

ERDC/CERL TR-01-30

Construction Engineering
Research Laboratory



**US Army Corps
of Engineers.**

Engineer Research and
Development Center

Site Evaluation for Application of Fuel Cell Technology

Naval Hospital – Naval Air Station Jacksonville, FL

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 documents work done at Naval Hospital B Naval Air Station Jacksonville, Jacksonville, FL. Special thanks is owed to the Naval Hospital at Jacksonville points of contact (POCs), Joe Simpkins, and Larry Forbes, 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 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), and have successfully executed several research and demonstration work units with a total funding of approximately \$55M.

As of 30 November 1997 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 Naval Hospital B Naval Air Station Jacksonville, FL along with a conceptual fuel cell installation layout and description of potential benefits the technology can provide at that location. Summaries of 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 Naval Hospital at Jacksonville as a potential location for a fuel cell application.

Approach

On 3 and 4 April 1996, CERL and SAIC representatives visited the Naval Air Station (NAS) Jacksonville (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
911 th Airlift Wing, Pittsburgh, PA	TR 00-18
934 th 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
Subbase 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

NAS Jacksonville is located in Jacksonville, FL. Its primary mission is to support antisubmarine operations. In addition, the base provides aircraft depot maintenance, serves as a regional supply and medical post, and provides training to regular and reserve duty personnel.

NAS Jacksonville has a nine-building hospital complex (Figure 1) that serves base personnel as well as service personnel from around the region. The hospital is an eight story building that was originally a 400-bed facility. Many of the rooms have been converted to office space. Currently, the hospital handles around 45 to 50 overnight patients. The remaining buildings in the hospital complex include a new 90,000 sq ft outpatient facility next door, office buildings, and barracks.

