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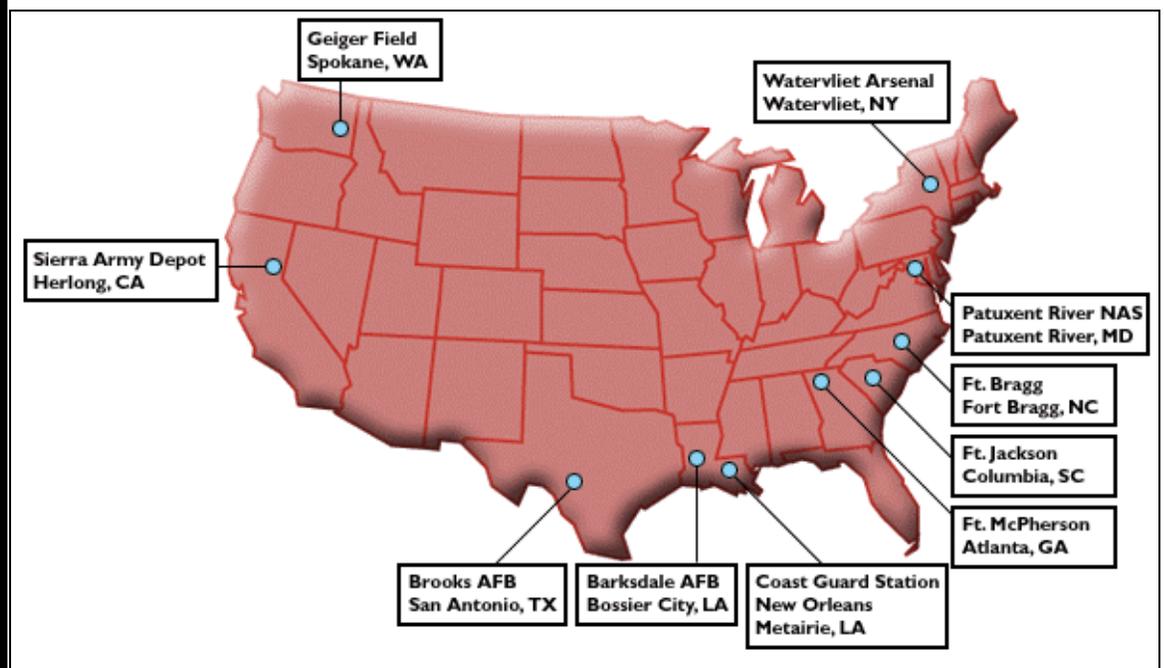
Engineer Research and
Development Center

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

Volume I – Summary of the Fiscal Year 2001 Program

Melissa K. White, Franklin H. Holcomb, Nicholas M. Josefik,
Scott M. Lux, and Michael J. Binder

February 2004



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ABSTRACT: Beginning in Fiscal Year 2001 (FY01), Congress funded the DOD Residential PEM Demonstration Program to demonstrate domestically-produced, residential Proton Exchange Membrane (PEM) fuel cells at military facilities. The objective of the program was to assess PEM fuel cells in supporting sustainability in military installations, increasing efficiency in installation, operation, and maintenance of fuel cells at these sites, and assessing the role of PEM fuel cells in DOD training, readiness, and sustainability missions. Other objectives were to provide: a military base market for this technology, evaluation and feedback to promote commercialization and market growth, operational product testing and validation, grid interconnection standards, and system operation in diverse environmental conditions.

For this program, researchers developed and advertised a Broad Agency Announcement (BAA), which outlined a core set of requirements for proposals. Twelve pre-proposals were received from the FY01 Program BAA solicitation. After review and evaluation of full proposals, six contracts were awarded, representing 22 fuel cells at 10 military installations. The awardees are required to report operational performance of each of the fuel cell power plants in the DOD program, including total operating hours, total electricity production, total fuel usage, total waste heat recovery, availability, electrical efficiency, and thermal efficiency.

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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	$(5/9) \times (^\circ\text{F} - 32)$	degrees Celsius
degrees Fahrenheit	$(5/9) \times (^\circ\text{F} - 32) + 273.15$	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 years 93 and 94, Congress provided funds for natural gas utilization equipment, part of which was specifically designated for procurement of natural gas fuel cells for power generation at military installations. The purchase, installation, and ongoing monitoring of the fuel cells provided by these appropriations came to be known as the “DOD Fuel Cell Demonstration Program.” This follow-on study was conducted under Work Unit 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 fiscal year 2001 program, proton exchange membrane (PEM) fuel cells, ranging in size from 1 to 20 kilowatts (kW), were demonstrated at U.S. military bases. Fuel cell operating hours were required to reach a minimum total duration of 1 year at rated or load capacity and achieved at least 90 percent availability. Contract awards for the FY01 program were made in September through December of 2001, and the first units were installed in January of 2002. This report documents the work done at 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; Sierra Army Depot, CA; and Watervliet Arsenal, NY during the first phase of this project. Part of the work at Coast Guard Station New Orleans, Barksdale AFB, Fort Bragg, Fort Jackson, and Fort McPherson was performed by LOGANEnergy, under Contract DACA42-02-C-0001. The LOGANEnergy Project Manager was Sam Logan. Part of the work at Geiger Field was performed by Avista Laboratories, under Contract DACA42-02-C-0002. The Avista Laboratories Project Manager was Dave Holmes. Part of the work at Patuxent River NAS was performed by Southern Maryland Electric Cooperative (SMECO), under Contract DACA2-02-C-0003. The SMECO Project Manager was Mike Rubala. Part of the work at Sierra Army Depot was performed by Delta-Montrose Electric Association (DMEA), under Contract DACA42-02-C-0005. The DMEA Project Manager was Ron Fle-shood. Part of the work at Watervliet Arsenal was performed by Plug Power, under Contract DACA42-01-C-0053. The Plug Power Project Manager was Brian Davenport. 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), of the Construction Engineering Research Laboratory (CERL). The CERL Principal Investigators were Michael J. Binder and Franklin H. Holcomb. The technical editor was William J. Wolfe. Dr. Thomas Hartranft is Chief, CEERD-CF-E, and Mr. L. Michael Golish is Chief, CEERD-CF. The associated Technical Director was Gary Schanche, CEERD-CV-T. The Director of CERL is Dr. Alan W. Moore.

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 similar to battery technology. In their simplest form, fuel cells generate electricity through an electrochemical process that combines hydrogen and oxygen to generate direct current (DC) electricity, heat, and water. There are several kinds of fuel cells, categorized by the type of electrolyte the reaction uses. This project used Proton Exchange Membrane (PEM) fuel cell technology because it can be manufactured less expensively than other technologies and because it is more efficient for small-scale applications. Since fuel cell systems use an electrochemical process rather than combustion, they are environmentally clean, quiet, and highly efficient. They produce no particulate matter and only trace amounts of nitrogen and sulfur dioxides. Natural gas-driven fuel cell power plants operate at electrical conversion efficiencies of 23 to 50 percent. (These efficiencies are expected to climb in the near future.) If the fuel cell process is used in a cogeneration system, which uses the waste heat and water, efficiencies can exceed 85 percent. By comparison, conventional coal-based energy technologies operate at only 33 to 35 percent efficiency.

PEM fuel cells can be directly fueled by pure hydrogen, propane, natural gas, or other fuels that can be converted to hydrogen. The hydrogen gas is split into protons and electrons at the cell's anode, aided by a catalyst. The protons pass freely through the membrane to react with oxygen from the air to form water. The electrons, which cannot pass through the membrane, are harvested to produce DC electricity. This type of electricity can then be converted into AC power using an inverter.

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 cell for many years as the primary power source for space missions and currently uses fuel cells in the Space Shuttle program. Private corporations have recently been working on various approaches to developing fuel cells for stationary applications for utilities, industries, and commercial markets. Researchers at the U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC/CERL) have actively participated in the development and application of advanced fuel cell technology since

the early 1990s. Since that time, the Department of Defense (DOD) has installed the largest fleet of fuel cells world-wide.

In 2001, national attention was turned toward energy security in the United States. The energy shortages in California that led to rolling blackouts in January of 2001 and the devastating attacks on 11 September 2001 brought about the realization that energy security and new energy technologies were critical. Distributed generation technology and devices have received increased attention as a possible solution to energy security problems. Fuel cells, as a subset of distributed generation devices, have also received increased attention and publicity. The most recent example of increased publicity was the January 2003 Presidential State of the Union Address, where President Bush announced a \$1.2 billion hydrogen fuel initiative to reverse America's growing dependence on foreign oil by developing the technology for commercially viable hydrogen-powered fuel cells to power cars, trucks, homes, and businesses with no pollution or greenhouse gases.

Beginning in fiscal year 2001 (FY01), Congress appropriated funding to demonstrate residential PEM fuel cells, produced domestically, at military facilities. (Appendix A outlines and describes the PEM Demonstration program sites.) The Energy Branch of CERL, which has a great deal of experience with fuel cell demonstration projects, undertook the management and implementation of this activity, the "DOD Residential PEM Fuel Cell Demonstration Program." Subsequent funding in FY02 and FY03 has extended the Program, and has placed additional fuel cells at various military facilities.

CERL researchers have developed a methodology for selecting and evaluating application sites, 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. This accumulated expertise and experience has enabled CERL to lead the advancement of fuel cell technology major efforts such as this DOD Residential PEM Fuel Cell Demonstration Program.

In reviewing potential sites, researchers recognized that most military posts would provide the required diversity of applications including single and multi-family housing, commercial, support, and industrial functions. It became apparent that the most efficient approach to a demonstration of this magnitude was to install fuel cell power systems at military and government posts to support a diverse array of applications. This would allow for a diversity of fuel cell load applications including residential, commercial, and industrial, under the most uniform conditions available. The strategy also had an inherent economic advantage, in that it greatly reduced non-system costs, such as support costs.

This document is the first volume of a series of reports summarizing the progress of the DOD Residential PEM Fuel Cell Demonstration Program. It provides an in-depth overview of the program as a whole, to-date status of FY01 installations, cost analyses, project management, modifications resulting from changes in the industry, and lessons learned.

