ERDC/CERL TR-01-33

Construction Engineering Research Laboratory

US Army Corps of Engineers®
Engineer Research and Development Center

Site Evaluation for Application of Fuel Cell Technology

National Defense Center for Environmental Excellence (NDCEE), Johnstown, PA

Michael J. Binder, Franklin H. Holcomb, and William R. Taylor

March 2001

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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 summarizes information collected at the National Defense Center for Environmental Excellence (NDCEE), Johnstown, PA. Special thanks is owed to NDCEE personnel Mark Funyak, Dave Williams, Bob Lentz, and Larry Shirey, who provided tours of the facilities, energy bills and rates, site drawings, and contact with appropriate site personnel. The work was done 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. The Acting Director of CERL is William D. Goran.

CERL is an element of the U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers. The Director of ERDC is Dr. James R. Houston and the Commander is COL James S. Weller.

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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). CERL has 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, 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 NCDEE 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 NCDEE as a potential location for a fuel cell application.

Approach

1. On 12 and 13 September 1996, CERL and Science Applications International Corp. (SAIC) representatives visited the NCDEE (the Site) to investigate it as a potential location for a 200 kW fuel cell.
2. Additionally, a copy of the site evaluation form filled out at the Site is provided as an addendum to this report.
3. Date was collected from energy bills, site drawings, and by interviewing appropriate site personnel.

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

On 12 and 13 September 1996, CERL and SAIC representatives visited NDCEE to investigate it as a potential location for a 200 kW phosphoric acid fuel cell power plant. This report presents a conceptual fuel cell installation layout, thermal interface schematics, preliminary economic evaluation, description of potential benefits, and an overview of information collected at the site. Tables and figures are included following the written section of this report. A copy of the completed site evaluation form prepared during the site visit is included as an addendum.

Site Description

The NDCEE is located in Johnstown, PA, approximately 75 miles east of Pittsburgh. The NDCEE was established by the Department of Defense in 1991 to lead and support DoD facilities and the associated industrial base in adopting a comprehensive approach to pollution prevention and to address other high priority environmental issues. The NDCEE is operated by Concurrent Technologies Corp. (CTC), an independent nonprofit organization, and is encouraged to offer its services to private industry to improve U.S. competitiveness in the global economy. The Environmental Technology Facility (ETF), a part of NDCEE, houses a demonstration factory, which is supported by a test laboratory. Advanced technologies installed in the factory are demonstrated as alternatives to current industrial processes that produce environmentally unacceptable emissions or discharges. Approximately 28 technologies are operating in the factory.

The ASHRAE design temperatures for the site are 86 and 2 °F. The extreme temperatures experienced in Johnstown are 95 to −15 °F. The heating degree days are approximately 6000. Humidity is relatively high in the summer. The elevation is approximately 2300 ft. The Environmental Technology Facility was the primary focus for the fuel cell location. Figure 1 shows a facility site map.

The ETF was the only facility at NDCEE that was evaluated for the fuel cell due to the large thermal loads relative to other facilities. Based on discussions with site personnel, the primary thermal loads were space heating, process hot water, and a process evaporator. The ETF boilers produce 140 to 200 °F hot water for space heating.