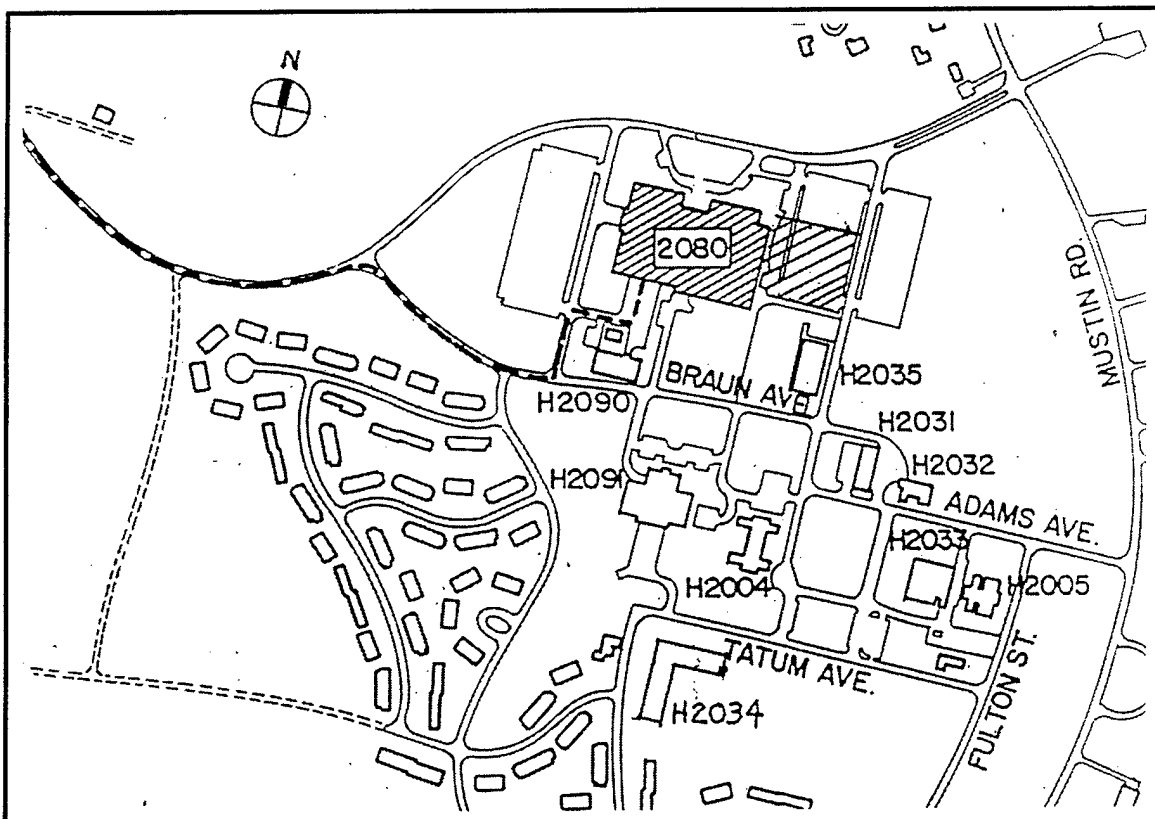


Figure 1. Naval Air Station Jacksonville site map.

The hospital complex is served by a central boiler steam plant. The boiler plant is undergoing extensive renovation and is currently operating using two truck-mounted boilers. The steam distribution system runs both above and below ground. The hospital and outpatient facilities are the largest buildings in the complex, but have separate mechanical rooms. The fuel cell could not be easily interfaced with both facilities.

At the hospital, there are three primary uses for the steam: hot water for patients, operating rooms, and the galley; autoclaves for sterilization; and space heating inside the building. The sterilization process does not represent a viable application for the fuel cell thermal output, as the enclaves require steam directly. The space heating system uses steam heat exchangers to heat three hot water space heating loops. Only one of these heat exchangers is located in the mechanical building and operates at between 140 and 180 °F. The other two are located elsewhere inside the hospital. Space heating is required for only 3 to 4 months per year. Domestic hot water (DHW) is currently provided by instantaneous hot water heaters using the central steam source. Pre-heating the make-up water for DHW and galley hot water use represents the most viable applications for the fuel cell thermal output.

Researchers briefly considered interfacing the fuel cell with the central steam plant. Two reasons were identified for eliminating this application. First, the steam plant is operated by a contractor who is responsible for its operation. Accruing the economic benefits of the fuel cell to the base becomes more difficult with a contractor operated facility. Second, the steam plant is going through extensive renovation, which made it nearly impossible to determine how to interface the fuel cell with the facility.

Site Layout

Figure 2 shows the building layout for much of the hospital complex. The hospital is identified as building 2080 and the outpatient facility next door is not labeled. Building H2032 is the central boiler facility. Figure 3 shows a more detailed layout of the hospital facility and identifies the location of electrical and mechanical equipment areas. The mechanical room houses the three instantaneous steam water heaters, two Trane centrifugal chillers, electrical switchgear, pumps, steam lines, and other equipment. A new chiller room was added recently and houses a Carrier chiller and hot water storage tank with a capacity of about 1500 gal.

