ERDC/CERL TR-00-15

Construction Engineering Research Laboratory

US Army Corps of Engineers®
Engineer Research and Development Center

Site Evaluation for Application of Fuel Cell Technology

Pine Bluff Arsenal, AR

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

December 2000

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 Pine Bluff Arsenal, White Hall, AR. Special thanks is owed to the Pine Bluff Arsenal point of contact (POC), Nancy Rimmer, 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), U.S. Army Construction Engineering Research Laboratory (CERL). The CERL principal investigator was Dr. Michael J. Binder. Part of this work was done by Science Applications International Corp., Reston, VA 20190 under contract No. DACA 88-94-D-0020, task orders 0002, 0006, 0007, 0010, and 0012. Larry M. Windingland is Chief, CECER-CF-E, and L. Michael Golish is Chief, CECER-CF. The associated Technical Director was Gary W. Schanche, CEERD-CV-T. The CERL technical editor was William J. Wolfe, Information Technology Laboratory. 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 electricity. Fuel cells are an environmentally clean, quiet, and 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 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 Pine Bluff Arsenal, White Hall, AR 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 (Table 1).

Objective

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

Approach

On 29 and 30 August 1996, CERL and SAIC representatives visited the Pine Bluff 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. Additionally, 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 00/DRAFT
Fort Eustis, VA	TR 00/DRAFT
Fort Huachuca, AZ	TR 00/DRAFT
Fort Richardson, AK	TR 00/DRAFT
Picatinny Arsenal, NJ	TR 00/DRAFT
Pine Bluff Arsenal, AR	TR 00/DRAFT
U.S. Army Soldier Systems Command, 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/DRAFT
934th Airlift Wing, Minneapolis, MN	TR 00/DRAFT
Barksdale Air Force Base (AFB), LA	TR 00/DRAFT
Davis-Monthan Air Force Base (AFB), AZ	TR 00/DRAFT
Edwards Air Force Base (AFB), CA	TR 00/DRAFT
Kirtland Air Force Base (AFB), NM	TR 00/DRAFT
Laughlin Air Force Base (AFB), TX	TR 00/DRAFT
Little Rock Air Force Base (AFB), AR	TR 00/DRAFT
Nellis Air Force Base (AFB), NV	TR 00/DRAFT
Westover Air Force Base (AFB), MA	TR 00/DRAFT
Construction Battalion Center (CBC) Port Hueneme, CA	TR 00/DRAFT
Naval Air Station Fallon, NV	TR 00/DRAFT
Naval Education Training Center, Newport, RI	TR 00/DRAFT
Naval Hospital • Marine Corps Base Camp Pendleton, CA	TR 00/DRAFT
Naval Hospital • Naval Air Station Jacksonville, FL	TR 00/DRAFT
Naval Oceanographic Office, John C. Stennis Space Center, MS	TR 00/DRAFT
Subase New London, Groton, CT	TR 00/DRAFT
U.S. Naval Academy, Annapolis, MD	TR 00/DRAFT
National Defense Center for Environmental Excellence, (NCDEE) Johnstown, PA	TR 00/DRAFT
Naval Hospital • Marine Corps Air Ground Combat Center (MCAGCC) Twentynine Palms, CA	TR 00/DRAFT

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.

SI conversion factors					
1 in.	=	2.54 cm	°F	=	°C (X 1.8) + 32
1 ft	=	0.305 m	1 ton (cooling)	=	12,000 Btu
1 mile	=	1.61 km	1 psi	=	6.89 kPa
1 acre	=	0.405 ha	1 Btu	=	1.055 kJ
1 gal	=	3.78 L	1 hp	=	745.699 W

2 Site Description

Pine Bluff Arsenal is located approximately 35 miles southeast of Little Rock, AR, in the town of White Hall. The Arsenal is about 8 mi long and 2.75 mi wide. It was established in 1941 as a manufacturing center for magnesium and thermite munitions. During World War II and afterwards, the Arsenal expanded its capabilities to manufacture, fill, and store various types of chemical-filled weapons. Today, it is part of the U.S. Army Industrial Operations Command (IOC), a subordinate command of the Army Materiel Command (AMC).

