ERDC/CERL TR-05-22

Construction Engineering Research Laboratory

US Army Corps of Engineers®
Engineer Research and Development Center

DOD Residential Proton Exchange Membrane (PEM) Fuel Cell Demonstration Program

Volume 2 – Summary of Fiscal Years 2001-2003 Projects

Melissa K. White, Scott M. Lux, James L. Knight, Dr. Michael J. Binder, Franklin H. Holcomb, and Nicolas M. Josefik

September 2005

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DOD Residential Proton Exchange Membrane (PEM) Fuel Cell Demonstration Program: Volume 2 – Summary of Fiscal Years 2001-2003 Projects

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Final Report

Prepared for U.S. Army Corps of Engineers
Washington, DC 20314-1000

Under Work Unit No. 007KE9

ABSTRACT: In Fiscal Year 2001 (FY01), Congress funded the Department of Defense (DOD) Residential PEM Demonstration Project to demonstrate domestically-produced, residential Proton Exchange Membrane (PEM) fuel cells at DOD Facilities. The objectives were to: (1) assess PEM fuel cells' role in supporting sustainability at military installations, (2) increase efficiency in installation, operation, and maintenance of fuel cell sites, (3) evaluate their potential in DOD training, readiness, and sustainability missions, (4) provide a military base market for this technology, and (5) evaluate and give feedback to promote commercialization and market growth, operational product testing and validation, grid interconnection standards, and system operation in diverse environmental conditions.

This project developed and advertised a Broad Agency Announcement each fiscal year, outlining core requirements for proposals. Sixty one pre-proposals were received and evaluated. In FY01, six contracts were awarded (22 fuel cells at 10 military installations). In FY02, five contracts were awarded (17 fuel cells at 15 military and DOD installations). In FY03, seven contracts were awarded (30 fuel cells at 20 military and DOD installations). Awardees were required to report detailed operational performance of each of their fuel cell system installations. This report discusses FY02 and FY03 Residential PEM Demonstrations, and revisits FY01 Projects.

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Conversion Factors

Non-SI* units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
acres	4,046.873	square meters
cubic feet	0.02831685	cubic meters
cubic inches	0.00001638706	cubic meters
degrees (angle)	0.01745329	radians
degrees Fahrenheit	(5/9) x (°F – 32)	degrees Celsius
degrees Fahrenheit	(5/9) x (°F – 32) + 273.15.	kelvins
feet	0.3048	meters
gallons (U.S. liquid)	0.003785412	cubic meters
horsepower (550 ft-lb force per second)	745.6999	watts
inches	0.0254	meters
kips per square foot	47.88026	kilopascals
kips per square inch	6.894757	megapascals
miles (U.S. statute)	1.609347	kilometers
pounds (force)	4.448222	newtons
pounds (force) per square inch	0.006894757	megapascals
pounds (mass)	0.4535924	kilograms
square feet	0.09290304	square meters
square miles	2,589,998	square meters
tons (force)	8,896.443	newtons
tons (2,000 pounds, mass)	907.1847	kilograms
yards	0.9144	meters

***Système International d'Unités* ("International System of Measurement"), commonly known as the "metric system."

Preface

In fiscal year 1993 (FY93) and FY94, 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 the fuel cells provided by these appropriations came to be known as the “DOD Fuel Cell Demonstration Project.” This study was conducted under CFE-B141, “Proton Exchange Membrane (PEM) Fuel Cell.” The technical monitor was Mr. Bob Boyd, Office of the Director, Defense, Research, and Engineering (ODDR&E).

Under the FY01 through FY03 projects, PEM fuel cells, ranging in size from 1 to 20 kilowatts (kW), were demonstrated at U.S. military bases and DOD-related facilities. Contract awards for the FY01 project were made from September through December of 2001, and the first units were installed in January of 2002. Contract awards for the FY02 project were made from November 2002 through August 2003, and the first units were installed in April of 2003. The contract awards for the FY03 project were made between February through May of 2004, and the first units were installed in November of 2004. The first volume of this report documented work done during the first stage of this project at FY01 sites: Barksdale AFB, LA; Coast Guard Station New Orleans, LA; Fort Bragg, NC; Fort Jackson, SC; Fort McPherson, GA; Geiger Field, WA; Patuxent River NAS; MD; and Watervliet Arsenal, NY and FY02 sites: DOS International Chancery Conclave, D.C; ERDC/CERL, IL; Georgia Institute of Technology ROTC Center, GA; Fort Belvoir, VA; Fort Gordon, GA; MCAS Cherry Point, NC; McChord AFB, WA; NASA Stennis Space Center, MS; NCA&T University, NC; Robins AFB, GA; Saratoga Springs NSU, NY; Selfridge ANGB, MI; Shaw AFB, SC; West Point Military Academy, NY; USCG Aids to Navigation Team, RI. This report documents the continuing work done at FY01 and FY02 sites, and documents work done at FY03 sites: Arizona Army National Guard, AZ; Montana Army National Guard, MT; Fort Benning, GA; U.S. Army Sgt. Herera Reserve Center, AZ; Offutt Air Base, NE; Fort A.P. Hill, VA; Sierra Army Depot, CA; Keesler AFB, MS; Los Angeles AFB, CA; Hill ARB, UT; NGB Camp Mabry, TX; Schofield Barracks, HI; MCB Kaneohe Bay, HI; U.S. Embassy, U.K.; March AFB, CA; McEntire ANG, SC; Gabreski Air National Guard Base, NY; Fort Lewis (Gray) Army Base, WA; Fort Rucker, AL; U.S. Antarctic Div, N.Z. during the continuation of this project.

Part of the work done at Coast Guard Station New Orleans, Fort McPherson, Fort Bragg, Fort Jackson, Barksdale AFB, NCA&T University, Robins AFB, Shaw AFB, Georgia Tech, NASA Stennis Space Center, Fort Gordon, CERL, Fort Belvoir, State Dept – ICC, Cherry Point, Sierra Army Depot, Keesler AFB, Los Angeles AFB, Hill ARB, NGB Camp Mabry, Schofield Barracks, MCB Kaneohe Bay, U.S. Embassy, UK, March AFB, and McEntire ANG was performed by LOGANEnergy Inc., under contracts DACA42-02-C-0001, DACA42-03-C-0024, and W91321-04-C-0023. The LOGANEnergy Project Manager was Sam Logan. Part of the work done at Geiger Field, McChord AFB, Gabreski Air National Guard (ANG) Base, Fort Lewis (Gray) Army Base, and Fort Rucker was performed by ReliOn, Inc., formerly Avista Laboratories, under contracts DACA42-02-C-0002, DACA42-03-C-0001 and W9132T-04-C-0017. The ReliOn Project Managers were Dave Holmes and Larry Hager. Part of the work done at Patuxant River NAS was performed by Southern Maryland Electric Cooperative (SMECO), under contract DACA42-02-C-0003. The SMECO Project Manager was Mike Rubala. Part of the work done at Watervliet Arsenal, Saratoga Springs, and West Point Military Academy, was performed by Plug Power, Inc., under contracts DACA42-01-C-0053 and DACA4202-R-0025. The Plug Power Project Manager was Brian Davenport. Part of the work done at USCG Aids to Navigation Team was performed by Nuvera, Inc., under contract DACA42-02-R-0023. The Nuvera Project Manager was James Jendrzejewski. Part of the work done at Selfridge ANGB was performed by DTE Energy Technologies, Inc. under contract DACA42-03-C-0040. The DTE Project Manager was Ted Bregar. Part of the work done at the Arizona Army National Guard site was performed by the City of Mesa, AZ, under contract W9132T-04-C-0012. The City of Mesa Project Manager was Harry Jones. Part of the work done at the Montana Army National Guard site was performed by Montana State University at Billings, under contract W9132T-04-C-0013. The Project Manager at MSU was Brian Gurney. Part of the work done at Fort Benning was performed by Flint Energy, under contract W9132T-04-C-0014. The Project Manager at Flint Energy was Larry Pearce. Part of the work done at the U.S. Army Sgt. Herera Reserve Center was performed by Arizona State University (ASU) under contract W9132T-04-C-0016. The ASU Project Manager was Govindasamy Tamizhmani. Part of the work done at U.S. Antarctic Division in Christchurch, N.Z. was performed by Industrial Research Limited, under contract W9132T-04-C-0021. The Industrial Research Limited Project Manager was Ben McQueen. Special thanks goes to the energy managers and site personnel at each individual installation.

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 Franklin H. Holcomb. Part of this work was done by Science Applications International Organization (SAIC), 1901 South First Street, Suite D-1, Champaign IL 61820 under a contract administered by the General Services Ad-

ministration (GSA). The technical editor was William J. Wolfe, Information Technology Laboratory. Dr. Thomas Hartranft 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 Dr. Ilker K Adiguzel.

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

1 Introduction

Background

Fuel cell technology is not a new idea. The root of the technology can be traced back to the 1800s, but the development of cheap fossil fuels eclipsed fuel cell technology. In its simplest form, a fuel cell is an electrochemical power generator, like a battery, using a fuel source to continuously recharge. Fuel cell technology has been shown to be 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 developed and continue to improve various approaches to using fuel cells in stationary applications for utilities and residences, industrial and commercial markets. Researchers at the U.S. Army Engineer Research and Development Center, Construction Engineering Research Lab (ERDC/CERL) have actively participated in the development and application of advanced fuel cell technology since the early 1990s. In that time, the Department of Defense (DOD) has installed the largest fleet of fuel cells in the world.

Fuel cells produce direct current (DC) electricity, heat, and water by combining hydrogen and oxygen. The hydrogen atoms enter a fuel cell at the anode where a chemical reaction, aided by a catalyst, strips them of their electrons. At this point, the hydrogen atoms are ionized and carry a positive electrical charge. The negatively charged electrons provide the current through wires to do work. Oxygen enters the fuel cell at the cathode and combines with electrons returning from the electrical circuit and hydrogen ions that have traveled through the electrolyte from the anode. The function of the electrolyte is to transmit the positive ions to the cathode side, while blocking the electrons.

There are several types of fuel cells, categorized by the type of electrolyte they use. This project used Proton Exchange Membrane (PEM) fuel cell technology because it can currently be manufactured less expensively than many other technologies, and because it is more efficient for small-scale applications. PEM fuel cells can be directly fueled using pure hydrogen, or can be operated in a system with a fuel processor to convert propane, natural gas, and other fuels into hydrogen-rich fuel gas. With the aid of a catalyst, the hydrogen or hydrogen-rich gas is split at the fuel cell's anode into protons and electrons. The electrolyte, or membrane, in the fuel cell allows the protons to pass through to the cathode side, where they react with oxygen from the air to form water and heat. The electrons, which cannot pass through the membrane, are harvested to produce DC electricity. The addition of a power inverter to the fuel cell system allows the electricity to be converted to alternating current (AC).

In practice, the fuel cell is only one part of the generator system, or fuel cell power plant. A typical fuel cell system is composed of: a fuel cell stack, a DC-to-AC power converter, and (if direct hydrogen is not being used as a fuel) a fuel processor or reformer. Figure 1 gives a conceptual illustration of these "Balance of Plant" (BOP) subsystems. A secondary subsystem for thermal management is also required if recoverable thermal energy is not fully used in some form of cogeneration application. The fuel processor combines a fuel such as natural gas or propane with steam (recovered from the power section) to reform the fuel into a hydrogen-rich mixture for use by the fuel cell stack in the power section. In the power section, the fuel mixture, rich in hydrogen, is combined with oxygen from the air to produce DC electricity. The process generates heat and produces carbon dioxide and water as exhaust gases. The DC-to-AC power converter takes the DC electricity from the fuel cell stack and converts it to usable AC power such as 480-volt, 60-cycle, 3-phase AC.

Since fuel cell systems use an electrochemical process, rather than combustion, they have the potential for attaining very high electrical energy conversion efficiencies while operating quietly with minimal polluting emissions. In addition, the byproduct thermal energy generated can be used for cogeneration of hot water or steam. Their high conversion efficiency is relatively independent of system capacity. PEM fuel cells can be sized to accommodate different capacity needs by connecting the same cell designs in series and/or parallel, which is referred to as "stacking" cells.

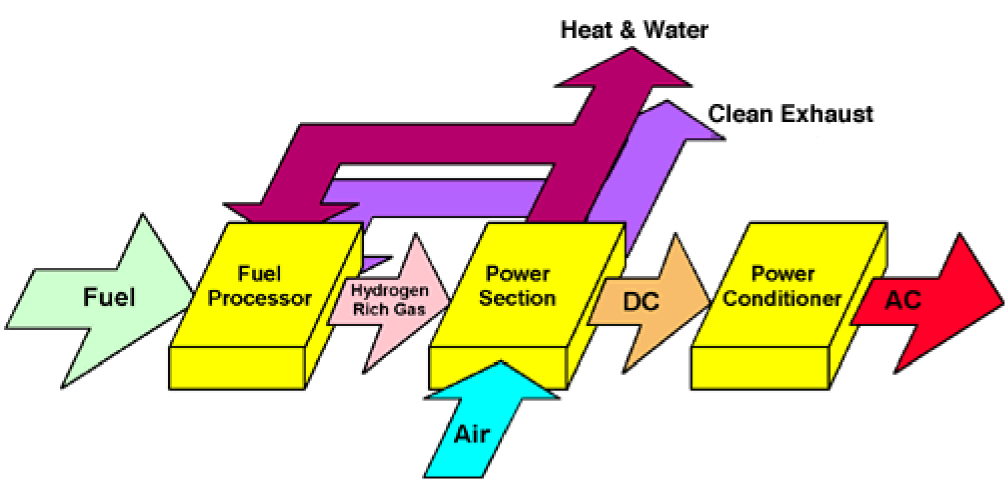

Figure 1. Fuel cell balance of plant.

ERDC/CERL manages the DOD Fuel Cell Project. With more than a decade of experience, the DOD Fuel Cell Project has offered valuable insights into evaluating and installing fuel cell power plant technology. Through all of its activities, the project has demonstrated more than 300 stationary power fuel cell installations. The fuel cell demonstrations have ranged in size from 1 kWe to 1 MWe, using Proton-Exchange Membrane Fuel Cells (PEMFCs), Phosphoric Acid Fuel Cells (PAFCs), Molten Carbonate Fuel Cells (MCFCs), and Solid Oxide Fuel Cells (SOFCs). In addition, DOD, in cooperation with Concurrent Technologies Corporation (CTC),* has developed a state-of-the-art test center to provide independent and unbiased testing, evaluation, and development support of fuel cell power plants for military and commercial applications.

This report is a continuation upon the *DOD Residential PEM Fuel Cell Demonstration Program, Volume 1 – Summary of the Fiscal Year 2001 Program* (White, et al. 2004). Volume 1 summarizes the initial stages of this project, with specific attention to Fiscal Year 2001 installations and early challenges to overcome. Volume 1 addresses the development of codes and standards in fuel cell installations, interconnect issues and challenges presented by the privatization and variation between utilities, and the changing face of a young industry. Volume 1 also illustrates the data that had been obtained and analyzed in the early stages of these demonstrations. Volume 2 addresses the completion of Fiscal Year 2001 projects and work done on Fiscal Years 2002 and 2003 projects, and case studies of three completed projects, as well as developments in project management, the face of the industry, economics, efficiencies, and life-cycles of PEM fuel cell installations. Following the completion of the DOD Residential PEM Fuel Cell Demonstration Project, the third volume of this report will discuss the demonstration as a whole, analyze the body or collected data, discuss programmatic findings, and provide suggestions for the future of PEM fuel cells for the DOD.

Objectives

The objectives of this demonstration were to:

- assess the role of PEM fuel cells in supporting DOD's training, readiness, mobilization, and sustainability missions
- assess fuel cells' role in supporting sustainable military installations

* Concurrent Technologies Corporation (CTC), 100 CTC Drive, Johnstown, PA 15904, http://www.ctc.com

- increase DOD's ability to more efficiently construct, operate, and maintain its installations
- provide operational testing and validation of the fuel cell product to assess installation, grid interconnection, operation of systems in all seasonal conditions, and integration of units into an existing military base environment
- provide a technology demonstration site for a military base market
- stimulate growth in the distributed generation /fuel cell industry.

Approach

Beginning in Fiscal Year 2001 (FY01), Congress appropriated funding to demonstrate residential-scale PEM fuel cells, produced domestically, at military facilities. The DOD maintains a large inventory of fixed facilities at its bases, which include buildings of all sizes and types such as office buildings, hospitals, industrial facilities, barracks buildings, gymnasiums, etc. All of these facilities can benefit from distributed generation, in particular fuel cells, to augment their power, heat, reliability, and security requirements in an environmentally-friendly fashion. The fuel cell team at CERL undertook the management and implementation of this activity, "The Department of Defense (DOD) Residential PEM Fuel Cell Demonstration Project." Subsequent funding in FY02, FY03, and FY04 has extended the program and has placed additional fuel cells at various military facilities.

CERL researchers have developed a methodology for selecting and evaluating fuel cell applications, have supervised the design and installation of fuel cell systems, have monitored the operation and maintenance of the fuel cells, and compiled feedback for manufacturers and investors. The accumulated expertise and diverse experience has enabled CERL to pursue research scenarios that lead to the advancement of fuel cell technology.

The DOD Residential PEM Demonstration Project installed, operated, and monitored Proton Exchange Membrane Fuel Cells (PEMFC) on select military and DOD-related locations. The electrical energy, and optionally the thermal energy, was used to power residential-scale loads, ranging from 1 kW to 20 kW. This document is the second volume in a series of reports summarizing this project. It continues the in-depth view of the project as a whole, to-date status of the project installations, project management, analysis of results, and lessons learned initiated in the first volume, *DOD Residential Proton Exchange Membrane (PEM) Fuel Cell Demonstration Program, Volume I – Summary of the Fiscal Year 2001 Program*, ERDC/CERL Technical Report 04-3. Whereas Volume I discussed the initial phase of this project, mainly the FY01 installations, and early progress, Volume II discusses the conclusion of FY01 installations and the progress into the FY02 and

FY03 installations. Appendixes A and B provide a description of the installations for FY02 and FY03, respectively. Appendixes C and D are the Broad Agency Announcement solicitation for FY02 and FY03, respectively.

From the FY01 Project BAA solicitation, 12 pre-proposals were received, requesting approximately $10.6 million in funding. After a review period, along with a request and evaluation of full proposals, six contracts were awarded, representing 21 fuel cells at nine military installations. From the FY02 Project solicitation, 20 pre-proposals were received, requesting approximately $15.8 million in funding. Five contracts were awarded, to place 24 fuel cells at eight military installations. From the FY03 Project solicitation 29 pre-proposals were received, requesting approximately $22 million. A total of eight contractors were selected for the FY03 PEM Demonstration, representing 31 PEM fuel cells at 20 U.S. military installations. The FY04 Project solicitation was released in September of 2004, and contract awards are expected to be made in the second quarter of 2005.

Mode of Technology Transfer

The role of the CERL fuel cell team in this project is management, data analysis, and technology transfer. The analysis of data and further related research is discussed in Chapter 6, "Analysis" (p 20). The results of these projects and the accumulated experience of the PEM Demonstration as a whole have been the subject of numerous articles, papers, and presentations by the fuel cell team. All collected data and reporting from the contractors, as well as this and other CERL fuel cell reports, can be found on the internet at these URLs:

http://www.DODfuelcell.com/

http://www.cecer.army.mil/

2 Project Management

The DOD Residential PEM Fuel Cell Demonstration Project is the second of its kind to be carried out by the fuel cell team at CERL. The first was a demonstration of large scale PAFCs begun in FY93. The PAFC Demonstration set a great deal of the groundwork for project management in the PEM Demonstration. Since start of the PAFC demonstration, the fuel cell industry has grown considerably. Where there was once essentially only one commercial fuel cell manufacturer, there are now many. With the growth of the industry, public awareness and political interest have also developed. As the PEM Demonstration enters its fourth year, several adjustments that have been made throughout the course of the project are also evident.

Given the status of the market in the early 1990s, the contract awards for the DOD PAFC Demonstration Project were all made to the only available manufacturer of PAFCs. With the market growth and increased awareness, the PEM demonstration projects were awarded not only to fuel cell manufacturers, but also energy contractors, on-site energy managers, and other interested individuals. The release of a Broad Agency Announcement (BAA) for the execution of this mission opened doors to a diverse set of sites and contractors.

Project Selection

The BAA, developed by ERDC/CERL researchers, outlined a core set of requirements for proposals:

- All PEM fuel cells shall be substantially produced in the United States.
- The units will be installed at U.S. military or related facilities.
- The fuel cell contract awardees are responsible for all siting and installation requirements.
- The fuel cells will provide 1 year of fuel cell power with a minimum 90 percent unit availability.
- All units will have comprehensive maintenance contract for a minimum demonstration period of 1 year.
- Data performance monitoring will be conducted for each PEM unit.
- Removal of the fuel cell(s) and site restoration will be included in the contract price.
- Location of the PEM fuel cell(s) will be in a specified U.S. geographic region.

