

The U.S. Army ERDC-CERL Stationary Fuel Cell Program

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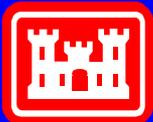
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Energy 2004

Rochester Riverside Convention Center

Rochester, NY

August 8-11 2004



US Army Corps
of Engineers

Engineer Research & Development Center

DoD PAFC Demonstration Program

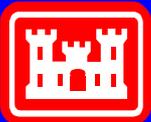
- DUECC Request for CERL Assistance
- FY93 Congressional Appropriation - \$18M
- FY94 Congressional Appropriation - \$18.75M
- Specify “...natural gas fuel cells in production in the United States...”



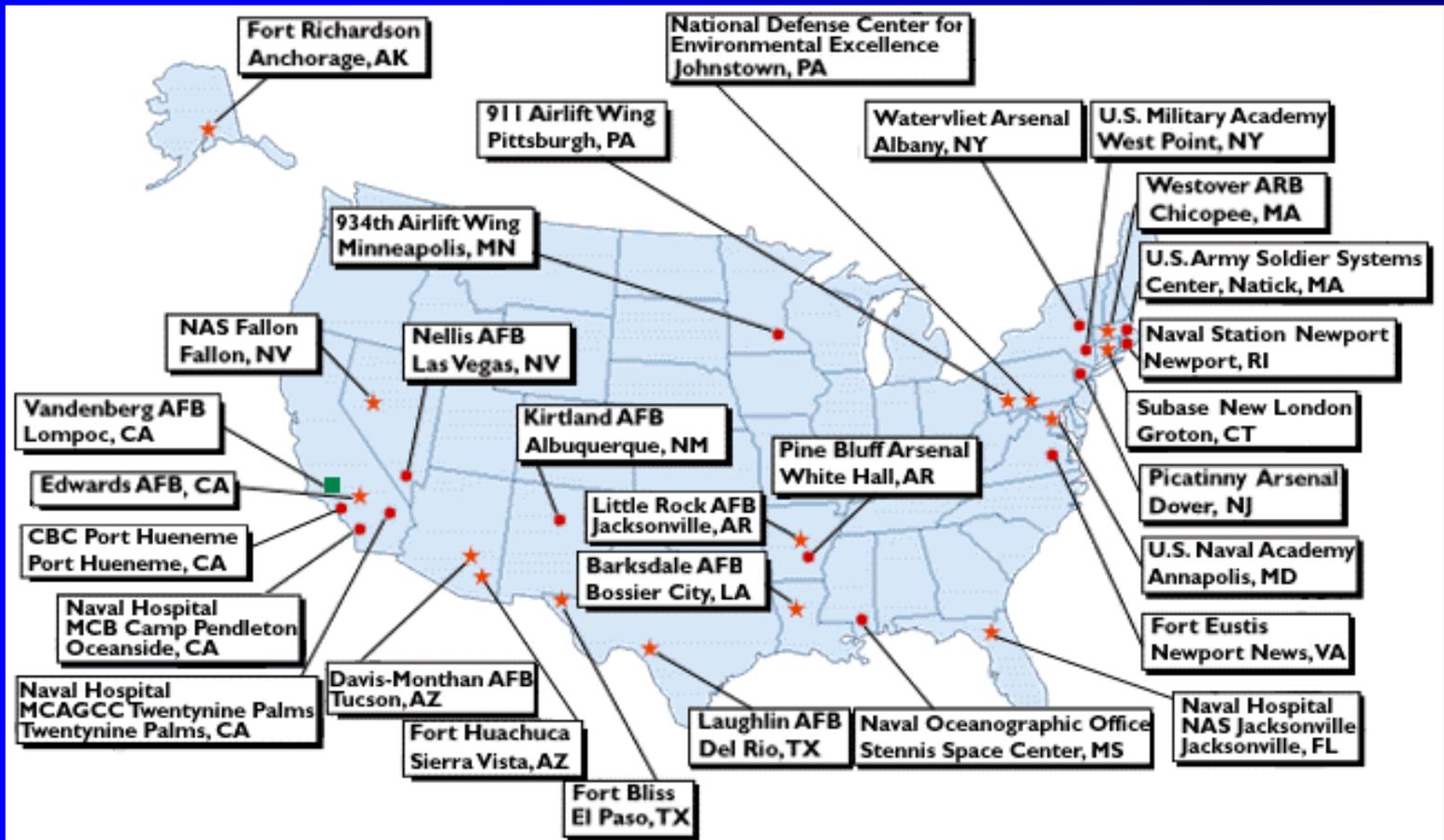
DoD PAFC

Turn-key Package

- IFC PC25 Fuel Cell Power Plant
Fy93 - 1 ea. Model A, 11 ea. Model B
Fy94 - 3 ea. Model B, 15 ea. Model C
- Engineering Design / Installation
- Training for Site Personnel
- 60 Months Maintenance
- Diagnostic / Remote Monitoring Computer



DoD PAFC Program Sites



- PC25A SITE
- PC25B SITE
- ★ PC25C SITE



DoD PAFC Facility Applications

- **Central Heat Plants**

11 Sites



- **Hospital Utility Plants**

7 Sites



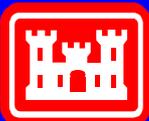
- **Pool / Gymnasiums**

3 Sites



- **Others**

Barracks, Dining Facility, Laundry,
NG Armory, Launch Control Bldg.,
Office, Evaporator process



Efficiency

At initial acceptance, power plants were required to demonstrate an output of 200 kW with a natural gas input of 1900 ±100 cubic feet per hour.

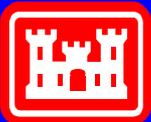


Electrical Efficiency LHV = 39% ± ~2%

HHV = 35% ± ~2%

*based on 925 Btu/cf (LHV) and 1027 Btu/cf (HHV)