The ASHRAE design temperatures at the site are 22 and 97 °F. Extreme temperatures range from the teens to 100 °F.

Three primary boiler plants at the Arsenal were the focus for a fuel cell site. The boiler plants feed a central steam distribution system used for various industrial processes. Two boiler plants, #32-060 and #33-060, were examined during the site visit. Boiler plant #32-060 was being renovated during the site visit, but was selected as the best boiler plant application for the fuel cell because it is expected to be the most utilized plant when completed. It is a dual fuel facility, with fuel oil used for back-up. The third boiler plant, #34-140, was eliminated from consideration due to the projected reduction in its utilization as a result of the improvements to #32-060.

Site Layout

Figure 1 shows a site map of Pine Bluff Arsenal. Boiler plant #32-060 is located toward the southern end of the base. Figure 2 shows the layout of boiler plant #32-060. Three 100 kVA pole-mounted transformers are located on the north side of the building. Fuel oil storage and natural gas are located on the south side of the building. On the west side of the building is a grassy area where the boiler plant exhaust stack, storage shed, and cooling tower are located. The building electric panel is located in the compressor room.

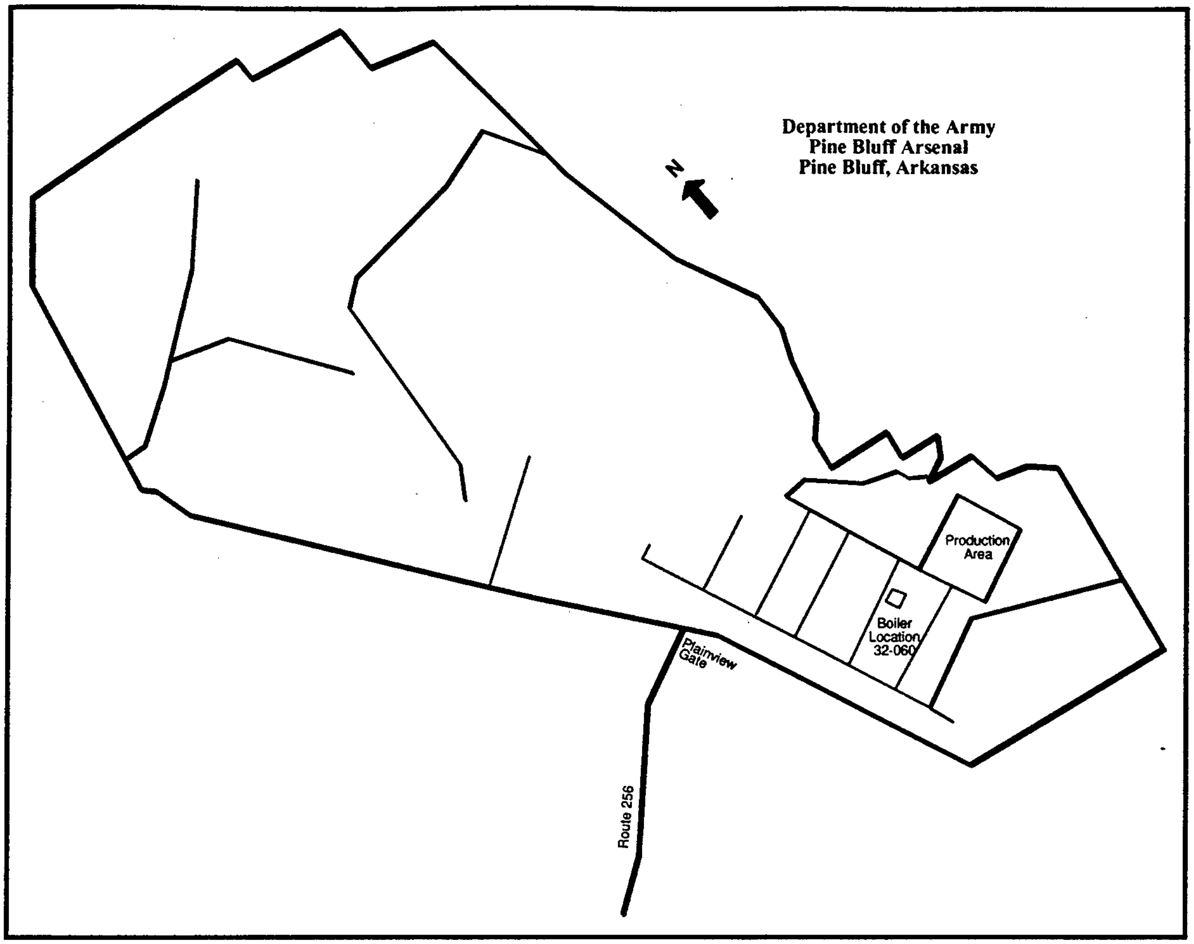

Figure 1. Pine Bluff Arsenal site map.

Electrical System

The site distributes electricity at 13,200 V. The boiler plant is supplied at 480 V from three pole-mounted 100 kVA electric transformers. The electric panel is located inside the compressor room and rated at 600 amps. There is currently an unused spot for a breaker to be installed.

Steam/Hot Water System

Boiler plant #32-060 is being renovated. It will have two 1989 York-Shipley boilers that have a rated input of 25 MBtu/hr and an output of 20,700 lb/hr each. Steam is distributed at 140 psi. The boilers operate on natural gas with fuel oil back-up capability.