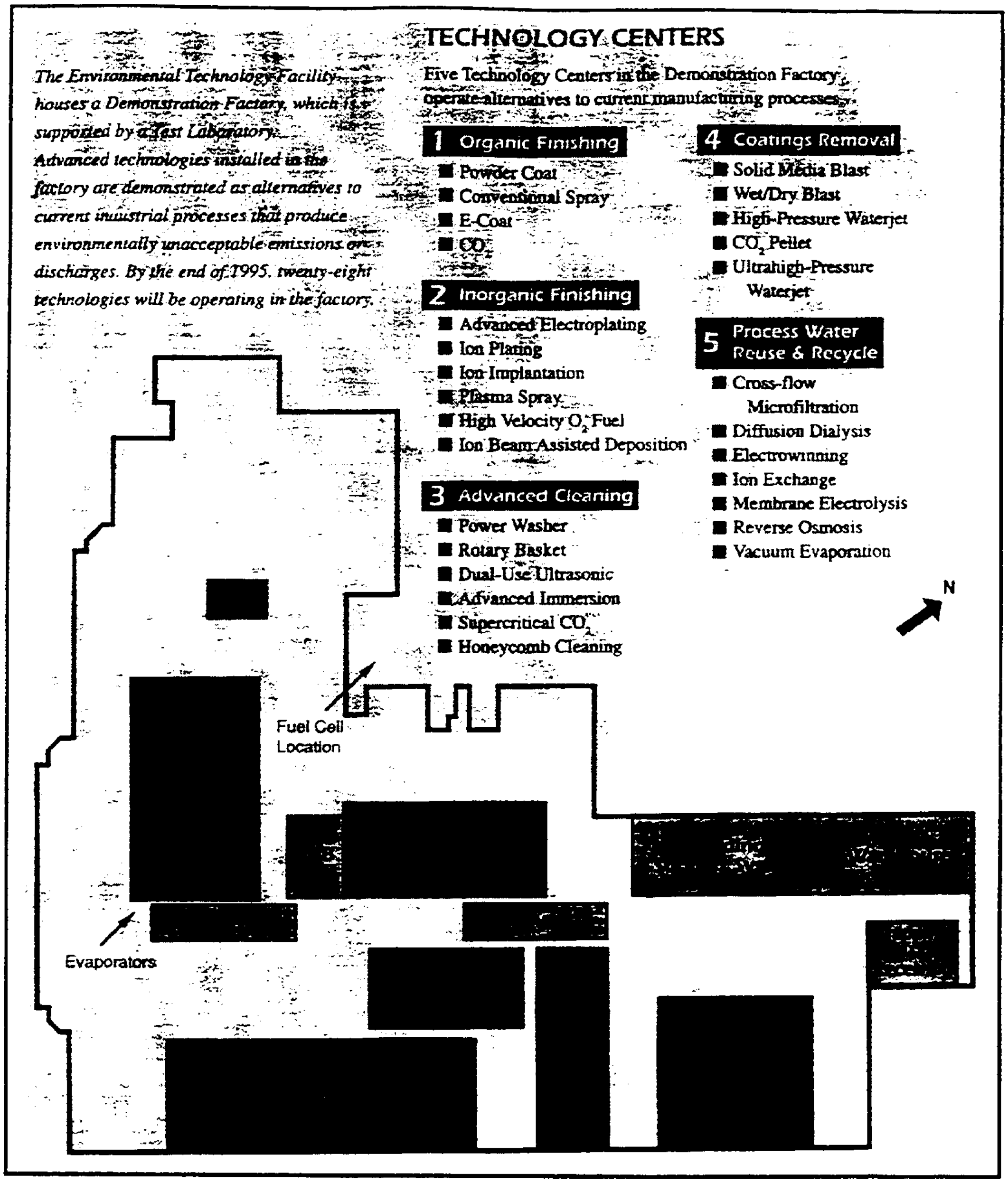

Figure 1. NDCEE Environmental Technology Facility site map.

The process hot water is provided to various process demonstrations in the ETF and is produced by an 8 MBtu/hr (million Btu per hour) burner coupled to a 2900-gal storage tank. Hot water is supplied at 175 to 180 °F, but only operates 4 hours per day, 5 days per week. Site personnel believed that the average makeup water requirement for this process was only 100 gal per day.

The evaporator consists of a 1.8 MBtu/hr gas burner and a 2600-gal tank that is maintained at 155 °F. Process waste water is fed to the tank where it is heated and evaporated so that the remaining residue can be removed. It operates 8 hours per day, 5 days a week. The application for the fuel cell's thermal output focused on the evaporator due to its ability to use a larger portion of the fuel cell's heat on a year round basis.

General Public Utilities (formerly Pennelec) provides power to the ETF through two billing meters. Site personnel indicated that power outages were not a problem since the ETF has a 100 kW and a 500 kW back up diesel generators. Natural gas is supplied by Peoples Gas Company.

The ETF consists of laboratory space, process demonstration areas, and office space. The various process demonstration areas are shown in Figure 1. The ETF is in the process of making a major 137,000 sq ft addition. There is an adequate natural gas line and spare electric breaker in the boiler/heater room for the installation of a 200 kW fuel cell. Make up water and telephone lines are available. More specific interface information for the site is provided in the Fuel Cell Interfaces section of this report.

Site Layout

Figure 2 shows an existing chiller/condenser pad located outside the ETF adjacent to the boiler/heater room on the northwest side of the building. The evaporator tank is located on the southeast side of the organic finishing area within the building.

Electrical System

The ETF has two main services, one for the old portion of the building and the other for the new portion. The old portion of the building is served by a 480/23,000 V, 1,500 kVA transformer. The new part of the building is served by a 480/23,000 V, 2,000 kVA transformer. The ETF has an average peak electric demand of 1,031 kW. However, during evenings and weekends, the load drops to 50 to 100 kW. The facility will be able to use all of the fuel cell's electrical output during weekday working hours. There is presently a 100 kW back up diesel generator on the old part of the building and a 500 kW back up diesel generator on the new portion of the building. There were no requirements for using the fuel cell as an emergency generator.