- avg from 10 sites



Fleet Performance Summary

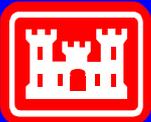
(29 Power Plants)
As of October 29, 2003

- Total Run Time 875,345 hrs
- Availability
 - Model B Fleet 57%
 - Model C Fleet 76%
- Energy \$ Saved \$5,959,411
- NOx Abated 281 tons
- SOx Abated 595 tons
- CO Abated 24 tons
- CO₂ Abated 36,043 tons



Site Management System (SMS)

- **Multi-Unit Load Share**
Parallel Fuel Cell Installations
- **Seamless Transfer Capability**
Instantaneous Backup Support for Critical Loads
- **Field Demonstration - U.S. Post Office, Anchorage, AK**
Five ONSI PC25 Fuel Cell Power Plants



Customer Needs

- **U.S. Postal Services Main Processing Center in Anchorage Experienced Frequent Momentary Outages**
 - **Caused Shutdown of Mail Sorters**
 - **Elapsed Time to Clear and Restart-- 2 Hours**
 - **Lost Productivity and Time**
- **Concurrently, Facility Needed to Replace Back-up Diesel / Generator and Inadequate Ups System**



System Operational Parameters

Electrical - Normal

- Operates in Parallel to Grid
- Provides All Power to Facility (~ 800 kW Peak)
- Provides Excess Power to Chugach Grid

Electrical - Grid Outage

- Operates Grid Independent; Provides All Facility Power
- Transfers Seamlessly (1/4 Cycle); No Equipment Outages
- Units Share Facility Load (Multi-unit Load Share Option)
- Replaces Existing Diesel Generator Set and UPS

Thermal

- Provides Facility Heating With PC25 C High Grade Heat Option





1MW Fuel Cell Project
US Post Office, Anchorage, Alaska

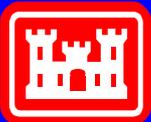


US Army Corps
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Project “Firsts”