Beyond the core set of requirements, proposers had the flexibility to propose the number of units, the manufacturer, and subsequently the specific size and fuel input of the units, and the electrical and/or thermal application of the units, among other attributes. Applicants were required to submit a pre-proposal giving a basic outline of a project, including: output level, fuel, and quantity of the fuel cell units, location, application, and other project information. Approved pre-proposals are followed by a full proposal containing project details. The specific requirements can be found in the BAA for FY02 and FY03, which are located in Appendixes C and D respectively.

By establishing the project as a set of turnkey contracts, awardees were chosen through a two-part proposal process. An initial pre-proposal suggests a site, fuel cell size and manufacturer, and cost estimate, and provides information about the abilities and experience of the proposers. Those whose pre-proposals were accepted were then invited to submit a full proposal. The full proposal had to give greater detail on the subjects in the pre-proposal, plus it required approval from the site personnel to proceed, and it required the contact information for all parties potentially involved. The proposal review process resulted in the selection of as many of the top-ranked proposals as funding would allow and awarded contracts to those proposers.

Contractor Requirements

The selected contractors were required to submit three principal reports: an Initial Project Description, a Midterm Project Status Report, and a Final Report. The Initial Report outlines information regarding the site, the specific application, points of contact (POCs) at the site, digital pictures of the site, utility rates at the site, an estimate of the energy savings (the sum of electric energy and demand savings plus heat energy savings, minus input fuel cost), and a predicted project timeline. The Midterm Report includes digital pictures of the installed fuel cell, documentation of the installation process, and documentation of the acceptance test of the fuel cell. The Final Report completely documents the project, including material from the Initial Project Description and the Midterm Project Status Report, as well as all maintenance logs, all monthly performance monitoring data, and a comparison of actual fuel cell performance to the expectations provided in the full proposal. It should also include a breakdown of actual project costs and a comparison to the estimated costs in the cost proposal, a discussion of any pertinent installation, acceptance, or permitting issues, and summary of lessons learned.

In addition to the three main reports, monthly reports were required for every month of fuel cell operation. These monthly reports include maintenance, parts replacements and lifespan, and downtimes. They also include month by month performance monitoring data on run hours, availability, thermal and electric efficiency, fuel usage, capacity factor, and output.

In addition to their reporting obligation, the contract awardees must also conduct meetings with the fuel cell team at CERL and representatives of the fuel cell installation site. In FY01 and FY02, a Kickoff Meeting was required before the start of installation or any other work on the site. This meeting took place at the site, and included the representatives from CERL, the site, and the contract awardees, as well as any interested parties at the site, such as the fire marshal or equivalent, security personnel, energy managers, and VIPs. These meetings provided an overview of the project objectives and requirements, and gave the opportunity to have questions answered. In FY03, in addition to the Kickoff Meeting, an Acceptance Test Meeting was added to the project requirements. This meeting took place following the installation and testing of the fuel cell system, and provided CERL and site representatives the opportunity to inspect the installation and ascertain that the system was, in fact, installed and running properly.

Numerous changes were made to the management of the PEM Demonstration Projects between FY02 and FY03, streamlining the data collection and information gathering procedure. One, as mentioned above, was the addition of the Acceptance Test Meeting. The need for this meeting was determined after several projects completed installation and started their 12-month demonstration, only to encounter problems with the unit that reduced availability and increased the cost of maintenance and parts. Also, the requirements of a draft Initial Project Description before the Kickoff Meeting and a draft Midterm Progress Report before the Acceptance Test Meeting were added. These additions assured the CERL fuel cell team that the contractors were on the right course, or enabled them to assist the contractors in getting on the right track.

3 Site Summary

The award of contracts for the DOD Residential PEM Fuel Cell Demonstration Project was preceded by a two-part proposal process. Pre-proposals submitted by all interested parties were reviewed by the CERL team. The approved proposers were each invited to submit a full proposal, which in turn, were reviewed by the CERL team for approval. Proposals were required to identify a fuel cell manufacturer and potential site, and as of FY02, were required to provide evidence of agreement with the site's energy manager or superior personnel at the site. The proposers were encouraged to propose more than one site or more than one unit per site, if their requirements allowed.

The 10 project sites selected for the FY01 demonstration were discussed in volume one of this report. Those sites were:

1. Brooks Air Force Base, TX
2. Barksdale Air Force Base, LA
3. Coast Guard Station New Orleans, LA
4. Fort Bragg, NC
5. Fort Jackson, SC
6. Fort McPherson, GA
7. Geiger Field, WA
8. Naval Air Station Patuxent River, MD
9. Sierra Army Depot, CA
10. Watervliet Arsenal, NY.

The 14 project sites selected for FY02 were:

1. Fort Belvoir, VA
2. Fort Gordon, GA
3. Georgia Institute of Technology Reserve Officers Training Corps (ROTC)
4. Marine Corps Air Station Cherry Point, NC
5. McChord Air Force Base, WA
6. NASA Stennis Space Center, MS
7. North Carolina Agriculture & Technology University
8. U.S. Army Corps of Engineers, Construction Engineering Research Laboratory (CERL), IL
9. U.S. Coast Guard Aids to Navigation Team, SC
10. Robins Air Force Base, GA

11. Saratoga Springs Naval Support Unit, NY
12. Selfridge Air National Guard Base, MI
13. Shaw Air Force Base, SC
14. West Point Military Academy, NY.

The 20 project sites selected for the FY03 demonstration were:

1. Arizona Army National Guard
2. Fort A.P. Hill, VA
3. Fort Benning, GA
4. Fort Lewis – Gray Army Base, WA
5. Fort Rucker, AL
6. Gabreski Air National Guard Base, NY
7. Hill Air Force Base, UT
8. Keesler Air Force Base, MS
9. Los Angeles Air Force Base, CA
10. March Air Force Base, CA
11. Marine Corps Base Kaneohe Bay, HI
12. McEntire Air National Guard, SC
13. Montana Army National Guard, MT
14. National Guard Base Camp Mabry, TX
15. Offutt Air Base, NE
16. Schofield Barracks, HI
17. Sierra Army Depot, CA
18. U.S. Antarctic Division, Christchurch, New Zealand
19. U.S. Army Sergeant Herera Reserve Center – Arizona State University
20. U.S. Embassy to the United Kingdom.

The 44 total sites of fiscal year 2001 (FY01), FY02, and FY03 represent a total of 85 PEM fuel cell installations from four manufacturers and 13 contractors. Figure 2 shows the location of these sites. At the time of this report, 11 of those installations had completed their 1-year demonstration, and another eight had been completely installed and were operational. The manufacturers represented in these demonstrations were Plug Power, ReliOn, Nuvera, and IdaTech. Applications included residential, commercial, and industrial buildings, as well as remote air traffic control installations. Tables 1, 2, and 3 list the applications for the FY01, FY02, and FY03 sites, respectively.

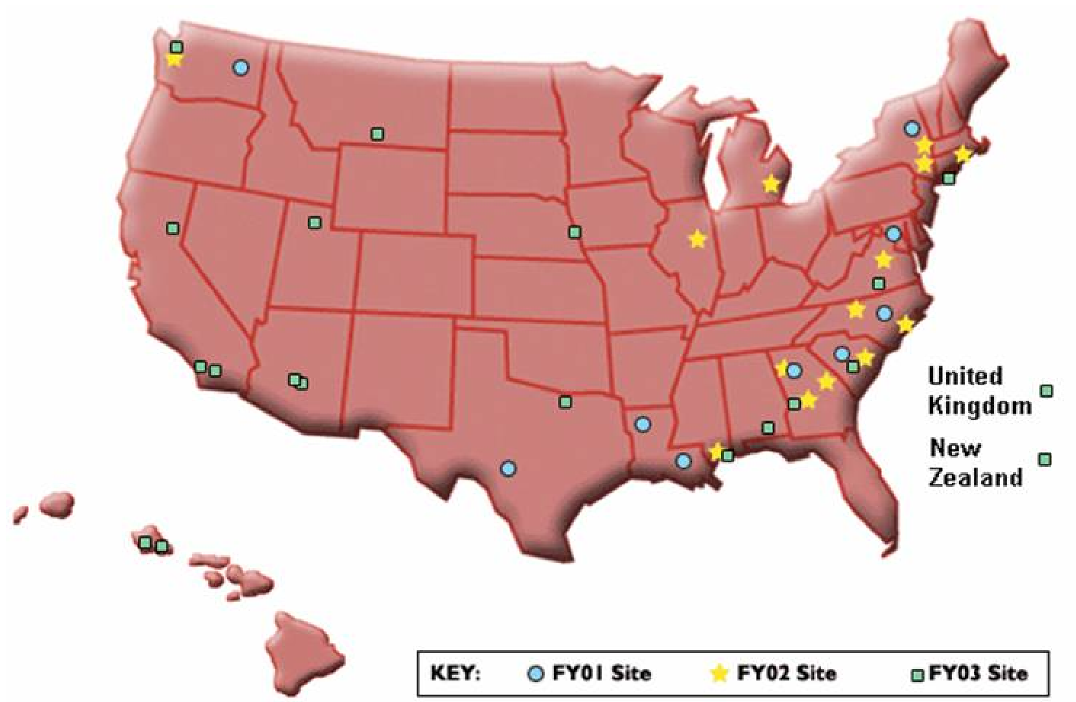

Figure 2. Site locations.

Table 1. Site and application summary, FY01 projects.

Site Name	Building Application	Fuel Cell Mfg.	Input Fuel	Size (kW)	No. Units	Cogen. Y/N
Coast Guard Station New Orleans	Office Building	Plug Power	Natural Gas	5	1	Yes
Fort McPherson	Officer's Quarters	Plug Power	Natural Gas	5	1	Yes
Brooks AFB	Base Housing	Plug Power	Natural Gas	5	3	No
Fort Bragg	Office Building	Plug Power	Natural Gas	5	1	No
Fort Jackson	Officer's Quarters	Plug Power	Natural Gas	5	1	Yes
Barksdale AFB	Base Housing	Plug Power	Natural Gas	5	1	No
NAS Patuxent River	Office Building	Plug Power	Propane	5	1	Yes
	Officer's Quarters	Plug Power	Natural Gas	5	1	Yes
Geiger Field	Maintenance Facility	ReliOn	Hydrogen	3	1	No
Watervliet Arsenal	Research Facility	Plug Power	Natural Gas	5	3	No
	Manufacturing Facility	Plug Power	Natural Gas	5	3	No
	Officer's Quarters	Plug Power	Natural Gas	5	4	No

Table 2. Site and application summary, FY02 projects.

Site Name	Building Application	Fuel Cell Mfg.	Input Fuel	Size (kW)	No. Units	Cogen. Y/N
ERDC-CERL	Undecided[1]	Plug Power	Natural Gas	5	1	Yes
Fort Belvoir	Undecided[2]	Plug Power	Natural Gas	5	1	Yes
	Undecided[2]	Plug Power	Hydrogen	5	1	No
Fort Gordon	Army University of Technology Resource Center	Plug Power	Natural Gas	5	1	No
Georgia Institute of Technology–ROTC	AF ROTC Building	Plug Power	Natural Gas	5	1	Yes
MCAS Cherry Point	Maintenance Facility	Plug Power	Propane	5	1	Yes
McChord AFB	FAA Radio Transmitter	ReliOn	Hydrogen	0.5	6	No
NCA&T University	ROTC Facility	Plug Power	Natural Gas	5	1	Yes
Robins AFB	Fire Station	Plug Power	Natural Gas	5	1	Yes

Site Name	Building Application	Fuel Cell Mfg.	Input Fuel	Size (kW)	No. Units	Cogen. Y/N
Saratoga Springs NSU[3]	Base Housing	Plug Power	Natural Gas	5	8	Yes
Selfridge ANGB	Fire Station	Plug Power	Natural Gas	5	2	Yes
Shaw AFB	Base Housing	Plug Power	Natural Gas	5	1	Yes
Stennis Space Center	Mars Habitat	Plug Power	Natural Gas	5	1	Yes
USCG Aids to Navigation Team	Maintenance Facility	Nuvera	Natural Gas	5	2	No
West Point Military Academy	Officers' Quarters	Plug Power	Natural Gas	5	3	Yes

[1]This project has been delayed by utility company restrictions and interconnection analysis.
[2]This project has been delayed due to changes in staff and support at demonstration site.
[3]This project was funded by the Naval Air Warfare Center, Weapons Division.

Table 3. Site and application summary, FY03 projects.

Site Name	Building Application	Fuel Cell Mfg.	Input Fuel	Size (kW)	No. Units	Cogen. Y/N
Arizona Army National Guard	National Guard Armory	Plug Power		5	1	Yes
Fort A.P. Hill	Administration Building	IdaTech	Propane	5	1	No
Fort Benning	Recreation Center	Plug Power		5	1	Yes
Fort Lewis	Localizer Building	ReliOn	Hydrogen	1	1	No
	Glide Slope Building	ReliOn	Hydrogen	1	1	No
	Middle Marker Beacon	ReliOn	Hydrogen	1	1	No
	Outer Marker Beacon	ReliOn	Hydrogen	1	1	No
Fort Rucker	Localizer Building	ReliOn	Hydrogen	1	1	No
	Glide Slope Building	ReliOn	Hydrogen	1	1	No
	Middle Marker Beacon	ReliOn	Hydrogen	1	1	No
	Outer Marker Beacon	ReliOn	Hydrogen	1	2	No
Gabreski Air National Guard	Base Telephone Exchange	ReliOn	Hydrogen	1	2	No
	Localizer Building	ReliOn	Hydrogen	1	1	No
	Glide Slope Building	ReliOn	Hydrogen	1	1	No
Hill AFB	Main Base Fire Station	Plug Power	Natural Gas	5	1	Yes

Site Name	Building Application	Fuel Cell Mfg.	Input Fuel	Size (kW)	No. Units	Cogen. Y/N
Keesler AFB	Officer's Quarters	Plug Power	Natural Gas	5	1	Yes
Los Angeles AFB	Airmen's' Barracks	Plug Power	Natural Gas	5	1	Yes
March ARB	Airmen's' Barracks	Plug Power	Natural Gas	5	1	Yes
MCB Kaneohe Bay	Officer's Residence	Plug Power	Natural Gas	5	1	Yes
McEntire ANG	Unknown[1]	Plug Power	Natural Gas	5	1	
Montana Army National Guard	Armed Forces Reserve Center	Plug Power	Natural Gas	5	1	Yes
NGB Camp Mabry	Unknown[1]	Plug Power		5	1	
Offutt Air Base	Communications Detachment	IdaTech	Propane & Natural Gas	5	2	No
Schofield Barracks	Unknown[1]	Plug Power		5	1	
Sierra Army Depot	Barracks Building	Plug Power	Propane	5	1	Yes
U.S. Embassy, UK	Abby Road Residence	Plug Power	Natural Gas	5	1	Yes
U.S. Antarctic Division	Scientific Foundation Building	ReliOn	Hydrogen	1	2	No
U.S. Army Reserve Center	Army Reserve Center	Plug Power	Natural Gas	5	1	No
	Army Reserve Center	IdaTech	Natural Gas	5	1	No

[1]Application has not yet been identified

4 Industry Challenges

Public Acceptance

One aspect of the adaptation of any new technology is public acceptance. Even if the technology is useful, the costs and environmental impacts are low, and product is readily available, there is still the issue of raising public interest and support for it. The DOD Residential PEM Fuel Cell Demonstration addresses this issue directly by installing PEM fuel cells at homes, businesses, and other publicly accessed locations. Yet, despite the fact that CERL and its contractors provide all the funding for the fuel cell unit, and the installation and maintenance, many site personnel remain uncomfortable about the presence of a fuel cell. At one residential site, for example, the fuel cell technician was asked to install a fence and ornamental garden around the fuel cell, to camouflage its existence. This mentality of not wanting to have to think about where the electricity comes from is a significant factor that holds back public acceptance of alternative energy technology.

At Fort Jackson, the fuel cell was installed outside the home of the Garrison Commander. This demonstration, despite the Colonel and his family's interest in keeping the fuel cell, was unable to continue due to an accident. The Colonel's son, who had recently received his driving learner's permit, was backing up in their driveway, when his foot slipped off the brake pedal and hit the accelerator. He accelerated through his mother's garden and hit the side of the carport where the gas meter and all of the fuel cell thermal piping and electric lines were connected to the wall. The Colonel described the incident thus: "He didn't hit the fuel cell, but there sure [we]re a lot of pipes dangling." Experiences such as these are unfortunate, but also contribute to the public perception of PEM fuel cell systems as a reality.

A positive perspective came from the resident at one of the U.S. Military Academy, West Point, PEM fuel cell installations. In August 2003, a blackout swept across a large portion of the Northeastern United States, but the fuel cell at the residence kept the lights and the refrigerator running. Four months later, the boiler went out in the home while the residents were away for the winter holidays. The thermal recovery kept the internal temperature at 65 ˚F, despite the external temperature staying below 48 °F. These experiences support the idea that distributed generation and back-up power systems can improve the quality of life in the United States as energy demands grow.

Economics

Economic viability is a major impediment to any new technology. The manufacturer and consumer must not only bear the cost of the new product, but also the cost of the infrastructure, research and development, and market development. Breaking through the economic barriers of the new technology is one of the primary objectives of this project.

At the time of this report, much of the economic data from the DOD Residential PEM Demonstration Projects was not yet available. The projects associated with FY01 did not contractually require the economic data related to the installation, operation, and maintenance costs. This was corrected in the later projects, but many of those projects are not yet complete. The cost factors involved in a complete DOD Residential PEM Demonstration Project included:

- site preparation and installation
- fuel cell system (including fuel storage where applicable)
- monitoring and communications
- labor
- fuel
- travel
- site restoration
- miscellaneous other (i.e., tools, pesticide, etc.).

Based on six projects for which data was available, the average cost was $260,775.00 per project, or $104,310.00 per fuel cell unit installed. This was equivalent to $41,966.50/kW, or $31.93/kW-hr. The average cost to simply purchase a 3-5 kilowatt fuel cell system was $56,917.00, and the average cost to have it installed was $11,135.00.

Very little cost analysis has been performed on the economic feasibility of PEM fuel cells. One study performed by the U.S. Department of Energy (Collins and Parker 1995) stated that the life-cycle cost required to make fuel cells economically feasible is $1500/kW. This value takes into account everything from the price of the system and installation, to the cost of fuel and maintenance, to the environmental savings in the form of CO_2, NO_x, and SO_x emissions each year. At this point, it is not possible to calculate, using the same methods, the life-cycle cost of the demonstration systems of this project. As more data is accumulated it may become possible to move toward this ideal economic viability.

5 Department of Defense Challenges

Reliability and Security

Energy security is one of the most important current issues for the U.S. government. The term “energy security” encompasses three main issues:

- How do we keep the power on?
- How do we keep our rates low?
- How do we meet our energy requirements with a minimum of adverse environmental impacts?

For the DOD, particularly in forward areas where the necessity of importing fuel and supplies has already driven the prices up, and where the defense of soldiers and personnel is paramount, the first question outweighs the other two.

The blackouts experienced in California and New England over the last several years have driven home the fact that our electricity grid system is out of date and insecure. Whether from terrorist attack, natural disaster or equipment failure, the interconnected nature of our electric system is vulnerable to a broad array of serious security risks, with potentially costly consequences (Regulatory Assistance Project, 2002). In addition, the rising prices of petroleum and the vehicularization of highly populous nations, such as China and India, leave little doubt that alternative energy sources will soon be a necessity. The DOD requires secure and stable sources of electricity both at home and abroad.

One strategy that can greatly reduce the risks facing energy availability is the use of distributed generation resources, which can lower stresses on the electric grid and lower the grids reliance on remote central stations and long transmission links.

> Just as desktop computers and local area networks have moderated the central role of mainframe computers, distributed electric resources can lessen the number of hours and the number of facilities where the loss of strategic assets would cause widespread outages or cascading failures (Regulatory Assistance Project, 2002).

Thermal Recovery

To date, this study has firmly supported the hypothesis that using the thermal energy from a PEM fuel cell greatly increases the efficiency of the system. Chapter 6 of this report (“Analysis,” p 20) describes the results for increased efficiency that can be achieved from thermal recovery. In a conventional electricity distribution system, a grid is used to conduct electricity from a central production facility to substations, then to the user’s home. The heat produced during electricity production in these conventional systems is too far from the consumer to be transported, and thus must be dealt with as a waste product. Disposal of waste heat can be difficult and often environmentally dangerous.

Because distributed generation systems, such as fuel cells, are located at or near the site of consumption, the waste heat can be used rather than discarded. By using the heat in domestic water heaters, space heaters, or other applications that would otherwise require electricity, thermal recovery can actually decrease the costs and increase the overall efficiency of the fuel cell. Once a thermal recovery system is installed, the thermal energy used is a free resource.