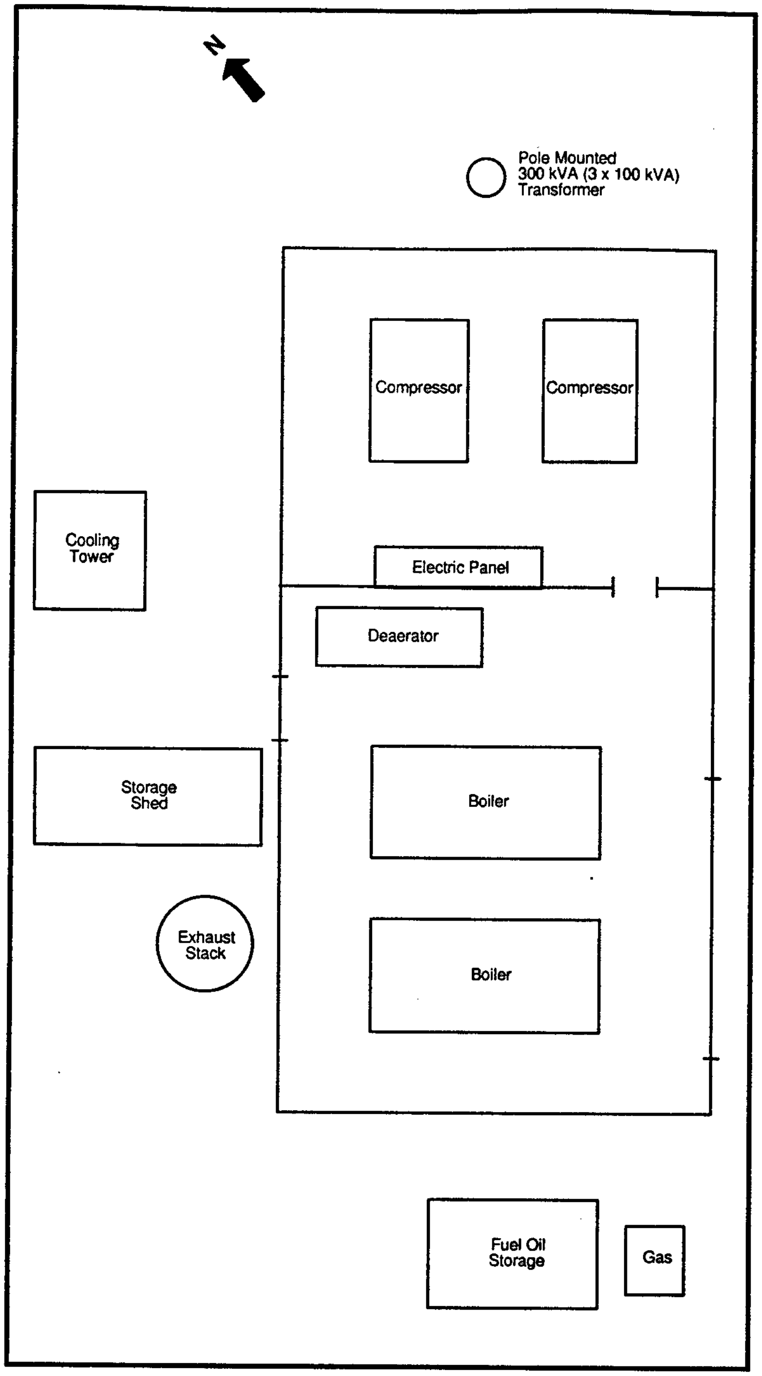

Figure 2. Pine Bluff Boiler Plant #32-060 site layout.

Space Heating System

There is no space heating inside the boiler plant. Steam from the central distribution loop provides heating for some