- 5 PC25 Unit Installation at Single Site
- Multi-unit Load Share and Site Management System (SMS) for Control
- Use of Fuel Cell Installation As Distributed Generation Asset by Local Utility
- Power Continuity to Load Using Seamless Transfer (1/4 Cycle Transition)
 - Grid Parallel to Grid Independent, and
 - Grid Independent to Grid Parallel



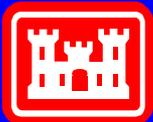
UTC Fuel Cells - Current PAFC Status

- PC25 Cell Stack Production Ceased in Early 2002
- PC25 Power Plant Production Ceased in Early 2003
- PC25 Now Called PureCell™ 200



UTC Fuel Cells - Current PAFC Status (con't)

- **11 Power Plants in Inventory (2 UTC Fuel Cells; 6 Toshiba – US - 60 cycle; 3 Toshiba – Japan - 50 cycle)**
- **Power Plant Production to Resume in Summer 2005 Using Existing Cell Stack Inventory**
- **New Design Cell Stack to Begin Production in Summer 2007 – Compatible With Existing Power Plant – Power Plant Power TBD**



DoD Climate Change Fuel Cell Program Objectives

- Reduction of Fuel Cell Prices via Economy of Scale
- Proactive Approach for DoD Involvement



DoD Climate Change Fuel Cell Program Highlights

- **Grant Money Available / Fiscal Year**

FY04	~\$ 1.4M
FY03	~\$ 6.0M
FY02	\$ 2.8M
FY01	\$ 0.0M
FY00	\$ 2.0M
FY99	\$ 2.3M
FY98	\$ 4.2M
FY96/97	\$10.6M
FY95	\$ 8.2M

- **Cost-Shared Program Incentives**
\$1,000 / kW up to 1/3 of the total cost



Application Rating Criteria

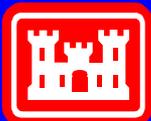
- Firmness of Financial Commitment (15%)
- Site Information (15%)
- DoD Relationship (40%)
- Project Merit (30%)



DoD Climate Change Fuel Cell Program Totals

Current as of September 2003

Program Totals Matrix			
Program Year	Contracts Awarded	Fuel Cells Awarded	Funding Awarded
FY95	31	38	\$7,600,000
FY96-97	20	34	\$6,800,000
FY98	11	17	\$3,400,000
FY99	4	18	\$1,876,410
FY00	8	8	\$1,750,000
FY02	10	93	\$2,810,000
Total	84	208	\$24,236,410



DoD Climate Change Fuel Cell Program Totals

Current as of September 2003

Yearly Fuel Cell Totals Matrix

Program Year	Fuel Cell Manufacturer	Fuel Cell Technology	Fuel Cells Awarded	Fuel Cell Size (kW)
FY95	UTC Fuel Cells	PAFC	38	200
FY96-97	UTC Fuel Cells	PAFC	34	200
FY98	UTC Fuel Cells	PAFC	17	200
FY99	UTC Fuel Cells	PAFC	8	200
	IdaTech	PEM	9	3
	Fuel Cell Energy	MCFC	1	250
FY00	UTC Fuel Cells	PAFC	5	200
	Fuel Cell Energy	MCFC	3	250
FY02	UTC Fuel Cells	PAFC	7	200
	Fuel Cell Energy	MCFC	4	250
	Plug Power	PEM	82	5

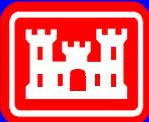


DoD Climate Change Fuel Cell Program Totals

Current as of September 2003

Fuel Cell Totals Matrix

Fuel Cell Manufacturer	Fuel Cell Technology	Fuel Cells Awarded	Fuel Cell Size (kW)
UTC Fuel Cells	PAFC	109	200
IdaTech	PEM	9	3
Plug Power	PEM	82	5
Fuel Cell Energy	MCFC	8	250
Total		208	