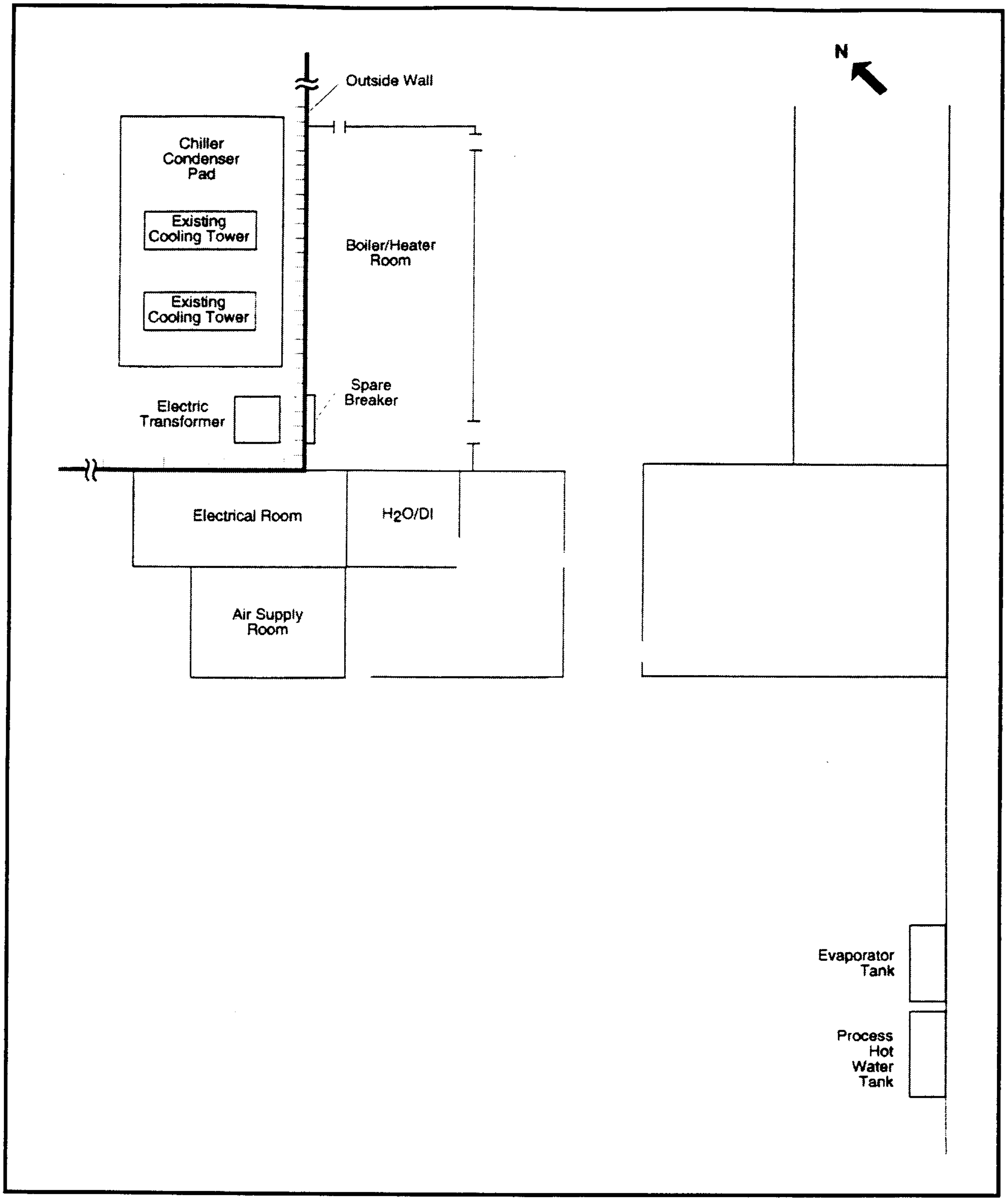

Figure 2. NDCEE Environmental Technology Facility site layout.

Steam/Hot Water System

There is very little domestic hot water used in the ETF. Process hot water is supplied to various demonstration and laboratory processes. The hot water is heated to 175 to 180 °F in a 2900-gal tank with an 8 MBtu/hr gas burner. There is also an evaporator that receives waste water from the ETF processes. The evaporator consists of a 2600-gal tank that is heated to 155 °F by a 1.8 MBtu/hr gas burner.

Space Heating System

Three boiler/heaters (720, 1200, and 1680 MBtu/hr) in the boiler/heater room of the ETF produce 140 to 200 °F hot water for space heating. There are also some direct-fired roof-mounted gas space heating units for the office space.