buildings, but is used primarily for industrial processes.

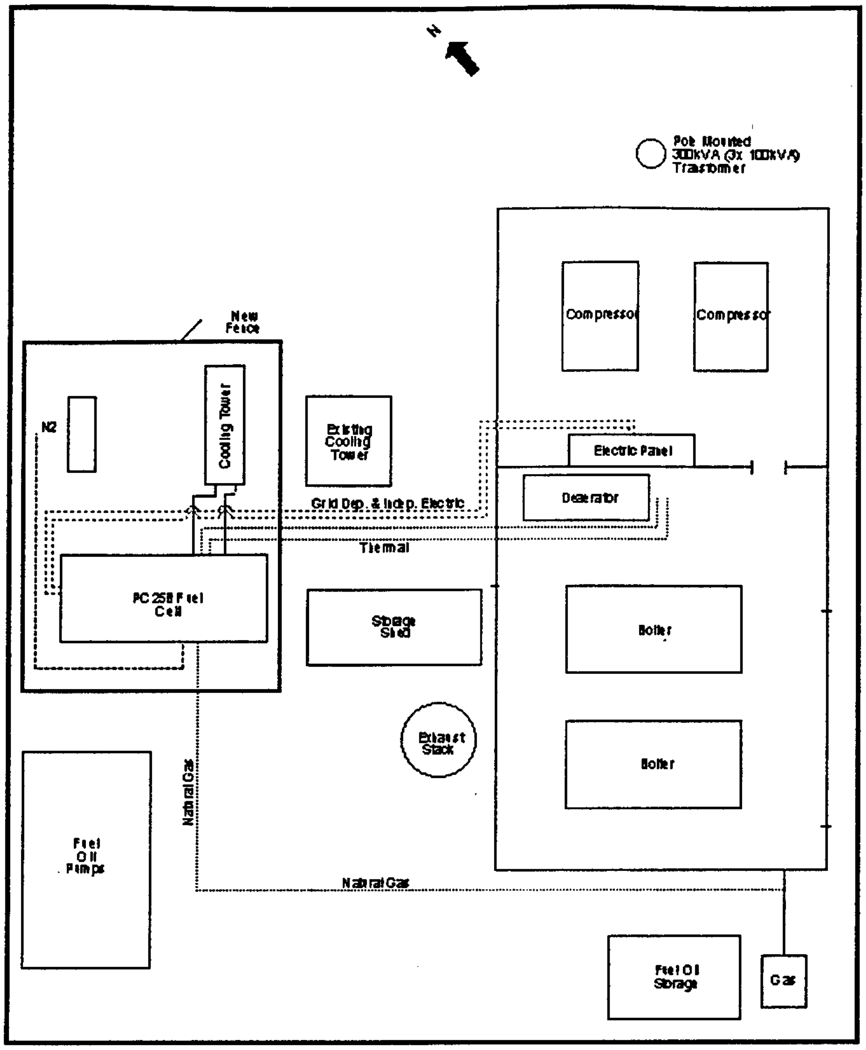

Figure 3. Fuel cell location and layout for Boiler Plant #32-060.

Space Cooling System

There is no space cooling at the boiler plant.