DoD Residential PEMFC Demonstration Program

- PEM Units, 1 kW to 20 kW
- US Military Facilities/Embassies, etc.
- Turn-key Packages Requested
- Maximum Diversity Desired
- 1 Year of “Fuel Cell Power” Required
 - (90% Availability)

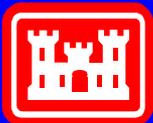


“PEM” Program Highlights

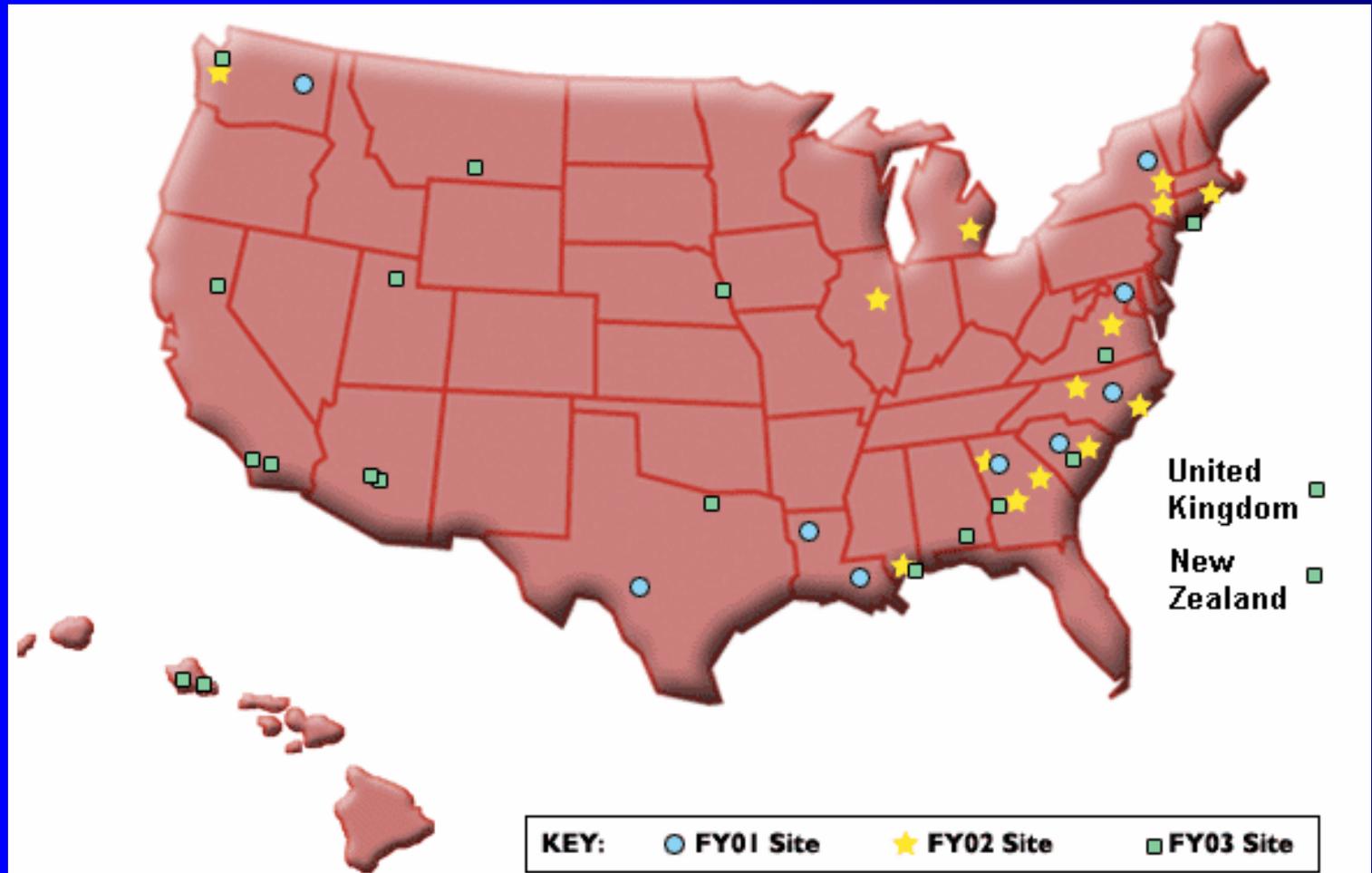
- **Grant Money Available / Fiscal Year**