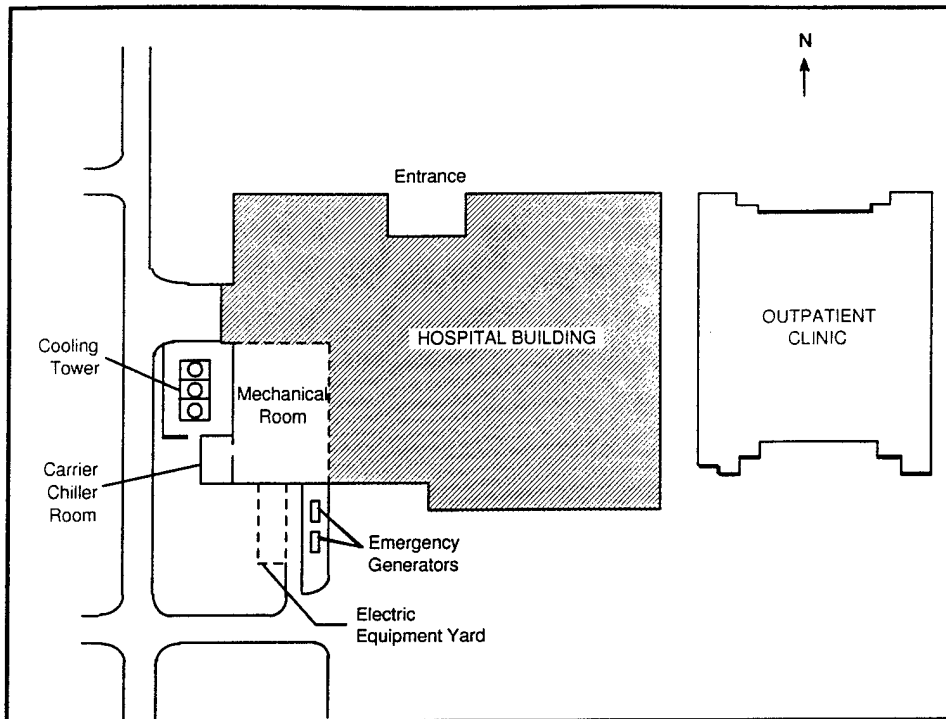


Figure 2. Hospital facility layout.

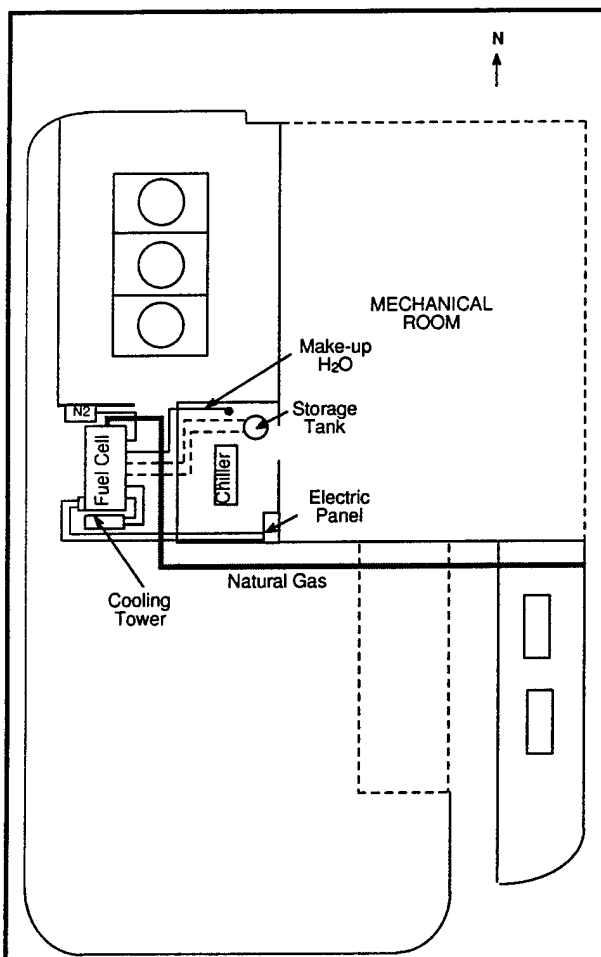


Figure 3. Fuel cell location and interface diagram.

South of the mechanical room is the electrical switchgear yard, located outside. There are also two 500 kW emergency generators located outside the entrance to the mechanical room.

Electrical System

The hospital purchases electrical power from the Public Works Center which is operated by an independent contractor. The base pays a flat rate for electricity, which is negotiated every year. The base distribution system is rated at 4160 volts. There are multiple electrical transformers for the hospital facility.

Steam/Hot Water System

The central steam plant provides steam, space heating, and hot water to the hospital. The steam is distributed at 120 psi. For hot water, there are three Patterson Kelly Compact II instantaneous hot water generators. Two of the instantaneous hot water heaters are used to provide 140 °F water to the DHW system in the hospital. Only one of these heaters operate at one time. The third heater is used for the galley and operates at 180 °F.

Space Heating System

Space heating is provided by the central steam plant and distributed throughout the hospital building. Steam is used to heat the distributed hot water space heating loops to between 140 and 180 °F, depending on outside air temperature. Space heating is required from the end of November to sometime in March.

Space Cooling System

The hospital has two 550 ton Trane Centravac centrifugal chillers and one 400 ton Carrier chiller. The chilled water is distributed throughout the hospital to deliver cooling to individual areas. All three chillers operate during the summer months while only one chiller typically operates during the winter months.

Fuel Cell Location

The fuel cell should be located outside the west wall of the Carrier chiller room (Figure 3). The fuel cell should run in a north-south direction with the thermal outlet side facing the building. The thermal piping run will be approximately 65 ft and the electrical run will be 60 ft to the electrical panel inside the chiller room. The natural gas piping will be over 150 ft and taken at the abandoned incinerator site.