Thermal recovery is associated with some problems, specifically, how to capture and use the heat. One simple method is to route the heat into a domestic water heater via heat exchangers, although this method is relatively inefficient (it generally attains only 15 to 20 percent thermal energy efficiency).

Interconnections and Utilities

A major roadblock facing most distributed generation technologies, including fuel cells, is interconnection with the electrical grid maintained by the utility companies. The problem of safe and practical integration of a new technology into the existing system is common to any new technology. For those who are responsible for servicing the electric grid, an unfamiliar or unanticipated source of electricity integrated into the grid can cause the threat of electrocution. Normal grid outages can be monitored from the central power plant. A worker might assume that a portion of the grid was without power based on Central Power Plant data—while a fuel cell or other distributed generation device may be feeding electricity back into the system. Under such conditions, service personnel could be seriously injured by attempting to work on a system that has an undetected electric charge.

To address these safety issues, utility companies develop a set of regulations that must be met before a grid-interconnected fuel cell system can be activated. As a result of the deregulation of electric utilities in the United States, these regulations are set by the individual utility companies and can vary widely from utility to utility. One company may require only a set of plans ensuring the device has been safely installed and may even pay the fuel cell owner for excess electricity fed back to the grid, a practice known as "net metering," while another may demand a costly and complicated interconnection study before giving approval for interconnection. In some locations, the interconnection study is so costly that installation of the fuel cell becomes completely impractical.

For military installations that own their own electric grids, this problem is irrelevant. However, as more facilities contract out their electricity needs to private utilities to save military resources, the issue of grid-interconnected distributed generation systems becomes more pronounced. There is need for improved awareness of the capabilities and safety issues of distributed generation technology, and for increased standardization for grid interconnection.

6 Analysis

At the time of this writing, 11 of the 21 FY01 and FY02 demonstrations had been completed. The collection of final data and written reports made the comparative analysis of the various projects possible. This chapter discusses the availability, reliability, and electrical and thermal efficiencies of PEM fuel cell systems, the calculation of average PEM fuel cell stack life, and economic feasibility of these systems, including installation and maintenance efforts.

Availability and Reliability

The DOD Residential PEM Fuel Cell Demonstration Project was the second of its kind begun by the CERL fuel cell team. The first was a 5-year demonstration of 200kW phosphoric acid fuel cells (PAFCs). One of the most significant setbacks seen in the PAFC project was discontinuous data that occurred when a fuel cell shut down and was left until a maintenance crew could arrive at the site. Sometimes such outages lasted weeks or months.

To prevent prolonged outages and to improve the quality and accuracy of data acquired, the PEM Demonstration was designed with a requirement of a minimum 90 percent availability for a minimum of 12 months of operation. The requirement effectively ensured that the contract awardees would develop a solid communications system and commit the necessary technical staff at each installation, thus limiting extensive downtime and improving data collection. Although 90 percent availability would not seem a challenge to a conventional power delivery system, it was unknown at the start of the PEM Demonstration Project whether the fuel cell systems could actually achieve this level of output. Of the 11 PEM demonstration sites where projects have been completed, eight achieved or exceeded the minimum 90 percent availability requirement.

Table 4 lists the performance data for the FY01 and FY02 fleets, including availabilities, efficiencies, and fuel usage. At the cutoff point for this report (31 October 2004), no data had yet been collected for the FY03 sites, and not all of the FY01 and FY02 demonstration projects were complete. Of the nine FY01 projects, all had been started, but only six project sites (with a combined total of 17 units) were complete. Of the 15 FY02 sites, 10 were underway, and only five project sites (with a combined total of 14 units) had completed their 1-year demonstration. Each individual unit's operations data is measured for each month of performance, and thus the other operational projects contributed between 1 and 11 months to the data summary. Table 4 shows the data for a total of 246 months of operations data for FY01 and 222 months of data for FY02, and the equations used to derive most of the values. Of note are the thermal energy data.

In general, most sites achieved the goal availability. Lessons were learned from both the successes and from the projects that fell short. One of the most vital lessons was the importance of continuous communication with the fuel cell unit. Whether a technician was on site for the duration of the project, or a strong long-distance communication system was installed, it became evident that immediate awareness of problems or potential problems were directly related to high availability.

Reliability is a newer issue to this project. In the FY02 project, the first back-up power application of the demonstration was installed at McChord Air Force Base. Chapter 7 gives further detail on that demonstration. Three more back-up power sites were begun in FY03. These back-up power applications from the FY02 and FY03 demonstrations differed from the others in that they would run and produce electricity only when triggered by a power outage.

Table 4. Fleet summaries.

Year	Operating Hours	Availability %	Capacity Factor %	Fuel Usage, LHV (BTUs)	Energy Produced (kWe-hrs)	Average Output (kW)
FY01 Summary	163,774	89.09%	47.34%	6,231,290,270	430,926	2.63
FY02 Summary	142,559	88.83%	44.25%	5,015,360,979	362,344	2.54
Total Fleet Summary	306,333	88.97%	45.86%	11,246,651,249	793,270	2.59
Year	**Electrical Efficiency (%)**	**Thermal Efficiency (%)[1]**	**Overall Efficiency (%)[2]**	**Fuel Usage (SCF)**	**Thermal Heat Recovery (BTUs)**	**Heat Recovery Rate (BTUs/hr)**
FY01 Summary	23.6%	9.64%	25.9%	2,944,757	127,813,408	4619
FY02 Summary	24.7%	10.40%	30.2%	4,947,111	315,072,257	3752
Total Fleet Summary	24.1%	10.17%	27.9%	7,891,869	442,885,665	3967

Data through 31 October 2004

Availability (%)	=	Operating Hours / Total Hours in Period
Capacity Factor (%)	=	Energy Produced (kWe) / (Fuel Cell Power Rating * Total Hours in Period)
Average Output (kW)	=	Energy Produced (kWe) / Operating Hours (hrs)
Electrical Efficiency (%)	=	(Energy Produced (kWe) * 3414 BTUs/kW-hr) / Total Fuel Usage (BTUs)
Heat Recovery Rate (BTUs/hr)	=	Thermal Heat Recovery (BTUs) / Operating Hours (hrs)
Thermal Efficiency (%)	=	Thermal Heat Recovery (BTUs) / Fuel Usage (BTUs)
Overall Efficiency (%)	=	Electrical Efficiency + Thermal Efficiency

1 The averages shown for thermal energy and thermal efficiency are based only on the sites that used thermal recovery, but the values for those sites were recorded and included in the calculation whether or not any thermal data was recovered that month.

2 The overall efficiency values shown are the average of the overall efficiency at each site, and not the sum of the average electrical and average thermal efficiencies.

The difference lies in the definitions of availability and reliability. In this application, availability is defined as the *actual run time* in scheduled period divided by *scheduled run time* in that period. Reliability is defined as the *actual starts* divided by *attempted starts*. The reliability achieved at McChord AFB was 99.4 percent. This encouraging number gives the fuel cell team high hopes for the other back-up power demonstrations that have not yet completed. The high reliability means that the fuel cell could be cycled off as a dependable source of power in times that the grid goes down.

Electrical and Thermal Efficiency

One of the principal advantages in using fuel cells to generate electricity is their increased efficiency. Fuel cells, particularly those powered directly by hydrogen gas, can achieve extremely high electrical efficiencies. Also, because PEM fuel cells are installed close to the power application, a concept known as distributed generation, the waste heat from the power generation can be used, rather than discarded. This further increases the unit's efficiency. On the other hand, the process of reforming fuel into hydrogen or hydrogen-rich gas reduces the overall efficiency. In addition, the efficient capture of waste heat is not always a simple matter; capturing and using the byproduct heat can often add complexity and expense to the fuel cell installation.

When considering the efficiency of a fuel cell system, one must consider whether the system uses fuel directly, or reforms a fuel into a hydrogen-rich gas before fueling the power plant. In the PEM fuel cells examined in this demonstration, some of the power plants were directly fueled with hydrogen, while the rest were fueled with either natural gas or propane, which was reformed into hydrogen-rich gas in the fuel cell system.

The fuel cells power plants that are directly fueled by hydrogen can attain a much higher electrical efficiency than the reformer-based fuel cell systems. On the other hand, hydrogen-fueled systems cannot use waste heat in combined heat and power applications. This is because the reformation process is an extra step, one that requires energy to be added to the system. Reforming hydrocarbon fuels, such as natural gas or propane, requires intense heating of the fuel, followed by a rapid cooling cycle, which lowers the net electricity and heat output. It is primarily this heat that can be used for combined heat and power applications. Thus, hydrogen-fueled systems can attain greater electrical efficiencies, but reformer-based systems can to a degree counteract the efficiency loss by using a portion of the waste heat.

It is also important to remember that elemental hydrogen does not occur naturally on the surface of the Earth; the hydrogen must be produced outside the fuel cell system. So, while the system efficiency of direct-hydrogen fuel cells is generally higher that reformer systems, reformation losses are still a part of the whole process.

The data in Table 4 summarize the performance, including efficiencies, for the fleet of fuel cells installed in this demonstration project. Only 13 of the 20 installations represented in Table 4 used thermal recovery systems. The overall fleet efficiency is sum of the overall efficiency for each site, whether the site used the waste heat or not. The highest efficiency achieved during this project was 56.1 percent at McChord AFB, a direct-hydrogen fuel cell. This fuel cell system, discussed in greater detail in Chapter 7 (p 26), provided a load with direct current (DC) electricity. While this site did not have waste heat to use, the high efficiency can in large part be credited to two factors: (1) the ability to use hydrogen fuel directly, and (2) the requirement for DC current (i.e., there was no need to use an AC/DC power inverter).

The thermal efficiency measured to date ranges from less than 2 percent to as high as 38 percent. These values rely highly on the application of the thermal energy. Many of the sites employ domestic water heaters, but other sites use thermal energy through fan coil heaters, baseboard heaters, and desiccant chillers, to name a few. The efficiency of these systems varies, but they all use heat that would otherwise be wasted. Thus the addition of Combined Heat and Power (CHP) technology improves the overall efficiency of the fuel cell system. The highest thermal efficiency site used thermal energy in a large water heater. However, there were too many independent factors involved to assume that using a water-heater for heat recovery is always the most efficient use of waste heat.

Stack Life

A great deal of data was gathered during the course of the DOD Residential PEM Demonstration Project, and yet it remains difficult to draw conclusions about the durability and lifetime of the fuel cells. This is due to numerous factors; primarily the ever-changing technology in the fuel cell field, the variation between the technology employed by each manufacturer, and the duration of these demonstrations. The dominant manufacturer in this project, Plug Power, Inc, has made significant technological changes to their product during the demonstration’s 4 years. They have replaced the power inverter that was part of the first demonstration units with a more reliable one, and they have improved the software and communications systems in the unit, to name two significant changes. These changes affect not only durability, but also the ability to collect and monitor performance data.

The PEM demonstration project strives for diversity to fully test and demonstrate the capability of the technology. This diversity, though, also hinders the ability to draw conclusions pertaining to system durability and stack life. For instance, ReliOn Inc, another PEM fuel cell manufacturer represented in this demonstration, uses a modular cartridge technology, instead of solid state stacks. In the cartridge system, the PEM membranes are housed within simple, individual 100W cartridges. If a cartridge fails, the system automatically bypasses the cartridge with the problem, and continues to provide power to the load, and the cartridge can be replaced quickly, without shutting down the system. In fuel cell stacks, however, the membranes are stacked together to achieve a particular output and power density. In the event of a failure of any one of the stack seals, equipment components, or membranes, the entire stack ceases to operate, and the system must be shut down to replace the whole stack (ReliOn, Inc., "Cartridges Versus Stack Architecture").

Figure 3 shows the life spans of the stack-based fuel cells in this demonstration, and their average. Figure 4 shows the life spans of the cartridge-based fuel cells in this demonstration, and their average. Clearly, the life span of a fuel cell stack is longer than that of a fuel cell cartridge, and thus have the advantage of durability. On the other hand, fuel cell cartridges are smaller, less expensive, easier to replace, and do not cause an outage when a failure occurs, and so the cartridge systems have the advantages of maintainability and sustainability. Because of these differences, it makes sense to study them separately.

Another hindrance to the study of durability and stack life in these projects is the limited time provided by the 12-month demonstration period. This time limit has been very beneficial in the collection of data and the management of this project for the most part, but it does not allow for a thorough study of PEM fuel cell durability. At each installation, the fuel cell stack is usually not changed more than once, and occasionally does not need to be changed at all. This makes it practically impossible to determine whether stack degradation and failure are impacted by special factors, such as the local environment, a circuitry anomaly in the application, or a system defect. To perform a more accurate study of stack life, a demonstration should use more systems and run the units for a longer period of time.

For the purposes of the DOD Residential PEM Fuel Cell Demonstration Project, the data collected in the FY01 and FY02 demonstrations, to date, are plotted in Figures 3 and 4. These values are based on the hours of run-time in the demonstration before a stack was replaced, and thus does not account for any stack that may have lasted the entire 1-year demonstration period. The average life span of a 4-5kW PEM fuel cell stack is 4722.75 hrs, and the average life span of a 100W PEM fuel cell cartridge is 86.25 hrs.

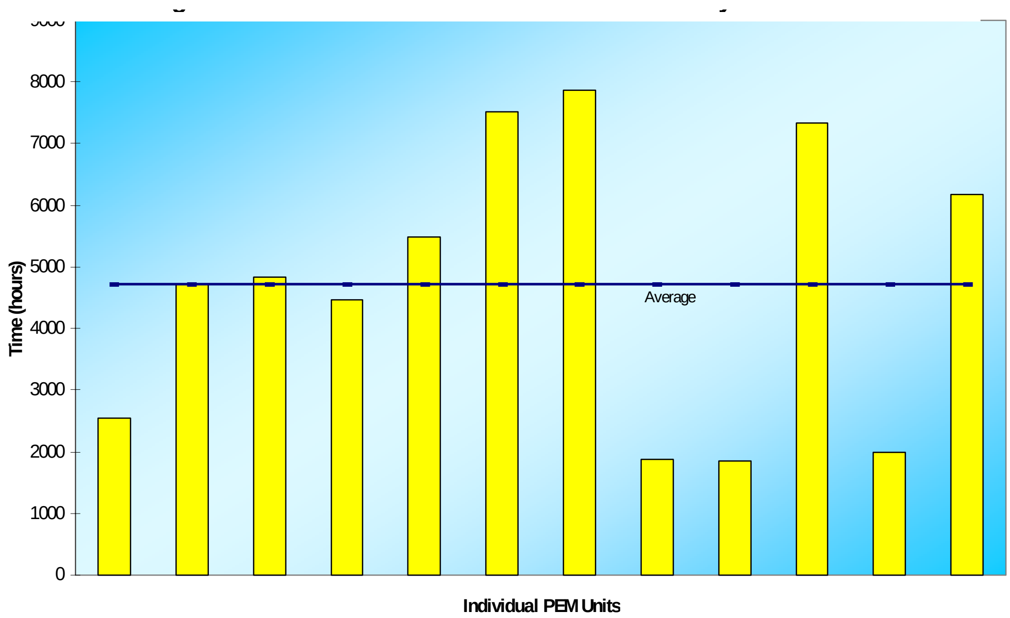

Figure 3. Average life span of demonstrated PEM fuel cell stacks, by unit.

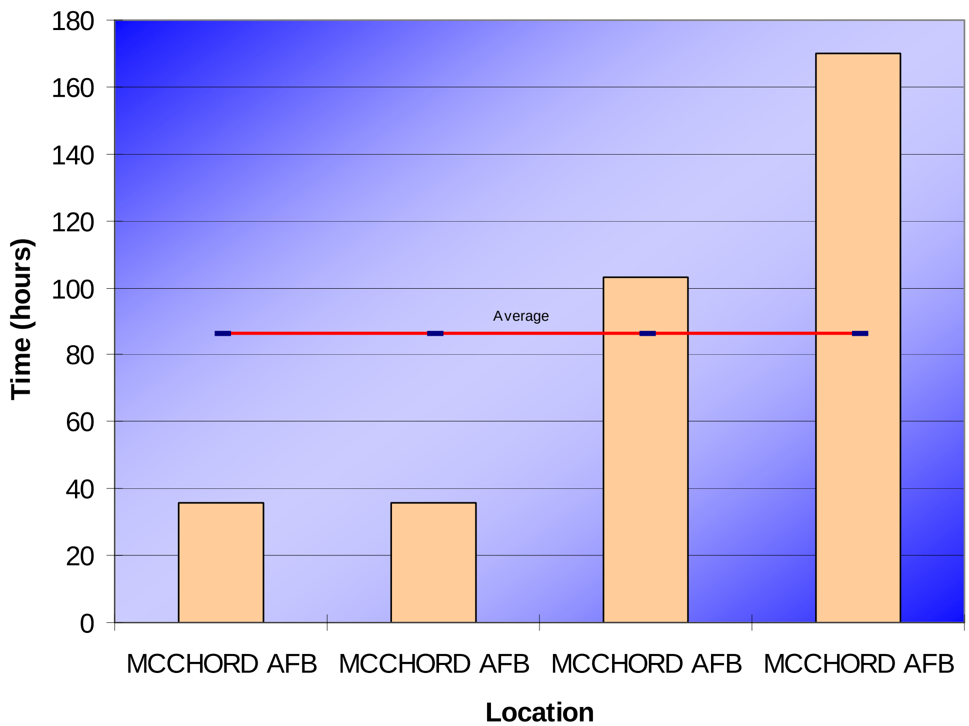

Figure 4. Average life span of demonstrated PEM fuel cell cartridges.

7 CASE Studies – Fuel Cell Technology as Critical Backup Power

This chapter discusses in greater detail three of the demonstration projects completed as part of the DOD Residential PEM Demonstration Project. Each of the three projects emphasizes a different aspect or issue faced during the Demonstration as a whole. The first case study, at McChord Air Force Base, was the first of these projects to deal with the installation and analysis of a hydrogen-fueled backup power fuel cell system, and the successes and lessons taken away from that demonstration. Discussion of the second case study, at Brooks City-Base, explores the successful demonstration of three primary power PEM fuel cells at a significant geographical distance from the manufacturer, and how that contractor dealt with maintenance and component replacement. Discussion of the third case study, at Barksdale AFB, describes the first attempt to demonstrate a reconditioned PEM fuel cell power plant, the problems that occurred, and the lessons learned from that experience.

McChord Air Force Base

In FY02, ReliOn (formerly known as Avista Laboratories) was awarded a contract for the installation of a 3 kW hydrogen-fueled, DC power output fuel cell system to provide critical backup power at a Federal Aviation Administration (FAA) Remote Transmitter/Receiver site on McChord AFB, WA. The FAA is responsible for the National Airspace Systems (NAS) infrastructure. They currently use standby batteries or engine generators for thousands of critical NAS components. The engine generators are in need of modern replacement. Battery systems have advantages over engine generators. However, capital and maintenance costs can be very high.

This demonstration used PEM fuel cells in a hybrid configuration with batteries to extend standby capability. This project differed from similar experiments, though, by placing emphasis on the fuel cell's ability to start up "cold" several times per day, and to provide power as a battery extender.

This project was designed to demonstrate the application of PEM fuel cells as an alternative to conventional backup power generators for FAA facilities. This demonstration differed from previous DOD Residential PEM Demonstration sites by being the first to demonstrate a back-up power source, thus requiring a redefinition of 90 percent availability. Typically, back-up systems require 99 percent or greater availability, but do not require power to be provided constantly. For the purposes of this demonstration, regular outages had to be simulated to imply a load upon the fuel cell, and availability was defined by the amount of time the fuel cell provided power over the cumulative duration of the simulated outages.

The system designed for this installation used six ReliOn Independence 500™ modular Proton Exchange Membrane (PEM) fuel cells. The Independence 500™ fuel cell is a 500 Watt battery-charging system. The six fuel cells were connected in parallel to the FAA's Radio Transmit Receive (RTR) battery system. These batteries serve as a source of backup power in the event of AC power loss. In this configuration, the fuel cells can significantly extend the backup power run time if called upon. The ultimate run time is limited only by the hydrogen fuel replenishment beyond the nominal 48 kWh storage capacity in the system.

During the first 6 months of the test program, the control system simulated a 20 minute loss of AC power, three times a day, 7 days a week. The fuel cell system automatically detected the loss of AC power and started up. Until the fuel cell completely started up, power was drawn from the battery array, and then the fuel cell would kick in to recharge the batteries. For this daily test, the fuel cell power was dissipated in a resistive load bank. During the final 6 months of the program, a weekly 2 hour grid power failure simulation was added on Sunday morning. For this weekly test, the load bank was disconnected and the fuel cells carried the full RTR load and maintained charge voltage to the facility battery system for the 2-hr period.