FY04	~\$ 2.2M
FY03	\$ 3.9M
FY02	\$ 3.0M
FY01	\$ 3.0M

- **No Cost-Share Required**

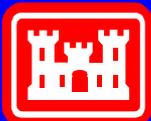


FY01-FY03 Residential PEMFC Program Sites



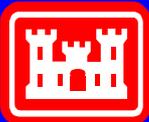
FY01 Residential PEMFC Demonstration Program

Site Name	Building Application	Fuel Cell Manufacturer	Input Fuel	Size (kW)	No. Units	Cogen. Y/N
Brooks AFB, TX	Base Housing	Plug Power	Natural Gas	5	3	No
Ft. Bragg, NC	Office Building	Plug Power	Natural Gas	5	1	No
Ft. Jackson, SC	Officer's Quarters	Plug Power	Natural Gas	5	1	Yes
Barksdale AFB, LA	Base Housing	Plug Power	Natural Gas	5	1	No
Ft. McPherson, GA	Base Housing	Plug Power	Natural Gas	5	1	Yes
Coast Guard Station, LA	Administration & Operations Building	Plug Power	Natural Gas	5	1	Yes
Patuxent River NAS, MD	Office Building	Plug Power	Propane	5	1	Yes
Patuxent River NAS, MD	Officer's Quarters	Plug Power	Natural Gas	5	1	Yes
Geiger Field, WA	Maintenance Fac.	Avista Labs	Hydrogen	3	1	No
Watervliet Arsenal, NY	Research Facility	Plug Power	Natural Gas	5	3	No
Watervliet Arsenal, NY	Manufacturing Fac.	Plug Power	Natural Gas	5	3	No
Watervliet Arsenal, NY	Officer's Quarters	Plug Power	Natural Gas	5	4	No



FY01 Residential PEMFC Demonstration Program

Site Name	Proposer	Fuel Cell Start-up	Demo End Date
Brooks AFB, TX	Southwest Research Institute	03-Feb-03	15-Mar-04
Ft. Bragg, NC	LOGAN Energy	21-Nov-02	18-Feb-04
Ft. Jackson, SC	LOGAN Energy	05-Mar-03	04-Mar-04
Barksdale AFB, LA	LOGAN Energy	27-Feb-03	18-Feb-04
Ft. McPherson, GA	LOGAN Energy	30-Oct-03	N/A
Coast Guard Station, LA	LOGAN Energy	01-Nov-03	N/A
Patuxent River NAS, MD Office Building	Southern Maryland Electric Cooperative	14-Jan-04	N/A
Patuxent River NAS, MD Officer's Quarters	Southern Maryland Electric Cooperative	08-Jan-04	N/A
Geiger Field, WA	Avista Laboratories	06-Mar-02	06-Mar-03
Watervliet Arsenal, NY Research Facility	Plug Power	18-Jan-02	18-Jan-03
Watervliet Arsenal, NY Manufacturing Facility	Plug Power	18-Jan-02	18-Jan-03
Watervliet Arsenal, NY Officer's Quarters	Plug Power	15-Jan-02	15-Jan-03



FY01 PEM Fleet

Performance Summary

January 15,2002 - April 30,2004

- Total Run Time 147,789 Hrs
- Average Availability 88.94%
- Capacity Factor 45.66%
- Total Electric Output 375,144 kWh
- Average Output 2.54 kW
- Electrical Efficiency
 - Natural Gas 23.54%
 - Hydrogen 27.25%
 - Propane 24.12%