Space Cooling System

There are two, 400-ton centrifugal chillers that supply cooling to the old portion of the ETF. Two new, 150-ton rotary screw chillers were installed in the new portion of the ETF. There are 14 old, roof-mounted direct expansion (DX) air conditioning units in the office space area of the old portion of the facility and there are seven new DX units in the new portion of the ETF.

3 Fuel Cell Description

Fuel Cell Location

The proposed location for the fuel cell is the northwest side of the ETF as shown in Figures 1 and 3. There is adequate room around the fuel cell to maintain the desired 8-ft spacing. The electrical connection to the electrical panel in the heater/boiler room will require an 80-ft run. The fuel cell thermal lines will need to be run approximately 330 ft to the evaporators in the organic finishing area. The natural gas line can be connected to the gas line presently feeding the boilers in the heater/boiler room, which is a piping run of approximately 40 ft. The fuel cell can be located on the existing chiller/condenser pad just outside the heater/boiler room.

Fuel Cell Interfaces

The Environmental Technology Facility is undergoing significant electric service expansion. There is an existing 1500 kVA, 480/23,000 V transformer located outside next to the existing chiller/condenser pad. There is also a new electrical room for the facility expansion with a 2,000 kVA 480/23,000 V transformer. It is recommended that the fuel cell be grid connected at a spare 400 amp, 480 V breaker in the boiler/heater room. The electric load for the facility averages 1,031 kW. However, the load drops to 50 to 100 kW during evenings and weekends. It is not economical for the NDCEE to sell power back to the utility. Therefore, it is recommended that a controller be installed that sends a 4-20 mA signal from the electric meter to the fuel cell to scale back power output so that no power is sold back to the utility. The fuel cell will need to be ordered with the C7 modification for external power and event signals option (FC14974). There is no need to use the back-up power capability of the fuel cell.

Another option that was discussed, was to install an additional thermal energy storage system. The electric chillers could be run at night and the chilled water stored and used to provide chilled process water during the day. This would increase the electric load at night for the fuel cell. This would be outside the DoD project. However, the current off-peak electric rate of 2.61¢/kWh does not make this economical.