The 1-year demonstration period was completed on Friday, 17 April 2004 and test operations were curtailed on 19 April. Through the end of the operating period, the system accumulated over 1100 successful starts and a total system run time of 418.9 hours. Total run time consisted of 410.9 hours of operation within the scheduled test periods, and additional run hours outside of the normally scheduled test periods. The scheduled test runs included 359.6 hours of load bank test data, and 51.3 hours of RTR load testing. This installation illustrates the technical viability and cost savings of using hydrogen-fueled PEM fuel cell systems to supplement and/or replace large lead acid battery systems.

Total reliability (Actual Starts/Attempted Starts) for the entire test program was 99.4 percent. Total availability (Actual Run Time in Scheduled Period/Scheduled Run Time in Period) for the entire test program was 97.4 percent. Reliability and availability factors of less than 100 percent are attributed to sub-components. These issues included overly sensitive hydrogen sensors causing system shutdown, inappropriate gas connections leading to early loss of fuel supply, and shorting of the pad heaters causing the system to not start up. These issues were remedied by installing new sensors based on the current ReliOn design, ensuring proper connection and delivery of fuels, and replacement of the pad heaters by a much more robust design. Sporadic cracking of the molded plastic outer covers on the fuel cell module cartridges were detected during the test program and a new design of fuel cell cartridge was installed, incorporating a foam aluminum heat sink. The installation of this new cartridge type provided additional field service data for the design.

At this time, PEM fuel cells alone have not achieved greater reliability than conventional back-up power sources, but this project demonstrates their clear potential when paired with a battery array. This successful demonstration indicates a move toward reliable, independent, efficient, and environmentally friendly backup power systems in the near future.

Brooks City-Base

In FY01, Southwest Research Institute (SwRI) was awarded a contract from the DOD PEM Demonstration Project to install and operate three 5 kW PEM fuel cells at Brooks City-Base in San Antonio, TX. The fuel cells, manufactured by Plug Power Inc., were fueled with natural gas and supplemented primary power to three individual base housing units at Brooks City-Base. The units were grid connected and did not use waste heat.

These three units operated for a 13-month period from 6 February 2003 through 15 March 2004. Due to difficulties at the start of the project, this site opted to run for an additional month to achieve the minimum 90 percent availability. The average availability for the three units at this site was 90.79 percent, with the individual units achieving 94.1 percent, 85.4 percent, and 93.0 percent, respectively. By running an extra month, and resetting the start date to account for time lost in the problematic startups, the average for all three units achieved the minimum 90 percent availability. During the demonstration period, the fuel cells generated more power than was consumed by the base housing units, and the excess was fed back to the local grid. The three systems produced a combined total of 70,166 kWh AC of electricity, operating at an average efficiency of 21.02 percent.

SwRI sought out an independent company to design and install a web-based data acquisition and control system to monitor and control the fuel cells, gas meters, and electric meters. Connected Energy Corporation (CEC) was selected by SwRI because they had prior experience in monitoring Plug Power fuel cells and was work-ing on the interface with their fuel cells. The fuel cells required a ModBus communication protocol that CEC was familiar with, and provided a database to store the information from the demonstration and a web-based interface. It provided one of the first real-time accesses for the public to operational fuel cells. This system has been adopted by several other projects in the DOD Residential PEM Demonstration Project.

One of the results of this project was the demonstration of potentially environmentally friendly electric generation technologies through an effort to monitor the emissions and efficiency of the fuel cell systems. As a result of project activities, fuel cells running on natural gas or propane have been granted De Minimis status by the Texas Council on Environmental Quality. This rating exempts future fuel cell projects from obtaining air quality permits in Texas.

The Brooks City-Base Demonstration provided practical experience to base and utility personnel in fuel cell siting, installation, and maintenance, providing a basis for decisionmaking on future fuel cell projects, as well as other alternative energy and distributed generation projects. At the conclusion of the project, the fuel cells were donated for education programs at St. Philips College, Lamar Technical College, and Texas State Technical College.

Barksdale Air Force Base

Barksdale Air Force Base is located near Bossier City, LA, directly across the river from Shreveport. Barksdale AFB is home to the Eighth Air Force, 2nd Bomb Wing and 917th Fighter Wing. It serves as a total force warfighting headquarters, employing decisive global air power for U.S. Atlantic Command and U.S. Strategic Command.

Logan Energy (LOGAN) contracted with ERDC-CERL to install a fuel cell at Barksdale AFB and at four other locations in the FY01 PEM Demonstration. Originally, an Avista Labs fuel cell unit was planned for installation at Barksdale, but after award of the contract, it was discovered that the unit did not meet the FY01 BAA product specifications. Since the contract for the installation of an Avista unit was a lower cost than that of a Plug Power unit, the only available option for this project to continue was to use a reconditioned Plug Power fuel cell power plant.

It became obvious from the very beginning of this project that the Barksdale AFB demonstration would run into many difficulties. A 5 kW GenSys™ PEM fuel cell manufactured by Plug Power was installed at Building 4650, an airman's dormitory building on 22 November 2002. This reconditioned unit had previously been tested in Plug Power's laboratories in Latham, NY, so many of the parts had already gone through wear and tear, which is significant given the state of PEM fuel cell technology. In addition, this demonstration was one of LOGAN's first of many projects with the PEM demonstration, giving them a lot of responsibility without much experience with the technology. Finally, this was one of the first Plug Power units ever installed without the expertise of their own company technicians.

This project has exposed LOGAN, at once, to major field service tasks and overhauls, including rebuilding reformers, replacing cell stacks and rebuilding inverters, and even inventing new field modifications and service procedures to impress performance. Meanwhile, continuous troubleshooting episodes have covered every possible system deficiency. Many parts had to be replaced on this unit, which is not extremely uncommon, but the single most important problem with this demonstration was the communications equipment.

During the period October 2002 to August 2003, LOGAN's field service technicians performed their tasks with the support of a basic Supervisory Control And Data Acquisition (SCADA) system developed by Plug Power for communicating with deployed units. This system provided one-way communication from each unit to Plug Power Inc's customer support center, allowing the unit to call in overnight to download a data package and an operating status report. However, LOGAN realized very quickly that the system was inadequate and insufficiently reliable to provide the high level of support needed for its wide-ranging PEM demonstration program. At times a unit called in and provided only partial or incorrect data. This created uncertainty in troubleshooting and further delay in restoring the unit to service. On other occasions the unit might fail to call in for a week or more, frustrating the normal chain of events leading to a service advisory.

While Plug and LOGAN struggled initially with the learning curve experience in developing cooperative service norms, the weakness of the SCADA system became a major source of dissatisfaction with Plug Power. Under these circumstances, the only means of determining a unit's actual status was to make a service call to the site. However, with multiple sites, the scope of LOGAN's work under the PEM Demonstration Project required a better solution. Finally, in March 2003, an event occurred that gave Plug Power direct insight into the shortcomings of its SCADA system. After advising of a shutdown at Fort Bragg, another of LOGAN's FY01 demonstration sites, Plug sent its own technician to the site because LOGAN's technicians were servicing other units. The technician flew from Albany, NY to Raleigh, NC, and then drove another 2 hours to the site. On arriving, the technician found that the unit was operating normally, but that the SCADA system was not.

This event was an important turning point for the LOGAN/Plug Power relationship and its cooperative efforts in pursuing the objectives of the PEM Demonstration Program. Six weeks later in early June, six representatives from LOGAN, eight from Plug Power, and one from ERDC-CERL met in Atlanta for 2 days of forthright discussions. The meeting focused on short-term methods and longer term solutions to improve remote PEM fuel cell performance monitoring. Most significantly Plug Power determined that it would institute immediate software changes and upgrades to ensure the accuracy of fuel cell data communications. Following LOGAN's recommendations, Plug Power also promised to initiate a design change to its SCADA system that would permit bi-directional remote communications with the fuel cell controller. More importantly, Plug Power promised that LOGAN's technicians would be able to remotely troubleshoot, change set points, and attempt restarts under some circumstances. Lastly they also promised to publish a daily status report covering all of LOGAN's units. By early August 2003, Plug Power began sending daily status reports, and by mid September, Plug Power shipped LOGAN new control software that allowed remote diagnostics, monitoring, troubleshooting, and restart capabilities. Since the introduction of this new service capability along with the adoption of improved service techniques to go with it, fleet performance, availability, and operating costs have begun to show positive new trends.

Despite the advancements in the communications equipment, the demonstration at Barksdale AFB still had too many other electrical and mechanical hurdles to overcome. After repeated troubleshooting with the GenSys™ unit, the system was determined to be ill-suited to the demonstration, and a second refurbished GenSys™ was installed in the hopes that this would solve the problems. LOGAN believes that both reconditioned units provided for this site were insufficient for the task because of the chronic electrical and mechanical deficiencies uncovered in the unit.

The unit was decommissioned in April 2004, and the project was declared a failure due to the low availability (which reached only 42.44 percent). In spite of these shortcomings, LOGAN and Plug Power have made great strides in advancing PEM fuel cell technology. In addition to an improved communications system for the fuel cell units, LOGAN and Plug Power collaborated to create a more efficient spare parts support system, which will assist the units to reach the minimum 90 percent availability requirement, by eliminating delivery time for commonly-replaced components. LOGAN also suggested that Quality Assurance / Quality Control documents should be requested for any unit, especially if it is refurbished, which is something that was not done on this demonstration.

8 Conclusion

This demonstration project has overseen the planning and monitoring, installation, operation and maintenance, and documentation of PEM fuel cells in a variety of geographic locations, supporting operations at military and other DOD installations. The size and versatility of PEM fuel cells show promise for providing a residential-scale alternative power supply. There are still technological hurdles to overcome, including cost and public perception, but this demonstration project made strides toward this end.

Many lessons have been learned during the course of this demonstration. First, for future DOD applications it will be very important to develop a strong, reliable communications system with the fuel cell power plant to minimize downtime and avoid the costs of having a technician constantly on-site at the unit. The units that have achieved the minimum 90 percent availability requirement thus far in the demonstration have, for the most part, had strong communications or an on-site technician. The exceptions to this rule have been faulty fuel cell units.

Second, it has been shown that achieving the minimum 90 percent availability requirement is possible. This 90 percent availability requirement was set in place for the purposes of guaranteeing a continuous stream of data and contractor commitment to maintaining constant run-time, but at the start of this project there was no certainty that 90 percent availability could be maintained for the year-long period. This requirement does not prove that PEM fuel cells are sufficiently reliable for DOD applications, because existing generator technology can site availabilities of 99.99 percent and higher, but it is a very promising to demonstrate progress in the direction of high availability.

Third, back-up power is a viable DOD application for PEM fuel cells. Particularly where direct hydrogen-fuel fuel cells are used in a hybrid configuration with a battery array, these systems are both technically and economically realistic. Finally, cogeneration fuel cell systems that use both the electricity and the heat produced by the fuel cell integrated with a fuel reformer have been found have greater overall system efficiency than those that do not use the heat. The most efficient DOD thermal recovery option explored thus far in this demonstration was a system that fed the heat into large domestic water heaters using heat exchangers.

The fleet of residential PEM fuel cells in this demonstration has provided valuable experience and feedback. The lessons learned through this demonstration have provided greater understanding of the role of PEM fuel cells in DOD applications. The demonstration feedback has also contributed to technological advancements and improvements of these products by manufacturers and increased proficiency of the contractors who install, operate, and maintain these fuel cell systems.

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Appendix A: FY02 DOD Residential PEM Fuel Cell Demonstration Sites

This Appendix provides a brief overview of the character, significance, and approach at each site in the Fiscal Year 2002 (FY02) DOD Residential Fuel Cell Demonstration Project. This technical report is a continuation of ERDC/CERL TR-04-3, *DOD Residential PEM Fuel Cell Demonstration Program: Volume 1 – Summary of the Fiscal Year 2001 Program* (White et al., February 2004). The projects in the FY01 demonstration are summarized in Appendix A of ERDC/CERL TR-04-3. More information on all sites, including operations data, points of contact (POCs), and contract deliverables (Initial Project Descriptions, Midpoint Reports, Monthly Reports, and Final Reports), is available through URL:

http://www.DODfuelcell.com

Engineer Research and Development Center, Construction Engineering Research Lab (ERDC-CERL)

The Construction Engineering Research Laboratory (CERL) is part of the U.S. Army Engineer Research and Development Center (ERDC), which is the Army Corps of Engineers' integrated research and development (R&D) organization. CERL conducts research to support sustainable military installations. Research is directed toward increasing the Army's ability to more efficiently construct, operate, and maintain its installations and to ensure environmental quality and safety at a reduced life-cycle cost. Excellent facilities support the Army's training, readiness, mobilization, and sustainability missions. An adequate infrastructure and realistic training lands are critical assets to installations, which serve as platforms to project power worldwide. CERL also supports ERDC's R&D mission in civil works and military engineering.

ERDC/CERL is located in Champaign, IL, and is home to the DOD Fuel Cell Project. Champaign is also home to the University of Illinois. Cooperation between CERL and the university allows the sharing of property and equipment, and the employment of graduate students as research assistants, an arrangement that benefits both entities.

LOGANEnergy Corporation coordinated with Fuel Cell Team members at CERL to purchase, install, and evaluate one 5-kW PEM fuel cell at this site. LOGANEnergy chose to purchase the fuel cell system from Plug Power, Inc. This project was contracted on 27 August 2003. At the time of this report, the fuel cell had been delivered, but not installed.

Fort Belvoir

Fort Belvoir is a beautiful, historic installation located in Alexandria, VA. A list of the nearly 100 tenant organizations who call Fort Belvoir home reads like a "Who's Who" of the DOD. It is home to one Army major command headquarters and elements of 10 others; 19 different agencies and direct reporting units of the Department of Army; eight elements of the U.S. Army Reserve and the Army National Guard; and 26 DOD agencies. Also located at Fort Belvoir are a Marine Corps detachment, a U.S. Air Force activity, and an agency from the Department of the Treasury. Fort Belvoir's singular mission is to provide both logistical and administrative support to a diverse mix of tenant and satellite organizations.

LOGANEnergy originally contracted to provide, install, monitor, and maintain two 5-kW PEM fuel cells at Fort Belvoir, one Plug Power Inc. GenSys primary power fuel cell, and one Plug Power GenCore back-up power system. Between the time of contract award and the start of the project, changes in staffing and interests at Fort Belvoir resulted in the lack of interest in the back-up power fuel cell. At the time of this report, the primary power fuel cell was on schedule to begin its 1-year demonstration, and the back-up power system was in search of a new home.

Fort Gordon

Fort Gordon is near Augusta, GA., on the eastern side of the state, in the area known as the Central Savannah River Area (CSRA). Fort Gordon is home to the Army's University of Information Technology, which serves as the central training facility for the Signal Regiment that is also located at Fort Gordon. LOGANEnergy, in cooperation with CERL and Fort Gordon, has contracted to provide, install, monitor, and maintain one 5-kW PEM fuel cell at the Technology Resource Center for the University of Information Technology. The fuel cell provided power to the building, and made excess power available to the adjacent buildings. A critical power circuit was also installed, allowing the fuel cell to provide electric power to the server room, in case of a power outage. The thermal waste at this installation is not being used. Figure A1 shows a water filtration system and communication and data acquisition box at Fort Gordon.

Figure A1. Water filtration system and communication and data acquisition box at Fort Gordon.

Georgia Institute of Technology

The Georgia Institute of Technology is a highly ranked technical university, with more than 16,000 undergraduate and graduate students. Georgia Tech's campus occupies 400 acres in the heart of Atlanta. The Georgia Tech Reserve Officers Training Corps (ROTC) program serves Emory University, Southern Polytechnic University, and Devry Institute of Technology, in addition to Georgia Tech.

LOGANEnergy coordinated with CERL and Georgia Tech to provide, install, monitor, and maintain one 5-kW PEM fuel cell at the site. The Plug Power, Inc. fuel cell will be sited at the ROTC headquarters building on campus.

Marine Corps Air Station Cherry Point

The Marine Corps Air Station in Cherry Point, NC is located about 90 miles west-southwest of Cape Hatteras, at the foot of the great Outer Banks, on the Atlantic coast. The Naval Air Depot provides extensive maintenance and engineering support to Navy and Marine Corps aviation, as well as to other armed services, Federal agencies, and foreign governments. This naval activity is a major tenant at the Cherry Point, home of the Second Marine Aircraft Wing.

LOGANEnergy installed one Plug Power GenSys5P 5kW PEM fuel cell power plant at Building 154AE, a maintenance facility belonging to the Naval Air Depot at MCAS Cherry Point. The unit was fueled by LP gas (propane) and operated in both grid parallel and grid independent configurations. To demonstrate the thermal energy capability of the fuel cell, a 22,000 BTU fan coil unit will be installed on the facility's ceiling to distribute waste heat from the fuel cell.

McChord Air Force Base

McChord Air Force Base, located in McChord, WA is the site of a Federal Aviation Administration (FAA) Radio Transmit Receive (RTR) Location. This FAA facility supports the Seattle/Tacoma International Airport, McChord AFB, and Fort Lewis.

ReliOn, Inc., formerly known as Avista Labs, was awarded a contract to install six 500 W (3 kW total) Independence 500 fuel cells for 1 year at Building 1505 on the FAA RTR Site. The radio equipment at this facility is grid connected with a battery bank as a backup. The six hydrogen-fueled fuel cells operating in parallel provide DC power backup for the RTR site battery bank (Figure A2). The hydrogen fuel is delivered to this installation on a weekly basis.

Figure A2. Fuel Cells in outdoor enclosure installed at McChord AFB.

The objective of this installation is to test the ability of the fuel cell to respond to a primary power outage, and continue to meet the needs of the load under various operating conditions. The first phase of testing involves simulating a 20-minute loss of AC grid power and automatic startup of the fuel call system three times a day, 7 days a week, for the first 2 months. A 3kW resistive load bank will be ramped in as a load in 1kW increments during the 20-minute test, with the first 5 minutes at 1 kW, the next 5 minutes at 2 kW and the final 10 minutes at 3kW. The second phase involves continuing the test performed in the Phase 1, 6 days a week, and connecting to the FAA RTR site for 2 hours, 1 day a week. The connection to the FAA RTR site involves simulating an AC grid power outage at the RTR site, automatic startup of the fuel cell system, and automatic connection of the fuel cell system to the RTR site DC buss.

North Carolina State Agricultural and Technical University ROTC

North Carolina State Agricultural and Technical University (NCA&T) is located in Greensboro, NC. LOGANEnergy installed and operated one Plug Power Inc GenSys™ 5CS–5kW PEM fuel cell for 1 year at Campbell Hall Combined Services ROTC Building on the NCA&T campus.

This building supports the Army Reserve Officers Training Corps (ROTC) program at NCA&T, which is made up of a broad cross-section of college students. NCA&T hosts Army ROTC for all colleges and universities in the greater Greensboro area including; Bennet College, Guilford College, Greensboro College, and the University of North Carolina at Greensboro. ROTC is an elective course, in which subjects include principles of management, leadership development, national defense, and military history.

The fuel cell was sited between the student cafeteria and the Campbell Hall Combined Services ROTC Building. The fuel cell installation includes both a grid parallel and a grid independent configuration. The fuel cell provides stand-by power to a new 100 amp critical circuit panel that serves plug loads throughout the facility. The fuel cell installation is also outfitted with a thermal recovery system that is designed to capture waste heat from the fuel cell and transfer it to a hot water storage tank for distribution within the building to supplement the current hot water system. The fuel cell's utility interfaces including power and water are located in the adjacent mechanical room of Campbell Hall. Natural gas was not initially available to Campbell Hall, but Piedmont Natural Gas of North Carolina, the site's natural gas supplier, provided matching funds of $10,500 to run a natural gas supply line approximately 300 ft to supply the fuel cell with natural gas.

Robins Air Force Base

Robins Air Force Base, in Warner Robins, GA, is the state's largest industrial facility employing 5,253 military and over 12,749 civilian employees. Robins AFB is home to over 50 organizations including the Warner Robins ALC, Headquarters Air Force Reserve, the 78th Air Base Wing, the 19th Air Refueling Group or "Black Knights," 5th Combat Communications Group, 93rd Air Control Wing, and the 116th Bomb Wing of the Air National Guard.

In October 2001, LOGANEnergy Corporation received a contract award from CERL to test and evaluate a PEM fuel cell at Robins Air Force Base, in Warner Robins. The Robins Fire Station hosts this 5kW Plug Power CHP, PEM fuel cell installation. The fuel cell is a technology demonstration unit manufactured by Plug Power Corporation, Latham, NY. The unit operates in both grid parallel/grid synchronized and grid independent configurations. The system operating set point is 2.5kW for the 1-year demonstration test program. The unit is instrumented with an external wattmeter, a gas flow meter, a BTU meter, and an Ultralite data logger. A phone line is connected to the power plant communication's modem to permit it to call-out with alarms or events that require service and attention, or to permit a technician to call into the controller to diagnose operating problems. Initial start-up at Robins AFB occurred on 24 April 2003.