FY01 PEM Program Sites



**Watervliet Arsenal
Officer's Quarters**



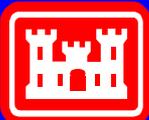
**Fort McPherson
Base Housing**



**Geiger Field
Maintenance Facility**



**Coast Guard Station
Administration & Operations Building**



FY01 PEM Program Sites



**Barksdale AFB
Base Housing**



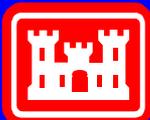
**Fort Jackson
Officer's Quarters**



**Fort Bragg
Office Building**

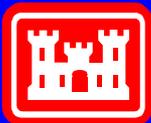


**Brooks AFB
Base Housing**



FY02 Residential PEMFC Demonstration Program

Site Name	Building Application	Fuel Cell Manufacturer	Input Fuel	Size (kW)	No. Units	Cogen. Y/N
ERDC/CERL, IL	Research Facility	Plug Power	Propane	5	1	Yes
Fort Belvoir, VA	Undecided	Plug Power	Natural Gas	5	1	Yes
Fort Belvoir, VA	Undecided	Plug Power	Natural Gas	5	1	Yes
Fort Gordon, GA	Resource Center	Plug Power	Natural Gas	5	1	Yes
Georgia Institute of Technology ROTC, GA	ROTC Facility	Plug Power	Natural Gas	5	1	Yes
MCAS Cherry Point, NC	Maintenance Facility	Plug Power	Propane	5	1	Yes
McChord AFB, WA	FAA Radio Transmitter	Avista Labs	Hydrogen	3	1	No
NCA&T University, NC	ROTC Facility	Plug Power	Natural Gas	5	1	Yes
Robins AFB, GA	Fire Station	Plug Power	Natural Gas	5	1	Yes
Saratoga Springs NSU, NY	Base Housing	Plug Power	Natural Gas	5	8	Yes
Selfridge ANGB, MI	Fire Station	Plug Power	Natural Gas	5	2	Yes
Shaw AFB, SC	Base Housing	Plug Power	Natural Gas	5	1	Yes
Stennis Space Center, MS	Mars Habitat	Plug Power	Natural Gas	5	1	Yes
USCG Aids to Navigation Team, RI	Maintenance Facility	Nuvera	Natural Gas	3.7	2	No
West Point Military Academy, NY	Officer's Quarters	Plug Power	Natural Gas	5	3	Yes



FY02 Residential PEMFC Demonstration Program

Site Name	Proposer	Fuel Cell Start-up	Demo End Date
ERDC/CERL, IL	LOGAN Energy	N/A	N/A
Fort Belvoir, VA	LOGAN Energy	N/A	N/A
Fort Belvoir, VA	LOGAN Energy	N/A	N/A
Fort Gordon, GA	LOGAN Energy	15-Mar-04	N/A
Georgia Institute of Technology ROTC, GA	LOGAN Energy	29-Feb-04	N/A
MCAS Cherry Point, NC	LOGAN Energy	N/A	N/A
McChord AFB, WA	Avista Labs	17-Apr-03	N/A
NCA&T University, NC	LOGAN Energy	24-Apr-03	N/A
Robins AFB, GA	LOGAN Energy	19-Jun-03	N/A
Saratoga Springs NSU, NY	Plug Power	29-Apr-03	N/A
Selfridge ANGB, MI	DTE Energy	26-Nov-03	N/A
Shaw AFB, SC	LOGAN Energy	1-May-03	N/A
Stennis Space Center, MS	LOGAN Energy	15-Feb-04	N/A
USCG Aids to Navigation Team, RI	Nuvera	12-Feb-04	N/A
West Point Military Academy, NY	Plug Power	2-May-03	N/A



