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Site Evaluation for Application of Fuel Cell Technology

Watervliet Arsenal, NY

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Foreword

In fiscal years 93 and 94, Congress provided funds for natural gas utilization equipment, part of which was specifically designated for procurement of natural gas fuel cells for power generation at military installations. The purchase, installation, and ongoing monitoring of 30 fuel cells provided by these appropriations has come to be known as the "DOD Fuel Cell Demonstration Program." Additional funding was provided by: the Office of the Deputy Under Secretary of Defense for Industrial Affairs & Installations, ODUSD (IA&I)/HE&E; the Strategic Environmental Research & Development Program (SERDP); the Assistant Chief of Staff for Installation Management (ACSIM); the U.S. Army Center for Public Works (CPW); the Naval Facilities Engineering Service Center (NFESC); and Headquarters (HQ), Air Force Civil Engineer Support Agency (AFCESA).

This report documents work done at Watervliet Arsenal, Albany, NY. Special thanks is owed to the Watervliet Arsenal points of contact (POCs), Phil Darcey and Vanessa Duenas, for providing investigators with access to needed information for this work. The work was performed by the Energy Branch (CF-E), of the Facilities Division (CF), Construction Engineering Research Laboratory (CERL). The CERL Principal Investigator was Michael J. Binder. Part of this work was performed by Science Applications International Corp. (SAIC), under Contract DACA88-94-D-0020, task orders 0002, 0006, 0007, 0010, and 0012. The technical editor was William J. Wolfe, Information Technology Laboratory. Larry M. Windingland is Chief, CEERD-CF-E, and L. Michael Golish is Chief, CEERD-CF. The associated Technical Director was Gary W. Schanche, CEERD-CV-T. The Acting Director of CERL is William D. Goran.

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1 Introduction

Background

Fuel cells generate electricity through an electrochemical process that combines hydrogen and oxygen to generate direct current (DC) electricity. Fuel cells are an environmentally clean, quiet, and a highly efficient method for generating electricity and heat from natural gas and other fuels. Air emissions from fuel cells are so low that several Air Quality Management Districts in the United States have exempted fuel cells from requiring operating permits. Today's natural gas-fueled fuel cell power plants operate at electrical conversion efficiencies of 40 to 50 percent; these efficiencies are predicted to climb to 50 to 60 percent in the near future. In fact, if the heat from the fuel cell process is used in a cogeneration system, efficiencies can exceed 85 percent. By comparison, current conventional coal-based technologies operate at efficiencies of 33 to 35 percent.

Phosphoric Acid Fuel Cells (PAFCs) are in the initial stages of commercialization. While PAFCs are not now economically competitive with other more conventional energy production technologies, current cost projections predict that PAFC systems will become economically competitive within the next few years as market demand increases.

Fuel cell technology has been found suitable for a growing number of applications. The National Aeronautics and Space Administration (NASA) has used fuel cells for many years as the primary power source for space missions and currently uses fuel cells in the Space Shuttle program. Private corporations have recently been working on various approaches for developing fuel cells for stationary applications in the utility, industrial, and commercial markets. Researchers at the U.S. Army Engineer Research and Development Center (ERDC), Construction Engineering Research Laboratory (CERL) have actively participated in the development and application of advanced fuel cell technology since fiscal year 1993 (FY93), and have successfully executed several research and demonstration work units with a total funding of approximately $55M.

As of November 1997, 30 commercially available fuel cell power plants and their thermal interfaces have been installed at DOD locations. CERL managed 29 of these installations. As a consequence, the Department of Defense (DOD) is the

owner of the largest fleet of fuel cells worldwide. CERL researchers have developed a methodology for selecting and evaluating application sites, have supervised the design and installation of fuel cells, and have actively monitored the operation and maintenance of fuel cells, and compiled "lessons learned" for feedback to manufacturers. This accumulated expertise and experience has enabled CERL to lead in the advancement of fuel cell technology through major efforts such as the DOD Fuel Cell Demonstration Program, the Climate Change Fuel Cell Program, research and development efforts aimed at fuel cell product improvement and cost reduction, and conferences and symposiums dedicated to the advancement of fuel cell technology and commercialization.

This report presents an overview of the information collected at Watervliet Arsenal, NY along with a conceptual fuel cell installation layout and description of potential benefits the technology can provide at that location. Similar summaries of the site evaluation surveys for the remaining 28 sites where CERL has managed and continues to monitor fuel cell installation and operation are available in the companion volumes to this report (see Table 1).

Objective

The objective of this work was to evaluate Watervliet Arsenal as a potential location for a fuel cell application.

Approach

On 25 and 26 April 1996, USACERL and SAIC representatives visited Watervliet Arsenal (the site) to investigate it as a potential location for a 200 kW fuel cell. This report presents an overview of information collected at the site along with a conceptual fuel cell installation layout and description of potential benefits. The Appendix to this report contains a copy of the site evaluation form filled out at the site.

Table 1. Companion ERDC/CERL site evaluation reports.