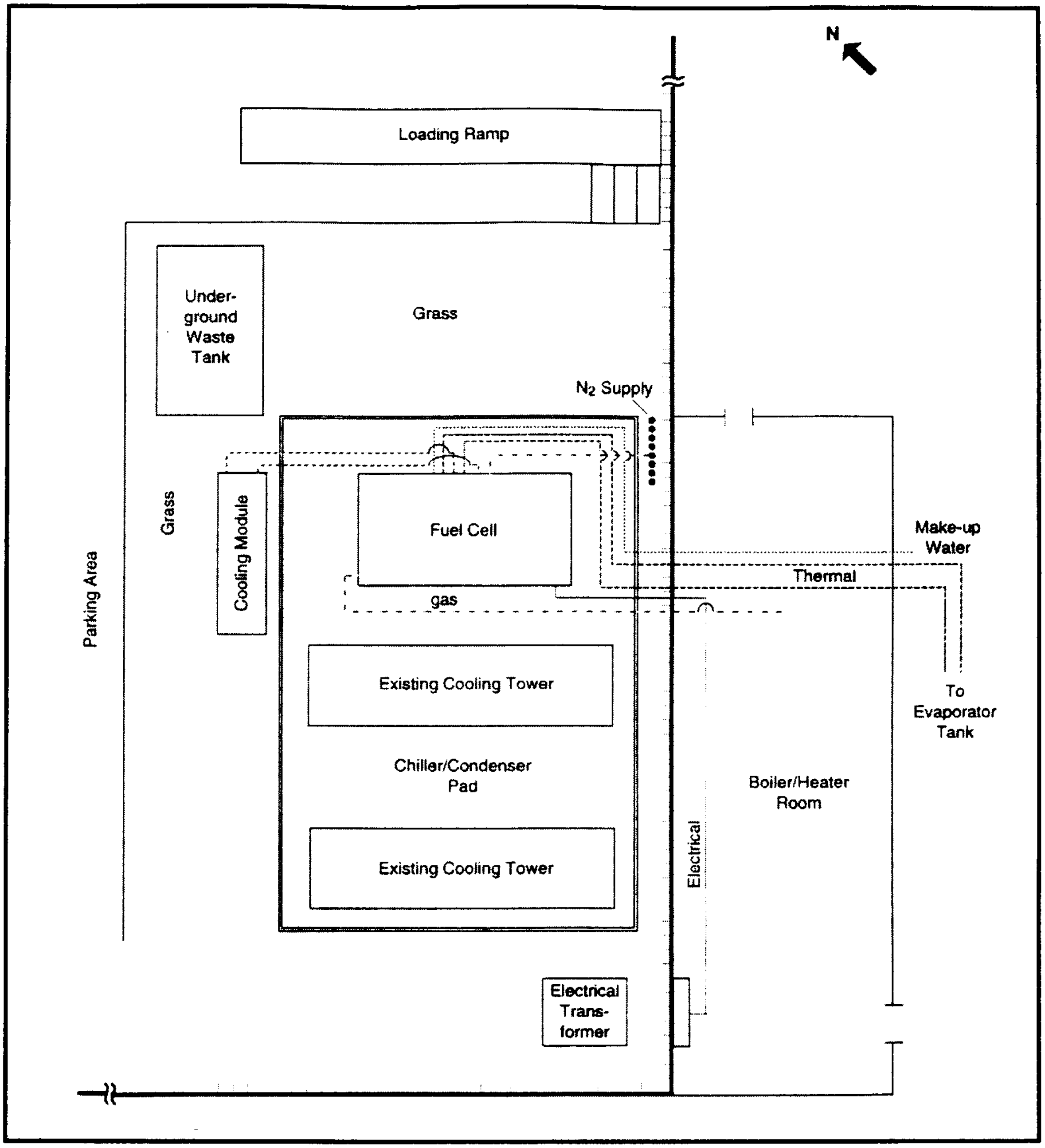

Figure 3. Fuel cell location and site interfaces.▾

If the fuel cell operated continuously at full capacity, it would produce 1,752,000 kWh/yr:

1,752,000 kWh/yr = 200 kW * 8,760 hr/yr

However, the fuel cell will not operate continuously at full capacity. It is estimated by site personnel that the fuel cell will operate at full capacity for 12 hours per day during weekdays and at an average of 75 kW for the remainder of the weekday hours, weekends, and holidays.

Based on this assumption, the fuel cell will supply 1,032,000 kWh per year:

200 kW * 12hr/day * 250 days/yr = 600,000 kWh

75 kW* 12hr/day * 250 days/yr = 225,000 kWh

75 kW * 24hr/day * 115 days/yr = 207,000 kWh

1,032,000 kWh

This represents 59 percent of the fuel cell's total electrical capacity (1,032,000 kWh/1,752,000 kWh).

The fuel cell high grade thermal output should be used to heat the 2,600-gal evaporator tank. The liquid in the tank is waste from various processes and tests within the facility. The tank is heated to 155 °F by a gas burner and a serpentine heat exchanger located in the tank. The waste water is fed to the tank, which evaporates the water allowing the solid waste products to be removed. The 155 °F temperature requirement can only be met by the high grade heat exchanger of the fuel cell.

It is recommended that a closed hydronic loop be installed between the fuel cell high grade heat exchanger and a new stainless steel serpentine heat exchanger to be installed in the evaporator tank (Figure 4). Stainless steel is recommended due to the potentially corrosive nature of the waste water in the tank. A 25 gpm pump should be installed in the loop to circulate water from the fuel cell to the tank heat exchanger. This pump should run whenever the fuel cell is operating.

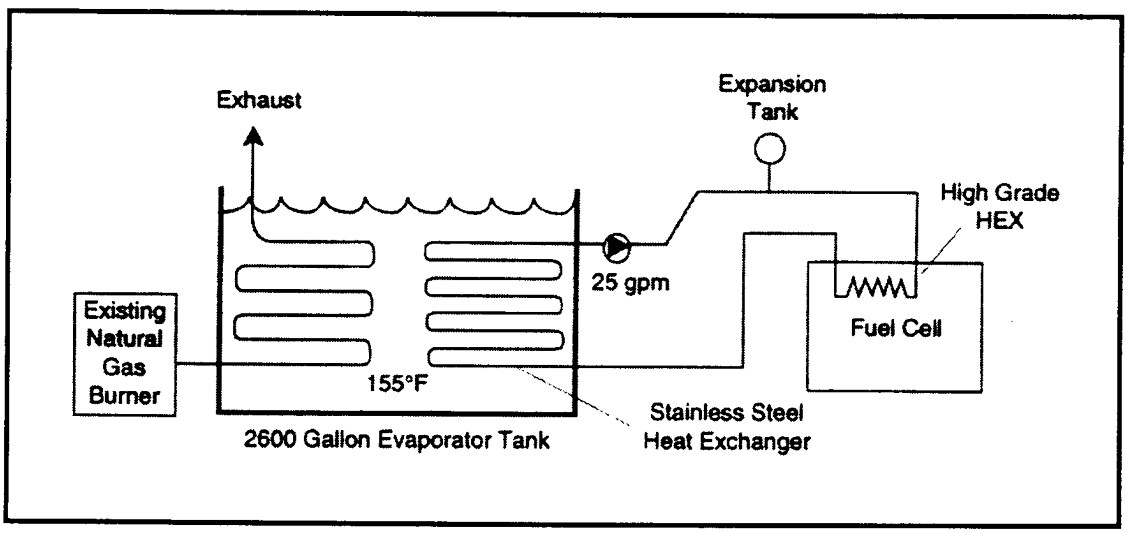

Figure 4. Fuel cell thermal interface—evaporator.