FY02 PEM Fleet

Performance Summary

April 17,2003 - April 30,2004

- Total Run Time 121,509 Hrs
- Average Availability 85.93%
- Capacity Factor 43.80%
- Total Electric Output 305,277 kWh
- Average Output 2.51 kW
- Electrical Efficiency
- Natural Gas 24.88%
- Hydrogen 56.08%



FY02 PEM Program Sites



**Saratoga Springs NSU
Base Housing**



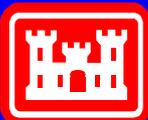
**West Point Military Academy
Officer's Quarters**



**McChord AFB
FAA Radio Transmitter**



**NCA&T University
ROTC Facility**



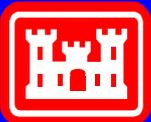
FY02 PEM Program Sites



**Shaw AFB
Base Housing**



**Robins AFB
Fire Station**



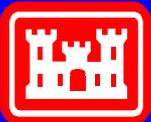
DoD Residential PEM Program

Fleet Performance Summary

January 15, 2002 - April 30, 2004

Program Performance Matrix

Program Year	Total Run Hours	Availability (%)	Capacity Factor (%)	Total Energy Produced (kWe-hrs)	Average Output (kW)	Natural Gas Electrical Efficiency (%)	Hydrogen Electrical Efficiency (%)	Propane Electrical Efficiency (%)
FY01	147,789	88.9%	45.7%	375,144	2.54	23.5%	27.2%	24.1%
FY02	121,509	85.9%	43.8%	305,277	2.51	24.9%	56.1%	N/A
Program Totals & Averages	269,298	87.6%	44.8%	680,421	2.53	24.1%	29.0%	24.1%



FY03 Residential PEMFC Demonstration Program

Site Name	Building Application	Fuel Cell Manufacturer	Input Fuel	Size (kW)	No. Units	Cogen. Y/N
Arizona Army National Guard, AZ	Army National Guard Armory	Plug Power	Natural Gas	5	1	Y
Montana Army National Guard, MT	Armed Forces Reserve Center	Plug Power	Natural Gas	5	1	Y
Ft. Benning, GA	Sandhill Recreation Center	Plug Power	Natural Gas	5	1	Y
US Army Sgt. Herrera Reserve Center, AZ	Herrera Army Reserve Center	Plug Power	Natural Gas	5	1	N
US Army Sgt. Herrera Reserve Center, AZ	Herrera Army Reserve Center	IdaTech	Natural Gas	5	1	N
Offutt Air Base, NE	Boiler Plant	IdaTech	Natural Gas	5	1	N
Offutt Air Base, NE	Communications Building	IdaTech	Propane	5	1	N
Ft. AP Hill, VA	Administrative Building	IdaTech	Propane	5	1	N
Sierra Army Depot, CA	Base Housing	Plug Power	Propane	5	1	Y
Keesler AFB, MS	Base Housing	Plug Power	Natural Gas	5	1	Y
Los Angeles AFB, CA	Security Center	Plug Power	Natural Gas	5	1	Y



FY03 Residential PEMFC Demonstration Program Continued

Site Name	Building Application	Fuel Cell Manufacturer	Input Fuel	Size (kW)	No. Units	Cogen. Y/N
Hill AFB, UT	Base Housing	Plug Power	Natural Gas	5	1	Y
NGB Camp Mabry, TX	Base Housing	Plug Power	Natural Gas	5	1	Y
Schofield Barracks, HI	Clinic	Plug Power	LP Gas	5	1	Y
MCB Kaneohe Bay, HI	Base Housing	Plug Power	LP Gas	5	1	Y
March AFB, CA	Base Housing	Plug Power	Natural Gas	5	1	Y
McEntire ANG, SC	Security Center	Plug Power	Natural Gas	5	1	Y
U.S. Embassy, UK	Embassy Housing	Plug Power	Natural Gas	5	1	Y
Gabreski ANGB, NY	Telephone Exchange System	ReliOn, Inc.	Hydrogen	1	4	N
Fort Lewis, WA	Marker Beacon	ReliOn, Inc.	Hydrogen	1	4	N
Fort Rucker, AL	Marker Beacon	ReliOn, Inc.	Hydrogen	1	5	N
US Antarctic Div, Christchurch, N.Z.	Marine House	ReliOn, Inc.	Hydrogen	1	2	N