Location	Report No.
Fort Bliss, TX	TR 01-13
Fort Eustis, VA	TR 00-17
Fort Huachuca, AZ	TR 00-14
Fort Richardson, AK	TR 00-Draft
Picatinny Arsenal, NJ	TR 00-24
Pine Bluff Arsenal, AR	TR 01-15
U.S. Army Soldier Systems Center, Natick, MA	TR 00-Draft
U.S. Military Academy, West Point, NY	TR 00-Draft
Watervliet Arsenal, Albany, NY	TR 00-Draft
911th Airlift Wing, Pittsburgh, PA	TR 00-18
934th Airlift Wing, Minneapolis, MN	TR 00-19
Barksdale Air Force Base (AFB), LA	TR 01-29
Davis-Monthan AFB, AZ	TR 00-23
Edwards AFB, CA	TR 00-Draft
Kirtland AFB, NM	TR 00-Draft
Laughlin AFB, TX	TR 00-Draft
Little Rock AFB, AR	TR 00-Draft
Nellis AFB, NV	TR 01-31
Westover Air Reserve Base (ARB), MA	TR 00-20
Construction Battalion Center (CBC) Port Hueneme, CA	TR 00-16
Naval Air Station Fallon, NV	TR 00-15
Naval Education Training Center, Newport, RI	TR 00-21
Naval Hospital, Marine Corps Base Camp Pendleton, CA	TR 00-Draft
Naval Hospital, Naval Air Station Jacksonville, FL	TR 01-30
Naval Oceanographic Office, John C. Stennis Space Center, MS	TR 01-3
Subase New London, Groton, CT	TR 00-Draft
U.S. Naval Academy, Annapolis, MD	TR 00-22
National Defense Center for Environmental Excellence (NDCEE), Johnstown, PA	TR 01-33
Naval Hospital, Marine Corps Air Ground Combat Center (MCAGCC), Twentynine Palms, CA	TR 01-32

Units of Weight and Measure

U.S. standard units of measure are used throughout this report. A table of conversion factors for Standard International (SI) units is provided below.

1 ft	=	0.305 m
1 mile	=	1.61 km
1 acre	=	0.405 ha
1 gal	=	3.78 L
°F	=	°C (X 1.8) + 32

2 Site Description

Watervliet Arsenal is located 7 miles from Albany, New York on the west bank of the Hudson River. Founded in 1813, Watervliet is the oldest continually active arsenal in the United States. It is currently the only manufacturing facility in the United States for large caliber cannon. The arsenal is an installation within the U.S. Army Industrial Operations Command.

Several potential applications were evaluated at the Site. The buildings included an immersion plating facility, two boiler plants, an office building and a housing complex. Each potential application was reviewed for potential integration with the fuel cell including site thermal loads, electrical interface requirements and space availability. The best application identified for a 200 kW fuel cell was the main boiler facility (Building 136). It has the largest estimated thermal utilization and was the easiest to interface with the fuel cell. The four other applications examined are discussed briefly in the Fuel Cell Interfaces section of this report. Building 136 houses four boilers and operates for 7 months during the year. Two of the boilers will be replaced with a new low NOx boiler, which is scheduled to be field tested at the Arsenal in 1997. The main boiler plant provides steam throughout the Arsenal for space heating, domestic hot water (DHW), and heating for the immersion plating tanks.

Site Layout

Figure 1 presents the building layout for the main boiler facility at the ground floor level. There is a large roll up door on the south side of the building. Just outside the door is an unpaved parking area. The area slopes up to the street approximately 10 ft above ground level. The water softeners, electric room, and natural gas line are all located on the ground floor of the building.

Electrical System

The base distributes electricity at 13,200 V throughout the Arsenal. There is a 480/13,200 V, 750 kVA transformer located inside the ground floor electrical room. There are also spare panels available where the fuel cell could be tied in electrically.