Fuel Cell Location

The fuel cell should be located on the back side of the boiler plant in the grassy area near the exhaust stack. Figure 3 shows its proposed orientation, perpendicular to boiler plant #32-060. The cooling module can be located northeast of the fuel cell, parallel to the building. The nitrogen tanks can be located inside of the fenced area as shown.

The fuel cell thermal piping should face northeast and run directly into the boiler plant. Thermal piping runs would be about 50 ft. Piping to the cooling module will be 10 ft long. The electrical run over to the electric panel will be about 80 ft. Natural gas should be brought in from the main building entry point, about 95 ft. The nitrogen piping run will be about 35 ft.

Fuel Cell Interfaces

The central plant uses 480 volt power fed through three 480/13,200 V, 100 kVA pole-mounted transformers (net 300 kVA transformer). The fuel cell electrical output should be connected at the electric panel in the room adjacent to the boilers. The panel is rated at 480 volts, 600 amps, and has an unused slot for a breaker. The PC25B fuel cell should be used because it has the grid-independent capability and the base would like to have electrical back-up for boiler plant #32-060. Before this work, a back-up generator had been on order, but the base canceled the order when the fuel cell opportunity came up. It is the responsibility of the base to identify a load less than 200 kW for the grid-independent output. The two 150 hp motors for the large compressors cannot be connected to the grid-independent output terminals of the fuel cell.

The fuel cell thermal output should be used to preheat the boiler make-up water. The make-up water flows through two water softeners and then to a deaerator tank. The condensate return also flows into the deaerator. The make-up water should flow to the fuel cell after the water softeners and prior to the deaerator (Figure 4). A separate 25 gal per minute (gpm) circulating pump should be used to control the flow to the fuel cell. The pump should run whenever the fuel cell is operating and the flow is above the pump minimum flow. A flow switch should be used to shut off the pump when the flow falls below the minimum.

To estimate the potential thermal load for the fuel cell, boiler make-up water requirements and supply temperatures were taken from the site boiler logs. The average annual cold water make-up flow for the October 1994 to September 1995 period was 24.3 gpm. These data were used to calculate monthly average thermal use (kBtu/hr) and percent thermal utilization of the fuel cell thermal output (based on 700,000 Btu/hr and return temperature of 60 °F) (Table 2).

Based on the monthly average make-up water flow rate and a maximum fuel cell supply temperature of 165 °F, the fuel cell thermal use was determined. The previous table shows that the fuel cell thermal utilization was less than 100 percent for only 2 months, December and September.

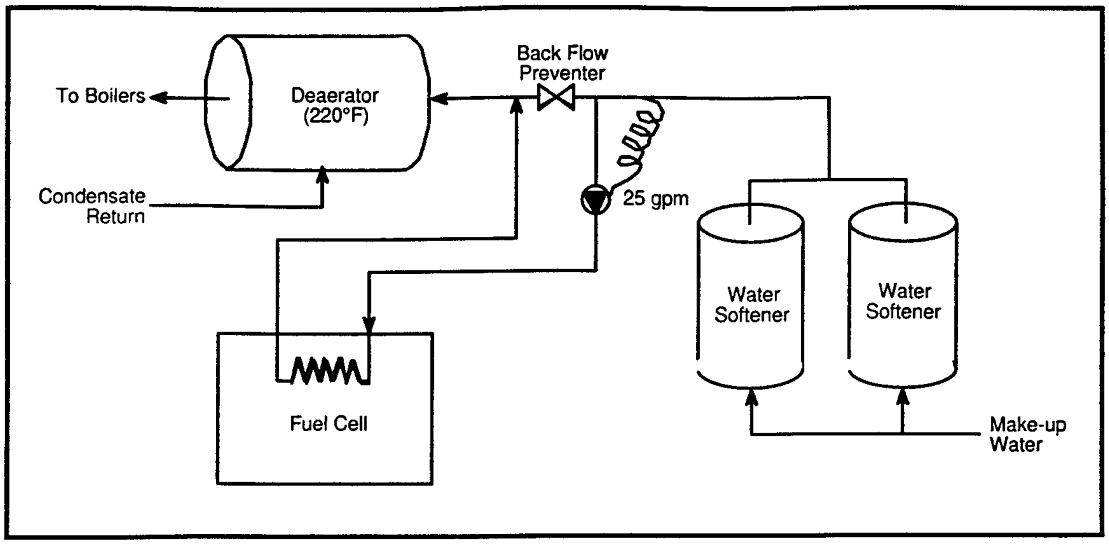

Figure 4. Fuel cell thermal interface at Pine Bluff.