Objectives

The objectives of this demonstration were to:

1. Plan and implement the DOD Residential PEM Fuel Cell Demonstration Program
2. Install and operate PEM fuel cells in a variety of locations supporting operations at the sites
3. Document the results and analyze the overall program and PEM fuel cell performance.

Approach

This report summarizes the steps taken to initiate the DOD Residential PEM Fuel Cell Demonstration Program, in which researchers:

1. Defined core requirements, offeror requirements, and deliverables
2. Defined and implemented a pre- and final-proposal process
3. Evaluated proposals
4. Awarded contracts
5. Monitored the installation and operation of PEM fuel cell units
6. Documented and analyzed the operation, performance, and costs of the PEM fuel cell units.

Scope

The DOD Residential PEM Fuel Cell Demonstration Program installed, operated, and monitored Proton Exchange Membrane fuel cells on select military installations. The electricity produced by these systems was used to power both residential and industrial loads.

Mode of Technology Transfer

It is anticipated that the material collected and developed during this study will be used to further refine the application of fuel cell technology in residential, commercial, industrial, and remote building settings. This report will be made accessible through the World Wide Web (WWW) at these URLs:

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

<http://www.dodfuelcell.com>

2 Program Management

The DOD Residential PEM Fuel Cell Demonstration Program is the second of its type to be carried out at CERL. The first demonstration, for large-scale Phosphoric Acid Fuel Cells (PAFC), set the groundwork for program management. The release of a Broad Agency Announcement (BAA) for the execution of basic and applied research in support of this mission opened the doors to a diverse set of sites and contractors. Since the start of the PAFC Demonstration Program, the fuel cell industry has grown considerably. The number and size of manufacturers has increased, as has public awareness and interest. Thus the PEM Demonstration depended on not just the fuel cell manufacturers, but energy contractors, on-site energy managers, and interested individuals.

By establishing the program as a set of turnkey projects, contractors were required to submit not only a proposal and final report, but also initial and interim reports. This gave the PEM program team at CERL the opportunity to thoroughly monitor the progress of each installation. The complete and analyzed data could also then be returned to the contractors, manufacturers, and site managers for use in program and product improvement.

Technology and information transfer was also a significant aspect of this program. The DOD Fuel Cell Web Site (<http://www.dodfuelcell.com>) is constantly updated with reports, data, and images for each installation. Nearly all data and files for this program were maintained in digital form on a local computer database. Each proposal submitted to the Department of Defense for the Residential PEM Demonstration Project was required to provide a project cost estimate, including the costs of the fuel cell unit, installation, thermal recovery (if applicable), performance monitoring equipment, project management, maintenance, unit removal, related travel, and other related costs. The reports that followed the award of a demonstration program included maintenance information, performance data, and any changes to the program plans.

The requirements for each program in the fiscal year 2001 program were:

1. All PEM fuel cells must be produced in the United States.
2. Units are to be installed at U.S. military facilities.
3. Fuel cell contract awardees are responsible for all siting and installation requirements.

4. Fuel cells will provide a minimum of 1 year of fuel cell power with a minimum 90 percent unit availability. Unit availability is defined as the number of fuel cell run hours divided by the total number of hours in the period. This requirement was necessary to bridge the gap between an “experimental” system, and one that can be expected to meet commercial demands. The average consumer demands a high level of reliability, so the minimum 90 percent availability requirement is an important step toward commercialization. The 1-year requirement is in place to allow researchers involved to obtain information on a relatively short time frame.
5. All units must have a comprehensive maintenance contract for the minimum 1-year demonstration period. This is reinforced by the minimum 90 percent availability requirement, because downtime while waiting for maintenance reduces the overall availability of the system.
6. For completeness of information drawn from this demonstration program, performance monitoring must be conducted for each PEM unit.
7. The contracts for this program include an option for removal of fuel cell, and for site restoration. This requirement allows for a simplified method of removal of these systems.
8. Location of PEM fuel cell will be in a specified U.S. geographic region. Maximum geographic and climatic diversity is desired for this program.

Appendix B to this report includes the complete BAA document.

3 Site Summary

Approval of individual sites for the DOD Residential PEM Fuel Cell Demonstration Program was preceded by a pre- and full-proposal process. Interested parties were required to identify a potential site and fuel cell manufacturer, and then to submit a pre-proposal to CERL. CERL researchers screened the pre-proposals and then requested full proposals from selected contractors.

The project sites selected for the fiscal year 2001 PEM demonstration (mapped in Figure 1) were:

- Brooks Air Force Base
- Barksdale Air Force Base
- Coast Guard Station New Orleans
- Fort Bragg
- Fort Jackson
- Fort McPherson
- Geiger Field
- Naval Air Station Patuxent River
- Sierra Army Depot
- Watervliet Arsenal.

At the time of this first phase report, five of those sites (Geiger Field, Watervliet Arsenal, Brooks AFB, Fort Jackson, and Barksdale AFB) had completely installed fuel cells and operating systems, and had 1-year demonstrations underway or completed. The sites employed PEM fuel cells from three different fuel cell manufacturers: Plug Power, Avista Labs, and H Power. Table 1 lists the type, size, and number of fuel cells used, by site. Six contractors were selected for the FY01 PEM demonstration project representing a total of 21 PEM fuel cells. Building applications included residential, commercial, industrial, and remote building applications. Table 2 lists the current status of each project site at the time of this writing.

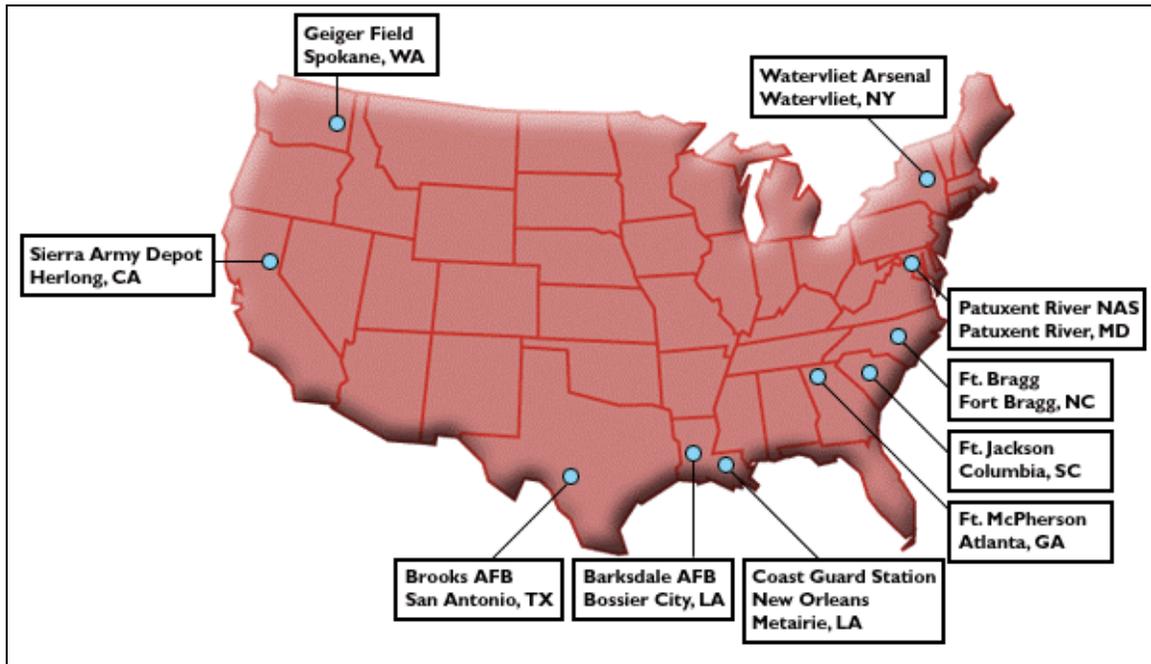


Figure 1. PEM demonstration site map (FY01).

Table 1. DOD Residential PEM Demonstration Fuel Cell Program sites.

Site Name	Building Application	Input Fuel	Size (kW)	No. Units	Cogen. Y/N
Coast Guard Station New Orleans	Office Building	Natural Gas	5	1	Yes
Fort McPherson	Officer's Quarters	Natural Gas	5	1	Yes
Sierra Army Depot	Barracks	Propane	4.5	1	Yes
Brooks AFB	Base Housing	Natural Gas	5	3	No
Fort Bragg	Office Building	Natural Gas	5	1	No
Fort Jackson	Officer's Quarters	Natural Gas	5	1	Yes
Barksdale AFB	Base Housing	Natural Gas	5	1	No
NAS Patuxent River	Office Building	Propane	4.5	1	Yes
NAS Patuxent River	Officer's Quarters	Natural Gas	4.5	1	Yes
Geiger Field	Maintenance Facility	Hydrogen	3	1	No
Watervliet Arsenal	Research Facility	Natural Gas	5	3	No
Watervliet Arsenal	Manufacturing Facility	Natural Gas	5	3	No
Watervliet Arsenal	Officer's Quarters	Natural Gas	5	4	No

Table 2. Fuel cell performance by site, as of September 2003.