Fuel Cell Interfaces

The electrical output of the fuel cell will feed into the hospital's 480 volt system through the motor control panel (MCC 2) in the Carrier chiller room. This panel is fed through a 2,500 kVA transformer. The peak load of the hospital is 1.2 MW. It is unlikely that the hospital load will drop below the 200 kW fuel cell output. If it does drop below 200 kW, then the fuel cell electric output will backfeed through the 2,500 kVA transformer into the base grid. No fuel cell power will be exported off the base.

The fuel cell thermal output will interface with the hospital's DHW system. Hot water is supplied to the rooms and lavatories at about 140 °F and to the kitchen at about 180 °F. (Note that room and lavatory valves have a built-in scald guard.) The DHW load for the rooms was estimated using ASHRAE's typical hospital value of 18.4 gal per bed per day. The hospital averages 45 beds occupied per day. The DHW load for the hospital was calculated as:

$$20 \text{ kBtu/hour} = (45 \text{ beds} * 18.4 \text{ gal/bed/day} * 8.35 \text{ lb/gal} * (140 \text{ °F} - 70 \text{ °F}) * 0.001 \text{ kBtu/°F-lb}) / 24 \text{ hr per day}$$

The DHW load for the kitchen was estimated using ASHRAE's value for dining facilities of 2.4 gal of hot water per meal served. It was estimated by site personnel that the kitchen prepares an average of 600 meals per day. The fuel cell will only heat the water to 160 °F. The DHW load for the kitchen is estimated as:

$$45 \text{ kBtu/hour} = (600 \text{ meals/day} * 2.4 \text{ gal/day} * 8.35 \text{ lb/gal} * 160 \text{ °F} - 70 \text{ °F} * 0.001 \text{ kBtu/°F-lb}) / 24 \text{ hr per day}$$

The fuel cell will be interfaced with an existing hot water storage tank. The tank was used for recovering heat off the chiller condensers, but is no longer in use. Site personnel said that the tank could be repaired for use with the fuel cell. The tank is about 6 ft in diameter and 7 ft high with a capacity of approximately

1,480 gal. The fuel cell will be able to meet the entire DHW load for the rooms and 80 percent for the galley. Thermal utilization was estimated at 9 percent of the fuel cell thermal output capacity of 700 kBtu/hour:

$$9\% \text{ Thermal Utilization} = (20 \text{ kBtu/hour} + 45 \text{ kBtu/hour}) / 700 \text{ kBtu/hour}$$

Figure 4 shows the recommended thermal interface. The fuel cell will tie into the existing piping entering and leaving the storage tank. An additional 25 gpm circulation pump should be used to circulate water from the storage tank through the fuel cell and back to the storage tank. The pump should operate whenever the fuel cell operates.

A maximum tank temperature of about 180 °F is possible. The existing scald guards will protect personnel. The storage tank is already plumbed to the hot water steam heaters for the room DHW. An additional line must be added to connect to the kitchen DHW.