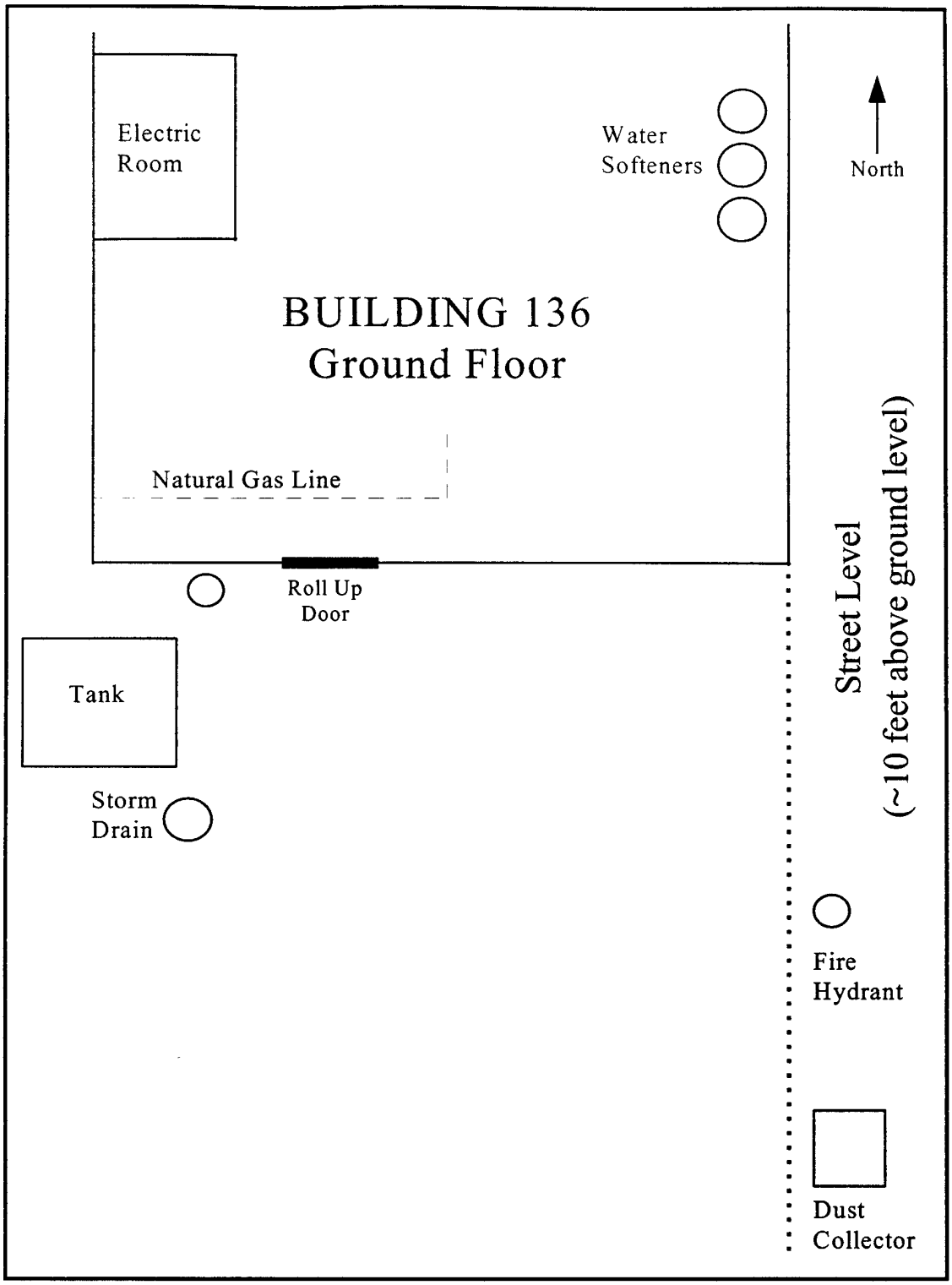

Figure 1. Building 136 site layout.

Steam/Hot Water System

There are two Union Iron Works boilers located in Building 136, which were installed in 1956. The boilers are each rated at 110,000 lb/hr at 150 psi and have a surface area of 9,166 sq ft. The boilers operate primarily on natural gas, but operate intermittently on fuel oil. There are two other boilers at the facility, which are scheduled to be removed and replaced with a low NOx boiler that will be field tested at the Arsenal.

The main boiler plant operates for 7 months each year and provides steam to the entire Arsenal for space heating, hot water and heating of the immersion plating tanks. During the summer, boiler #6, located in Building 35, operates in place of the main boiler plant. Last year boiler #6 only operated for 18 days.

Space Heating System

Steam is distributed to buildings throughout the base for space heating. Each building has its own interface.

Space Cooling System

There is no space cooling at the boiler plant except for a very small cooling unit in the plant control room.

Fuel Cell Location

The fuel cell should be sited on the south side of the main boiler plant as shown in Figure 2. The fuel cell should run in a north-south direction with the thermal outlet side facing east towards the water softener side of the building. The cooling module can be positioned in an east-west direction and the nitrogen tanks can be positioned against the wall as shown.

The thermal piping from the fuel cell to the water softeners will be approximately 100 ft. Natural gas and make-up water can be taken from inside the boiler plant (about 35-ft runs). The electrical run will be approximately 140 ft over to the electrical room. The cooling module run is about 20 ft.

