join together and supplement the common hot water system in the mechanical room.
- In standby mode, the fuel cell will continue to power the entire main apartment panel with the exception of the 240 VAC electric clothes dryer.

Niagara Mohawk Power Corporation individually meters electricity supply to each of the units. Table 2 displays the breakdown of sites and average power usage. Figures 2 through 5 are typical photos of the mechanical room and fuel cell siting area. Figures 6 and 7 are installation schematics common to all sites.

Table 2: Quiet Harbor Installation Sites

Fuel Cell Site *	Number of Systems	Operating Profile Steady State	Monthly Average - Production	Monthly Average - Demand	Expected % of Demand Provided *
		kW	Kilowatt-hours	Kilowatt-hours	
16 Quiet Harbor Dr	2	2.5	3600	2447	147%
17 Quiet Harbor Dr	2	2.5	3600	2473	146%
20 Quiet Harbor Dr	2	2.5	3600	2543	142%
21 Quiet Harbor Dr	2	2.5	3600	2616	138%

* Demand at each Fuel Cell Site includes 4 apartments and 1 mechanical room

Figure 2: Mechanical Room (Typ.)

Figure 3: Mechanical Room (Typ.)

Figure 4: Electrical Panel

Figure 5: 80-Gal. Hot Water Tank

Program Initial Economic Analysis

This program consists of the planning, installation, and operation of 8 Plug Power fuel cell systems at various locations supporting operations at the Naval Support Unit (NSU) – Quiet Harbor Complex, Saratoga Springs, NY. The NSU is serviced by Niagara Mohawk for both its electricity and natural gas supply.

The NSU Housing Department (Mike Cyktich – PWO) has supplied utility billing information for FY2002. The rates below were calculated by dividing the total electrical/gas cost by the total number of kW-hrs/therms used respectively. The rates, therefore, include delivery charges, taxes and other fees included within the Niagara Mohawk cost structure and will allow a more realistic economic analysis.

- Electrical = $0.16/kW-hr

- Natural Gas = $1.19/therm

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 8 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 8 = 63,072 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 63,072 hrs. = 157,680 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 63,072 hrs X 0.03412 therms/kW-hr = 5466.8 therms

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 = 157,680 kW-hrs X 0.138 therm/kW-hr = 21,759.8 therms

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

- NG cost = 21,759.8 therms X $1.19/therm = $25,894.16

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 = 157,680 kW-hrs$_e$ X $0.16/kW-hr = $25,228.80

- Thermal cost = 5466.8 Therms X $1.19/therm = $6,505.49

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 = $25,228.80 + $6,505.49 – $25,894.16 = **$5,840.13 total**
- Avoided cost per residence = $5,840.13 / 8 = $730.02

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Figure 6: Mechanical Installation Schematic

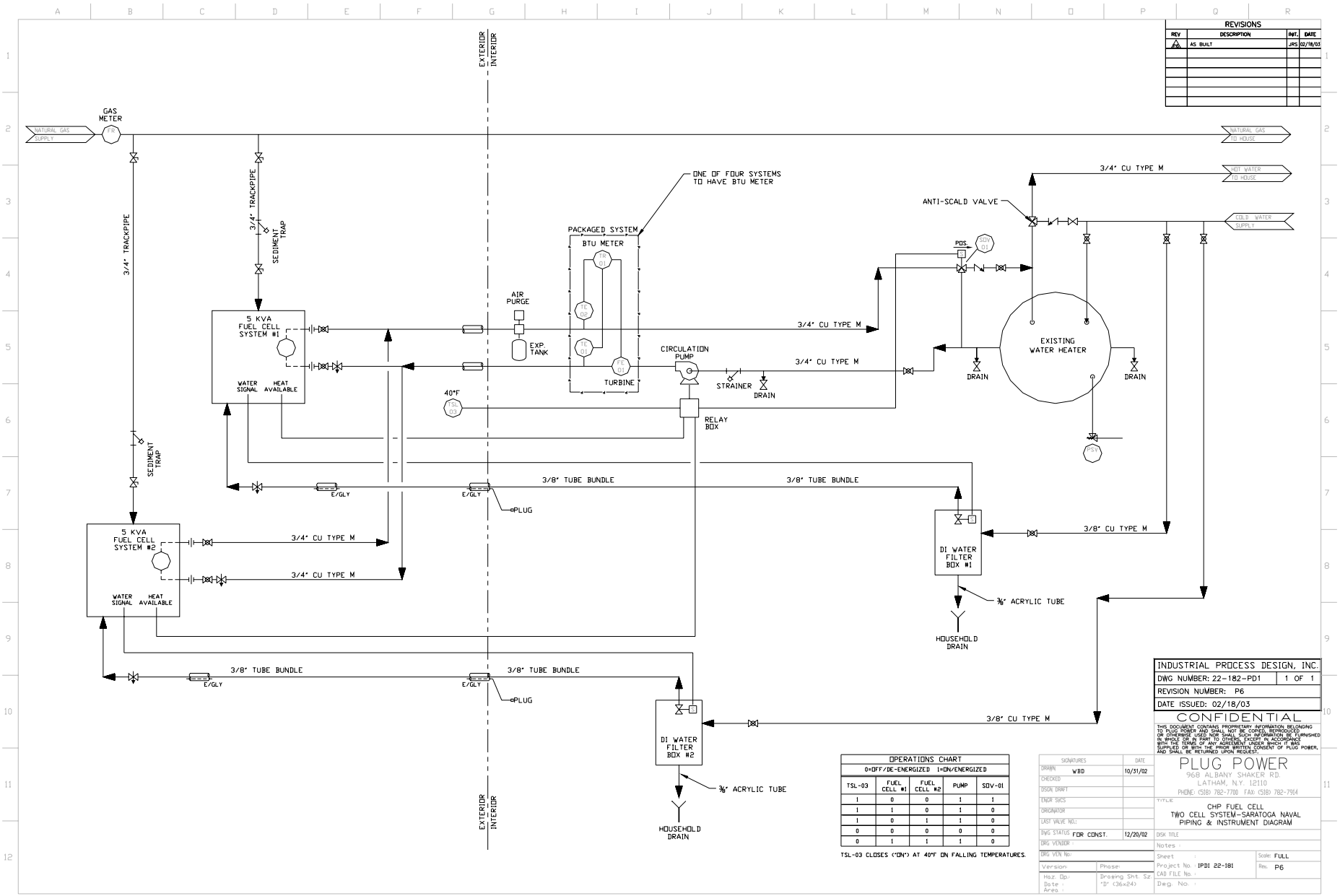

Figure 7: Electrical Installation Schematic