Location	Start Date	Avg. Total Run Time (per unit)	Availability	Capacity Factor	Avg. Total Electrical Output (kWe-hrs AC)	Avg. Output for Site (kWe)	Avg. Electrical Efficiency
Brooks Air Force Base							
Tess – SU01R09	2/6/2003	5,267	92.77%	50.53%	14,342	2.72	21.61%
Joe – SU01R04	2/6/2003	4,428	78.00%	41.88%	11,888	2.68	16.43%
Mariah – SU01R013	2/6/2003	5,138	90.50%	50.06%	14,209	2.77	19.38%
Barksdale Air Force Base	2/28/2003	2,679	52.16%	26.00%	6,677	2.49	19.80%
Coast Guard Station New Orleans	11/15/2003*						
Fort Bragg	11/21/2002	4,893	67.06%	34.36%	12,536	2.56	21.78%
Fort Jackson	3/5/2003	4,777	94.77%	47.57%	11,987	2.51	23.03%
Fort McPherson	11/15/2003*						
Geiger Field	3/6/2002	8,330	94.96%	24.21%	6,370	0.76	27.25%
Naval Air Station Patuxent River	Not Installed						
Watervliet Arsenal							
Unit # B100	1/18/2002	8,467	95.81%	50.80%	22,446	2.65	24.75%
Unit # B102	1/18/2002	8,283	93.53%	49.72%	22,017	2.66	24.98%
Unit # B103	1/18/2002	8,667	97.99%	53.65%	23,723	2.74	26.44%
Unit # B104	1/18/2002	8,382	94.78%	48.77%	21,566	2.57	23.64%
Unit # B105	1/21/2002	8,194	93.44%	48.92%	21,449	2.62	24.82%
Unit # B106	1/18/2002	8,520	96.21%	49.67%	21,993	2.58	23.91%
Unit # B95	1/16/2002	8,032	90.31%	44.02%	19,578	2.44	22.78%
Unit # B96	1/15/2002	7,946	89.17%	44.35%	19,761	2.49	23.47%
Unit # B97	1/18/2002	8,412	95.11%	48.40%	21,407	2.54	23.60%
Unit # B98	1/16/2002	8,103	91.17%	46.39%	20,617	2.54	23.37%

* Not yet determined.

4 Analysis

One of the major goals of this demonstration program was to study the efficiency, durability, and total cost of installing and running a stationary PEM fuel cell system. These studies can determine the viability of this technology for many DOD and commercial applications, and can also contribute to the development and improvement of the technology. The feedback from these studies to the industry's manufacturers, technicians, and investors will direct research and development for product improvement.

Table 2 (p 9) lists the current status of each project site at the time of this writing, including total run time, percent availability, capacity factor, average output, and average efficiency for each unit in the FY01 demonstration. Table 3 lists the overall performance of the program to date. The average program efficiency of the fuel cell systems in this demonstration was 23.34 percent. This value is affected by the type of fuel used at each site, as well as the site applications, run time, and variation in machines that are not yet mass-produced. The average capacity factor was 45.10 percent. Capacity factor is defined as the actual energy (kilowatt-hours [kWh]) produced by a fuel cell in a given period, divided by the total energy (kWh) that could be generated by the fuel cell in a given period if the fuel cell were operating at maximum power for 100 percent of the time during that period. Thus, the average fuel cell in this program was running at about 45 percent of its capacity. In future reports, these and other performance values will be compared to those of the FY02 and FY03 demonstrations to note variations due to maintenance, improved products, different loads, etc.

Table 3. Overall program performance to date.

Commission Date	Total Run Hours	Availability (%)	Capability Factor (%)	Energy Produced (kWe-hrs)	Average Output (kW)	Electrical Efficiency (%)
15-Jan-02	115273.2	90.41%	45.10%	283611.3	2.46034	23.20%
Total Hours	Overall Efficiency (%)	Fuel Usage (SCF)	Number of Scheduled Outages	Scheduled Outage Hours	Number of Unscheduled Outages	Unscheduled Outage Hours
127499	23.34%	1337213.8	11	1127	48	5058

Many of the sites were able to achieve the required minimum 90 percent availability during this project. Several did not, for various reasons. At Brooks AFB, one of the three systems initially fell below the availability requirements due to an additional maintenance requirement caused by an experimental catalyst used in this system during the first months of the demonstration. To compensate for this extra maintenance, CERL researchers negotiated with the contractor (Southwest Research Institute) and agreed to: (1) extend the period of the demonstration by 1 month, and (2) reset the start date of the demonstration to drop the data from the first month. Using this strategy, all three units were successful in meeting the 90 percent availability. In another case, the Barksdale AFB installation fell far below required availability due to a high volume of required maintenance, the cause of which has not yet determined. This system will be replaced and the demonstration restarted.

During the course of this project, a trend in PEM fuel cell efficiency degradation was calculated for the Plug Power fuel cells at Watervliet Arsenal. These units were chosen to demonstrate efficiency because of the large number of systems at constant conditions, and because Plug Power systems were the most frequently occurring systems in this demonstration program. Figure 2 plots the efficiency versus run time loss. The data indicates an efficiency degradation of 4.77 percent per 10,000 hours of operation.

The actual installation and maintenance costs of this project are challenging to estimate. It is the responsibility of the contractors to provide a cost estimate with the proposal, but with little previous experience with this type of demonstration, and particularly with the unprecedented minimum 90 percent availability requirement, these estimates required a considerable margin for error to account for unpredictable added costs. The average CERL funding award per fuel cell system was \$151,050. For the 22 systems, the total was \$3,323,092. Future reports should reflect the actual installation and maintenance costs incurred at each site.

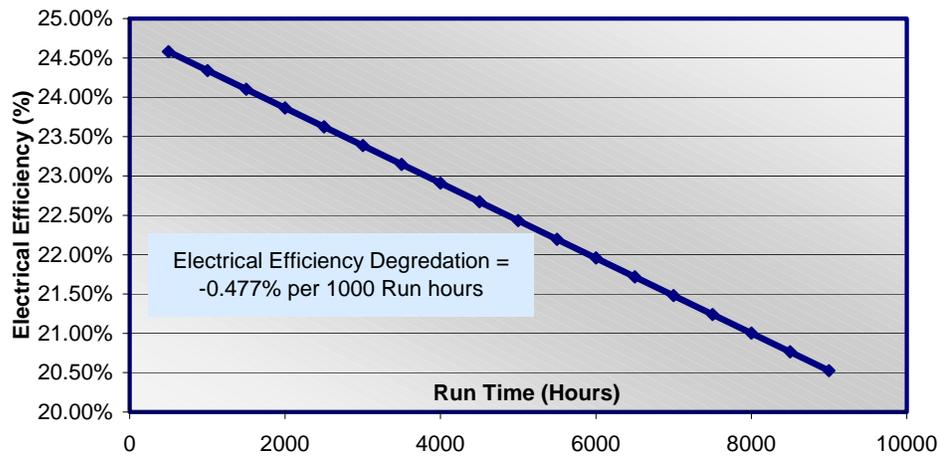


Figure 2. FY01 Plug power units electrical efficiency performance.

5 Industry Changes and Challenges

Utilities

The operational period for each unit at each site in the DOD Residential PEM Fuel Cell Demonstration Program was defined as a minimum of 1 year, but the start date and progress for each depends on a great number of variables. Some of the variables that have affected this program to date include changes within the fuel cell industry, utility interconnect and other siting challenges, and the availability of experienced maintenance personnel as well as spare parts for equipment.

One major challenge faced by the participants of the DOD Residential PEM Fuel Cell Demonstration Program stemmed from the need to coordinate with the local electric utility for electrical grid interconnection. For the most part, DOD installations still own their respective gas, electric, and water utility systems within the confines of the base. However, there is a strong movement currently underway to privatize, or to designate responsibility to someone else for operating and maintaining these utility systems. One of the reasons that 30 Phosphoric Acid Fuel Cells (PAFCs) under the DOD PAFC Demonstration Program could be installed relatively quickly and easily was because the units could be installed and interconnected to the base utility systems with little to no siting or permitting requirements. Some codes and standards related to fuel cells have been developed, and many more are currently under development. Likewise, many DOD installations have privatized their utility systems, and many more are currently negotiating with third parties to take over their utility systems.

For the FY01 DOD Residential PEM Fuel Cell Demonstration Program, the local electric utility company was consulted in most cases before any fuel cells were installed at the individual bases. Where the base was privatized, such as Brooks AFB, the local utility company worked very closely with the contractor and base personnel to satisfy any siting requirements before installing and electrically interconnecting the fuel cell. Many of the 3000+ independent utilities across the nation have yet to adopt a simplified interconnection process, which has slowed the spread of distributed generation technology. Each utility has different standards regarding interconnect with the local grid, and many have no system to reimburse residential generator owners that give power back to the grid.

These types of challenges have led to increased efforts by Public Utility Commissions, the fuel cell industry, and various other public and private entities to standardize, simplify, and reduce the cost of interconnection activities. If the equipment could be certified to a national interconnection standard by a nationally recognized testing laboratory, many of these roadblocks would be lifted.

The electrical interconnect issue was particularly noteworthy at the Watervliet Arsenal site. The local utility, Niagara Mohawk, required a review, an application fee, and additional metering before granting permission to interconnect any power generation equipment to their grid. The expected application and review time of 8 to 12 weeks and the cost of approximately \$5000 per site (Niagara Mohawk Power Corporation, P.S.C. No. 207, v. 5, Rule 12) were challenges that threatened the schedule and budget of the demonstration. The site is a military facility with a single main metered connection line to the grid, so it was decided that Niagara Mohawk did not have the jurisdiction to assess the interconnection. Thus Watervliet Arsenal chose to forgo the interconnection approval process. This action set a precedence; the same argument and decision have subsequently been used at other government and military installations.

Codes and Standards

On 12 June 2003, the IEEE Standards Board approved IEEE 1547 Standard for Interconnecting Distributed Resources With Electric Power Systems (DeBlasio 2003). This standard establishes the long-awaited technical foundation to allow the interconnection of all distributed generation technologies with the electric grid. It also ensures that major investments in distributed generation technology development by the Federal government and industry will result in real-world applications providing alternative sources of electric power to the electric utility operating infrastructure. Many other fuel cell related codes and standards have been and are currently being developed. They deal with installation of fuel cells, performance testing of fuel cells, and many other topics. Appendix C lists the known codes, standards, and regulations that relate to stationary fuel cells and systems.

Companies

As in any new industry, the face of the fuel cell industry is constantly changing. In November 2002, Plug Power Inc. announced its intent to acquire H Power, Inc. Previously, the two competing companies each held contracts with CERL under the FY01 DOD Residential PEM Fuel Cell Demonstration Program to sup-

supply PEM fuel cell units to multiple program sites. When the acquisition of H Power by Plug Power was complete in March of 2003, Plug Power began discussions with CERL to determine options for how to address H Power equipment already installed under FY01 contracts. In the FY02 DOD Residential PEM Fuel Cell Demonstration Program, a contract had been awarded to H Power to install fuel cells at two sites before the announcement of the Plug Power acquisition of H Power. This particular contract and its requirements needed to be addressed as well.