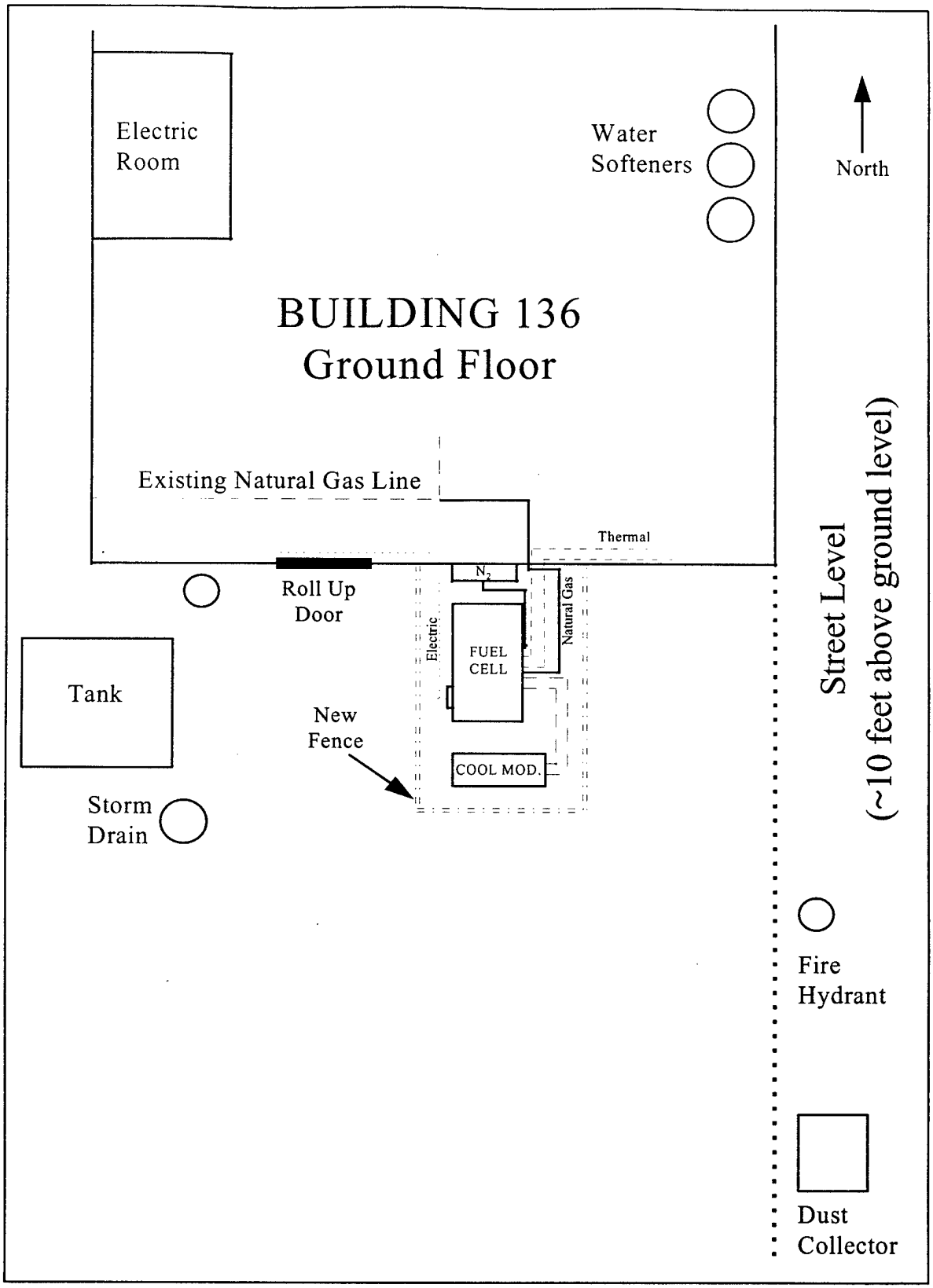

Figure 2. Fuel cell location and interface at Building 136.

Fuel Cell Interfaces

Five potential fuel cell installations were examined at this site. Four locations on the base itself and a satellite housing complex about 15 miles from the base. The electric demand for the base ranges from 7 MW to 10 MW and is distributed at 13,200 V. Many of the buildings have 480 V service and, therefore, utilizing the entire fuel cell electrical output within the base is viable. The effort thus focused on maximizing the fuel cell thermal use and siting the fuel cell to minimize piping and electrical interface runs. Potential installation locations are:

- Rodderdam Housing Facility
- Building # 35 (Boiler #6)
- Building # 40
- Gun 2 Plating Facility (Bldg. #35)
- Building # 136 (Central Boiler Plant).

Rodderdam Housing Facility

The Rodderdam housing facility is approximately 15 miles from the Arsenal and consists of four separate buildings containing 34 apartment units. These four buildings are served through one electric meter. Current electric bills show that the average electric demand is about 61 kW. Occupancy is currently low. Utility bills from 1992, when the occupancy was high, showed that the average electric demand was 100 kW. Siting the fuel cell at Rodderdam would result in at least half of the fuel cell electric output being exported making it a poor fuel cell site.