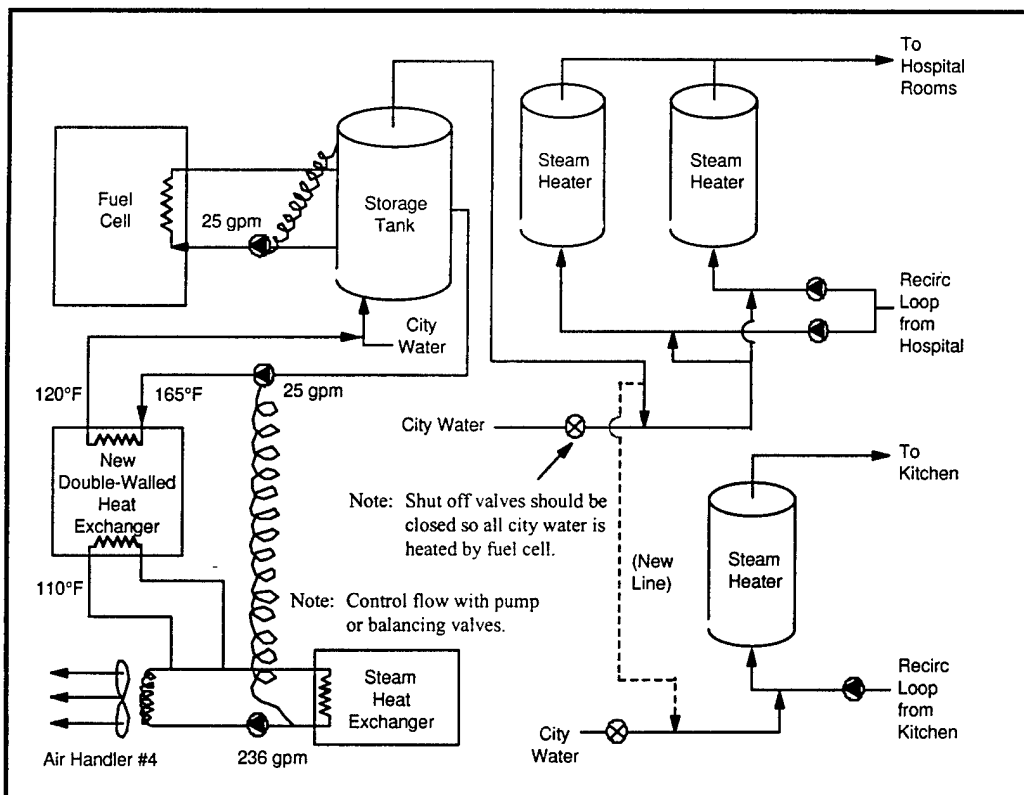


Figure 4. Fuel cell thermal interface—DHW.

3 Economic Analysis

The hospital complex paid a flat 6.75 cents/kWh to the Public Works Center in FY95 for its electricity. In FY96, the electric rate is 6.874 cents/kWh. There is no demand charge. Table 2 presents the electric bills for the hospital complex during 1995 (August - September data was not available).

Natural gas is purchased directly from Peoples Gas only for a small barracks building. This gas consumption is not related to the hospital itself. Natural gas is used to generate steam by the Public Works Center's steam boiler. The hospital does not purchase natural gas directly for this purpose, but purchases the product steam from the central plant. Table 3 shows the steam bills paid by the hospital complex. The cost of the steam was \$13.18/MBtu in FY95 and is \$14.75/MBtu in FY96.

Electric savings from the fuel cell were calculated based on the fuel cell operating 90 percent of the year (1,576,800 kWh). Based on an average electric rate of \$0.06784/kWh, the fuel cell would generate \$106,974 in electric savings per year.

Table 2 . Hospital complex electricity consumption and costs.

Date	KWH	Cost	\$/KWH
Jan-95	966,605	\$65,246	\$0.0675
Feb-95	1,030,785	\$69,578	\$0.0675
Mar-95	807,837	\$54,529	\$0.0675
Apr-95	1,137,955	\$76,812	\$0.0675
May-95	1,214,535	\$81,981	\$0.0675
Jun-95	1,443,400	\$97,429	\$0.0675
Jul-95	1,385,600	\$93,528	\$0.0675
Aug-95	1,589,004	\$107,258	\$0.0675
Sep-95			
Oct-95			
Nov-95			
Dec-95	1,111,662	\$75,415	\$0.0678
Tot/Avg	10,687,383	\$721,776	\$0.0675

Table 3. Hospital complex steam consumption and costs.

Date	MBTU	Cost	\$/MBTU
Jan-95	3,811	\$50,148	\$13.16
Feb-95	4,515	\$59,421	\$13.16
Mar-95	3,033	\$39,912	\$13.16
Apr-95	3,081	\$40,546	\$13.16
May-95	2,491	\$32,782	\$13.16
Jun-95	1,193	\$15,700	\$13.16
Jul-95	2,354	\$30,979	\$13.16
Aug-95			
Sep-95			
Oct-95			
Nov-95			
Dec-95	3,484	\$51,386	\$14.75
Tot/Avg	23,962	\$320,874	\$13.36

Thermal savings were estimated based on a thermal utilization of 9 percent. At a displaced steam cost of \$14.75/MBtu, the fuel cell would displace 512 MBtu of steam:

$$512 \text{ MBtu} = (0.020 \text{ MBtu/hr} + 0.045 \text{ MBtu/hr}) * 8,760 \text{ hr/yr} * 90\% \text{ capacity factor}$$

Using the \$14.75/MBtu of steam, thermal cost savings of \$7,552 were calculated for the fuel cell.