Discussions between CERL and Plug Power resulted in a number of options for each H Power contract site:

1. continue operation with the existing H Power unit(s),
2. substitute an equivalent Plug Power unit(s),
3. postpone the project, or
4. cancel the contract entirely.

Only one of the FY01 project contract sites was postponed because the fuel cell had not yet been installed. Two other sites, Sierra Army Depot and Naval Air Station Patuxent River, had already begun demonstration programs with H Power units installed. The units at Naval Air Station Patuxent River are scheduled to be replaced with Plug Power's equivalent (one natural gas-fueled and one propane-fueled) fuel cells. Sierra Army Depot's installation was cut from the program. This type of industry change, while complicating, is not uncommon in young businesses.

Delta Montrose Electric Association (DMEA), the contract company for the Sierra Army Depot PEM installation, experienced setbacks and other technical challenges resulting from the Plug Power buy-out of H Power, Inc. The highlight of the project proposal for Sierra Army Depot was the expected use of the electrical output of the fuel cell to power a specific geothermal heat pump, called a SynDex system, that would provide heating and cooling to a barracks facility. When the SynDex system did not demand an electrical load, the electricity was to be used to power the pump for an adjacent swimming pool. The fuel cell/SynDex system cost approximately \$200,000 more than the average similar fuel cell demonstration installation at other sites, but due to its potential technological and ecological advantages, CERL approved the contract.

Unfortunately, DMEA found the fuel cell and the SynDex system to be incompatible, and thus elected to use the fuel cell exclusively to power the swimming pool pump. The interim project report reported this change to CERL and also revealed that the fuel cell's performance far met the minimum 90 percent avail-

ability required by the program. These issues, along with the fact that the H Power fuel cell had become obsolete (and was no longer receiving factory parts and service), led CERL to discontinue support for this installation.

Other changes in the fuel cell industry became evident throughout the course of the FY01 program. The Broad Agency Announcement (BAA) that was developed called for pre-proposals from interested parties, and then full proposals after a screening process. Energy Partners, LC. was one company who had submitted a pre-proposal to the initial BAA solicitation. CERL researchers had visited their offices in March of 2001 and had determined that their PEM products and business plan appeared viable. However, Energy Partners received most of their operating capital from a private investor, and in April of 2001 this funding was directed to other investments. As a result, Energy Partners locked the doors to their offices and fired most of its employees.

Modifications to FY01 program contract awards were required due to fuel cell manufacturer bankruptcies and changes in corporate direction. Both Logan Energy Corporation and Southwest Research Institute had awards under the FY01 program where DCH Technology, Inc. fuel cells were to be supplied for various sites. Logan Energy had proposed a DCH Technology fuel cell for Fort Jackson, and Southwest Research Institute had proposed three DCH Technology fuel cells for Brooks AFB. These contracts were awarded before DCH Technology filed a Form 8-K with the Securities and Exchange Commission (SEC) in June 2002, which described the furloughing of all employees. DCH Technology subsequently disbanded its operations. The contracts with Logan Energy and with Southwest Research Institute were modified to substitute Plug Power fuel cells for the DCH Technology units.

Regarding changes in corporate direction, Logan Energy had proposed installing natural gas-fueled Avista Labs' fuel cells at Fort Bragg and Barksdale AFB, and a propane-fueled Avista Labs fuel cell at MCB Kaneohe Bay. After the contract was awarded, Avista Labs announced in May of 2002 that it was laying off six of its managers, including its president and chief operating officer. This was a result of the inability to find a funding partner for the company. Subsequently, Avista Labs restructured its business plan to focus the majority of its resources on the development of hydrogen-fueled fuel cells, and to scale back its efforts on developing natural gas and propane reformers. Consequently, the units which were slated for Logan Energy's contracts would not be available to meet the proposed delivery and installation schedule. Logan Energy's FY01 program contract was then modified to eliminate MCB Kaneohe Bay as a site (because of the lack of availability of a propane-fueled fuel cell from any manufacturer at the time), and to substitute Plug Power fuel cells for Fort Bragg and Barksdale AFB.

6 Summary

This demonstration planned, installed, operated, and documented the performance of PEM fuel cells in a variety of geographic locations supporting operations at military installations. This demonstration set an unprecedented requirement for the fuel cells to achieve minimum 90 percent availability since the requirement was necessary to demonstrate PEM fuel cell systems as a viable technology for various building applications and other small-scale stationary demands. The demonstration was a success in this respect, as the first sites to complete the 1-year program DOD Residential PEM Fuel Cell Demonstration Program (Geiger Field and Watervliet Arsenal) both met and surpassed the minimum 90 percent availability requirement.

All of the fuel cells in the FY01 program have provided valuable experience and feedback that has led to the greater understanding of the role of these fuel cells in the DOD, manufacturers' technological advancements and enhancements of their products, and an increased proficiency and promulgation of the contractors who are installing, operating, and maintaining PEM fuel cell systems.

References

Bush, G.W., *Presidential State of the Union Address* (Washington, DC, 2003).

106th Congress, 2d Session (FY 2001), *Defense Appropriations House Committee Report* (H. Rpt. 106-644)

Niagara Mohawk Power Corporation, P.S.C. No. 207, v. 5, Rule 12.

DeBlasio, Richard, Hydrogen Safety Report, *IEEE 1547 Interconnection Standard Approved* (National Hydrogen Association, July 2003), available through URL:
<http://www.hydrogensafety.info/articles/03-July-01.asp>

Appendix A: DOD Residential PEM Fuel Cell Demonstration Program Sites

This Appendix provides a brief overview of the character, significance, and approach at each site in the DOD Residential PEM Fuel Cell Demonstration Program. More complete details on each individual site including photographs, operational data, points of contact (POCs) and the contract deliverables (Initial Project Description, Midpoint Report, and Final Report), are available through URL:

<http://www.dodfuelcell.com>

Barksdale Air Force Base

Barksdale Air Force Base is located next to 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 (Figure A1). It serves as a total force war fighting headquarters, employing decisive global air power for U.S. Atlantic Command and U.S. Strategic Command.

LOGANEnergy Corporation coordinated with CERL and Barksdale AFB to purchase, install, test, and evaluate PEM fuel cells at this site. This project was commissioned on 28 February 2003. One 5 kW PEM fuel cell manufactured by

Plug Power is installed at Building #4650, an airman's dormitory building (Figure A2). The unit was installed just outside a doorway that leads directly into the building mechanical room, providing the necessary water and power interfaces. Natural gas was also available adjacent to the building. The unit is set to operate at 2.5 kW for the 1-year demonstration period, but has accomplished an average availability of only 57.0 percent, due to countless system problems. At this writing, the fuel cell program at Barksdale Air Force Base was suspended until the failed fuel cell system could be replaced, and the program timeline restarted.



Figure A1. Front entrance at Barksdale AFB.



Figure A2. Installation at Barksdale AFB, LA.

Brooks Air Force Base

Brooks Air Force Base (AFB) is located in San Antonio, TX. It is home to the 311th Human Systems Wing whose primary mission is “the development of combat power and efficiency through the many facets of aerospace medicine.” Also known as “Brooks City-Base,” this site serves as a partnership between the Air Force and the San Antonio community, to promote bioscience, academic, environmental, and technical development. Local electricity for Brooks AFB is supplied by San Antonio City Public Service, and natural gas is provided by El Paso Natural Gas.



Figure A3. Fuel cells at Brooks AFB residence.

Southwest Research Institute contracted with CERL and Brooks AFB to provide and test PEM fuel cells at this site. Three 5 kW PEM fuel cells manufactured by Plug Power Inc have been installed at Brooks AFB, and are providing power to individual base housing units (Figure A3). The fuel cell systems at this site were all commissioned on 31 January 2003. There is no thermal recovery of fuel cell heat at this site. To date, the average availability at this site is 87.3 percent. Continuously updated real-time data on this site project obtained by SwRI is available through URL:

<http://www.swri.org/fuelcell>

Coast Guard Station New Orleans

Coast Guard Station New Orleans is located 20 minutes south of downtown New Orleans, LA, and is home to VP-94, Coast Guard, and the U.S. Customs Service. New Orleans Station maintains a 24-hour operational capability to support launches and recoveries of U.S. Coast Guard Sea-Air Rescue, U.S. Customs Alert, and 159th Fighter Group/Louisiana Air National Guard.

LOGANEnergy chose this site for a PEM fuel cell demonstration. The U.S. Coast Guard Station in New Orleans was one of two program sites chosen to be accelerated from the fiscal year 2002 program to the 2001 program to replace project sites canceled due to industry changes. At the time of this report, the fuel cell unit had been placed on site (Figure A4), but has not yet been installed. Installation is anticipated to take place before the end of the year.



Figure A4. Unit at Coast Guard Station New Orleans.

Fort Bragg

Fort Bragg, near Fayetteville, NC, is home of the Airborne and Special Operations Command. Founded in 1918, Fort Bragg prides itself on its ability to deploy anywhere in the world on little or no notice. Fort Bragg has average high and low temperatures between 91 and 33 °F. It is located at approximately 35 degrees N latitude, 79 degrees W longitude, and has an elevation of 305 ft.

The demonstration site will be located at the base Environmental Center. It will host a 5kW 120/240 vac, SU-1 PEM technology demonstration unit manufactured by Plug Power Corporation, Latham, NY. The unit will be installed in a grid parallel / grid synchronized configuration and operate nominally at 2.5kW during the 1-year demonstration test program (Figures A5 and A6). The unit will be instrumented with an external Wattmeter and a gas flow meter. A phone line will be connected to a data modem within the power plant to call out to Plug Power with alarms or events requiring service and attention.



Figure A5. Installation at Fort Bragg, NC.



Figure A6. Thermal recovery system.

Fort Jackson

Fort Jackson lies near historic Columbia, SC and was founded in 1917 as a new Army training camp to prepare soldiers for WWI. Today, Fort Jackson is the largest and most active Initial Entry Training Center in the United States Army, providing training to almost 50 percent of the men and women who enter the

service each year. While some military installations have experienced downsizing and closure in recent years, Fort Jackson has added several new schools and training institutions including the Soldier Support Institute, the Chaplains Center and School, and the Department of Defense Polygraph Institute. Fort Jackson has average high and low temperatures between 95 and 36 °F. It is located at approximately 34 degrees N latitude, 81 degrees W longitude, and has an elevation of 193 ft.