Building #35 (Boiler #6)

This small central plant provides steam for distribution throughout the base during the summer months when the larger central plant is shutdown. The fuel cell thermal output would be used to pre-heat the boiler make-up water. Based on logged data, the make-up water flow ranged from about 10,000 to 19,000 gal/day during the summer. Assuming the make-up water was heated by the fuel cell from 60 °F to 140 °F, the fuel cell would provide 265 kBtu/hr - 500 kBtu/hr.

$$\text{Thermal kBtu/hr} = (\text{gal/day})\ (24\ \text{hr/day})\ (8.35\ \text{lb/gal})\ (140 - 60\ °\text{F})\ (0.001\ \text{kBtu/ lb-°F})$$

During last summer (May '95 – Sept '95), boiler #6 only operated for 18 days. The plant is shutdown on the weekends, which alternate 2 days and 3 days. Thus the annual overall thermal utilization at Boiler #6 was estimated to be only 3 percent :

$$3\% = [(383\ \text{kBtu/hr})\ (18\ \text{days/yr})\ (24\ \text{hrs/day})] \,/\, [(700\ \text{kBtu/hr})\ (8760\ \text{hrs/yr})]$$

Building #40

Building #40 is an office complex. The hydronic space heating system is heated by a steam heat exchanger off the central steam distribution system. The space heating loop supply temperature varies as a function of the outdoor ambient temperature. The operator stated that the supply temperature ranged from about 110 °F to 180 °F and averaged about 140 °F. With these temperature requirements, the high grade fuel cell heat exchanger would be required. The steam consumption data (steam-used for hydronic space heating, steam heat and the health center) indicated that the maximum hydronic heating load ranged from 230 kBtu/hr to 1,000 kBtu/hr. The average hydronic space heating load was estimated to be about 300 kBtu/hr.

Thus, the annual fuel cell thermal utilization was estimated to be 25 percent;

25% = [(300 kBtu/hr)(7 months)(30 days/mo)(24 hrs/day)] / [(700 kBtu/hr)(8760 hrs/yr)]

Gun 2 Plating Facility (Building #35)

The Gun 2 plating facility was also evaluated. In this facility, there are a number of large plating tanks that are maintained at about 130 °F. The tank temperature is maintained by a glycol/water heating loop. The glycol loop is heated by a steam heat exchanger off the central steam distribution system. The glycol is heated to about 136 °F and returns at about 130 °F. This low temperature differential precludes the use of the low-grade heat exchanger. It would be technically feasible to use the high grade heat exchanger to heat this loop. The glycol could be heated to much higher temperatures (250 °F) in the fuel cell and mixed with unheated glycol back down to the desired supply temperature. However, the heating load to maintain the tank temperature is unknown. The tanks are maintained at 130 °F from Sunday midnight to Friday midnight, or 120 hours per week for 51 weeks per year. The maximum fuel cell thermal utilization would be 35 percent if all the available high grade heat could be used when the tanks are heated.

35% = [(350 kBtu)(6120 hrs)] / [(700 kBtu)(8760 hrs)]

However, the use of the plating facility has been decreasing in recent years. During the summer 1995, boiler plant #6, which provides heat to the plating facility, only operated 18 days. Therefore, the expected fuel cell thermal utilization at this facility is probably well below the 35 percent maximum value.

Building #136 (Central Boiler Plant)

The central boiler plant provides steam for distribution throughout the base from mid-October through mid-May. The steam is used for DHW, space heating, and the plating operations. The fuel cell thermal would be used to pre-heat the boiler make-up water. Table 2 lists the make-up water usage as recorded in the daily boiler logs.

For the 1 year of log data, the central plant boiler operated for 211 days. Listed along with the daily average use for each month is the average flow rate for the minimum day for each month. The lowest average flow rate was 14.6 gpm. Assuming a city water temperature of 60 °F, the fuel cell will heat it to about 155 °F using all of the 700 kBtu/hr available. When higher flows occur, the fuel cell supply temperature will be lower and 100 percent of the fuel cell thermal will be used. Therefore, the fuel cell thermal utilization will be 58 percent (100 percent * 211 days/365 days).

Based on the above analyses of the five potential applications, the recommended fuel cell site is the main boiler plant (Building 136).

The fuel cell electrical output should be connected to the 480 V panel in the electrical room on the ground floor. The electricity is supplied through a 480/13,200 V, 750 kVA transformer. If the fuel cell output is greater than the central plant load, the excess power will be fed into the base grid through the transformer. As discussed previously, the fuel cell will pre-heat the boiler make-up water. The estimated annual thermal utilization is 58 percent.

The recommended fuel cell thermal interface is shown in Figure 3. The make-up water should be pulled from the line after the water softeners using a 25 gpm pump to control the flow. The fuel cell will heat this portion of the make-up flow and return the heated water to the line. The 25 gpm pump will provide the required flow to the fuel cell heat exchanger without restricting the flow during periods of high demand. A back flow preventer should be installed to prevent recirculation of the heated water.

Table 2. Make-up water use.