The natural gas cost for the fuel cell was assumed to be \$4.15/MBtu based on FY96 gas rates provided by the Public Works Center. 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 \$62,038.

The net savings for the 9 percent thermal utilization case is \$52,488 as shown in Table 4. If the site could utilize all the thermal output of the fuel cell, then net savings would increase to \$126,341.

The analysis is a general overview of the potential savings from the fuel cell. For the first 3 years, 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 Steam (MBtu)	Electrical Savings	Thermal Savings	Nat. Gas Cost	Net Savings
Max. Thermal	90%	100%	1,576,800	5,519	\$106,974	\$81,405	\$62,038	\$126,341
Base Case	90%	9%	1,576,800	512	\$106,974	\$7,552	\$62,038	\$52,488

Assumptions:

- Input Natural Gas Rate: \$4.15/MBtu
- Displaced Thermal Steam Rate: \$14.75/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 the hospital at NAS Jacksonville represents the best application for a 200 kW phosphoric acid fuel cell. The central hot water system can be supplemented with heat provided by the fuel cell thermal output. An existing hot water storage tank should be repaired and integrated with the fuel cell and the three instantaneous steam/hot water generators. Thermal utilization is relatively low, but the high cost of steam increases the value of the fuel cell thermal that is displacing it. Economic savings for the fuel cell were estimated at \$52,488.

The fuel cell should be located on the west side of the Carrier room addition. Thermal and electric runs will be short. However, the gas line will have to run at least 150 ft.

Appendix: Fuel Cell Site Evaluation Form

Site Name: **Naval Air Station Jacksonville**

Location: **Jacksonville, FL**

Contacts: **Joe Simpkins, Larry Forbes**

1. Electric Utility: **Public Works Center** Rate Schedule: **Negotiated Rate**
Contact: **N/A**
2. Gas Utility: **Public Works Center/Peoples Gas**
Rate Schedule: **Negotiated/GS**
Contact: **N/A**
3. Available Fuels: **Natural Gas /Fuel Oil** Capacity Rate:
4. Hours of Use and Percent Occupied: Weekdays 5 Hrs. 24
Hospital occupied continuously Saturday 1 Hrs. 24
Peak occupancy 7:30 am -4:30 pm M-F Sunday 1 Hrs. 24
5. Outdoor Temperature Range: **Design temperatures are 32 and 94 °F**
6. Environmental Issues: **Ground contamination needs to be checked at proposed fuel cell location**
7. Backup Power Need/Requirement: **Two 500 kW back-up generators for hospital. Identified "red load" is 250 kW.**
8. Utility Interconnect/Power Quality Issues: **None**
9. On-site Personnel Capabilities: **Boiler plant personnel at facility.**
10. Access for Fuel Cell Installation: **O.K. - Street access. Entry way to cooling towers may be blocked, but not considered a problem by base.**
11. Daily Load Profile Availability: **None available.**
12. Security: **Fence may be required. To be determined later by site.**

Site Layout

Facility Type: **Hospital**

Age: **30 years**

Construction: **Concrete and Steel**

Square Feet: **341,000 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: **4,160 volt service to building (multiple transformers); 480 and 120/208 volt service in building**

Electrically Sensitive Equipment: **N/A**

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

Grid Independent Operation?: **No**

Steam/Hot Water System

Description: **Steam provided by central steam plant (under extensive renovation)**

System Specifications:

Fuel Type: **Natural Gas**

Max Fuel Rate:

Storage Capacity/Type: **None**

Interface Pipe Size/Description: **4 in.**

End Use Description/Profile: **Steam used for DHW, enclaves, space heating, cool reheat.**

Space Cooling System

Description: **Two 550 ton Trane chillers and one 400 ton Carrier chiller; Heat recovery off of chillers.**

Air Conditioning Configuration:

Type: **Trane/Carrier**

Rating: **550/400 ton**

Make/Model:

Seasonality Profile: **One chiller operates during winter. All three operate during summer.**

Space Heating System

Description: **Provided by central steam plant to distribution throughout building;
Three steam/hot water space heating heat exchangers in hospital.**