Figure A7. Installation at Fort Jackson, SC.

In March 2002, LOGANEnergy contacted Mr. Jerry Fuchs, utility engineer at Fort Jackson, to introduce the DOD Residential PEM Fuel Cell Demonstration Program. In May 2002, Mr. Fuchs informed LOGAN that Fort Jackson would like to be considered as a host site in the PEM program. LOGAN subsequently contracted with Plug Power to supply a 5kW GenSys5C for the Fort Jackson project. The chosen site for the PEM demonstration was the personal residence of the garrison commander (Figure A7).

Fort McPherson

Fort McPherson is located a short distance to the southwest of Atlanta, GA, and serves as the headquarters of the U.S. Army Garrison. The base stands on the 1835 site of the Army of Atlanta's meeting and training grounds. Today, the greater than 100-acre site contains over 40 buildings on the National Register of Historic Places. Together with nearby Fort Gillem, Fort McPherson is Atlanta's fifth largest employer.

LOGANEnergy Corporation has chosen the oldest building at Fort McPherson for a PEM demonstration project site. Fort McPherson was one of two program

sites chosen to be accelerated from the fiscal year 2002 program to the 2001 program to replace project sites canceled due to industry changes. At the time of this report, the fuel cell unit has been sited, but will not be officially installed until later this year (Figure A8).



Figure A8. Siting at Fort McPherson, GA.

Geiger Field

The Air National Guard base is located at Geiger Field is 5 miles west of Spokane, WA. The Air National Guard Unit stationed at the base is the 242nd Combat Communications Squadron. The 242nd provides mobile communications infrastructure to military operations. Average high and low temperatures AT Geiger Field range between 83 and 22 °F. It is located at approximately 47 degrees N latitude, 117 degrees W longitude, and has an elevation of 2372 ft.

The site chosen for the PEM demonstration unit at Geiger Field is a maintenance facility (Figure A9). The Avista Labs SR-72, 3kW fuel cell is installed in Building 401 at the Geiger Field installation. This building is dedicated to servicing and maintaining the 242nd's portable generators.



Figure A9. Avista Labs fuel cell units at Geiger Field, Spokane WA.

Patuxent River NAS

Naval Air Station Patuxent River (PAX River NAS) is located at the mouth of the Patuxent River, in southern Maryland. PAX River NAS occupies about 7800 acres on Cedar Point, overlooking the Chesapeake Bay. It was commissioned in 1943 and has since become an integral part of historic St. Mary's County. PAX River NAS is the home of the Naval Air Systems Command, Naval Air Warfare Center Aircraft Division and approximately 50 tenant activities. Today it is considered one of the most beautiful and vital shore installations in existence. Average high and low temperatures at PAX River NAS range between 86 and 28 °F.

The two sites chosen for PEM demonstration sites were: (1) an Office Building, and (2) an Officers' Quarters. The original 4.5-kW PEM units were manufactured by H Power, Inc. (Figure A10), and the original contract was awarded to Southern Maryland Electric Cooperative (SMECO). This project was later challenged to efficiently and with relative economical feasibility replace the H Power unit with the equivalent Plug Power fuel cell.



Figure A10. Interior of H Power fuel cell.



Figure A11. Installing fuel cell at Patuxent River.

The units were installed and operational in October of 2002 (Figure A11), but in November of 2002, Plug Power announced the intended acquisition of H Power and all of their assets. From that point forward, the two H Power units at PAX River NAS were not adequately maintained, and had been unable to achieve the minimum 90 percent availability as stated in the contract. In March 2003, Plug Power completed acquisition of H Power, and ERDC/CERL was able to begin negotiations with SMECO to determine how the project could be salvaged. SMECO obtained a proposal from Plug Power for \$192,000 to replace the H Power units at PAX River NAS with Plug Power units. Further terms were that Plug Power would provide the maintenance, through Logan Energy Corp., to achieve the minimum 90 percent availability requirement for a demonstration period of 1 year.

The two H Power units would be disposed of by transferring title of the natural gas unit to PAX River NAS, who intended on putting it in their museum, and the

propane unit would be shipped to the DOD Fuel Cell Test & Evaluation Center (FC *Tec*) in Johnstown PA.

Sierra Army Depot

Sierra Army Depot is located in Herlong, CA. Their mission is to provide rapid deployment of the best quality equipment and supplies to anywhere in the world. They provide maintenance, storage, logistics, and training to all Army assets worldwide, including Operational Project Stocks for Deployable Medical Systems, Medical Supplies, Petroleum and Water Systems, Aviation Systems, and Force Provider.

A contract to Delta Montrose Electric Authority (DMEA) was awarded to install a 4.5 kW PEM fuel cell manufactured by H Power adjacent to the swimming pool facility. Heat from the fuel cell was to be used for heating the swimming pool. Originally, the electrical output was to run across the street to power a ground-source heat pump that would provide heating and cooling to a barracks facility. When there was no load demand from the ground-source heat pump, the fuel cell electrical output would be fed to a 3 hp motor in the pool's pump room. The system was also designed to operate in the event of a utility grid outage.

Unfortunately, the ground-source heat pump SynDex system, which was to be the highlight of this installation, was found to be electrically and physically incompatible with the fuel cell. Due to the combined setbacks from the change of ownership at H Power and the incompatibility of the SynDex system, this installation was dropped from the DOD Residential PEM Fuel Cell Demonstration Program.

Watervliet Arsenal

Watervliet Arsenal is located on the Hudson River just a few miles north of the New York state capital of Albany. Founded in 1813, Watervliet Arsenal is the nation's oldest manufacturing arsenal. It remains to be one of the countries most sophisticated cannon and armaments manufacturing and metals processing facilities.



Figure A12. Four Plug Power units installed at Watervliet Arsenal, NY.

The Watervliet Arsenal in Watervliet, NY was considered and eventually chosen primarily due to its proximity to the PEM fuel cell manufacturer, Plug Power. Average high and low temperatures at Watervliet range between 83 and 10 °F, with extremes reaching 101 and -25 °F. It is located at approximately 43 degrees N latitude, 75 degrees W longitude, and has an elevation of 275 ft.

The three sites chosen for PEM demonstration sites were: (1) the Officers' Quarters (Building 19), (2) a Manufacturing Facility (Building 110), and (3) a Research Facility (Building 115). The Officers' Quarters is a historic building at the Arsenal that has been converted into four units designed for family housing (Figure A12). One PEM fuel cell was installed at each housing unit's electrical service. Building 110 is a heavy machining facility. The three PEM fuel cells at this site (Figure A13) support the electrical loads in this room. Building 115 is a laboratory facility. The three PEM fuel cells at this site supported a destructive testing lab inside the building.



Figure A13. Installation of PEM fuel cells at Watervliet Arsenal, NY.

The 5 kW PEM units were manufactured by Plug Power, Inc. Based on a system setpoint of 2.5 kW, the 10 fuel cell systems produced over 214,000 kWh in support to the Arsenal operations during the operational period of the demonstration. The total energy savings from the operation of these units for the demonstration period was approximately \$6,000.

Appendix B: Broad Agency Announcement (CERL-BAA-FY01)

Preface

The Construction Engineering Research Laboratory (CERL) is part of the U.S. Army Engineer Research and Development Center (USAERDC), 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. CERL's 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 for 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 and 20 kW will be considered in this BAA. Initial proposals received under this announcement must be submitted by 31 May 2001 for awards to be made from current FY2001 funding (approximately \$3 million currently available). Although funding is not currently available for awards beyond 30 September 2001, this announcement shall remain open for a period of up to 1 year or until superceded. As a result, proposals received beyond 31 May 2001 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.

If you have any questions concerning submittal or contractual requirements, please contact Mrs. Rita Brooks of the Vicksburg Consolidated Contracting Office, Champaign Field Office, at (217)373-7280 or via email at:

Rita.S.Brooks@erdc.usace.army.mil.

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, however, this is not a requirement of this BAA. Identification of specific sites is not a requirement of this BAA, however, identification of a geographic region where the offeror can install the unit(s) is required. 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.

1. *Domestically Produced Residential Fuel Cells.* Only units between the sizes of 1 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 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).
2. *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.
3. *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.
4. *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.
5. *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).
6. *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 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 encour-

aged to propose additional data collection to provide more detailed performance analyses of the unit(s).

7. *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.
8. *Geographic Regions.* The offeror shall identify in the 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 U.S. Census Map (Figure B1) include: 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.

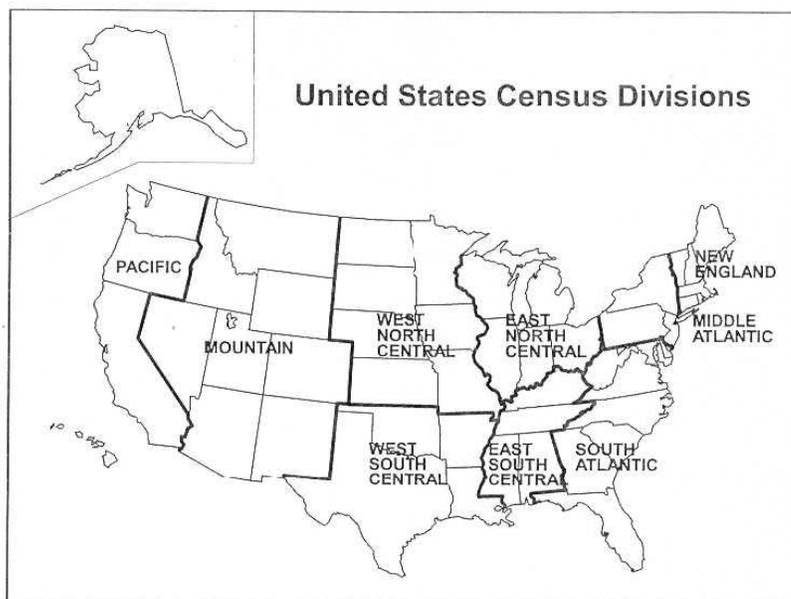


Figure B1. U.S. census divisions.