Month	Monthly Average (1,000 gal/day)	Minimum Day (gpm - avg)
October 1994 (starts 10/11)	41.9	21.3
November 1994	41.2	16.4
December 1994	49.4	21.2
January 1995	55.1	28.7
February 1995	50 (est.)	21.1
March 1995	43.3	21.4
April 1995	34.5	21.4
May 1995 (ends 5/10)	26.5	14.6

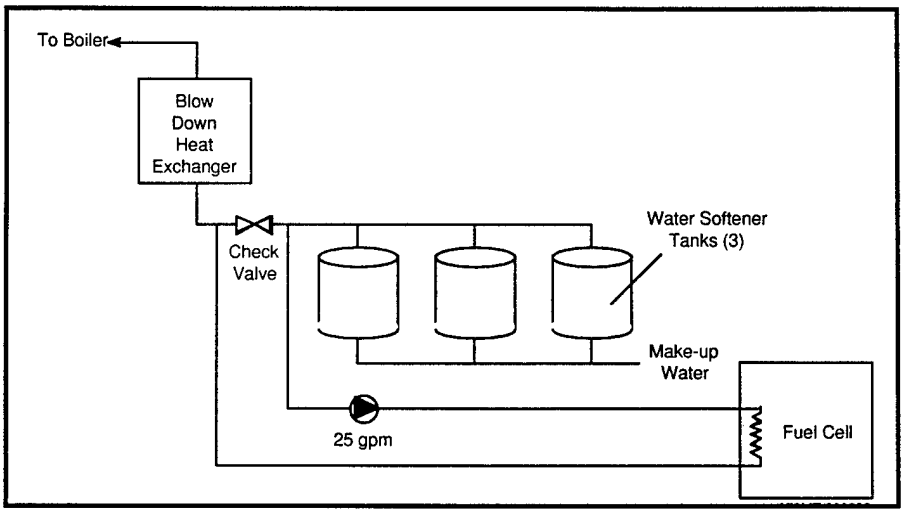

Figure 3. Fuel cell thermal interface.

3 Economic Analysis

The Arsenal purchases electricity from Niagara Mohawk under rate schedule SC3A, which has a demand charge and on-peak/off-peak energy charges. On-peak hours are 8:00 a.m. to 10:00 p.m., Monday-Friday with major holidays excepted. The off-peak period is all remaining hours. Table 3 presents the base electricity consumption and costs for the April-95 to March-96 time period. The SC3A rate schedule is currently:

Demand Charge:	$7.42/kW
Energy Charge (On-Peak):	$0.0655/kWh
Energy Charge (Off-Peak):	$0.0549/kWh.

Natural gas is purchased from Interenergy Corporation and transported by Niagara Mohawk. Table 4 presents natural gas consumption and costs for Building 136 for the last two heating seasons. The average rate during this period was $3.37/MBtu (million Btu) with a high of $5.79/MBtu in March, 1996 and a low of $2.16/MBtu in October, 1994. The gas rate more than doubled from October, 1995 to March, 1996. This fluctuation in rates makes it difficult to estimate the fuel cell energy savings because of the importance of gas costs. A sensitivity analysis is presented below.

Table 3. Watervliet arsenal electricity consumption and costs.

Date	Peak KW	On-Peak KWh	Off-Peak KWh	Demand Cost	On-Peak Cost	Off-Peak Cost	Demand $/kW	On-Peak $/kWh	Off-Peak $/KWh
Apr-95	9,080	1,685,863	1,442,463	$63,323	$110,617	$79,387	$6.97	$0.0656	$0.0550
May-95	7,728	1,699,200	1,687,758	$57,448	$113,266	$92,887	$7.43	$0.0667	$0.0550
Jun-95	7,728	1,550,073	1,403,276	$57,448	$101,708	$77,230	$7.43	$0.0656	$0.0550
Jul-95	9,273	1,628,060	1,569,272	$68,937	$106,825	$86,366	$7.43	$0.0656	$0.0550
Aug-95	7,341	1,647,328	1,461,713	$54,575	$108,089	$80,447	$7.43	$0.0656	$0.0550
Sep-95	7,245	1,666,596	1,707,284	$53,857	$109,353	$93,961	$7.43	$0.0656	$0.0550
Oct-95	8,114	1,638,609	1,385,319	$60,320	$107,517	$76,242	$7.43	$0.0656	$0.0550
Nov-95	8,017	1,657,875	1,611,607	$59,601	$108,781	$88,696	$7.43	$0.0656	$0.0550
Dec-95	8,887	1,617,508	1,501,185	$66,065	$106,132	$82,618	$7.43	$0.0656	$0.0550
Jan-96	7,148	1,532,639	1,520,189	$53,021	$100,341	$83,479	$7.42	$0.0655	$0.0549
Feb-96	8,500	1,753,296	1,628,647	$63,052	$114,787	$89,434	$7.42	$0.0655	$0.0549
Mar-96	8,867	1,730,993	1,452,159	$65,775	$113,327	$79,743	$7.42	$0.0655	$0.0549
Tot/Avg.	8,161	19,808,040	18,370,872	$723,422	$1,300,743	$1,010,490	$7.39	$0.0657	$0.0550

Table 4. Building 136 natural gas consumption and costs.