Table 2. Fuel cell thermal output utilization.

Month	Make-up Water 1,000 gal/mo	Water Use GPM	Supply Temp °F	Thermal Use kBtu/hr	Util %**
Oct 94	689	15.4	151	702	100
Nov 94	1,260	29.2	108	702	100
Dec 94	543	12.2	165	642	92
Jan 95	3,364	75.4	79	718	103
Feb 95	1,597	39.6	95	694	99
Mar 95	1,119	25.1	116	704	101
Apr 95	800	18.5	136	704	101
May 95	736	16.5	145	703	100
Jun 95	974	22.5	122	699	100
Jul 95	747	16.7	144	703	100
Aug 95	680	15.2	152	701	100
Sep 95	253	5.8	165	305	44
Total/Avg	12,762	24.3		665	95

* kBtu/hr = GPM * 8.35 lb/gal. * 60 min/hr * (Supply temp. °F - 60°F) * 0.001 kBtu/lb-°F (Note: max. heat available ~700 kBtu/hr; max supply temperature ~165 °F)

** % Utilization = Thermal use (kBtu/hr) / 700 kBtu/hr * 100

The annual average thermal utilization was 95 percent. However, this is based on average monthly flow rates and there will be times when the flow rates are higher and lower than the average. Therefore, it was estimated that the annual fuel cell thermal utilization would be about 90 percent.

3 Economic Analysis

The Arsenal purchases electricity from Arkansas Power and Light under rate schedule Large Power Service (LPS), which has both demand and energy rate components for summer and "other" periods. The summer is the 4 months of June through September, and "other" period is the 8 remaining months of the year. Pine Bluff Arsenal receives three electric bills corresponding to its three substations (A, B, and C).

Substations A and B are owned by the utility and thus, electricity coming into these substations has a higher rate than Substation C, which is owned by the Arsenal. The boiler plant #32-060 receives electricity through substations A and B. Table 3 lists the LPS rates for the boiler plant.

Table 4 presents total electricity consumption and costs for the August 1995 to July 1996 time period. Only total energy consumption and costs were provided. The average rate paid by the Arsenal during this period was 5.84 cents/kWh. Natural gas is purchased from Falling Tree Enterprises, Inc., under an annually bid contract. Gas is transported by ARKLA. Table 5 presents total natural gas costs (includes both commodity and transportation costs) for the August 1995 to July 1996 time period. The average total gas cost for this period was $2.84/MBtu.

Table 3. LPS rates for the boiler plant.

	Summer	Other
Demand	$13.73/kW	$12.23/kW
Energy	$0.03949/kWh	$0.03261/kWh

Table 4. Pine Bluff Arsenal electricity consumption and costs.

Date	Total KWh	Total Cost	$/KWh
Aug 95	2,769,200	$175,399	$0.0633
Sep 95	2,699,200	$156,438	$0.0580
Oct 95	1,792,000	$106,164	$0.0592
Nov 95	1,758,400	$105,769	$0.0602
Dec 95	1,618,400	$87,932	$0.0543
Jan 96	1,713,600	$85,799	$0.0501
Feb 96	1,668,800	$89,769	$0.0538
Mar 96	1,822,800	$86,788	$0.0476
Apr 96	1,806,000	$91,611	$0.0507
May 96	1,993,600	$137,480	$0.0690
Jun 96	2,517,200	$162,651	$0.0646
Jul 96	2,833,600	$172,921	$0.0610
Tot/Avg	24,992,800	$1,458,723	$0.0584

Table 5. Pine Bluff Arsenal natural gas consumption and costs.