Figure A3. Water heater used for thermal recovery at Robins AFB.

Saratoga Springs Naval Support Unit

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

Plug Power Inc. manufactured, installed, and operated a total of eight Plug Power GenSys™ 5CS–5kW PEM fuel cell systems for 1 year at the NSU–Quiet Harbor housing complex. Plug Power and NSU personnel have identified four sites within the complex for the fuel cell installation. The locations were selected using criteria based on location, environmental impact, security, staffing, and access. The site selection process attempted to match as closely as possible the fuel cell output and average demand of the facility being served. The fuel cells are sited at the following buildings:

- Base Housing, Building 16
- Base Housing, Building 17
- Base Housing, Building 20
- Base Housing, Building 21.

Two natural gas-powered fuel cell systems were placed at each building. These fuel cells provided electricity to the buildings and incorporated combined heat and power capability that allowed waste heat to be recovered from the fuel cell and used to supplement the existing domestic hot water system. Additionally, the fuel cell systems included standby capability that allowed the units to operate during periods of electric utility grid outage. The units operated from May 2003 through April 2004, and achieved an overall availability of 95 percent and an overall efficiency of 32.5 percent. Funding for this project was provided by Mr. Chuck Combs of the Naval Warfare Center, Weapons Division, located at China Lake, CA.

Figure A4. Two 5-kW fuel cells installed at Saratoga Springs.

Selfridge ANGB

Selfridge Air National Guard Base is a joint military community located 22 miles east of Warren, MI, on Lake St. Claire. The base is home to both U.S. Air Force and U.S. Army garrisons and supports a population of 50,000 people. The electricity provider for Selfridge is Detroit Edison, and CMS Energy provides natural gas service to the base.

The fuel cell systems are installed outdoors in a plaza situated adjacent to the new base Fire, Crash, and Rescue Building 859. This building is a large facility that provides Crash and Rescue capability for the Base and Airfield in the surrounding Macomb County Area. The building's electrical and hot water (thermal) requirements can fully use the continuous output of the fuel cells.

Plug Power Inc. manufactured, installed, and operated the two GenSys™ 5CS–5kW PEM fuel cell systems for 1 year. The 5kW fuel cells provided electricity and recovered waste heat for domestic hot water usage. The units ran on natural gas fuel and operated in parallel with the Base electrical grid. Additionally, the fuel cells incorporated standby capability to allow the units to supply power to segregated critical loads during periods of electric utility grid outage.

The fuel cell electrical system consisted of two 5kW fuel cells connected directly to the building's electrical grid through an existing power panel. Each fuel cell fed into this panel through a single pole 50A circuit breaker. Any fuel cell power not used at this power panel was consumed upstream in the building's electrical system. Site personnel specified that the fuel cell should not export power to the grid at any time during the demonstration. This requirement ensures that the fuel cell would not export power if the utility grid were lost.

The thermal recovery system was designed for continuous operation to supplement the present heating system. During normal building procedures the building's boilers were used to offset building envelope heat loss as well as to provide reheat for each occupied space. The fuel cell thermal recovery feature effectively provides supplementary thermal heat for the boiler system.

Shaw Air Force Base

Shaw Air Force Base, the home of the 9th Air Force, 20th Fighter Wing, is located in Sumter, SC. LOGANEnergy installed and operated one Plug Power Inc. GenSys™ 5CS–5kW PEM fuel cell for 1 year at Shaw AFB. Lieutenant Colonel Jeffrey Jackson's residence was chosen as the host site on the base. Lt. Col. Jackson is the commander of the Shaw Civil Engineering Squadron.

The fuel cell provided power in a grid parallel and a grid independent configuration to the residence, from May 2003 through April 2004. It provided stand-by power to a 100 amp critical circuit panel that served plug loads in the kitchen area of the home. The system also contained a thermal recovery loop that supplemented the residence's hot water heater. Because of the size and location of the equipment room containing the water heater and the closet containing the electrical distribution panel, the electrical conduit and thermal recovery piping were routed through the attic crawl space. A weatherproof equipment shed constructed near the fuel cell housed the thermal recovery water heater, the reverse osmosis filtration system, the circulating pump, and the instrumentation devices that monitored and logged the fuel cell's performance. This project achieved an overall availability of 87 percent and an overall efficiency of 25.3 percent.

Stennis Space Center

Stennis Space Center, near the Louisiana border in southern Mississippi, is one of 10 NASA field centers in the United States. It is NASA's primary center for testing and proving flight-worthy rocket propulsion systems for the Space Shuttle and future generations of space vehicles. Because of its important role in engine testing for four decades, Stennis Space Center is NASA's program manager for rocket propulsion testing with total responsibility for conducting and/or managing all NASA propulsion test programs. Stennis Space Center's award-winning visitor center features 14,000 sq ft of informative displays and exhibits, including the Mars Habitat building, from NASA, the Naval Meteorology and Oceanography Command, and other agencies. Visitors from around the world tour the space center each year.

LOGANEnergy coordinated with CERL and Stennis Space Center to provide, install, monitor, and maintain one 5kW Plug Power CHP fuel cell at the site. The unit will operate in both grid parallel/grid synchronized and grid independent configurations. The system operating set point is 5 kW for the 1-year demonstration test program. A phone line is connected to the power plant communication's modem to permit it to call-out with alarms or events that require service and attention, or to permit a technician to call into the controller to diagnose operating problems. A desiccant chiller air conditioner will be incorporated to cool the room while using ambient Mississippi humidity and waste heat from the fuel cell.

U.S. Coast Guard Aids to Navigation Team

The U.S. Coast Guard, Aids to Navigation Team is located in Bristol, RI on a peninsula located between the Narragansett and Mount Hope Bays. Bristol is about 12 miles southeast of Providence and 12 miles north of Newport. This site maintains waterway navigation equipment and support of the heavily traveled waterways.

Nuvera Fuel Cells has installed two Avanti™ fuel cell power systems (FCPSs) at the maintenance facility of the Aids to Navigation Team, U.S. Coast Guard site. Avanti™ is Nuvera's second-generation distributed generation fuel cell system, designed to provide approximately 3.5 kW each of base-load electricity and heat. It is a residential-scale PEM fuel cell that uses natural gas as a fuel, operates in parallel with the grid, and has cogeneration capabilities. This coastal installation site provides an opportunity to operate systems in a high salt air atmosphere with rapidly changing climatic conditions. The fuel cells are located in the interior of a maintenance building used to repair equipment and fabricate metal and wooden parts for ships. The maintenance building also houses an electronics repair facility and offices. The facility is staffed 24 hours per day, 7 days per week with a night watchperson, but has primary operation hours of 7 a.m. to 3:30 p.m.

Figure A5. Two fuel cell power plants installed at the U.S. Coast Guard, Aids to Navigation Team in Bristol, RI.

West Point Military Academy

The U.S. Military Academy (USMA) in West Point, NY is the home and training ground of the future leaders of the U.S. Army. Plug Power Inc. manufactured, installed, and operated three Plug Power GenSys™ 5CS–5kW PEM fuel cell systems at the USMA from May 2003 until August 2004. The natural gas-powered fuel cell systems provided electricity to the facility and incorporated combined heat and power capability that allowed waste heat to be recovered from the fuel cell and used to supplement the existing domestic hot water system. The demonstration achieved an overall availability of 96 percent and an overall efficiency of 31.5 percent.

Plug Power and USMA personnel identified three residential sites within the campus for the fuel cell installation. These sites were:

- LTC Boettner Residence
- LTC Massie Residence
- COL Nygren Residence.

Each residence had a fuel cell that was configured for standby power generation mode, where the system would continue to power the residence in the event of a power outage. Each tenant selected five circuits in their existing panel that they would like to power during a grid failure. These circuits were switched over to a new critical load panel, which was powered by the fuel cell during outages.

Thermally, the fuel cells were integrated to support and supplement the existing domestic and water heating needs of each residence. BTU meters were installed at each site to measure the amount of heat transferred from the fuel cell into the site host's hot water system.

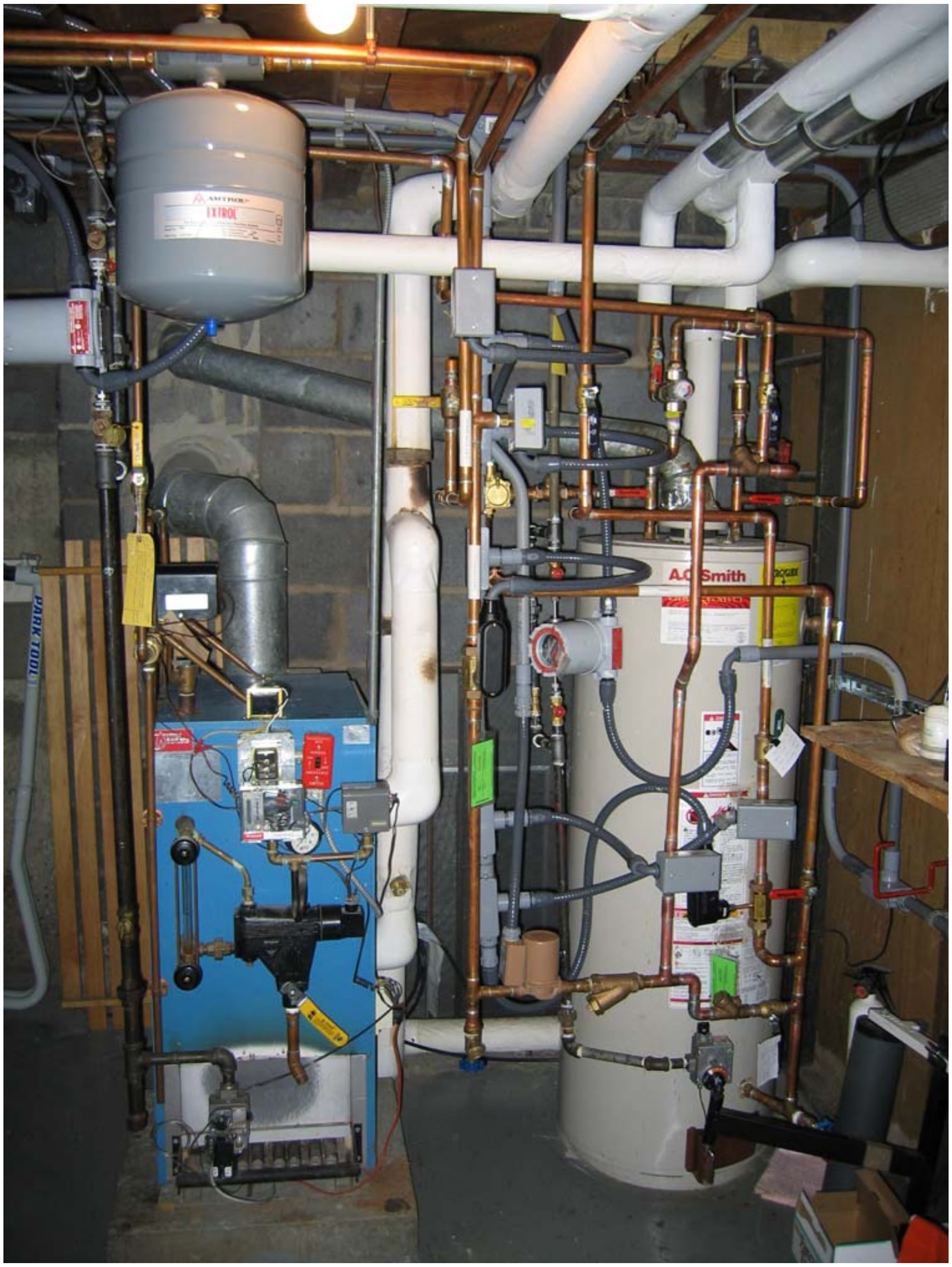


Figure A6. An extreme case of thermal recovery at West Point U.S. Military Academy.

Appendix B: FY03 DOD Residential PEM Fuel Cell Demonstration Sites

This Appendix summarizes the details of each site in the FY03 PEM Demonstration Project, including unique characteristics, significance, and approach of each location. More complete details on each individual site, including photographs, operations data, points of contact, and the contract deliverables (Initial Project Descriptions, Midpoint Reports, Monthly Reports, and Final Reports) are available through the project URL:

http://www.DODfuelcell.com

Arizona Army National Guard

The Army National Guard in Mesa, AZ is located adjacent to the Chicago Cubs winter training site. City of Mesa Gas Division in partnership with the Arizona Army National Guard (AZARNG) will install a single, domestically produced, GenSys™ 5CS, 5kWe PEM fuel cell natural gas power plant purchased from Plug Power located in Latham, NY.

The Gas Division shall operate the unit at the host military site a minimum of 1 year, and as long as necessary thereafter to obtain a minimum average availability over the life of its operation of 90 percent. The GenSys™ 5CS fuel cell will operate exclusively on natural gas in the grid connected parallel mode. The thermal energy produced by the GenSys™ 5CS fuel cell will be used to generate domestic hot water for building use throughout the proposed 1 year of operation.

Fort AP Hill

Fort AP Hill is a U.S. Army installation named in honor of Lieutenant General Ambrose Powell Hill, a Virginia native who distinguished himself as a Confederate commander during the Civil War. The Fort was first established as an Army training and mobilization area in 1941. It was an important staging area during World

War II, where more than 75 percent of the North African invasion force was trained and equipped.

IdaTech, Fort AP Hill, and Rappahannock Electric Cooperative (REC) will install one (1) 5 kW propane-fueled outdoor system. The fuel cell system will be located at the Administrative Support Building and will provide grid independent power to field office support loads. The loads will be varied throughout the day, but are expected to average approximately 2.0 kW AC over the course of the year-long demonstration. There will be demand spikes from office equipment that will be turned on and off during the day. A water-heating dump load will be connected to maintain a minimum power demand of at least 1.5 kW from the fuel cell system at all times. These loads will be connected to the fuel cell system's inverter output via an automatic transfer switch (ATS) that feeds an electrical sub-panel. In the case of a fuel cell power interruption, the ATS will automatically switch to grid power. This fuel cell will not provide thermal energy to the building.

Fort Benning

Fort Benning is a U.S. Army Training and Doctrine Command (TRADOC) installation. Fort Benning's mission is to "provide the world's best Infantry Soldiers and trained units; to provide a power projection platform that can deploy soldiers and units anywhere in the world on short notice; and to provide the Army's premier installation and home for Soldiers, families, civilian employees, and military retirees." There are five types of infantry at Fort Benning; mechanized, light, airborne, air assault, and ranger.

Fort Benning was established in 1918 and is named for Major General Henry L. Benning. It is known as the "Home of the Infantry," and has an active duty population of 34,834. Fort Benning covers 181,626 acres of land with 93 percent in west central Georgia and the remaining 7 percent in east central Alabama, divided by the Chattahoochee River. Fort Benning is south of Columbus, GA on U.S. highway 27.

Flint Energies, an electric membership corporation, was awarded a contract to install one PEM fuel cell at the Recreation facility area in Fort Benning. The fuel cell system will operate in grid parallel mode, using natural gas, to provide supplemental on-site power and usable heat for the facility. Cogeneration heat will be used for heating and domestic hot water. The fuel cell will include a standby capability to allow electricity and heat to be provided during periods of electric utility grid outage.

Fort Lewis

Gray Army Airfield at Fort Lewis is located on Main Post at Fort Lewis, near Tacoma, WA. It is the headquarters of the 66th Aviation Brigade of the Washington Army National Guard, which provides transportation support for fighting wildfires. The Fort Lewis Battle Simulation Center Headquarters is also located at Gray Army Airfield. The U.S. Army helicopters stationed at Gray Army Air Base at Fort Lewis are used to insert search-and-rescue [SAR] teams into inaccessible areas on the east, north, and west sides of Mount Rainier, lowering rangers to the ground by a cable device known as a “jungle penetrator.”

ReliOn, Inc., in cooperation with Fort Lewis and CERL, will install fuel cells at four individual sites – localizer, glide slope, middle marker beacon, and outer marker beacon. The localizer and glide slope are located on Gray Army Airfield, within the property of Fort Lewis. The middle marker is located outside of Gray Army Airfield, but still within Fort Lewis, and the outer marker is gated in an area located approximately 1 mile north of Fort Lewis on a property known as Goddard Woods. Each site will use one ReliOn Independence 1000 (1kW) fuel cell system as a source of backup power.

This project will test the reliability of the ReliOn backup power solution for U.S. Military Air Traffic Control and Landing Systems (ATCALS). The fuel cell systems will be connected to the DC bus at each site. The systems will be in an “off, but ready” state the majority of the time. The system will be designed to start up and run for 1 hour a day, to test the availability of the fuel cell system. If the system fails to start up properly or provide required power to the load this will be noted in the logs as a failure and count against the 90 percent availability of the system. Because ReliOn’s PEM fuel cells operate at low temperatures, the system is not a cogeneration system. The system will be installed in an outdoor enclosure designed to maintain the internal temperature within the operating range of the Independence 1000.

Fort Rucker

The Army Aviation Center at Fort Rucker, AL, is located in the southeast corner of lower Alabama. Fort Rucker is approximately 80 miles south of Montgomery and 20 miles northwest of Dothan. Florida’s Gulf Coast lies 80 miles to the south. The post covers about 64,500 acres of countryside in an area known as the “Wiregrass,” named for a wild grass peculiar to the region. Fort Rucker supports a daytime population of about 14,000, including about 5,100 service members, 6,400 civilian and contract employees, and 3,200 military family members residing on post. This post supports about 14,500 retirees.

The current mission of the Army Aviation Center is to develop the aviation force for worldwide missions. This includes developing doctrine, organization, training, leader development, materiel, and soldier requirements, as well as providing aviation maintenance, logistics and leadership training for the sustainment of joint and combined aviation operations.

ReliOn, Inc., in cooperation with Fort Rucker and CERL, will install five Independence 1000 (1kW) fuel cells at four individual sites – localizer, glide slope, middle marker beacon, and outer marker beacon. The localizer and glide slope are located on Cairns Army Air Field just outside of Fort Rucker. The middle marker is located just outside of Cairns Army Air Field and the outer marker is located approximately 10 miles from Cairns Army Air Field near a peanut farm. Each of the localizer, glide slope, and middle marker sites will use one 1kW fuel cell system as a source of backup power, while the outer marker beacon will use two.

This project will test the reliability of the ReliOn backup power solution for U.S. Military Air Traffic Control and Landing Systems (ATCALS). The fuel cell systems will be connected to the DC bus at each site. The systems will be in an "off, but ready" state the majority of the time. The system will be designed to start up and run for 1 hour a day, to test the availability of the fuel cell system. If the system fails to start up properly or provide required power to the load this will be noted in the logs as a failure and count against the 90 percent availability of the system. Because ReliOn's PEM fuel cells operate at low temperatures, the system is not a cogeneration system. The system will be installed in an outdoor enclosure designed to maintain the internal temperature within the operating range of the Independence 1000.

Gabreski Air National Guard

Gabreski Air National Guard Base is the home of the 106th Rescue Wing. The 106th Rescue Wing, New York Air National Guard, is the parent organization of the Oldest Air National Guard unit in the Country, the 102nd Rescue Squadron, which traces its roots back to the 1st Aero Squadron, which was formed in 1908 in New York. The 106th is located in Westhampton Beach, Long Island, NY, which is approximately 80 miles east of New York City. The unit occupies one half of the Suffolk County airport named after Colonel Francis S. Gabreski, the leading living ace of World War II and Korea.

The peacetime mission of the 106th Rescue Wing is two-fold. Firstly, it is tasked with conducting Search and Rescue (SAR) and Medevac Operations in an area delineated from the Northeast United States, south to the Bahama Islands and east to the Azores. Secondly, the 106th Rescue Wing provides the Airborne Mission Commander (AIRBOSS) for every shuttle launch, as well as pararescuemen on board the HC-130 for deployment in the event of a Mode VIII event.

ReliOn, Inc., in cooperation with Gabreski ANGB, will install fuel cells at the telephone switch system. The project at Gabreski ANGB consists of a backup power solution for the base telephone switch system. The base telephone switch is located in the 106th Communications Squadron building on Gabreski ANGB. The site will use four ReliOn Independence 1000 (1kW) fuel cell systems connected in parallel as a 4 kW source of backup power. The fuel cell systems will be housed in an outdoor enclosure that will be installed outside of the building.

This project will test the reliability of the ReliOn backup power solution for the base telephone switch though an Uninterruptible Power Supply (UPS). The fuel cell systems will be connected though the DC connection on the UPS. The systems will be in an "off, but ready" state the majority of the time. The system will be designed to start up and run for 1 hour a day, to test the availability of the fuel cell system. Data will be collected concerning start-up times, power availability, shutdown capability, system efficiencies, load following, and the effects of varying environmental conditions. If the system fails to start up properly or provide required power to the load, this will be noted in the logs as a failure and count against the 90 percent availability of the system. Because ReliOn's PEM fuel cells operate at low temperatures, the system is not a cogeneration system. The system will be installed in an outdoor enclosure designed to maintain the internal temperature within the operating range of the Independence 1000.