Date	Natural Gas			Transportation		Total	
	MBTU	Cost	$/MBTU	Cost	$/MBTU	Cost	$/MBTU
Oct-94	24,707	$41,895	$1.70	$11,522	$0.47	$53,417	$2.16
Nov-94	22,119	$46,521	$2.10	$24,150	$1.09	$70,671	$3.20
Dec-94	19,995	$43,836	$2.19	$13,807	$0.69	$57,643	$2.88
Jan-95	41,996	$90,780	$2.16	$29,484	$0.70	$120,264	$2.86
Feb-95	44,800	$84,921	$1.90	$24,740	$0.55	$109,661	$2.45
Mar-95	34,999	$65,986	$1.89	$20,713	$0.59	$86,699	$2.48
Apr-95	20,200	$35,966	$1.78	$13,131	$0.65	$49,097	$2.43
Shut Down							
Oct-95	16,200	$32,084	$1.98	$10,166	$0.63	$42,250	$2.61
Nov-95	31,858	$69,466	$2.18	$17,631	$0.55	$87,097	$2.73
Dec-95	40,000	$109,620	$2.74	$21,882	$0.55	$131,502	$3.29
Jan-96	47,738	$191,453	$4.01	$21,418	$0.45	$212,871	$4.46
Feb-96	34,086	$132,271	$3.88	$20,349	$0.60	$152,620	$4.48
Mar-96	42,863	$230,217	$5.37	$18,130	$0.42	$248,347	$5.79
Tot/Avg	421,561	$1,175,016	$2.79	$247,123	$0.59	$1,422,139	$3.37

Electric savings from the fuel cell were calculated based on the fuel cell operating 90 percent of the year (1,576,800 kWh). Demand and energy savings were calculated as follows:

Demand Savings:

200 kW * 12 mo * $7.42/kW = $17,808

On-Peak Energy Savings:

1,576,800 kWh * 41% on-peak hrs/yr * $0.0655/kWh = $42,345

Off-Peak Energy Savings:

1,576,800 kWh * 59% on-peak hrs/yr * $0.0549/kWh = $51,074

Total electric savings based on 100 percent demand savings total $111,227.

The thermal utilization for the fuel cell was estimated previously at 58 percent. Assuming a 70 percent displaced boiler efficiency, the fuel cell would displace 4,573 MBtu at the boiler plant.

4,573 = (0.700 MBtu/hr. * 8,760 hrs/yr * 58% TU * 90% capacity factor) / 70% boiler eff.

Using an average natural gas rate of $3.37/MBtu, thermal cost savings of $15,411 were calculated for the fuel cell. At the October, 1995 rate of $2.61/MBtu, thermal savings would be $11,936. Using the March, 1996 rate of $5.79/MBtu, thermal savings are $26,478.

The assumed average natural gas cost for fuel cell input fuel is $3.37/MBtu. The fuel cell will consume 14,949 MBtu per year based on an electrical efficiency of 36 percent HHV (higher heating value). Input natural gas cost for the fuel cell is $50,378. Using $2.61/MBtu, input fuel costs would be $39,017. Using $5.79/MBtu, input fuel costs would be $86,555.

The net savings for the 58 percent thermal utilization case and 100 percent demand savings were calculated at $76,260 as shown in Table 5. Table 5 also presents savings for maximum thermal savings, partial demand savings and the high and low gas rate scenarios. The lower gas rate improves the savings to $83,606 and the higher gas rate lowers the savings to $51,150.

The analysis is a general overview of the potential savings from the fuel cell. For the first 3 to 5 years (dependent on remaining program funds after fuel cell options are selected for each Service branch), ONSI will be responsible for the fuel cell maintenance. Maintenance costs are not reflected in this analysis, but could represent a significant impact on net energy savings. Since detailed load energy profiles were not available, net energy savings could vary depending on actual thermal and electrical utilization.

Table 5. Economic savings of fuel cell installation.

Case	ECF	TU	Displaced kWh	Displaced Gas (MBtu)	Electrical Savings	Thermal Savings	Nat. Gas Cost	Net Savings
100% Demand Savings								
Max. Thermal	90%	100%	1,576,800	7,884	$111,227	$26,569	$50,378	$87,418
Base Case	90%	58%	1,576,800	4,573	$111,227	$15,411	$50,378	$76,260
Low Gas Case ($2.61/MBtu)	90%	58%	1,576,800	4,573	$111,227	$11,396	$39,017	$83,606
High Gas Case ($5.79/MBtu)	90%	58%	1,576,800	4,573	$111,227	$26,478	$86,555	$51,150
50% Demand Savings								
Max. Thermal	90%	100%	1,576,800	7,884	$102,323	$26,569	$50,378	$78,514
Base Case	90%	58%	1,576,800	4,573	$102,323	$15,411	$50,378	$67,356
Low Gas Case ($2.61/MBtu)	90%	58%	1,576,800	4,573	$102,323	$11,396	$39,017	$74,702
High Gas Case ($5.79/MBtu)	90%	58%	1,576,800	4,573	$102,323	$26,478	$86,555	$42,246
No Demand Savings								
Max. Thermal	90%	100%	1,576,800	7,884	$93,419	$26,569	$50,378	$69,610
Base Case	90%	58%	1,576,800	4,573	$93,419	$15,411	$50,378	$58,452
Low Gas Case ($2.61/MBtu)	90%	58%	1,576,800	4,573	$93,419	$11,396	$39,017	$65,798
High Gas Case ($5.79/MBtu)	90%	58%	1,576,800	4,573	$93,419	$26,478	$86,555	$33,342