Date	MBTU	Cost	Avg $/MBTU
Aug 95	34,199	$101,971	$2.98
Sep 95	35,284	$104,476	$2.96
Oct 95	41,937	$119,834	$2.86
Nov 95	58,597	$158,956	$2.71
Dec 95	77,762	$202,763	$2.61
Jan 96	83,246	$233,524	$2.81
Feb 96	68,976	$184,210	$2.67
Mar 96	75,327	$206,970	$2.75
Apr 96	49,397	$123,366	$2.50
May 96	33,754	$104,801	$3.10
Jun 96	32,892	$102,673	$3.12
Jul 96	34,625	$133,931	$3.87
Tot/Avg	625,996	$1,777,474	$2.84

Electric savings from the fuel cell were calculated based on the fuel cell operating 90 percent of the year (1,576,800 kWh). Demand savings were calculated assuming that the energy bill for the site would be reduced for the full 200 kW each month. The full demand savings and 90 percent capacity factor savings were estimated as follows:

Demand Savings:

200 kW * 4 mos. * $13.73/kW =	$10,984
200 kW * 8 mos. * $12.23/kW =	$19,568
	$30,552

Energy Charge Savings:

200 kW * 90 percent * 2,928 hr/yr * $0.03949/kWh =	$20,813
200 kW * 90 percent * 5,832 hr/yr * $0.03261/kWh =	$34,233
	$55,046

Total Savings:

$30,552 + $55,046 = $85,598

It was previously estimated that 90 percent of the fuel cell thermal output could be used by the boiler plant in a year. Assuming a 70 percent boiler efficiency and a 90 percent fuel cell capacity factor, the fuel cell would displace 7,096 MBtu at the boiler plant:

7,096 MBtu = (0.7 MBtu/hr * 8,760 hr/yr * 90 percent thermal util. * 90 percent capacity factor) / 70 percent boiler eff.

The fuel cell would be displacing natural gas at an average rate of $2.84/MBtu. The thermal savings from the fuel cell would be:

$20,152 = 7,096 MBtu * $2.84/MBtu

The fuel cell will consume 14,949 MBtu per year based on an electrical efficiency of 36 percent higher heating value (HHV). Input natural gas cost for the fuel cell is $42,455.

$42,455 = 14,949 MBtu * $2.84/MBtu

Table 6 lists estimated savings for the fuel cell. Net annual savings of $63,295 were estimated for the boiler plant. Table 5 also gives savings for 100 percent thermal utilization if all the fuel cell output could be used by the site. If all the fuel cell thermal output could be used, net savings would increase an additional $2,200. A 50 percent reduction in demand savings would reduce annual savings to $48,019.

This analysis was meant to give 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 energy load profiles were not available, net energy savings could vary depending on actual thermal and electrical use.

Table 6. 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								
Max. Thermal Case	90%	100%	1,576,800	7,884	$85,598	$22,390	$42,455	$65,533
Base Case	90%	90%	1,576,800	7,096	$85,598	$20,152	$42,455	$63,295
50% Demand Savings:								
Max. Thermal Case	90%	100%	1,576,800	7,884	$70,322	$22,390	$42,455	$50,257
Base Case	90%	90%	1,576,800	7,096	$70,322	$20,152	$42,455	$48,019
Zero Demand Savings:								
Max. Thermal Case	90%	100%	1,576,800	7,884	$55,046	$22,390	$42,455	$34,981
Base Case	90%	90%	1,576,800	7,096	$55,046	$20,152	$42,455	$32,743

Assumptions

Natural Gas Rate: $2.84 /MBtu

Electricity Rate: LPS See Text

Fuel Cell Thermal Output: 700,000 Btu/hour

Fuel Cell Electrical Efficiency (HHV): 36%

Seasonal Boiler Efficiency: 70%

ECF = Fuel cell electric capacity factor

TU = Thermal utilization

4 Conclusions and Recommendations

This study concludes that the Pine Bluff Arsenal boiler plant #32-060 represents a good application for a 200 kW phosphoric acid fuel cell (model PC25B). The thermal and electrical interfaces are straightforward; piping and wiring distances are relatively short.