The maximum acceptable tank temperature is above the maximum temperature that the fuel cell can supply (~165 °F). An expansion tank will also be needed in the closed loop. The stainless steel heat exchanger should be installed in a vertical position in the tank so that sludge buildup on the bottom of the tank does not deter heat transfer.

The existing gas burner in the evaporator tank is 1.8 MBtu/hr and operates 8 hours per day, 5 days per week. Gas consumption data was provided, which showed that the evaporator was consuming 841 kBtu/hr. Using gas consumption data provided by the site and assuming the burner operates at 70 percent efficiency, the thermal load is 589 kBtu/hr:

589 kBtu/hr = 841 kBtu/hr * 0.70 efficiency

The thermal load for an 8 hour day is 4.71 MBtu:

4.71 MBtu/day = 589 kBtu/hr * 8 hr/day * 1 MBtu/1000 kBtu

The fuel cell high grade heat exchanger produces 380 kBtu/hr. Therefore, the fuel cell would have to operate for 12.4 hours per day (4700 kBtu / 380 kBtu/hr) to meet the required thermal load.

Site personnel have indicated that there would be no problem to operate the evaporator 12 hours instead of the present 8 hours per day. They also stated that if the waste water were fully evaporated, the system would not be damaged. Therefore, it is assumed that the fuel cell high grade heat will be fully utilized for 12 hours per day, 5 days per week, for 50 weeks per year (the plant is down for 2 weeks a year). The annual thermal energy supplied by the fuel cell would be 1140 MBtu:

1140 MBtu = 380 kBtu/hr * 12 hrs/day * 5 days/wk * 50 wk/yr * 1 MBtu/1000 kBtu

This represents an overall thermal utilization of 19 percent. It should be noted that if the fuel cell is turned down to below 50 percent of the rated electrical output , no high grade heat is available:

19% = 1140 MBtu/(0.7 MBtu/hr * 8760 hrs/yr)

4 Economic Analysis

NDCEE is located in General Public Utilities (GPU) service territory and purchases electricity under schedule GST (General Service/Time of Day). This rate schedule has both demand and energy charge (on-peak/off-peak) components. The on-peak period is between 8:00 a.m. and 8:00 p.m., Monday through Friday. The off-peak period is all remaining hours. Table 2 presents the base electricity consumption and costs for the July-95 to June-96 time period. The GST rate schedule is:

Demand Charge: $10.27/kW

Energy Charge (on-peak): $0.041765/kWh*

Energy Charge (off-peak): $0.033065/kWh*

Table 2. NDCEE (ETF) electricity consumption and costs.

Date	Peak Demand	On-Peak kWh	Off-Peak kWh	Total kWh	Total Cost	$/kWh
Jul-95	1,200	180,800	119,100	299,900	$23,719	$0.0791
Aug-95	1,250	170,500	128,500	299,000	$24,090	$0.0806
Sep-95	1,186	157,000	101,500	258,500	$21,976	$0.0850
Oct-95	1,120	155,500	101,000	256,500	$21,345	$0.0832
Nov-95	1,042	140,000	120,500	260,500	$20,627	$0.0792
Dec-95	902	130,500	114,000	244,500	$18,575	$0.0760
Jan-96	762	121,000	107,500	228,500	$16,523	$0.0723
Feb-96	887	135,000	125,000	260,000	$18,952	$0.0729
Mar-96	882	142,750	115,250	258,000	$19,323	$0.0749
Apr-96	877	150,500	105,500	256,000	$19,694	$0.0769
May-96	1,155	151,500	107,000	258,500	$22,641	$0.0876
Jun-96	1,119	160,500	95,000	255,500	$22,243	$0.0871
Tot/Avg	1,032	1,795,550	1,339,850	3,135,400	$249,708	$0.0796
December 1995 and March 1996 data not available; interpolated between surrounding months.						

* This charge includes a $0.0069695/kWh energy cost rate adjustment.

NDCEE purchases natural gas from Peoples Gas. Table 3 presents natural gas consumption and costs from June-1995 to May 1996 under rate schedule IS-S (small industrial rate). As of July 1996 NDCEE switched to rate schedule CS-L (large commercial rate). The new rate has a commodity charge of $6.4199/MCF.

Table 3. NDCEE (ETF) natural gas consumption and costs.