Assumptions:
Natural Gas Rate: $3.37/MBtu
Fuel Cell Thermal Output: 700,000 Btu/hour
Fuel Cell Electrical Efficiency: 36%
ECF = Fuel cell electric capacity factor
TU = Thermal utilization

4 Conclusions and Recommendations

This study concludes that Building 136 at Watervliet Arsenal represents a good application for the 200 kW fuel cell. The boiler plant can utilize all of the thermal output from the fuel cell for 7 months. Net savings range from $51,150 to $83,606, depending on the future gas rate. The Arsenal should attempt to negotiate a favorable rate for the fuel cell.

The fuel cell should be located on the south side of Building 136. Interface piping will be relatively short. There is a spare panel in the electrical room for interfacing the fuel cell. The thermal interface should be after the water softeners and before the existing blow down heat exchanger. Because of the slope up to the street, some minor grading will be required for locating the fuel cell.

Appendix: Fuel Cell Site Evaluation Form

Site Name: **Watervliet Arsenal** Contacts: **Phil Darcey**

Location: **Watervliet, New York**

1. Electric Utility: **Niagara Mohawk** Rate Schedule: **SC3A**

2. Gas Utility: **Interenergy Corp.** Rate Schedule: **Negotiated**

3. Available Fuels: **Natural Gas, Fuel Oil** Capacity Rate:

4. Hours of Use and Percent Occupied:
   Building 136
   14 hour operation, 7 months of year

Weekdays	5	Hrs. 24
Saturday	1	Hrs. 24
Sunday	1	Hrs. 24

5. Outdoor Temperature Range:
   Design dry bulb temperatures: _**1**_ °F to _**91**_ °F

6. Environmental Issues:
   Noise is an issue near fence line for building #35. Air permit not an issue.

7. Backup Power Need/Requirement:
   Various generators around base total 100's of kW.

8. Utility Interconnect/Power Quality Issues:
   None.

9. On-site Personnel Capabilities:
   Boiler plant personnel at facility

10. Access for Fuel Cell Installation:
    Plenty of room. Hill must be partially removed.

11. Daily Load Profile Availability:
    Charts show fairly constant load at boiler plant.

12. Security:
    Fence is required.

Site Layout

Facility Type: **Central Boiler Plant** Age: **55 years**

Construction: **Concrete**

Square Feet: **~27,000 sq ft**

See Figure 1

Show:

electrical/thermal/gas/water interfaces and length of runs
drainage
building/fuel cell site dimensions
ground obstructions

Electrical System

Service Rating: **480/13,200 Volt 750 kVA transformer at central boiler.**

Electrically Sensitive Equipment: **N/A**

Largest Motors (hp, usage): **N/A**

Grid Independent Operation?: **No**

Steam/Hot Water System

Description: **Two Union Iron Works steam boilers provide steam to a central loop that is distributed throughout the base.**

System Specifications: **Union Iron Works boilers (2); 110,000 lbhr @ 150 psi Surface area 9166 sq ft**

Fuel Type: **Natural Gas / Fuel Oil**

Max Fuel Rate: **5,052/3,608 kBtu/hr**

Storage Capacity/Type: **None**

Interface Pipe Size/Description: **4-in. blow down heat exchanger**

End Use Description/Profile: **Central steam loop provides heat for immersion tanks, space heating.**

Space Cooling System

Description: **None at boiler facility.**

Air Conditioning Configuration:

Type:

Rating:

Make/Model:

Seasonality Profile:

Space Heating System

Description: **Central steam plant distributes throughout base**
Fuel: **Natural Gas / Fuel Oil**

Rating: **2 X 110,000 Btu/hr**

Water supply Temp: **_120_** °F to **_160__** °F

Water Return Temp: **_115__** °F to **_160__** °F

Make/Model:

Thermal Storage (space?): **None**

Seasonality Profile: **Central plant operates 7 months per year.**

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14. ABSTRACT

Fuel cells are an environmentally clean, quiet, and a highly efficient method for generating electricity and heat from natural gas and other fuels. Researchers at the U.S. Army Engineer Research and Development Center (ERDC), Construction Engineering Research Laboratory (CERL) have actively participated in the development and application of advanced fuel cell technology since fiscal year 1993 (FY93). CERL selected and evaluated application sites, supervised the design and installation of fuel cells, actively monitored the operation and maintenance of fuel cells, and compiled "lessons learned" for feedback to manufacturers for 29 of 30 commercially available fuel cell power plants and their thermal interfaces installed at Department of Defense (DOD) locations.

This report presents an overview of the information collected at Watervliet Arsenal, NY, along with a conceptual fuel cell installation layout and description of potential benefits the technology can provide at that location. Similar summaries of the site evaluation surveys for the remaining 28 sites where CERL has managed and continues to monitor fuel cell installation and operation are available in the companion volumes to this report.

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