Hill Air Force Base

Hill Air Force Base is an Air Force Materiel Command base located in northern Utah. Hill is home to many operational and support missions, with the Ogden Air Logistics Center (OO-ALC) serving as the host organization. The center provides worldwide engineering and logistics management for the various aircraft and weapons. Hill is also responsible for providing photonics imaging and reconnaissance equipment; aircraft and missile crew training devices; avionic, hydraulic, pneudraulic and radar components; instruments; gas turbine engines; power equipment systems; special purpose vehicles; shelters; and software engineering, development, and support.

LOGANEnergy will install one 5kW CHP GenSys5C PEM fuel cell power plant manufactured by Plug Power at Building 9, the Base Fire Station. The unit will be electrically configured to provide grid parallel/grid independent service to the fire station and it will also be thermally integrated with the facility's hot water system to support domestic hot water loads. Each unit will operate at 2.5kW set point with particular emphasis on achieving 90 percent operational availability.

Keesler Air Force Base

Keesler Air Force Base, in Biloxi, MS, is located approximately 83 miles east of New Orleans, LA, and approximately 65 miles west of Mobile, AL. Keesler is part of Air Education and Training Command, and its primary mission since 1941 has been training. The emphasis is on high-technology training in a number of fields, primarily in the electronics specialties. Keesler AFB is home to the 81st Training Wing, one of Air Education and Training Command's largest technical training wings.

LOGANEnergy will install one 5kW CHP GenSys5C PEM fuel cell power plant manufactured by Plug Power at the residence of Lt. Col. T. Yang. The unit will be electrically configured to provide service and will also be thermally integrated with the facility's hot water system. Each unit will operate at 2.5kW set point with particular emphasis on achieving 90 percent operational availability.

Los Angeles Air Force Base

Los Angeles Air Force Base is located within the El Segundo city limits, the base is divided into two areas; Area A where most major units are located, and Area B, which houses the 61 Air Base Group, the clinic, BX, and the commissary. Space and Missile Systems Center, part of Air Force Materiel Command, is responsible for research, development, acquisition, on-orbit testing and sustainment of military space and missile systems. In addition to managing Air Force space and missile programs, SMC participates in space programs conducted by other U.S. military services, government agencies and North Atlantic Treaty Organization allies. At present, Fort MacArthur serves as a residential community for personnel of the Air Force Space Division Based at El Segundo. Fort MacArthur, the actual site for the fuel cell installation, is in San Pedro, about 13 miles south of the main base.

LOGANEnergy will install and operate a Plug Power GenSys 5kWe Combined Heat and Power fuel cell power plant at Los Angles AFB. The unit will be sited at a very visible location at Fort MacArthur Civil Engineering Headquarters, Building 56. It will be electrically configured to provide grid parallel/grid independent service and will also be thermally integrated with the facility's hot water system. Each unit will operate at 2.5kW set point with particular emphasis on achieving 90 percent operational availability.

March Air Force Base

March Air Reserve Base is named for 2nd Lt. Peyton C. March, killed in action on 18 February 1918. It is located 9 mi. southeast of Riverside, CA. The base covers about 6,700 acres. Of these 6,700 acres, the Air Force Reserves retain 2,258 acres at the airport. The airfield's 13,300-foot runway is the longest in California. The 4th Air Force, part of Air Force Reserve Command, is headquartered at March ARB. Air Force Reserve Command provides trained units and individuals to accomplish assigned taskings in support of national objectives, and performs peacetime missions that are compatible with training and mobilization readiness requirements.

LOGANEnergy will install and operate a Plug Power GenSys 5kWe Combined Heat and Power fuel cell power plant at March AFB. The unit will be sited at a very visible location at the front of Kisling Hall, Building 400, an airman's dormitory. It will be electrically configured to provide grid parallel/grid independent service and also thermally integrated with the facility's hot water system. Each unit will operate at 2.5kW set point with particular emphasis on achieving 90 percent operational availability.

Marine Corps Base Kaneohe Bay

LOGANENERGY will install one 5kW CHP GenSys5C PEM fuel cell power plant manufactured by Plug Power, Latham, NY at MCB Kaneohe Bay, HW. Each unit will operate at 2.5kW set point with particular emphasis on achieving 90 percent operational availability. The fuel cell will be installed in a CHP GC/GI application at a visitor's residential unit to be determined and will test Plug Power's new LP Gas units for the first time.

Montana Army National Guard

The Billings Armed Forces Reserve Center is located in Billings, MT. The structure is approximately 6 years old and is constructed of pre-formed concrete panels. The facility is located in west Billings, in a commercial/industrial area of the city. The topography is relatively flat and is part of the Yellowstone River valley. The front range of the Rockies (i.e., the Beartooth Mountains) is located approximately 60 miles west. The Big Horn Mountains lie approximately 80 miles to the south.

Plug Power of Latham, NY in a cooperation with the Montana Army National Guard, Montana-Dakota Utilities, Ace Electric and Wagner Mechanical will install one GenSys™ 5CS, Proton Exchange Fuel Cell. The GenSys™ 5CS has a Power Output rated at 2.5 – 5kW. The plan is to stay on the low end of operating capacity, operating at a set point of 2.5kW.

NGB Camp Mabry

LOGANEnergy, in cooperation with Austin Energy, will install one 5kW CHP GenSys5C PEM fuel cell power plant manufactured by Plug Power, Latham, NY at NGB Camp Mabry, TX. Each unit will operate at 2.5kW set point with particular emphasis on achieving 90 percent operational availability. The fuel cell will be installed in a CHP GC/GI application at a visitor's residential unit to be determined.

Offutt Air Base

Offutt AFB is home to the Fifty-Fifth Wing of the U.S. Air Force. The 55th Wing is the largest wing in Air Combat Command and the second largest in the Air Force. The Fightin' Fifty-Fifth has made significant contributions to the defense of our nation for more than 50 years.

IdaTech, Offut AFB, and Omaha Public Power District (OPPD) will install two "etaGen 5" PEM fuel cell systems. One fuel cell system will be placed at each of the two Offutt AFB sites described below. Each fuel cell system will have a continuous power capacity of 4.6 kW AC net out.

Building 304 is located on the NE corner of the historic Martin Bomber Plant at Offutt AFB. This building contains a major portion of the electrical distribution switchgear that serves approximately 35 percent of the Base electrical loads. Building 304 also houses the mechanical equipment that serves the HVAC needs of the Plant and numerous surrounding support buildings. Building 304 is an ideal location for the fuel cell because of the numerous electrical distribution systems inplace and the 24/7 operating schedules of the electrical distribution, HVAC, and lighting systems. The system that will be sited at Building 304, will be a natural gas etaGen 5 fuel cell system that will be running inside, off grid and will be continuous powering a 2 kW load that includes a UPS system battery charger and security lighting. The planned operating procedure for the system is to provide power for some security lighting that should amount to 1.5 to 2kW$_e$. This will serve as the systems base load.

Building 200 is Offutt AFB's remote UHF/VHF communications and relay facility located approximately 30 miles NW of Offutt AFB near Elk Horn, NE. This communication facility serves numerous military, space, and civilian communication needs in the region. The facility has a peak electrical demand of less than 150 KW and has minimum operation personnel assigned to it. The system that will be sited at Offutt Air Force Base at Elkhorn Building 200 will be a propane etaGen 5 fuel cell system that will be running outside, off grid and will continuously power 2 kW AC of security lighting. The planned operating procedure for the system is to provide power for a battery charger and some security lighting that should amount to 1.5 to 2kW$_e$.

Schofield Barracks Schofield

LOGANENERGY will install one 5kW CHP GenSys5C PEM fuel cell power plant manufactured by Plug Power, Latham, NY at USAG Schofield Barracks, HW. Each unit will operate at 2.5kW set point with particular emphasis on achieving 90 percent operational availability. The fuel cell will be installed in a CHP GC/GI application at a visitor's residential unit to be determined and will test Plug Power's new LP Gas units for the first time.

Sierra Army Depot

The Sierra Army Depot is located at Herlong, CA, in sparsely populated Lassen County's Honey Lake Valleuy, which lies nestled in the northeastern foothills of the Sierra Nevada Mountains. Reno, NV. It is 55 miles southeast of the depot while Susanville, CA, and 35 miles northwest. The mission of Sierra Army Depot is to provide U.S. armed forces with rapid deployment of equipment and supplies anywhere in the world and to provide maintenance, storage, logistical, and training support to Active and Reserve units, and to the National Guard.

LOGANEnergy Corporation will install, monitor, test, document, evaluate, and report on the performance of one 5 kW Plug Power GenSys5P LPG PEM fuel cell power plant in a combined heat and power application. The Plug Power unit will be installed at Barracks Building 27. This location is directly across the street from the base pool, site of the original H-Power unit. In so doing, the new Plug unit will be collocated with both the electric and thermal loads that will be integrated into the fuel cell CHP system. The unit will be electrically connected to the facility through both a Grid Parallel line connection and a Grid Independent critical load connection. Fuel cell waste heat will be integrated into the existing SynDex heat pump system to provide supplemental heat to Barracks Building 27.

The Sierra fuel cell web site will allow visitors to view several display screens to educate and inform public interest. In addition, the installation will correct the deficiencies of the prior unsuccessful Sierra PEM project, and proceed with a fresh start.

U.S. Embassy to the United Kingdom

The Abby Road Residence is home to over 50 U.S. London Embassy staff and family members. The building is located next door to the historic Abby road recording studio that produced many of the Beatles 1970s recordings. This facility was selected to host the UK PEM demonstration project from a selection of four potential sites that were suggested by Geoff Miller, U.S. Embassy facilities manager, for the following reasons: (1) it provides an accessible location where the PEM unit may be easily sited, (2) natural gas is conveniently located at the building, (3) the facility has a continuous thermal load that will optimize the fuel cell's thermal output, (4) fuel cell integration with the facility's existing energy services do not require costly modifications, and (5) embassy facilities staff are highly supportive of the project. LOGANEnergy has enlisted the support of Scottish and Southern Utility (S&S) to take the lead in procuring local support for the project to ensure timely submission and process of all permits that may be required to install and operate the PEM fuel cell.

LOGANEnergy, in cooperation with Scottish- Southern Utility, will install and operate a Plug Power GenSys 5kWe Combined Heat and Power fuel cell power plant at the U.S. Embassy Abby Road Residence, London, UK. The multi-unit facility provides resident quarters for U.S. embassy staff and families on assignment in London. The unit will be sited at the rear of the building adjacent to the mechanical room, and it will be electrically configured to provide grid parallel/grid independent service to the facility. The fuel cell installation will also provide up to 8,000 Btu/h to the facility's hot water system. LOGANEnergy has hired Southern Electrical Contracting (SEC) to provide installation services.

U.S. Antarctic Division

The International Antarctic Centre is the logistics base for freight and personnel movements to Antarctica for programs run by several nations, including New Zealand and the United States. All personnel being flown to Antarctica pass through this facility and within a few meters of the proposed fuel cell installation location, with over 270 aircraft movements per year. The New York Air National Guard provides aircraft, logistics and support for USAP passenger and freight movements between Christchurch, Antarctica, and the United States.

Industrial Research Limited will install two Independence 1000 units manufactured by ReliOn Inc in the yard adjacent to the U.S. Antarctic Program Clothing Warehouse. The system will be used to provide year round night time yard lighting, and will be used for various other field energy supply applications during the day, such as charging of mobile equipment batteries and providing power for the system performance monitoring equipment and other building loads through a grid connected inverter. The fuel cells will provide conditioned power for the battery bus with a minimum total available capacity of 1kW, with a typical average power setpoint of 1.2kW.

U.S. Army Reserve Center

The Sergeant Silvestre S. Herrera U.S. Army Reserve Center is located near the Williams Gateway Airport, Mesa, AZ (formerly Williams Air Force Base). The Photovoltaic Testing Laboratory, a part of Arizona State University East, in cooperation with the Army Reserve, will install two PEM fuel cells at the Sergeant Silvestre S. Herrera U.S. Army Reserve Center. The manufacturers of the fuel cells are Plug Power and Ida Tech. Both units are rated as approximately 5 kilowatt units, but both will be set to the 2.5 or 2.0 kilowatt setpoints for the duration of the test. Both fuel cells will be using natural gas as their fuel and will be mounted side by side at the host site and connected to the Salt River Project grid system. There is no plan to attempt during this demonstration to use the thermal energy provided by these units.

Appendix C: FY02 Broad Agency Announcement

Preface

The Construction Engineering Research Laboratory (CERL) is part of the U.S. Army Engineer Research and Development Center (USAERDC), which is the Army Corps of Engineers' integrated research and development (R&D) organization. CERL conducts research to support sustainable military installations. Research is directed toward increasing the Army's ability to more efficiently construct, operate, and maintain its installations and ensure environmental quality and safety at a reduced life-cycle cost. Excellent facilities support the Army's training, readiness, mobilization, and sustainability missions. An adequate infrastructure and realistic training lands are critical assets to installations, which serve as platforms to project power worldwide. CERL also supports ERDC's R&D mission in civil works and military engineering.

CERL works closely with its Army customers to develop quality products and services and to help customers implement new technologies. User groups and steering committees have been established to help identify existing problems, establish research priorities, and provide input into the development of products. Many CERL products developed under this teamwork approach are in daily use, both within the Department of Defense (DOD) and the private/public sectors. An active technology transfer program ensures these products receive the widest dissemination among prospective users.

The provisions of the Competition in Contracting Act of 1984 (P.L. 98-369) as implemented in the Federal Acquisition Regulation provide for the issuance of a Broad Agency Announcement (BAA) as a means of soliciting proposals for basic and applied research, and that part of development not related to the development of a specific system or hardware procurement. BAAs may be used by agencies to fulfill their requirements for scientific study and experimentation directed toward advancing the state-of-the-art or increasing knowledge or understanding rather than focusing on a specific system or hardware solution. The BAA shall only be used when meaningful proposals with varying technical/scientific approaches can be reasonably anticipated.

“Basic Research” is defined as research directed toward increasing knowledge in science with the primary aim being a fuller knowledge or understanding of the subject under study, rather than any practical application of that knowledge. “Applied Research” is the effort that normally follows basic research, but may not be severable from the related basic research; attempts to determine and exploit the potential of scientific discoveries or improvements in technology, materials, processes, methods, devices, or techniques; and attempts to advance the state-of-the-art. This announcement must be general in nature, identify the areas of research interest, include criteria for selecting proposals, and solicit the participation of all offerors capable of satisfying the Government’s needs. The proposals submitted under this BAA will be subject to peer or scientific review. Proposals that are selected for award are considered to be the result of full and open competition and in full compliance with the provisions of P.L. 98-369, the Competition in Contracting Act of 1984.

This guide provides prospective offerors information on the preparation of proposals for applied research. Suggestions as to form and procedures are included. Proposals from U.S. Government facilities and organizations will not be considered under this program announcement. PERSONS SUBMITTING PROPOSALS ARE CAUTIONED THAT ONLY A CONTRACTING OFFICER MAY OBLIGATE THE GOVERNMENT TO ANY AGREEMENT INVOLVING EXPENDITURE OF GOVERNMENT FUNDS.

This BAA is specifically designated for proposals related to a Proton Exchange Membrane (PEM) Fuel Cell Demonstration Of Domestically Produced Residential PEM Fuel Cells in Military Facilities. This BAA is open to all offerors, however, offerors who are not residential PEM fuel cell manufacturers must submit a signed letter of agreement from a residential PEM fuel cell manufacturer, which states that the particular manufacturer will sell a specified number of specified sized units to the particular offeror. Only domestically-produced residential PEM fuel cells between the sizes of 1 kilowatt (kW) and 20 kW will be considered in this BAA. Preproposals received under this announcement must be submitted by 29 March 2002 for awards to be made from the anticipated FY2002 funding (approximately $3 million). All awards are subject to the availability of funds from the anticipated funding for FY2002. This announcement shall remain open for a period of up to 1 year or until superseded. However, proposals received after 29 March 2002 may be delayed in their review and correspondence.

All offerors submitting a proposal under this BAA must be registered and valid in the Central Contractor Registration (CCR) system at http://www.ccr2000.com before an award can be made. In addition, all offerors, by submission of an offer or execution of a contract in response to this solicitation, certify that they are not debarred, suspended, declared ineligible for award of public contracts, or proposed for debarment pursuant to FAR 9.406-2. If an offeror cannot so certify, or if the status of the offeror changes prior to award, the offeror must provide detailed information as to its current status.

Offerors submitting proposals are reminded that all transactions conducted under this announcement shall conform with the requirements of the FAR and its supplements. Contracts awarded by CERL will contain, where appropriate, detailed special provisions concerning patent rights, rights in technical data and computer software, reporting requirements, equal employment opportunity, and all other applicable FAR and supplementary clauses.

Please contact Mrs. Rita Brooks of the Vicksburg Consolidated Contracting Office, Champaign Field Office, at (217) 373-7280 or via email at r-brooks@cecer.army.mil if you have any questions concerning submittal or contractual requirements.

PART I

PROTON EXCHANGE MEMBRANE (PEM) FUEL CELL DEMONSTRATION OF DOMESTICALLY PRODUCED RESIDENTIAL PEM FUEL CELLS IN MILITARY FACILITIES

A. Core Requirement: The core requirement of this BAA is for the offeror to supply a turn-key package for the installation, operation, maintenance, monitoring, and option for removal/site restoration of domestically-produced residential PEM fuel cell(s) at military facilities. Beyond this core requirement, the offeror must state which conditions from the included matrix of parameters in Part I, Section C below that they will satisfy. The goal of this demonstration program is to have as much variety and meet as many of the matrix of parameters as possible, therefore multiple awards are anticipated. Offerors are encouraged to propose the installation of multiple units at multiple sites. Although this program is named "residential," the sites do not necessarily need to be dwellings as long as the load matches.

B. Core Requirement Definitions:

Domestically Produced Residential Fuel Cells – Only units between the sizes of 1 kW and 20 kW will be considered. If individual packaged units are combined together to form a larger unit, the individual packaged units must be between the sizes of 1 kW and 20 kW. "Domestically produced" is defined as the power plant(s) being substantially manufactured in the United States (i.e., at least 50 percent of the value of the components must be produced in the United States, and the unit must be assembled in the United States).

Military Facilities – Army, Air Force, Navy, Marine, and Coast Guard facilities, both active and reserve, are all acceptable host sites for the demonstration. Remote sites located on military installation grounds are also acceptable. Military or DOD related sites not included in this list will be considered on a case-by-case basis.

Installation of Unit(s) – The offeror shall install the unit(s) with full cooperation and consideration of the host military site(s), abiding by any safety, scheduling, or other requirements imposed by the site(s). The offeror will be responsible for any siting, permitting, or interconnect issues. Installation of the unit(s) will be complete when the offeror has completed a documented on-site acceptance test demonstrating the capability to produce power (and heat, if cogeneration is present) as per the manufacturer's specifications. The acceptance test will include a one-time measurement of total harmonic voltage distortion while providing power to the site under normal load conditions.

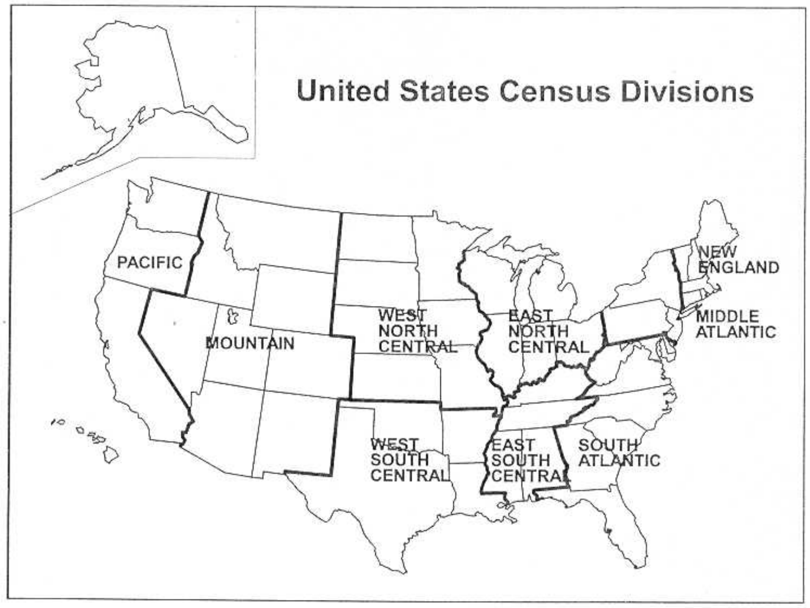
Operation of Unit(s) – The offeror shall operate the unit(s) at the host military site(s) and obtain a minimum of one (1) year of fuel cell power. Fuel cell power is defined as the host required power output up to the specified output of the fuel cell at an average availability of 90 percent.