Date*	Total MCF	Cost	$/MCF
June 95	365	$3,798	$10.41
July 95	185	$3,013	$16.29
August 95	140	$2,829	$20.21
September 95	369	$3,781	$10.25
October 95	595	$3,095	$5.20
November 95	1,839	$5,510	$3.00
December 95	2,147	$6,107	$2.84
January 1996	1,976	$9,385	$4.75
February 1996	2,025	$9,950	$4.91
March 1996	1,622	$8,924	$5.50
April 1996	1,219	$7,897	$6.48
May 1996	799	$5,846	$7.32
Tot/Avg	13,281	$70,135	$5.28
*March 1996 data not available; interpolated between Feb/Apr.			

Electric savings from the fuel cell were calculated based on the 1,032,000 kWh/yr previously discussed and a fuel cell availability of 90 percent for a total annual output of 928,800 kWh. Since the fuel cell will be operating at 200 kW during the on-peak period, demand savings were based on 200 kW rather than 75 kW. Demand and energy savings for NDCEE were calculated as:

Demand Savings:

200 kW * 12 months * $10.27/kW = $24,648

Energy Charge Savings:

On-Peak: 600,000 kWh * 90% * $0.041765/kWh = $22,553

Off-peak: 432,000 kWh * 90% * $0.033065/kWh = $14,284

First year electric savings based on 100 percent demand savings total $61,485. Thermal savings were estimated previously at 1,140 MBtu/yr. Total thermal displaced by the fuel cell assuming a 70 percent displaced boiler efficiency is calculated as:

1,465 MBtu displaced thermal = (1,140 MBtu * 90%) / 70% boiler eff.

Using a natural gas rate of \$6.42/MCF and an assumed 1.03 MBtu/MCF, thermal cost savings of \$9,131 were calculated for the fuel cell.

\$9,131 = (1,465 MBtu / 1.03 MBtu/MCF) * 6.42/MCF

The fuel cell will consume 8,806 MBtu per year based on an electrical efficiency of 36 percent HHV (higher heating value) and 928,800 kWh.

8,806 MBtu = 928,800 kWh * (0.003413 MBtu/kWh / 36%)

Input natural gas cost for the fuel cell at \$6.42/MCF would be \$54,887.

\$54,887 = (8,806 MBtu / 1.03 MBtu/MCF) * 6.42/MCF

The net savings for the fuel cell assuming 19 percent thermal utilization and 100 percent demand savings is \$15,729 (Table 4). The impact of a having a cogeneration gas rate was calculated. The 911th Airlift Wing in Pittsburgh, PA is currently receiving a gas rate of \$3.86/MBtu from Peoples Gas for its fuel cell. If NDCEE could obtain this rate, it would increase the energy savings to \$36,625. Table 4 also presents savings for maximum thermal savings and partial demand savings cases.

This analysis is a general overview of the potential savings from the fuel cell. For the first 56 months, 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 4. Economic savings of fuel cell installation.

Case	ECF	TU	Displaced kWh	Displaced Gas (MBtu)	Electrical Savings	Thermal Savings	Nat. Gas Cost	Net Savings
Full Demand Savings								
Maximum Thermal Case	53%	100%	928,800	7,884	$61,485	$35,363	$54,887	$41,961
Base Case	53%	19%	928,800	1,465	$61,485	$9,131	$54,887	$15,729
Cogen. Gas Rate ($3.86/MBtu)	53%	19%	928,800	1,465	$61,485	$9,131	$33,991	$36,625
50% Demand Savings								
Maximum Thermal Case	53%	100%	928,800	7,884	$49,161	$35,363	$54,887	$29,637
Base Case	53%	19%	928,800	1,465	$49,161	$9,131	$54,887	$3,405
Cogen. Gas Rate ($3.86/MBtu)	53%	19%	928,800	1,465	$49,161	$9,131	$33,991	$24,301
Zero Demand Savings								
Maximum Thermal Case	53%	100%	928,800	7,884	$36,837	$35,363	$54,887	$17,313
Base Case	53%	19%	928,800	1,465	$36,837	$9,131	$54,887	($8,919)
Cogen. Gas Rate ($3.86/MBtu)	53%	19%	928,800	1,465	$36,837	$9,131	$33,991	$11,977

Assumptions:

Natural Gas Rate: $6.42 /MCF @ 0.00103 MBtu/MCF
Electric Rate: see report text
Fuel Cell Thermal Output: 700,000 Btu/hour
Fuel Cell Electrical Efficiency: 36%
Seasonal Boiler Efficiency: 70%
ECE = Fuel cell electric capacity factor
TU = Thermal utilization

5 Conclusions and Recommendations

The Environmental Technology Facility (ETF) of NCDEE represents a unique application for a 200 kW phosphoric acid fuel cell. The thermal energy from the fuel cell would be used to heat an evaporator tank, which evaporates the liquid waste produced by various demonstration and testing processes in the facility. The high grade heat exchanger option for the fuel cell will need to be ordered. The net energy bill savings are expected to be $16,000/year with full demand savings. The fuel cell installation at the ETF should be straightforward since an existing pad just outside the heater/boiler room will provide close connections for all tie-ins except the thermal piping. The piping for the thermal output of the fuel cell will need to be run approximately 330 ft through the building to the evaporator. A security fence would not be required.