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 Table B1.

Table B1. Parameters under individual project(s) will be performed.

Fuel			Altitude
Natural Gas	Grid Connect	Cogeneration	Sea Level < 500 ft
Propane	Grid Independent	No Cogeneration	500 ft < 1250 ft
Hydrogen	Both (alternating)		1250 ft < 4000 ft
Other			4000 ft < 5280 ft
			> 5280 ft
Single Units	Fuel Switching	Remote Site?	Hybrid System?
Ganged Units	No Fuel Switching		
	Fuel Blending		
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 (Microsoft® Word for reports and summary data, Microsoft® 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). As an example of the type of information required, refer to the DOD Fuel Cell Demonstration Website 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. On 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. CERL-BAA-FY01. 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
PO 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:

1. A descriptive title of the research proposed.
2. The name and address of the individual, company, or educational institution submitting the pre-proposal.
3. The name and phone number of the principal investigator or senior researcher who would be in charge of the project.
4. 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.
5. The proposed duration of the project.
6. The estimated costs, including but not limited to labor, materials, fringe benefits, overhead, and profit (if any).
7. 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.

8. 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.
9. A one-page only resume/vitae of the principal investigator and/or key personnel who will be involved with the project.

F. Full Proposal Format and Requirements.

1. Full proposals will be accepted only on request from the Vicksburg Consolidated Contracting Office, as the direct result of a favorably evaluated pre-proposal.
2. Full proposals shall include a more detailed description of all the information submitted with the pre-proposal, 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.
3. 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 that 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, if available (the Government will provide the offeror with the name of any installation's energy manager, on request).
 - 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.
 - 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.

4. 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. A complete cost breakdown of direct labor by discipline, function or position, hours proposed or percentage of time, and hourly rate or salary
 - b. Fringe benefit percentage rate and cost base.
 - c. An itemized list of equipment showing the estimated cost of each item, including documentation of catalog or market prices, if applicable.
 - d. Description and cost of expendable supplies.
 - e. A complete breakdown of travel requested by the offeror to include airfare, rental car, per diem, etc.
 - f. 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.
 - g. A breakdown of other direct costs (e.g., reproduction, computer time, etc.).
 - h. 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.
 - i. Proposed fee or profit, if any.
5. 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 and phone number of the offeror's authorized negotiators.
 - 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 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 offeror's 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. On completion of the evaluation, each offeror will be notified either of rejection, and the rationale for this decision, or of acceptance:

1. *Total proposal cost / installed kW rating of fuel cells.*
2. *The offeror's capabilities, related experience, facilities, techniques, or unique combinations of these that are integral factors for achieving the proposal objectives.*
3. *Reasonableness and firmness of production/project timetables.*
4. *Uniqueness of proposal/project.*
5. *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.
6. *The qualifications, capabilities, and experience of the principal investigator, team leader, and other key personnel* who are critical to achievement of the proposal objectives.
7. *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 FY2001 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 C: Hydrogen Codes, Standards and Regulations for Stationary Applications

The source for the following information is:

DeBlasio, Richard, Hydrogen Safety Report, "IEEE 1547 Interconnection Standard Approved" (National Hydrogen Association, July 2003), available through URL:
<http://www.hydrogensafety.info/articles/03-July-01.asp>

		HYDROGEN CODES, STANDARDS AND REGULATIONS MATRIX (June		
Gregoire		<i>hydrogen_C&S_Matrix_Mas-ter_Gregoire_27Jun03.xls</i>	6/27/2003	
1.0 STATIONARY APPLICATIONS Residential, Commercial and Government Buildings and Utility Applications)				

	1.1 Fuel Cells		DESCRIPTION	TECHNICAL CONTACTS	STATUS
	1.1.1 Fuel Cell Hardware				
		ANSI Z21.83-1998: Fuel Cell Power Plants	The standard applies to packaged, self-contained or factory matched packages of integrated systems of fuel cell power plants for use with natural gas or LP gas and having a maximum output voltage of 600 VAC and power output of 1000 kW	Steven E. Kasubski CSA International (216) 524-4990 X8303	The standard is being revised to more adequately more types of fuel cells and the fuels to be utilized and will become CSA FC 1
		CSA FC 1: Fuel Cell Power Plants (Planned Replacement for ANSI Z21.83-1998)	The document applies to fuel cell systems for stationary applications having maximum output voltage of 600 V and power output up to 10 MW. CSA America Fuel Cell Technical Advisory Committee proposes CSA FC 1 to be the revised, enhanced version of ANSI Z21.83	Steven E. Kasubski CSA International (216) 524-4990 X8303	Draft of CSA FC 1 released for review after the April 2002 meeting of the Committee
		CSA FC 4: Fuel Cell Modules	This is a proposed future new standard for fuel cell modules.	Steven E. Kasubski CSA International (216) 524-4990 X8303	Proposed future effort of the CSA Fuel Cell Technical Advisory Committee.
		UL 2265: Replacement Fuel Cell Power Units for Appliances	This standard will cover stand-alone fuel cell power systems that may be connected within the enclosure of an appliance by a flexible cord and plug or other arrangement (auxiliary power supply)	Harry Jones Underwriters Laboratories (847) 664-2948	Underwriter Laboratories is working to develop this standard.
		IEC TC105 Working Group 1: Terminology	The document provides uniform terminology in the form of diagrams, definitions and equations related to fuel cell technologies for all applications. It is intended to be a resource for the other IEC TC 105 working groups.	Kelvin Hecht UTC Fuel Cells (860) 673-9181	Revised draft of the technical report is in the review process.

		IEC TC105 Working Group 2: Fuel Cell Modules	The Working Group is developing a standard that addresses the safety and performance of fuel cell modules.	Kelvin Hecht UTC Fuel Cells (860) 673-9181	The draft standard was completed in January and was in the review process from 2 Feb 02 - 10 May 02. The WG will meet in June 2002 to address review comments.
		IEC TC105 Working Group 3: Safety of Stationary Fuel Cell Power Plants	The Working Group is developing a standard that addresses safety requirements (design and performance) for packaged stationary fuel cell power plants. The standard will parallel ANSI Z21.83 and similar standards in Canada, Japan and Germany.	Kelvin Hecht UTC Fuel Cells (860) 673-9181	The Working group is in the process of developing the initial draFort This is expected to be completed by October 2002.
		CSA U.S. Requirements No. 1.01: Residential Fuel Cell Power Generators	This document supplements the provisions in ANSI Z21.83-1998. It applies to packaged, self-contained fuel cell systems for single-family and two-family dwellings installed outdoors rated at no greater than 50 kW. Plans call for replacing it with CSA FC 2	Todd Strothers CSA International (704) 552-5125	The document has been published and is available for sale.
1.1.2 Installation					
		NFPA 853: Standard for the Installation of Stationary Fuel Cell Power Plants	The standard covers siting requirements, fuel storage arrangements, exhaust requirements and fire protection requirements for stationary fuel cell plants exceeding 50 kW for non-residential applications	Richard P. Bielen NFPA International (617) 770-3000	The standard is in the process of being revised to include small fuel cell applications for residences
		NFPA 54: National Fuel Gas Code	The Code covers installation of fuel gas piping systems, fuel gas utilization equipment and related accessories. The Code covers fuel gas systems operating at a maximum pressure of 125 psi.	Theodore C. Lemoff NFPA International (617) 984-7434	NFPA 54 is a published code available for purchase.
		IEC TC105 Working Group 5: Installation of Stationary Fuel Cell Power Plants	The Working Group will develop a standard that covers the installation of stationary fuel cell power plants and their integration with the surrounding built environment. It will parallel NFPA 853.	Kelvin Hecht UTC Fuel Cells (860) 673-9181	The project was recently approved. The Working Group has been established and has started working on the draFort The draft is expected to be completed in 2003.

1.2 Fuel Processor/Reformer			DESCRIPTION	TECHNICAL CONTACTS	STATUS
		1.2.1 Fuel Processor/Reformer Hardware			
		CSA FC 1: Fuel Cell Power Plants	The document applies to fuel cell systems for stationary applications having maximum output voltage of 600 V and power output up to 10 Mw. CSA America Fuel Cell Technical Advisory Committee proposes CSA FC 1 to be the revised, enhanced version of ANSI Z21.83	Steven E. Kasubski CSA International (216) 524-4990 X8303	Draft of CSA FC 1 released for review after the April 2002 meeting of the Committee
		1.2.2 Fuel Processor/Reformer Installation			
		ANSI Z21.83-1998: Fuel Cell Power Plants	The standard applies to packaged, self-contained or factory matched packages of integrated systems of fuel cell power plants for use with natural gas or LP gas and having a maximum output voltage of 600 VAC and power output of 1000 kW	Steven E. Kasubski CSA International (216) 524-4990 X8303	The standard is being revised to more adequately more types of fuel cells and the fuels to be utilized and will become CSA FC

1.3 Fuels for Fuel Cells (Focusing on H2)			DESCRIPTION	TECHNICAL CONTACTS	STATUS
		NFPA 853: Standard for the Installation of Stationary Fuel Cell Power Plants	The standard covers siting requirements, fuel storage arrangements, exhaust requirements and fire protection requirements for stationary fuel cell plants exceeding 50 kW for non-residential applications	Richard P. Bielen NFPA International (617) 770-3000	The standard is in the process of being revised to include small fuel cell applications for residences
		NFPA 54: National Fuel Gas Code	The Code covers installation of fuel gas piping systems, fuel gas utilization equipment and related accessories on consumers' premises. The Code covers fuel gas systems operating at a maximum pressure of 125 psi.	Theodore C. Lemoff NFPA International (617) 984-7434	NFPA 54 is a published code available for purchase.