Maintenance of Unit(s) – The offeror shall provide reasonable on-site maintenance to the installed unit(s) as required to meet any operational, safety, scheduling, etc. requirements. If the unit(s) are beyond any on-site repair, replacement unit(s) will be furnished and installed. A log of maintenance activities performed will be required as part of the final report. Specifically, for any service activities, the maintenance personnel should record the date, time of arrival and departure from the site(s), and any applicable notes that relate to the repairs or actions undertaken while at the site(s).

Monitoring of Unit(s) – The offeror shall monitor all units at all sites during the demonstration period. Data shall be recorded, analyzed, and presented in the form of a report at the end of the demonstration period. As a minimum, the parameters that shall be monitored include total operating hours, fuel input, total kW hours (kWh) produced, availability, outages and duration (start/stop events with associated dates and times), maximum kW produced, outdoor ambient temperature, and total heat recovered (only if cogeneration is present). Data from the above parameters shall be collected on intervals of 1 hour or less. Offerors are encouraged to propose additional data collection to provide more detailed performance analyses of the unit(s).

Option for Removal/Site Restoration – The offeror shall include in the proposal an option for removing the unit(s) at the site(s), as well as restoration of the site(s), after the completion of the demonstration period or at the request of the Government, whichever occurs first.

Geographic Regions – The offeror shall identify in the pre-proposal, at a minimum, the geographic region(s) they are willing to perform the demonstration at. States and specific cities may be identified, if applicable. Geographic regions from the illustrated U.S. Census Map below include the following: Continental United States (CONUS) regions – New England, Middle Atlantic, South Atlantic, East North Central, West North Central, East South Central, West South Central, Mountain, and Pacific (which includes Alaska and Hawaii). Outside of the Continental United States (OCONUS) regions can be specified by Country and/or City.



C. Matrix of Offeror Specified Parameters:

Under this BAA, as long as the Core Requirements are first met, offerors must then specify the parameters under which they agree to perform individual project(s) from the following matrix:

Fuel Natural Gas Propane Hydrogen Other	Grid Connect Grid Independent Both (alternating)	Cogeneration No Cogeneration	Altitude Sea Level < 500 ft 500 ft < 1250 ft 1250 ft < 4000 ft 4000 ft < 5280 ft > 5280 ft
Single Units Ganged Units	Fuel Switching No Fuel Switching Fuel Blending	Remote Site?	Hybrid System?
Own/Lease Unit	Maximum/Minimum Temperature Restrictions?		

D. Deliverables: Beyond the turn-key package described above, the successful offerors will be required to submit documentation of the projects. Offerors shall include in their proposal, as a minimum, submission of the following documentation in electronic format (Word for reports and summary data, Excel for raw data, etc.):

1. An Initial Project Description Report, which includes information regarding the site(s), the specific building or other application(s), the site(s) points of contact (POCs), digital pictures of the site(s) along with the building(s) or area(s) where

the fuel cells are to be installed, utility rates at the site(s), and an estimate of the energy savings (electric energy and demand savings plus heat energy (if any) savings minus input fuel cost). The DOD Fuel Cell Demonstration Website gives an example of the type of information required at: http://www.DODfuelcell.com and the individual site information located within. The Project Description report shall be submitted within 4 months of award of any applicable contract awarded as a result of a proposal received under this BAA.

2. A Midpoint Project Status Report shall be submitted within 2 months after the fuel cell(s) are installed at the particular site(s). The midpoint Project Status Report shall contain digital pictures of the installed fuel cell(s), documentation of the installation process including the duration and other pertinent parameters, and documentation of the acceptance test of the fuel cell. This report shall also include the performance monitoring data collected as well as a month by month summary of this data.
3. A Final Report shall be developed at the end of the project after 1 full year of fuel cell power has been delivered at the individual site(s). The Final Report shall contain the complete documentation of the project, to include material from the initial Project Description Report and the midpoint Project Status Report, as well as all maintenance logs, all performance monitoring data and a month by month summary of this data, along with a conclusions section. The Final Report shall be submitted within 2 months after the end of the demonstration period.

PART II

PRE-PROPOSAL AND PROPOSAL PREPARATION AND SUBMISSION

A. BAA Process: Response to this BAA is a two-phase process. All offerors are required initially to submit a phase I pre-proposal. CERL staff will review each pre-proposal to determine if further consideration is warranted. This decision will be based on scientific merit; potential contribution to the CERL mission; the offeror's capabilities, qualifications and experience; and availability of funding for the effort. Upon completion of the initial review, each offeror will be notified either of rejection and the rationale for this decision; or encouraged to submit a phase II, full proposal. This part is intended to provide information needed in preparing phase I and phase II proposals. **It is important that the offeror carefully address the requirements of this section.** Omissions of required information may delay the CERL evaluation, or may result in rejection of a proposal.

B. Points of Contact (POCs): The CERL technical POCs for this BAA are Dr. Michael Binder, (217) 373-7214, and Mr. Frank Holcomb, (217) 352-6511, ext. 7412. Prior to submission of a phase I pre-proposal, prospective offerors are encouraged to call the appropriate CERL POC to ask questions of a technical nature. However, offerors **shall not** discuss cost or seek guidance on the direction that the research project should take. In other words, the offer submitted shall be the offeror's own ideas and may not be influenced by the Government. After submission of a pre-proposal, all questions and requests for assistance must be directed to the Contracts Office, to Mrs. Rita Brooks at (217) 373-7280 or Mrs. Deloras Adamson at (217) 373-7297. In addition, any questions regarding the BAA process or proposal preparation and submission shall be directed to the Contracts Office.

C. Submission Address: The Government requests that all pre-proposals and full proposals be submitted via electronic mail (Word format is preferred) to r-brooks@cecer.army.mil, and that they include a reference to this announcement, No. DACA42-02-R-0010. If a paper form is submitted, or for printed brochures, etc., they may be mailed to**:**

Vicksburg Consolidated Contracting Office
ATTN: Champaign Field Office/Mrs. Rita Brooks
P. O. Box 9005
Champaign, IL 61826-9005

or via express mail services to the following :

Vicksburg Consolidated Contracting Office
ATTN: Champaign Field Office/Mrs. Rita Brooks

2902 Newmark Drive
Champaign, IL 61822-1076

D. **Type of Contract:** It is anticipated that all contracts awarded under this BAA will be issued on a firm fixed-price basis. This type of contract is selected when the project costs can be reasonably estimated, and the services to be rendered are reasonably definite. In this type of contract, the negotiated price is not subject to any adjustment on the basis of the Contractor's cost experience in performing the contract. The offeror shall specifically identify any request for issuance of a contract on other than a firm fixed-price basis (e.g., cost-sharing) and identify the rationale for such request.

E. Pre-proposal Format and Requirements: Valid pre-proposals shall be limited to a brief letter, not to exceed six (6) pages (not including the curriculum vitae and/or resume), and shall contain the following information:

a. A descriptive title of the research proposed;

b. The name and address of the individual, company, or educational institution submitting the pre-proposal;

c. The name and phone number of the principal investigator or senior researcher who would be in charge of the project;

d. Product specifications and descriptions of the proposed fuel cell(s), and an estimated factory production schedule (required from both fuel cell manufacturers and non-fuel cell manufacturers). Please note that only domestically-produced residential PEM fuel cells between the sizes of 1 kW and 20 kW will be considered in this BAA;

e. The proposed start date and duration of the project;

f. The estimated costs, including, but not limited to labor, materials, fringe benefits, overhead, and profit (if any);

g. One or more paragraphs describing the proposed project to include the core requirements specified above; the proposed site or geographic region for installation along with the corresponding number, size, manufacturer(s), and model(s); the specific conditions to be addressed from the matrix identified above; and whether or not a military installation has been contacted and is amenable to becoming a host site. (The Government will provide the offeror with the name of any installation's energy manager, upon request.);

h. One or more paragraphs describing the technical approach to be taken in the course of the research. This shall include installation, operation, maintenance, monitoring, and removal/site restoration, and an estimated timetable of events;

i. A one-page only resume/vitae for each principal investigator and/or key personnel who will be involved with the project.

j. A description of the offeror's capabilities and previous experience as related to fuel cells. Include the agency the work was performed for, contract number, dollar value, and the name of a point of contact, phone and/or email address. (No more than two pages in length.)

F. Full Proposal Format and Requirements:

Full proposals will be accepted only upon request from the Vicksburg Consolidated Contracting Office, as the direct result of a favorably evaluated pre-proposal.

Full proposals shall include a more detailed description of all the information submitted with the pre-proposal, including the specific sites, along with any additional information requested by the Government based on review of the pre-proposal. This shall include a complete discussion stating the background and objectives of the proposed work, the approaches to be considered, the proposed level of effort and the anticipated results/products in terms of benefit to the particular research program. Full proposals shall also include a firm timeline or project schedule and a complete description of the fuel cell units.

The technical portion of the full proposal shall also contain the following:

a. An indication that the offeror is a manufacturer of residential PEM fuel cells, or a letter of agreement from a residential PEM fuel cell manufacturer, which states that the particular manufacturer will sell a specified number of specified sized units to the particular offeror. In addition, the proposal shall include a paragraph describing the manufacturing capability of the manufacturer (number of units per calendar year or similar);

b. Documentation regarding correspondence with potential host sites or copies of a letter or electronic mail from the military facility's energy manager equivalent or higher authority;

c. The names, brief biographical information, experience, education, and a list of recent publications of the offeror's key personnel who will be involved in the research;

d. A brief description of the offeror's organization;

e. A description of the reports and deliverables to be submitted; and

f. Past relevant performance information to include the name, address, point of contact, phone number, contract identification number, contract award date and amount, for a minimum of three (3) customers for whom the offeror has performed services in the last three (3) years.

The cost portion of the proposal shall contain a cost estimate sufficiently detailed by element of cost for meaningful evaluation. This cost estimate shall include the following, as applicable:

a. Fuel Cell Power Plant Cost–include an itemized list of equipment showing the estimated cost of each item, including documentation of catalog or market prices, if applicable;

b. Power Plant Installation Cost – A complete cost breakdown of direct labor by discipline, function or position, hours proposed or percentage of time, hourly rate or salary, fringe benefit percentage rate and cost base. Also, include an itemized list of materials required;

c. Thermal Recovery Connection Costs, if any;

d. Performance Monitoring Equipment Cost;

e. Project Management/Report Writing Expenses – include reproduction costs, computer time, etc.;

f. Maintenance Cost;

g. Travel Costs – A complete breakdown of travel requested by the offeror to include airfare, rental car, per diem, location, number of trips, duration of trips, number of people/trip, etc.;

h. Restoration Costs;

i. Other Costs – Include in this category any miscellaneous piping, tanks, fuel (if required), delivery charges, description and cost of expendable supplies;

j. A complete breakdown of any subcontracts, including the name and rationale for each selection. If the proposal is in excess of $500,000, subcontracts are proposed, and the offeror is not considered a small or small and disadvantaged business concern, a subcontracting plan will be required prior to award in accordance with FAR 52.219-9;

k. Indirect cost rates and bases with a statement as to whether the rates are fixed or provisional and the time frame to which they apply; and

l. Proposed fee or profit, if any.

In addition to the technical and cost proposals, the following additional information is requested with each submission in response to a full proposal request:

a. The name, phone number, fax number, and email address of the offeror's authorized negotiators; and

b. The offeror's Data Universal Numbering System (DUNS) number, the Commercial and Government Entity (CAGE) Code, and Taxpayer Identification Number (TIN), if known.

PART III

PRE-PROPOSAL AND FULL PROPOSAL EVALUATION

A. Pre-proposal Evaluation: On receipt of a valid Phase I pre-proposal (not to exceed six pages), CERL staff will provide an initial review of the offers scientific merit; potential contribution to the CERL mission; the offeror's capabilities, qualifications and experience; and the availability of funds for the proposed research. Offerors who have submitted pre-proposals that merit further consideration will be encouraged to submit a Phase II full proposal. The Government may make recommendations for the full proposal that should be considered prior to submission.

B. Full Proposal Evaluation: Full proposals requested by the Government will be evaluated by CERL staff in accordance with the criteria specified below which are equally important. However, if all other factors are considered equivalent, the total proposal cost/installed kW rating of the fuel cells (criteria #1 below) will be the deciding factor. Upon completion of the evaluation, each offeror will be notified either of rejection, and the rationale for this decision, or of acceptance.

a. Total Proposal Cost / Installed kW rating of fuel cells;

b. The offeror's capabilities, related experience, facilities, techniques, or unique combinations of these that are integral factors for achieving the proposal objectives;

c. Reasonableness and Firmness of Production / Project Timetables. Preference will be given to projects with earlier completion dates;

d. Uniqueness of Proposal/Project;

e. Extent to which Offeror meets Core Requirements. In addition, preference will be given to offerors who have identified amenable host sites, as evidenced by submittal of a signed letter or electronic mail from the military facility's energy manager equivalent or higher authority.

f. The qualifications, capabilities, and experience of the principal investigator, team leader, and other key personnel who are critical to achievement of the proposal objectives; and

g. The offeror's record of past performance.

C. Special Evaluation Criteria: It is the intent of the Government to review and evaluate each proposal independently in the order received. Due to the limited resources available for FY2002 and the goals of achieving maximum diversity in conditions and operations, any of the criteria listed above may be superseded if diversification has not been met. For example, if proposals for fuel cells in all CONUS regions have already been selected and a proposal for an OCONUS region is received along with another CONUS region proposal, the OCONUS region proposal could potentially be selected over the CONUS region proposal, even if the Total Proposal Cost / Installed kW rating of the OCONUS proposal is higher than that of the CONUS proposal.

D. Additional Information: Pre-proposals and proposals not considered to have sufficient scientific merit or relevance to CERL's needs may be declined without further review. If a Full Proposal is accepted by the Government, the Contracting Office will prepare a solicitation document to the offeror, which includes all the applicable clauses and requirements. If these terms are acceptable to the offeror, they shall complete and return copies of the solicitation document as instructed. Offerors are cautioned that no contract is final until signed by an authorized Contracting Officer.

Appendix D: FY03 Broad Agency Announcement

Preface

The Construction Engineering Research Laboratory (CERL) is part of the U.S. Army Engineer Research and Development Center (USAERDC), which is the Army Corps of Engineers' integrated research and development (R&D) organization. CERL conducts research to support sustainable military installations. Research is directed toward increasing the Army's ability to more efficiently construct, operate, and maintain its installations and ensure environmental quality and safety at a reduced life-cycle cost. Excellent facilities support the Army's training, readiness, mobilization, and sustainability missions. An adequate infrastructure and realistic training lands are critical assets to installations, which serve as platforms to project power worldwide. CERL also supports ERDC's R&D mission in civil works and military engineering.

CERL works closely with its Army customers to develop quality products and services and to help customers implement new technologies. User groups and steering committees have been established to help identify existing problems, establish research priorities, and provide input into the development of products. Many CERL products developed under this teamwork approach are in daily use, both within the Department of Defense (DOD) and the private/public sectors. An active technology transfer program ensures these products receive the widest dissemination among prospective users.

The provisions of the Competition in Contracting Act of 1984 (P.L. 98-369) as implemented in the Federal Acquisition Regulation provide for the issuance of a Broad Agency Announcement (BAA) as a means of soliciting proposals for basic and applied research, and that part of development not related to the development of a specific system or hardware procurement. BAAs may be used by agencies to fulfill their requirements for scientific study and experimentation directed toward advancing the state-of-the-art or increasing knowledge or understanding rather than focusing on a specific system or hardware solution. The BAA shall only be used when meaningful proposals with varying technical/scientific approaches can be reasonably anticipated.

"Basic Research" is defined as research directed toward increasing knowledge in science with the primary aim being a fuller knowledge or understanding of the subject under study, rather than any practical application of that knowledge. "Applied Research" is the effort that normally follows basic research, but may not be severable from the related basic research; attempts to determine and exploit the potential of scientific discoveries or improvements in technology, materials, processes, methods, devices, or techniques; and attempts to advance the state-of-the-art. This announcement must be general in nature, identify the areas of research interest, include criteria for selecting proposals, and solicit the participation of all offerors capable of satisfying the Government's needs. The proposals submitted under this BAA will be subject to peer or scientific review. Proposals that are selected for award are considered to be the result of full and open competition and in full compliance with the provisions of P.L. 98-369, the Competition in Contracting Act of 1984.

This guide provides prospective offerors information on the preparation of proposals for applied research. Suggestions as to form and procedures are included. Proposals from U.S. Government facilities and organizations will not be considered under this program announcement. PERSONS SUBMITTING PROPOSALS ARE CAUTIONED THAT ONLY A CONTRACTING OFFICER MAY OBLIGATE THE GOVERNMENT TO ANY AGREEMENT INVOLVING EXPENDITURE OF GOVERNMENT FUNDS.

This BAA is specifically designated for proposals related to a Proton Exchange Membrane (PEM) Fuel Cell Demonstration of Domestically Produced Residential PEM Fuel Cells in Military Facilities. This BAA is open to all offerors, however, offerors who are not residential PEM fuel cell manufacturers must submit a signed letter of agreement from a residential PEM fuel cell manufacturer, which states that the particular manufacturer will sell a specified number of specified sized units in a specified time frame and at a specified price to the particular offeror. Only domestically-produced residential PEM fuel cells between the sizes of 1 kilowatt (kW) and 20 kW will be considered in this BAA. This program represents a real world demonstration and validation of PEM fuel cells systems at military facilities; as such, projects requiring substantial research and development will not be funded. Initial pre-proposals received under this announcement must be submitted by 01 APR 03 for awards to be made from the anticipated FY2003 funding. Pre-proposals will be reviewed in the order received. All awards are subject to the availability of funds. Although this announcement shall remain open for a period of up to 1 year or until superseded, review of any pre-proposal received after 01 APR 03 may be delayed until all timely proposals have been processed. Please note that funding may not be available beyond that used for award of the proposals received by the specified deadline.

All offerors submitting a proposal under this BAA must be registered and valid in the Central Contractor Registration (CCR) system at http://www.ccr2000.com before an award can be made. In addition, all offerors, by submission of an offer or execution of a contract in response to this solicitation, certify that they are not debarred, suspended, declared ineligible for award of public contracts, or proposed for debarment pursuant to FAR 9.406-2. If an offeror cannot so certify, or if the status of the offeror changes prior to award, the offeror must provide detailed information as to its current status.

Offerors submitting proposals are reminded that all transactions conducted under this announcement shall conform with the requirements of the FAR and its supplements. Contracts awarded by CERL will contain, where appropriate, detailed special provisions concerning patent rights, rights in technical data and computer software, reporting requirements, equal employment opportunity, and all other applicable FAR and supplementary clauses.

Please contact Mrs. Rita Brooks of the Vicksburg Consolidated Contracting Office, Champaign Field Office, at (217) 373-7280 or via email at r-brooks@cecer.army.mil if you have any questions concerning submittal or contractual requirements.

PART I

PROTON EXCHANGE MEMBRANE (PEM) FUEL CELL DEMONSTRATION OF DOMESTICALLY PRODUCED RESIDENTIAL PEM FUEL CELLS IN MILITARY FACILITIES

A. Core Requirement: The core requirement of this BAA is for the offeror to supply a turn-key package for the installation, operation, maintenance, monitoring, and removal/site restoration of domestically-produced residential PEM fuel cell(s) at military facilities. Beyond this core requirement, the offeror must state which conditions from the included matrix of parameters in Part I, Section C below that they will satisfy. The goal of this demonstration program is to have as much variety and meet as many of the matrix of parameters as possible, therefore multiple awards are anticipated. Offerors are encouraged to propose the installation of multiple units at multiple sites. However, each individual project (as defined in Section B, Paragraph 1 below) shall be priced separately to facilitate partial award where merited. Discounts that may apply for funding of multiple projects should be identified separately. Although this program is named “residential,” the sites do not necessarily need to be dwellings as long as the load matches.

B. Core Requirement Definitions:

Domestically Produced Residential Fuel Cells – Individual projects may be proposed that consist of single fuel cell units, or a combination of fuel cell units at a single site. In either case, individual projects must be between the sizes of 1kW and 20kW. “Domestically produced” is defined as the power plant(s) being substantially manufactured in the United States (i.e., at least 50 percent of the value of the components must be produced in the United States, and the unit must be assembled in the United States).

Military Facilities – Army, Air Force, Navy, Marine, and Coast Guard facilities, both active and reserve, are all acceptable host sites for the demonstration. Remote sites located on military installation grounds are also acceptable. Military or DOD related sites not included in this list will be considered on a case-by-case basis.

Installation of Unit(s) – The offeror shall install the unit(s) with full cooperation and consideration of the host military site(s), abiding by any safety, scheduling, or other requirements imposed by the site(s). The offeror will be responsible for any siting, permitting, or interconnect issues. Installation of the unit(s) will be complete when the offeror has completed a documented on-site acceptance test demonstrating the capability to produce power (and heat, if cogeneration is present) as per the manufacturer's specifications. The acceptance test will include a one-time measurement of total harmonic voltage distortion while providing power to the site under normal load conditions.