Fuel: **Natural Gas**

Rating:

Water Supply Temp: **120 to 180 °F**

Water Return Temp: **110 to 170 °F**

Make/Model:

Thermal Storage (space?):

Seasonality Profile: **Winter space heating: end of November to mid-March**

Billing Data Summary

ELECTRICITY

Period	kWh	kW	Cost
1.	_____	_____	_____
2.	_____	_____	_____
3.	_____	_____	_____
4.	_____	_____	_____
5.	_____	_____	_____
6.	_____	_____	_____
7.	_____	_____	_____
8.	_____	_____	_____
9.	_____	_____	_____
10.	_____	_____	_____
11.	_____	_____	_____
12.	_____	_____	_____

NATURAL GAS

Period	Consumption	Cost
1.	_____	_____
2.	_____	_____
3.	_____	_____
4.	_____	_____
5.	_____	_____
6.	_____	_____
7.	_____	_____
8.	_____	_____
9.	_____	_____
10.	_____	_____
11.	_____	_____
12.	_____	_____

OTHER

Period	Consumption	Cost
1.	_____	_____
2.	_____	_____
3.	_____	_____
4.	_____	_____
5.	_____	_____
6.	_____	_____
7.	_____	_____
8.	_____	_____
9.	_____	_____
10.	_____	_____
11.	_____	_____
12.	_____	_____

Addendum to the Fuel Cell Site Evaluation Form

At the kick-off meeting at NAS Jacksonville on May 31, 1996, the site provided additional information on the HVAC system that had not previously been made available. In air handler #4, located in the mechanical room, there is a hot deck that provides warm air to the first and second floors of the hospital. During the summer (mid-March to mid-October), the warm air is used to temper the cooled air. During the winter (mid-October to mid-March), the warm air is used for space heating. In the summer, a steam heat exchanger provides hot water to the coil at temperatures between 100 °F and 120 °F, but generally around 110 °F. In the winter, the hot water is supplied at 150 °F - 160 °F. The site operator indicated that the hot water temperature drop across the coil was 10 °F - 20 °F and that the hot water flowed through the coil all year round, 24 hours per day, seven days per week. The hot water circulating pump nameplate stated that the design flow rate was 236 gpm. No other flow data was available.

This HVAC hot water load would provide a good load for the fuel cell thermal.

Assuming that the 236 gpm flow rate is correct, the hot water load is 1.18 MBtu/hr.

$$1.18 \text{ MBtu/hr} = (236 \text{ gal/min} * 8.35 \text{ lb/gal} * 60\text{min/hr})(1 \text{ Btu/lb} - ^\circ\text{F})(10 ^\circ\text{F})$$

The recommended interface is to heat the hot water return during the summer in a double walled heat exchanger as shown in the attached figure. The heated water in the storage tank should be used to provide heat to the heat exchanger.

Assuming an average summer return temperature of 110 °F and a 10 °F pinch at the heat exchanger, 120 °F water will flow back to the fuel cell. At 25 gpm and 120 °F, the fuel cell can supply about 560 kBtu/hr. Under these conditions, the storage tank would be heated to about 165 °F. This is good for the kitchen use but too hot for the rooms. The operation of the scald guards should be verified or a mixing valve should be installed on the DHW supply to the rooms.

The circulating pump between the storage tank and the double-walled heat exchanger should run whenever the fuel cell is operating and the hot water supply temperature is either below the set point or below 125 °F, whichever is less.

Interfacing with this HVAC load will increase the fuel cell heat recovery by 2,576 MBtu.

$$2,576 \text{ MBtu} = (.560 \text{ MBtu/hr})(8,760 \text{ hr/yr})(7/12)(90\% \text{ Capacity Factor})$$

This will increase the thermal savings by \$37,996.

$$\$37,996 = (2,576 \text{ MBtu})(\$14.75/\text{MBtu})$$

With the addition of this thermal interface the annual net savings would increase to \$90,484 (\$37,996 + \$52,488).

CERL Distribution

Commander, Naval Air Station Jacksonville
ATTN: 314th CES/CEOE (2)

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

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

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REPORT DOCUMENTATION PAGE

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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 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 Naval Air Station Jacksonville, FL, 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 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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