1.4 Fuel Storage and Dispensing (Focus on H2)			DESCRIPTION	TECHNICAL CONTACTS	STATUS
		ASME B31.1	Power Piping: This code prescribes minimum requirements for the design, materials, fabrication, erection, test, and inspection of power and auxiliary service piping systems for electric generation stations, industrial institutional plants, central and district heating plants. The code covers boiler external piping for power boilers and high temperature, high pressure water boilers in which steam or vapor is generated at a pressure of more than 15 PSIG; and high temperature water is generated at pressures exceeding 160 PSIG and/or temperatures exceeding 250 degrees F.	Gerry Eisenberg, ASME International, EisenbergG@asme.org	Published and available for sale.
		ASME B31.3	Process Piping: Rules for the Process Piping Code Section B31.3 have been developed considering piping typically found in petroleum refineries; chemical, pharmaceutical, textile, paper, semiconductor, and cryogenic plants; and related processing plants and terminals. This Code prescribes requirements for materials and components, design, fabrication, assembly, erection, examination, inspection, and testing of piping. This Code applies to piping for all fluids	Gerry Eisenberg, ASME International, EisenbergG@asme.org	Published and available for sale.
		ASME B31.9	Building Services Piping: This Code Section has rules for the piping in industrial, institutional, commercial and public buildings, and multi-unit residences, which does not require the range of sizes, pressures, and temperatures covered in B31.1. This Code prescribes requirements for the design, materials, fabrication, installation, inspection, examination and testing of piping systems for building services. It includes piping systems in the building or within the property limits.	Gerry Eisenberg, ASME International, EisenbergG@asme.org	Published and available for sale.

1.4 Fuel Storage and Dispensing (Focus on H2)			DESCRIPTION	TECHNICAL CONTACTS	STATUS
		ASME Hydrogen Piping Task Force	This task force is charged with addressing requirements for piping in hydrogen service within codes and standards. One possibility is a single standard that would contain requirements, including metallic and composite materials, for hydrogen piping and pipelines. Applications could include process plants, power generation stations, hydrogen vehicle refueling stations, transport tank refilling stations, pipelines and residential household applications.	John Koehr, ASME International, KoehrJ@asme.org	Potential new standard
		ASME Boiler and Pressure Vessel Code, Section VIII (BPVC-VIII), Division 1	Rules for Construction of Pressure Vessels, Division 1: This Division of Section VIII provides requirements applicable to the design, fabrication, inspection, testing, and certification of pressure vessels operating at either internal or external pressures exceeding 15 psig.	Gerry Eisenberg, ASME International, EisenbergG@asme.org	Published and available for sale.
		ASME BPVC-VIII Division 2	Rules for Construction of Pressure Vessels, Division 2,	Gerry Eisenberg, ASME International,	Published and available for sale.
			Alternative Rules: This Division of Section VIII provides requirements applicable to the design, fabrication, inspection,	EisenbergG@asme.org	
			testing, and certification of pressure vessels operating at either		
			internal or external pressures exceeding 15 psig. In comparison		
			the Division 1, Division 2 requirements on materials, design, and		
			nondestructive examination are more rigorous; however, higher		
			design stress intensify values are permitted.		
		ASME BPVC-VIII Division 3	Rules for Construction of Pressure Vessels, Division 3, Alternate	Gerry Eisenberg, ASME	Published and available for sale.
			Rules High Pressure Vessels: This Division of Section VIII	International,	
			provides requirements applicable to the design, fabrication,	EisenbergG@asme.org	
			inspection, testing, and certification of pressure vessels		
			operating at either internal or external pressures generally above		
			10,000 psi. Division 3 does not establish maximum pressure		
			limits for either Section VIII, Divisions 1 or 2, nor minimum		
			pressure limits for this Division.		
		ASME Code Case 2390	Composite Reinforced Pressure Vessels, Section VIII, Division	Gerry Eisenberg, ASME	Published and available for sale.
			3: This Code Case allows construction of CRPVs consisting of	International,	
			metallic cylindrical layer wrapped circumferentially with a layer	EisenbergG@asme.org	
			of glass fiber reinforced plastic laminate leaving the metallic		
			heads unwrapped, may be constructed under the rules of Section		
			VIII, Division 3 and additional requirements of the code case.		
			Max operating pressure shall not exceed 3625 psi (25 MPa).		
		ASME BPVC-X	Fiber-Reinforced Plastic Pressure Vessels: This Section	Gerry Eisenberg, ASME	Published and available for sale.
			provides requirements for construction of an FRP pressure	International,	
			vessel in conformance with a manufacturer's design report. It	EisenbergG@asme.org	

1.4 Fuel Storage and Dispensing (Focus on H2)			DESCRIPTION	TECHNICAL CONTACTS	STATUS
			includes production, processing, fabrication, inspection and		
			testing methods required for the vessel. Section X includes two		
			Classes of vessel design; Class 1 a qualification through the		
			destructive test of a prototype and Class II, mandatory design		
			rules and acceptance testing by nondestructive methods.		
		ASME Hydrogen Storage Tank Task Force	The task force is charged with addressing requirements for hydrogen storage tanks within codes and standards. A standard that would contain requirements, including metallic and composite materials, for both stationary and transport hydrogen storage tanks with capacities larger than 5 Kg of all types, including low-pressure metal hydride storage to storage at pressures up to say 10,000 psig. Tanks could be constructed of metal, non-metals and combinations thereof.	Gerry Eisenberg, ASME International, EisenbergG@asme.org	Potential new standard
		ISO TC/197: Standard for Hydride Containers	NHA Working Group 2 developed a standard for hydride		
			containers and successfully turned it over to ISO TC/197 for		
			adoption.		
		ISO-TC 58: Tanks and Hydrogen Embrittlement		Norm Newhouse	
				Lincoln Composites	
				(402) 464-8211	
		CGA G-5.4: Standard for Hydrogen Piping	The standard covers materials and components selection to	Roger Smith	The standard is published and available for
		Systems at Consumer Locations	help install a safe, effective hydrogen supply system at a user's	Compressed Gas Association	sale.
			site.		
				(703) 788-2721	

1.5 Safety Systems			DESCRIPTION	TECHNICAL CONTACTS	STATUS
		ANSI Z21.83-1998: Fuel Cell Power Plants	The standard applies to packaged, self-contained or factory matched packages of integrated systems of fuel cell power plants for use with natural gas or LP gas and having a maximum output voltage of 600 VAC and power output of 1000 kW	Steven E. Kasubski CSA International (216) 524-4990 X8303	The standard is being revised to more adequately more types of fuel cells and the fuels to be utilized and will become CSA FC 1
		NFPA 72: National Fire Alarm Code	The Code deals with the application, installation, performance and maintenance of protective signaling systems and their components	Lee F. Richardson NFPA	The standard is published and available for sale.

1.6 Interfacing (with Building or Utility Interconnection)			DESCRIPTION	TECHNICAL CONTACTS	STATUS
		1.6.1 Piping			
		ANSI Z21.83-1998: Fuel Cell Power Plants	The standard applies to packaged, self-contained or factory	Steven E. Kasubski	The standard is being revised to more
			matched packages of integrated systems of fuel cell power	CSA International	adequately more types of fuel cells and the

1.6 Interfacing (with Building or Utility Interconnection)			DESCRIPTION	TECHNICAL CONTACTS	STATUS
			plants for use with natural gas or LP gas and having a maximum	(216) 524-4990 X8303	fuels to be utilized and will become CSA FC
			output voltage of 600 VAC and power output of 1000 kW		1
		NFPA 853: Standard for the Installation of Stationary Fuel Cell Power Plants	The standard covers siting requirements, fuel storage arrangements, exhaust requirements and fire protection	Richard P. Bielen NFPA International	The standard is in the process of being revised to include small fuel cell applications
			requirements for stationary fuel cell plants exceeding 50 kW for non-residential applications	(617) 770-3000	for residences
		NFPA 58: Liquefied Petroleum Gas Code	This code applies to the highway transportation of LP gas and to the design, construction, installation and operation of all LP gas systems.	Theodore C. Lemoff NFPA International (617) 984-7434	The code has been published and is available for sale.
		NFPA 54: National Fuel Gas Code	The Code covers installation of fuel gas piping systems, fuel gas utilization equipment and related accessories on consumers' premises. The Code covers fuel gas systems operating at a maximum pressure of 125 psi.	Theodore C. Lemoff NFPA International (617) 984-7434	NFPA 54 is a published code available for purchase.
		ASME B31.1	Power Piping: This code prescribes minimum requirements for the design, materials, fabrication, erection, test, and inspection of power and auxiliary service piping systems for electric generation stations, industrial institutional plants, central and district heating plants. The code covers boiler external piping for power boilers and high temperature, high pressure water boilers in which steam or vapor is generated at a pressure of more than 15 PSIG; and high temperature water is generated at pressures exceeding 160 PSIG and/or temperatures exceeding 250 degrees F.	Gerry Eisenberg, ASME International, EisenbergG@asme.org	Published and available for sale.
		ASME B31.3	Process Piping: Rules for the Process Piping Code Section B31.3 have been developed considering piping typically found in petroleum refineries; chemical, pharmaceutical, textile, paper, semiconductor, and cryogenic plants; and related processing plants and terminals. This Code prescribes requirements for materials and components, design, fabrication, assembly, erection, examination, inspection, and testing of piping. This Code applies to piping for all fluids	Gerry Eisenberg, ASME International, EisenbergG@asme.org	Published and available for sale.
		ASME B31.9	Building Services Piping: This Code Section has rules for the piping in industrial, institutional, commercial and public buildings, and multi-unit residences, which does not require the range of sizes, pressures, and temperatures covered in B31.1. This Code prescribes requirements for the design, materials, fabrication, installation, inspection, examination and testing of piping systems for building services. It includes piping systems in the	Gerry Eisenberg, ASME International, EisenbergG@asme.org	Published and available for sale.