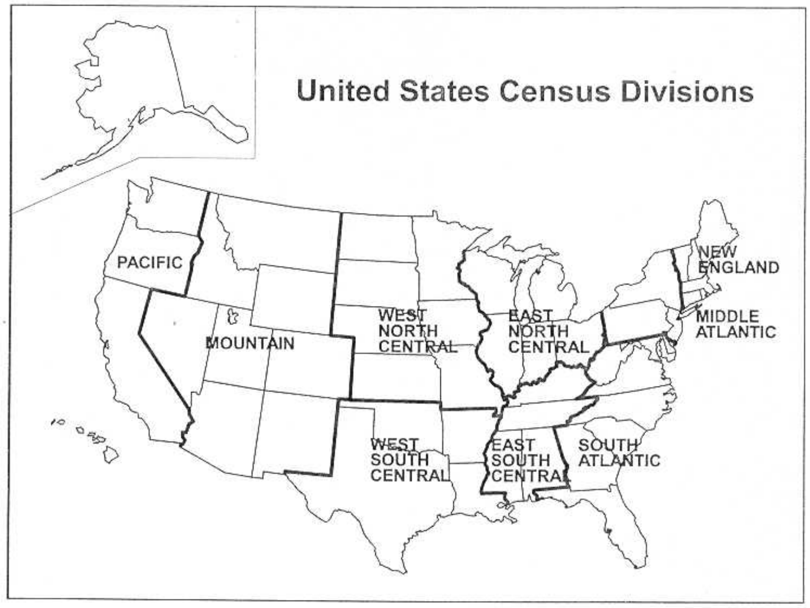
Operation of Unit(s) – The offeror shall operate the unit(s) at the host military site(s) and obtain a minimum of one (1) year of fuel cell power. Fuel cell power is defined as the host required power output up to the specified output of the fuel cell at an average availability of 90 percent.

Maintenance of Unit(s) – The offeror shall provide reasonable on-site maintenance to the installed unit(s) as required to meet any operational, safety, scheduling, etc. requirements. If the unit(s) are beyond any on-site repair, replacement unit(s) will be furnished and installed. A log of maintenance activities performed will be required as part of the final report. Specifically, for any service activities, the maintenance personnel should record the date, time of arrival and departure from the site(s), and any applicable notes that relate to the repairs or actions undertaken while at the site(s).

Monitoring of Unit(s) – The offeror shall monitor all units at all sites during the demonstration period. Data shall be recorded, analyzed, and presented in the form of a report at the end of the demonstration period. As a minimum, the parameters, which shall be monitored include total operating hours, fuel input, total kW hours (kWh) produced, availability, outages and duration (start/stop events with associated dates and times), maximum kW produced, outdoor ambient temperature, and total heat recovered (only if cogeneration is present). Data from the above parameters shall be collected on intervals of 1 hour or less. Offerors are encouraged to propose additional data collection to provide more detailed performance analyses of the unit(s).

Removal/Site Restoration – The offeror shall include in the proposal the costs associated with removal of the unit(s) from the site(s), as well as restoration of the site(s), after the completion of the demonstration period or at the request of the Government, whichever occurs first.

Geographic Regions – The offeror shall identify in the pre-proposal, at a minimum, the geographic region(s) they are willing to perform the demonstration at. States and specific cities may be identified, if applicable. Geographic regions from the illustrated U.S. Census Map below include the following: Continental United States (CONUS) regions – New England, Middle Atlantic, South Atlantic, East North Central, West North Central, East South Central, West South Central, Mountain, and Pacific (which includes Alaska and Hawaii). Outside of the Continental United States (OCONUS) regions can be specified by Country and/or City.



C. Matrix of Offeror Specified Parameters:

Under this BAA, as long as the Core Requirements are first met, offerors must then specify the parameters under which they agree to perform individual project(s) from the following matrix:

Fuel Natural Gas Propane Hydrogen Other	Grid Connect Grid Independent Both (alternating)	Cogeneration No Cogeneration	Altitude Sea Level < 500 ft 500 ft < 1250 ft 1250 ft < 4000 ft 4000 ft < 5280 ft > 5280 ft
Single Units Ganged Units	Fuel Switching No Fuel Switching Fuel Blending	Remote Site?	Hybrid System?
Own/Lease Unit	Maximum/Minimum Temperature Restrictions?		

D. Meetings: Successful offerors will be required to participate in two meetings to be held at each site as described below:

Kickoff Meeting – This meeting is to be held after contract award and prior to submission of the draft Initial Project Description Report as described in Section E below. The purpose of this meeting is to obtain formal agreement of the project plans from all parties having pertinent input to the project approval process.

Acceptance Meeting – This meeting is to be held after the acceptance test has been performed and prior to the submission of the final Midpoint Project Status Report as described in Section E below. The purpose of this meeting is to inspect the installation site and review the acceptance test results. The results of this meeting will form the basis for acceptance of the final Midpoint Project Status Report. This meeting may be held in conjunction with a public affairs/dedication event if desired by the offeror.

E. Deliverables: Beyond the turn-key package described above, the successful offerors will be required to submit documentation of the projects. All reports as described below are to be submitted in draft and final versions. CERL comments on draft reports will be provided to the offeror within 30 days of receipt of the draft report. Final reports are to be submitted within 30 days of receipt of CERL draft report comments. Offerors shall include in their proposal, as a minimum, submission of the following documentation in electronic format (Word for reports and summary data, Excel for raw data, etc.):

1. An Initial Project Description Report, which includes information regarding the site(s), the specific building or other application(s), the site(s) points of contact (POCs), digital pictures of the site(s) along with the building(s) or area(s) where the fuel cells are to be installed, utility rates at the site(s), and an estimate of the energy savings (electric energy and demand savings plus heat energy (if any) savings minus input fuel cost). the DOD Fuel Cell Demonstration Website gives an example of the type of information required at: http://www.DODfuelcell.com. The individual site information is also located within. The draft Initial Project Description report shall be submitted within 4 months of award of any applicable contract awarded as a result of a proposal received under this BAA.
2. A draft Midpoint Project Status Report shall be submitted within 2 months after the fuel cell(s) are installed at the particular site(s). The midpoint Project Status Report shall contain digital pictures of the installed fuel cell(s), documentation of the installation process including the duration and other pertinent parameters, and documentation of the acceptance test of the fuel cell. This report shall also include the performance monitoring data collected as well as a month by month summary of this data.
3. A Final Report shall be developed at the end of the project after 1 full year of fuel cell power has been delivered at the individual site(s). The Final Report shall contain the complete documentation of the project, to include material from the initial Project Description Report and the midpoint Project Status Report, as well as all maintenance logs, all performance monitoring data and a month by month

summary of this data, along with a conclusions section. The Final Report should include a comparison of actual fuel cell performance to the fuel cell specifications provided in the full proposal. It should also include a breakdown of actual project costs and a comparison to the estimated costs in the cost proposal. It should include a discussion of any pertinent installation, acceptance, or permitting issues, and summary of lessons learned. Of particular interest are any product improvements resulting as a direct consequence of this demonstration program. The draft Final Report shall be submitted within 2 months after the end of the demonstration period.

PART II

PRE-PROPOSAL AND PROPOSAL PREPARATION AND SUBMISSION

A. BAA Process: Response to this BAA is a two-phase process. All offerors are required initially to submit a phase I pre-proposal. CERL staff will review each pre-proposal to determine if further consideration is warranted. This decision will be based on scientific merit; potential contribution to the CERL mission; the offeror's capabilities, qualifications and experience; and availability of funding for the effort. Upon completion of the initial review, each offeror will be notified either of rejection and the rationale for this decision; or encouraged to submit a phase II, full proposal. This part is intended to provide information needed in preparing phase I and phase II proposals. **It is important that the offeror carefully address the requirements of this section.** Omissions of required information may delay the CERL evaluation, or may result in rejection of a proposal.

B. Points of Contact (POCs): The CERL technical POCs for this BAA are Dr. Michael Binder, (217) 373-7214, and Mr. Frank Holcomb, (217) 352-6511, ext. 7412. Prior to submission of a phase I pre-proposal, prospective offerors are encouraged to call the appropriate CERL POC to ask questions of a technical nature. However, offerors **shall not** discuss cost or seek guidance on the direction that the research project should take. In other words, the offer submitted shall be the offeror's own ideas and may not be influenced by the Government. After submission of a pre-proposal, all questions and requests for assistance must be directed to the Contracts Office, to Mrs. Rita Brooks at (217) 373-7280 or Mrs. Deloras Adamson at (217) 373-7297. In addition, any questions regarding the BAA process or proposal preparation and submission shall be directed to the Contracts Office.

C. Submission Address: The Government requests that all pre-proposals and full proposals be submitted via electronic mail (Word format is preferred) to r-brooks@cecer.army.mil, and that they include a reference to this announcement, No. DACA42-02-R-0010. If a paper form is submitted, or for printed brochures, etc., they may be mailed to:

Vicksburg Consolidated Contracting Office
ATTN: Champaign Field Office/Mrs. Rita Brooks
P. O. Box 9005
Champaign, IL 61826-9005

or via express mail services to the following :

Vicksburg Consolidated Contracting Office
ATTN: Champaign Field Office/Mrs. Rita Brooks
2902 Newmark Drive
Champaign, IL 61822-1076

D. **Type of Contract:** It is anticipated that all contracts awarded under this BAA will be issued on a firm fixed-price basis. This type of contract is selected when the project costs can be reasonably estimated, and the services to be rendered are reasonably definite. In this type of contract, the negotiated price is not subject to any adjustment on the basis of the Contractor's cost experience in performing the contract. The offeror shall specifically identify any request for issuance of a contract on other than a firm fixed-price basis (e.g., cost-sharing) and identify the rationale for such request.

E. Pre-proposal Format and Requirements: Valid pre-proposals shall be limited to a brief letter, not to exceed six (6) pages (not including the curriculum vitae and/or resume), and shall contain the following information:

a. A descriptive title of the research proposed;

b. The name and address of the individual, company, or educational institution submitting the pre-proposal;

c. The name and phone number of the principal investigator or senior researcher who would be in charge of the project;

d. Product specifications and descriptions of the proposed fuel cell(s), and an estimated factory production schedule (required from both fuel cell manufacturers and non-fuel cell manufacturers). Please note that only domestically-produced residential PEM fuel cells between the sizes of 1 kW and 20 kW will be considered in this BAA;

e. The proposed start date and duration of the project (preferably in terms of months after award of contract);

f. The estimated costs, including, but not limited to labor, materials, fringe benefits, overhead, and profit (if any);

g. One or more paragraphs describing the proposed project to include the core requirements specified above; the proposed site or geographic region for installation along with the corresponding number, size, manufacturer(s), and model(s); the specific conditions to be addressed from the matrix identified above; and whether or not a military installation has been contacted and is amenable to becoming a host site. (The Government will provide the offeror with the name of any installation's energy manager, upon request.);

h. One or more paragraphs describing the technical approach to be taken in the course of the research. This shall include installation, operation, maintenance, monitoring, and removal/site restoration, and an estimated timetable of events;

i. A one-page only resume/vitae for each principal investigator and/or key personnel who will be involved with the project.

j. A description of the offeror's capabilities and previous experience as related to fuel cells. Include the agency the work was performed for, contract number, dollar value, and the name of a point of contact, phone and/or email address. (No more than two pages in length.)

F. Full Proposal Format and Requirements:

Full proposals will be accepted only upon request from the Vicksburg Consolidated Contracting Office, as the direct result of a favorably evaluated pre-proposal.

Full proposals shall include a more detailed description of all the information submitted with the pre-proposal, including the specific sites, along with any additional information requested by the Government based on review of the pre-proposal. This shall include a complete discussion stating the background and objectives of the proposed work, the approaches to be considered, the proposed level of effort and the anticipated results/products in terms of benefit to the particular research program. Full proposals shall also include a firm timeline or project schedule (in terms of months after award of contract) and a complete description of the fuel cell units. The key technical specifications for the fuel cells should include, but are not limited to, sustainable power output, sustainable efficiency, voltage, polarization curves, heat recovery available, peak power capability, duration of peak power, durability, maintenance requirements, emissions, noise level, etc. These data should be later validated against the operating data following the installation of the units in the field.

The technical portion of the full proposal shall also contain the following:

a. An indication that the offeror is a manufacturer of residential PEM fuel cells, or a letter of agreement from a residential PEM fuel cell manufacturer, which states that the particular manufacturer will sell a specified number of specified sized units in a specified time frame and at a specified price to the particular offeror. In addition, the proposal shall include a paragraph describing the manufacturing capability of the manufacturer (number of units per calendar year or similar);

b. Documentation regarding correspondence with potential host sites or copies of a letter or electronic mail from the military facility's energy manager equivalent or higher authority;

c. The names, brief biographical information, experience, education, and a list of recent publications of the offeror's key personnel who will be involved in the research;

d. A brief description of the offeror's organization;

e. A description of the reports and deliverables to be submitted; and

f. Past relevant performance information to include the name, address, point of contact, phone number, contract identification number, contract award date and amount, for a minimum of three (3) customers for whom the offeror has performed services in the last three (3) years.

The cost portion of the proposal shall contain a cost estimate sufficiently detailed by element of cost for meaningful evaluation. This cost proposal is to be submitted in electronic format using a template that will be provided to the offeror at the time a full proposal is requested. This cost estimate shall include the following, as applicable:

a. Fuel Cell Power Plant Cost – include an itemized list of equipment showing the estimated cost of each item, including documentation of catalog or market prices, if applicable;

b. Power Plant Installation Cost (including costs associated with installation design and permitting) – A complete cost breakdown of direct labor by discipline, function or position, hours proposed or percentage of time, hourly rate or salary, fringe benefit percentage rate and cost base. Also, include an itemized list of materials required;

c. Thermal Recovery Connection Costs, if any;

d. Performance Monitoring Equipment Cost;

e. Project Management/Report Writing Expenses – include reproduction costs, computer time, etc.;

f. Maintenance Cost;

g. Travel Costs – A complete breakdown of travel requested by the offeror to include airfare, rental car, per diem, location, number of trips, duration of trips, number of people/trip, etc.;

h. Site Restoration Costs;

i. Other Costs – Include in this category any miscellaneous piping, tanks, fuel (if supplied by offeror), delivery charges, description and cost of expendable supplies;

j. A complete breakdown of any subcontracts, including the name and rationale for each selection. If the proposal is in excess of $500,000, subcontracts are proposed, and the offeror is not considered a small or small and disadvantaged business concern, a subcontracting plan will be required prior to award in accordance with FAR 52.219-9;

k. Indirect cost rates and bases with a statement as to whether the rates are fixed or provisional and the time frame to which they apply; and

l. Proposed fee or profit, if any.

m. Cost Share/Co-funding (if applicable)- Identify any proposed cash contributions or non-cash support (e.g., in-kind labor, etc). Proposed co-funding must be spent only on the project described in the proposal. Staff time, facility use, equipment, and most property can be considered co-funding as long as it is fully dedicated to the project for the time that the property or equipment is required by the contract.

In addition to the technical and cost proposals, the following additional information is requested with each submission in response to a full proposal request:

a. The name, phone number, fax number, and email address of the offeror's authorized negotiators; and

b. The offeror's Data Universal Numbering System (DUNS) number, the Commercial and Government Entity (CAGE) Code, and Taxpayer Identification Number (TIN), if known.

PART III

PRE-PROPOSAL AND FULL PROPOSAL EVALUATION

A. Pre-proposal Evaluation: On receipt of a valid Phase I pre-proposal (not to exceed six pages), CERL staff will provide an initial review of the offers scientific merit; potential contribution to the CERL mission; the offeror's capabilities, qualifications and experience; and the availability of funds for the proposed research. Offerors who have submitted pre-proposals that merit further consideration will be encouraged to submit a Phase II full proposal. The Government may make recommendations for the full proposal that should be considered prior to submission.

B. Full Proposal Evaluation: Full proposals requested by the Government will be evaluated by CERL staff in accordance with the criteria specified below, which are equally important. However, if all other factors are considered equivalent, the total proposal cost/installed kW rating of the fuel cells (criteria #1 below) will be the deciding factor. Upon completion of the evaluation, each offeror will be notified either of rejection, and the rationale for this decision, or of acceptance.

a. Total Proposal Cost / Installed kW rating of fuel cells;

b. The offeror's capabilities, related experience, facilities, techniques, or unique combinations of these that are integral factors for achieving the proposal objectives;

c. Reasonableness and Firmness of Production / Project Timetables. Preference will be given to projects with earlier completion dates;

d. Uniqueness of Proposal/Project;

e. Extent to which Offeror meets Core Requirements. In addition, preference will be given to offerors who have identified amenable host sites, as evidenced by submittal of a signed letter or electronic mail from the military facility's energy manager equivalent or higher authority.

f. The qualifications, capabilities, and experience of the principal investigator, team leader, and other key personnel who are critical to achievement of the proposal objectives; and

g. The offeror's record of past performance.

C. Special Evaluation Criteria: It is the intent of the Government to review and evaluate each proposal independently in the order received. Due to the limited resources available for FY2003 and the goals of achieving maximum diversity in conditions and operations, any of the criteria listed above may be superseded if diversification has not been met. For example, if proposals for fuel cells in all CONUS regions have already been selected and a proposal for an OCONUS region is received along with another CONUS region proposal, the OCONUS region proposal could potentially be selected over the CONUS region proposal, even if the Total Proposal Cost / Installed kW rating of the OCONUS proposal is higher than that of the CONUS proposal.

D. Additional Information: Pre-proposals and proposals not considered to have sufficient scientific merit or relevance to CERL's needs may be declined without further review. If a Full Proposal is accepted by the Government, the Contracting Office will prepare a solicitation document to the offeror that includes all the applicable clauses and requirements. If these terms are acceptable to the offeror, they shall complete and return copies of the solicitation document as instructed. Offerors are cautioned that no contract is final until signed by an authorized Contracting Officer. Any press releases or papers concerning projects awarded under this BAA must reference the CERL PEM Fuel Cell Demonstration Program, and must be provided to CERL for review and comment prior to release or publication.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE (DD-MM-YYYY)
09-2005

2. REPORT TYPE
Final

3. DATES COVERED (From - To)

4. TITLE AND SUBTITLE
DOD Residential Proton Exchange Membrane (PEM) Fuel Cell Demonstration Program: Volume 2 – Summary of Fiscal Years 2001-2003 Projects

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Melissa K. White, Scott M. Lux, James L. Knight, Dr. Michael J. Binder, Franklin H. Holcomb, and Nicolas M. Josefik

5d. PROJECT NUMBER

5e. TASK NUMBER
CFE-B141

5f. WORK UNIT NUMBER
007KE9

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Engineer Research and Development Center (ERDC)
Construction Engineering Research Laboratory (CERL)
PO Box 9005
Champaign, IL 61826-9005

8. PERFORMING ORGANIZATION REPORT NUMBER
ERDC/CERL TR-05-22

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Office of Director, Defense, Research, and Engineering (ODDR&E)
1777 N. Kent
Suite 9030
Rosslyn, VA 22209

10. SPONSOR/MONITOR'S ACRONYM(S)
ODDR&E

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES
Copies are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

14. ABSTRACT

In Fiscal Year 2001 (FY01), Congress funded the Department of Defense (DOD) Residential PEM Demonstration Project to demonstrate domestically-produced, residential Proton Exchange Membrane (PEM) fuel cells at DOD Facilities. The objectives were to: (1) assess PEM fuel cells' role in supporting sustainability at military installations, (2) increase efficiency in installation, operation, and maintenance of fuel cell sites, (3) evaluate their potential in DOD training, readiness, and sustainability missions, (4) provide a military base market for this technology, and (5) evaluate and give feedback to promote commercialization and market growth, operational product testing and validation, grid interconnection standards, and system operation in diverse environmental conditions.

This project developed and advertised a Broad Agency Announcement each fiscal year, outlining core requirements for proposals. Sixty one pre-proposals were received and evaluated. In FY01, six contracts were awarded (22 fuel cells at 10 military installations). In FY02, five contracts were awarded (17 fuel cells at 15 military and DOD installations). In FY03, seven contracts were awarded (30 fuel cells at 20 military and DOD installations). Awardees were required to report detailed operational performance of each of their fuel cell system installations. This report discusses FY02 and FY03 Residential PEM Demonstrations, and revisits FY01 Projects.

15. SUBJECT TERMS

fuel cells	energy efficient	Proton Exchange Membrane (PEM)
alternative energy	energy research	military installations

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
					Franklin H. Holcomb
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPHONE NUMBER (include area code)**
Unclassified	Unclassified	Unclassified	SAR	100	(217) 373-5864

NSN 7540-01-280-5500

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. 239.18