The fuel cell is compatible electrically with the site. There is a spare 480 V, 400 amp electrical breaker in the heater/boiler room. The electrical load will drop below the fuel cell's output during the evening. The installation will require a controller that will read a signal from the electrical meter when the load drops below 200 kW and reduce the fuel cell electrical output to prevent selling power back to the utility. The fuel cell will need to be ordered with the C7 modification for external power and event signals option (FC14974).

Appendix: Fuel Cell Site Evaluation Form

Site Name: **NDCEE**

Contacts: **Mark Funyak**

Location: **Johnstown, PA**

1. Electric Utility: **GPU (Pennelec)** Rate Schedule: **General Service**
2. Gas Utility: **Peoples Natural Gas Co.** Rate Schedule: **Commercial Service–Large**
3. Available Fuels: **Natural Gas, Diesel**
4. Hours of Use and Percent Occupied:

Weekdays	5	Hrs	12
Saturday	0	Hrs.	
Sunday	0	Hrs.	

5. Outdoor Temperature Range: **ASHRAE Design: 86 °F high, 2 °F low Extreme Weather Data: 95 °F high to –15 °F low, 6000 HDD**
6. Environmental Issues: **No major issues**
7. Backup Power Need/Requirement: **ETF has a 100 kW Diesel generator and a 500 kW Diesel generator. There are usually no extended power outages.**
8. Utility Interconnect/Power Quality Issues: **The ETF has experienced spikes and surges. Sensitive electrical equipment is connected to a UPS.**
9. On-site Personnel Capabilities: **Maintenance personnel are on call 24 hrs per day.**
10. Access for Fuel Cell Installation: **Very good.**
11. Daily Load Profile Availability: **Highs are ~1MW, lows are 50–100 kW.**
12. Security: **No major security issues at ETF.**

Site Layout

Facility Type: **Laboratory, Office** Age: **35 years**

Construction: **Old: precast concrete, roof joists. New: concrete block**

Square Feet: **Old: 65,000 sq ft. New: 137,000 sq ft; 45000 sq ft new office.**

See Figures 1, 2, 3

Show:

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

Electrical System

Service Rating: **23 kV service to building. 480 volt service in building**

Electrically Sensitive Equipment: **Computers, process controllers, electronic processes.**

Largest Motors (hp, usage): **Two 150-ton screw chillers, two 400-ton centrifugal chillers.**

Grid Independent Operation?: **No.**

Steam/Hot Water System

Description: **ETF produces hot water for space heating and DHW. An evaporator and process hot water in direct fired with natural gas.**

System Specifications:

Fuel Type: **Natural Gas**

Max Fuel Rate:

Storage Capacity/Type: **None.**

Interface Pipe Size/Description: **1-½ to 2-.**

End Use Description/Profile:
There are three heaters (720 MBtu/hr, 1200 MBtu/hr, and 1680 MBtu/hr) that produce 140 to 200 °F hot water for space heating. DHW use is insignificant. The evaporator hot water tank is heated to 155 °F with a 1.8 MBtu/hr burner. The process hot water is heated to 175 to 180 °F by an 8 MBtu/hr burner.

Space Cooling System

Description: **There are two 150-ton screw chillers for the new portion of the facility. There are two 400-ton centrifugal chillers for the old portion of the facility. There area also 14 old rooftop DX units for the office space in the old portion of the building and there are seven rooftop units for the new office space.**

Air Conditioning Configuration:
Type:
Rating:
Make/Model:

Seasonality Profile:

Space Heating System

Description: **There are three heaters (720 MBtu/hr, 1200 MBtu/hr, and 1680 MBtu/hr) that produce hot water for space heating.**

Fuel: **Natural gas**

Rating:

Water Supply Temp: **140 to 200 °F.**

Water Return Temp:

Make/Model: **Bryan Flexible Tube Boilers**

Thermal Storage (space?): **None.**
Seasonality Profile:

CERL Distribution

Commander, NDCEE
  ATTN: Facility Engineer (2)

Chief of Engineers
  ATTN: CEHEC-IM-LH (2)

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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 has 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 the National Defense Center for Environmental Excellence (NDCEE), Johnstown, PA, 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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