1.6 Interfacing (with Building or Utility Interconnection)			DESCRIPTION	TECHNICAL CONTACTS	STATUS
			building or within the property limits.		
		ASME Hydrogen Piping Task Force	This task force is charged with addressing requirements for piping in hydrogen service within codes and standards. One possibility is a single standard that would contain requirements, including metallic and composite materials, for hydrogen piping and pipelines. Applications could include process plants, power generation stations, hydrogen vehicle refueling stations, transport tank refilling stations, pipelines and residential household applications.	John Koehr, ASME International, KoehrJ@asme.org	Potential new standard
		1.6.2 Electrical			
		ANSI Z21.83-1998: Fuel Cell Power Plants	The standard applies to packaged, self-contained or factory matched packages of integrated systems of fuel cell power plants for use with natural gas or LP gas and having a maximum output voltage of 600 VAC and power output of 1000 kW	Steven E. Kasubski CSA International (216) 524-4990 X8303	The standard is being revised to more adequately more types of fuel cells and the fuels to be utilized and will become CSA FC 1
		NFPA 70: National Electric Code (Article 692)	2002 edition of National Electric Code includes new Article 692	Jean O'Conner	Existing Standard
			that covers electrical installation requirements for fuel cell	NFPA International	
			systems	(617) 984-7421	
		UL 1741: Standard for Inverters, Converters and Controllers for Use in Independent Power Systems	This standard covers requirements that distributed generators must satisfy to operate properly when interconnected to the utility grid. It is being modified to cover fuel cell systems for stationary and portable applications. In addition, the plan is to adopt the requirements in IEEE P1547.	Tim Zgonena Underwriters Laboratories (847) 272-8800 X4305	Working Group is working to reach a consensus with IEEE P1547. Draft is expected to be available in June 2002.
		IEEE P1608: Application Guide for IEEE	The Guide provides technical background and application	Richard DeBlasio	The Guide exists as a working draft
		Standard 1547 for Interconnecting Distributed	details to support the understanding of IEEE P1547.	NREL	
		resources with Electric Power Systems		(303) 275-3753	
		IEEE P1614: Guide for Monitoring	This proposed Guide will provide guidelines for monitoring,	Richard DeBlasio	Development of the Guide is in progress.
		Information Exchange and Control of	information exchange, and control for distributed resources (e.g.,	NREL	
		Distributed Resources Interconnected with	fuel cells, PV) interconnected with electric power systems.	(303) 275-3753	
		Electric Power Systems			
		IEEE P1547: Draft Standard for Interconnecting Distributed Resources with Electric Power Systems	This standard establishes criteria and requirements for interconnection of distributed resources (DR) with electric power systems (EPS). This document provides a uniform standard for interconnection of distributed resources with electric power systems. It provides requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection.	Richard DeBlasio NREL (303) 275-4333	Draft 11 was affirmed Feb 2003 by IEEE ballot group and was submitted to IEEE Standards Board for approval; publication targeted for summer 2003.

1.6 Interfacing (with Building or Utility Interconnection)			DESCRIPTION	TECHNICAL CONTACTS	STATUS
		IEEE P1547.1: Draft Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems	This standard specifies the type, production, and commissioning tests that shall be performed to demonstrate that interconnection functions and equipment of a distributed resource (DR) conform to IEEE Std 1547. Interconnection equipment that connects DR to an electric power system (EPS) must meet the requirements specified in IEEE Std. 1547. Standardized test procedures are necessary to establish and verify compliance with those requirements. These test procedures must provide both repeatable results, independent of test location, and flexibility to accommodate a variety of DR technologies.	Richard DeBlasio NREL (303) 275-4333	Draft 2 to be reviewed June 4-5, 2003 at meeting in Denver CO.
		IEEE P1547.2: Draft Application Guide for IEEE Standard 1547 for Interconnecting Distributed resources with Electric Power Systems	The guide provides technical background and application details to support the understanding of IEEE P1547. This document facilitates the use of IEEE P1547 by characterizing the various forms of distributed resource technologies and the associated interconnection issues. Additionally, the background and rationale of the technical requirements are discussed in terms of the operation of the distributed resource interconnection with the electric power system. Presented in the document are technical descriptions and schematics, applications guidance and interconnection examples to enhance the use of IEEE Std. 1547.	Richard DeBlasio NREL (303) 275-4333	Outline of the Guide to be reviewed June 45, 2003 at meeting in Denver CO.
		IEEE P1547.3: Draft Guide for Monitoring Information Exchange and Control of Distributed Resources Interconnected with Electric Power Systems	This document provides guidelines for monitoring, information exchange, and control for distributed resources (DR) interconnected with electric power systems (EPS). This document facilitates the interoperability of one or more distributed resources interconnected with electric power systems. It describes functionality, parameters and methodologies for monitoring, information exchange and control for the interconnected distributed resources with, or associated with, electric power systems. Distributed resources include systems in the areas of fuel cells, photovoltaics, wind turbines, microturbines, other distributed generators, and, distributed energy storage systems.	Richard DeBlasio NREL (303) 275-4333	Outline of the Guide to be reviewed June 45, 2003 at meeting in Denver CO.
1.6.3 Controls and Sensors					
		ANSI Z21.83-1998: Fuel Cell Power Plants	The standard applies to packaged, self-contained or factory matched packages of integrated systems of fuel cell power plants for use with natural gas or LP gas and having a maximum output voltage of 600 VAC and power output of 1000 kW	Steven E. Kasubski CSA International (216) 524-4990 X8303	The standard is being revised to more adequately more types of fuel cells and the fuels to be utilized and will become CSA FC 1
1.6.5 Other					

1.7 Issues Relating to or Use of Rejected Heat	DESCRIPTION	TECHNICAL CONTACTS	STATUS
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1.8 O&M Issues, Operating Instructions and Safety		<i>DESCRIPTION</i>	<i>TECHNICAL CONTACTS</i>	<i>STATUS</i>
	IEC TC105 Working Group 3: Safety of Stationary Fuel Cell Power Plants	The Working Group is developing a standard that addresses safety requirements (design and performance) for packaged stationary fuel cell power plants. The standard will parallel ANSI Z21.83 and similar standards in Canada, Japan and Germany.	Kelvin Hecht UTC Fuel Cells (860) 673-9181	The Working group is in the process of developing the initial draft. This is expected to be completed by October 2002.
	CSA FC1: Fuel Cell Power Plants	The document applies to fuel cell systems for stationary applications having maximum output voltage of 600 V and power output up to 10 Mw. CSA America Fuel Cell Technical Advisory Committee proposes CSA FC 1 to be the revised, enhanced version of ANSI Z21.83	Steven E. Kasubski CSA International (216) 524-4990 X8303	Draft of CSA FC 1 released for review after the April 2002 meeting of the Committee
	ANSI Z21.83-1998: Fuel Cell Power Plants	The standard applies to packaged, self-contained or factory matched packages of integrated systems of fuel cell power plants for use with natural gas or LP gas and having a maximum output voltage of 600 VAC and power output of 1000 kW	Steven E. Kasubski CSA International (216) 524-4990 X8303	The standard is being revised to more adequately more types of fuel cells and the fuels to be utilized and will become CSA FC 1

1.9 Testing and Evaluation Procedures		<i>DESCRIPTION</i>	<i>TECHNICAL CONTACTS</i>	<i>STATUS</i>
	CSA CAS No. 33: Component Acceptance Service for PEM Fuel Cell Modules	The document contains specifications for providing CSA International component acceptance service for PEM fuel cells stacks using hydrogen as the fuel	Todd Strothers CSA International (704) 552-5125	Document published and available for sale
	ASME PTC 50	Fuel Cell Power Systems Performance: This Code applies to all fuel cell power systems regardless of the electrical power output, thermal output, fuel cell type, fuel type, or system application. This Code applies to the performance of overall fuel cell power systems and addresses combined heat and power systems. The Code provides procedures for determination of electrical efficiency or heat rate and overall thermal effectiveness at rated or any other steady-state condition.	Jack Karian, ASME International, KarianJ@asme.org	Published and available for sale.
	NES Evaluation Protocol for Stationary Fuel Cell Power Plants	Protocol used by the NES to facilitate the process of evaluating stationary fuel cell power plants for compliance with US model codes	David Conover NES, Inc. (703) 931-2187	The Protocol exists and is in use
	IEC TC105 Working Group 4: Performance of Fuel Cell Power Plants	The standard describes how to measure the performance of stationary fuel cell power systems from an operational and an environmental standpoint.	Kelvin Hecht UTC Fuel Cells (860) 673-9181	The Working Group completed the draft in January 2002. During the period 8 Feb 02 -10 May 02, it was in the review process. The WG will meet in June to address review comments.
	IEEE P1589: Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems	The standard specifies the type, production and commissioning tests that are to be performed to demonstrate that the interconnection functions and that the distributed resource equipment conforms to IEEE P1547	Richard DeBlasio NREL (303) 275-3753	

	1.10 Other Issues	<i>DESCRIPTION</i>	<i>TECHNICAL CONTACTS</i>	<i>STATUS</i>
	UL 2265: Replacement Fuel Cell Power Units for Appliances (Covers an appliance that generates DC from hydrogen for stationary applications)	This standard will cover stand-alone fuel cell power systems that may be connected within the enclosure of an appliance by a flexible cord and plug or other arrangement (auxiliary power supply)	Harry Jones Underwriters Laboratories (847) 664-2948	Underwriter Laboratories is working to develop this standard.

REPORT DOCUMENTATION PAGE

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14. ABSTRACT Beginning in Fiscal Year 2001 (FY01), Congress funded the DOD Residential PEM Demonstration Program to demonstrate domestically-produced, residential Proton Exchange Membrane (PEM) fuel cells at military facilities. The objective of the program was to assess PEM fuel cells in supporting sustainability in military installations, increasing efficiency in installation, operation, and maintenance of fuel cells at these sites, and assessing the role of PEM fuel cells in DOD training, readiness, and sustainability missions. Other objectives were to provide: a military base market for this technology, evaluation and feedback to promote commercialization and market growth, operational product testing and validation, grid interconnection standards, and system operation in diverse environmental conditions. For this Program, researchers developed and advertised a Broad Agency Announcement (BAA), which outlined a core set of requirements for proposals. Twelve pre-proposals were received from the FY01 Program BAA solicitation. After review and evaluation of full proposals, six contracts were awarded, representing 22 fuel cells at 10 military installations. The awardees are required to report operational performance of each of the fuel cell power plants in the DOD program, including total operating hours, total electricity production, total fuel usage, total waste heat recovery, availability, electrical efficiency, and thermal efficiency.					
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