It is recommended that the fuel cell be located on the back side of the building in the open grassy area. A new breaker should be installed inside the existing electrical panel for the grid connect load. The grid-independent capability of the PC25B fuel cell should be interfaced with an isolated load within the boiler plant. It is the responsibility of the base to isolate an electric load less than 200 kW. The fuel cell would not be able to start the 150 hp air compressor motors.

A security fence is required around the fuel cell.

It is estimated that the fuel cell will save the Arsenal approximately $63,000 annually. Nearly all of the fuel cell thermal output should be used by the boilers.

Appendix: Fuel Cell Site Evaluation Form

Site Name: **Pine Bluff Arsenal**
Location: **Pine Bluff, Arkansas**

Contact: **Nancy Rimmer**

1. Electric Utility: **Energy**
   Rate Schedule: **LP-TOU**

2. Gas Utility: **ARKLA, transmission Falling Tree, Inc., natural gas**
   Rate Schedule: **Negotiated every 6 months**

3. Available Fuels: **Natural Gas, Fuel Oil Back-up**

4. Hours of Use and Percent Occupied: **Boilers operate continuously, periodic shutdowns of individual plant**

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

5. Outdoor Temperature Range:
   Winter Design Temperature: **22 °F**
   Summer Design Temperature: **97 °F**
   Extreme range: **Teens to 100 °F**

6. Environmental Issues: **No major issues.**

7. Backup Power Need/Requirement: **The base has 20 back-up generator units totaling 2,915 kW.**

8. Utility Interconnect/Power Quality Issues: **Power outages occur periodically as a result of storms. Not a major problem.**

9. On-site Personnel Capabilities: **Boiler plant personnel**

10. Access for Fuel Cell Installation: **O.K. - Will have to transport over a thick grass field. Need to avoid emissions stack support wires.**

11. Daily Load Profile Availability: **No data available.**

12. Security: **A security fence will be required.**

Site Layout

Facility Type: **Boiler Plant**

Age: **54 years**

Construction: **Brick**
Square Feet: **~2,900 sq ft**

See Figure 2

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

Electrical System

Service Rating: **13.2 kV / 480 V, 3 phase/ 4 wire service (300 kVA transformer)**

Electrically Sensitive Equipment: **N/A**

Largest Motors (hp, usage): Compressors **- 150 hp**

Grid Independent Operation?: **Not for fuel cell - existing generator unit already there.**

Steam/Hot Water System:

Description: **Boiler plant sends out steam at 140 psi.**

System Specifications: **York-Shipley (2) boilers at 20,700 lbs/hr. each**

Fuel Type: **Natural Gas with fuel oil as back-up**

Max Fuel Rate: **25 MBtu/hr each**

Storage Capacity/Type: **None**

Interface Pipe Size/Description: **1.5-in. diameter pipe for make-up water interface.**

End Use Description/Profile: **Boiler plant feeds main base central steam distribution system.**

Space Cooling System

Description: **The steam system does not supply any absorption chillers.**

Air Conditioning Configuration:

Seasonality Profile:

Space Heating System

Description: **Individual heat exchangers in each building.**

Fuel:

Rating:

Water supply Temp:

Water Return Temp:

Make/Model: Kewanee Boiler Corp.

Thermal Storage (space?):

Seasonality Profile:

CERL Distribution

Pine Bluff Arsenal
ATTN: SMCPB-CO (2)

Chief of Engineers
ATTN: CEHEC-IM-LH (2)
ATTN: HECSA Mailroom (2)
ATTN: CECC-R

Engineer Research and Development Center (Libraries)
ATTN: ERDC, Vicksburg, MS
ATTN: Cold Regions Research, Hanover, NH
ATTN: Topographic Engineering Center, Alexandria, VA

Defense Tech Info Center 22304
ATTN: DTIC-O (2)

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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), and have 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 Pine Bluff Arsenal, AR, 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.

15. SUBJECT TERMS
fuel cells
energy conservation
fuel technology alternatives
Pine Bluff Arsenal, AR

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					19b. TELEPHONE NUMBER (include area code) (217) 373-7214