FY03 Residential PEMFC Demonstration Program

Site Name	Proposer	Fuel Cell Start-up	Demo End Date
Arizona Army National Guard, AZ	City of Mesa	N/A	N/A
Montana Army National Guard, MT	Montana State University	N/A	N/A
Ft. Benning, GA	Flint Energy	N/A	N/A
US Army Sgt. Herrera Reserve Center, AZ	Arizona State University	N/A	N/A
US Army Sgt. Herrera Reserve Center, AZ	Arizona State University	N/A	N/A
Offutt Air Base, NE	IdaTech	N/A	N/A
Offutt Air Base, NE	IdaTech	N/A	N/A
Ft. AP Hill, VA	IdaTech	N/A	N/A
Sierra Army Depot, CA	LOGAN Energy	N/A	N/A
Keesler AFB, MS	LOGAN Energy	N/A	N/A
Los Angeles AFB, CA	LOGAN Energy	N/A	N/A



FY03 Residential PEMFC Demonstration Program Continued

Site Name	Proposer	Fuel Cell Start-up	Demo End Date
Hill AFB, UT	LOGAN Energy	N/A	N/A
NGB Camp Mabry, TX	LOGAN Energy	N/A	N/A
Schofield Barracks, HI	LOGAN Energy	N/A	N/A
MCB Kaneohe Bay, HI	LOGAN Energy	N/A	N/A
March AFB, CA	LOGAN Energy	N/A	N/A
McEntire ANG, SC	LOGAN Energy	N/A	N/A
U.S. Embassy, UK	LOGAN Energy	N/A	N/A
Gabreski ANGB, NY	ReliOn, Inc.	N/A	N/A
Fort Lewis, WA	ReliOn, Inc.	N/A	N/A
Fort Rucker, AL	ReliOn, Inc.	N/A	N/A
US Antarctic Div, Christchurch, N.Z.	Industrial Research Ltd.	N/A	N/A



PEMFCs Installed at Watervliet Arsenal

2003 Winner
DOE Federal
Energy
Saver
Showcase
Award



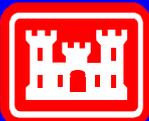
Research Facility



Manufacturing Facility



Officer's Quarters



Watervliet Arsenal Demonstration

- **Proposer** **Plug Power INC.**
- **Location** **Watervliet Arsenal
Watervliet, NY**
- **Fuel Cells**
 - **Power Output** **5 kW**
- **Fuel Cell System** **10 Fuel Cells**
- **Fuel Cell Sites** **Manufacturing Facility
Research Facility
Officer's Quarters**



GenSys™ 5C

Fuel Cell Specifications

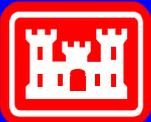
Comment	Specification
Unit Size	Base Unit with integral skid: 84.5"L x 32"W x 68"H (excludes 22" exhaust stack)
Installation Location	Outdoor
Grid Parallel	Yes
Power Output/Setpoints	2.5kW, 4 kW, 5 kW
Remote Monitoring Capability	Via phone line
Output Voltage	120 / 240 VAC @ 60 Hz
Certification	Integrated System CSA International Listed; Inverter UL Listed
Power Quality	IEEE 519 or better
Emissions (Steady-State)	NO _x < 5 ppm Sox < 1 ppm CO < 50 ppm
Standard Operating Conditions	Temperature: 0 °F to 104 °F Elevation: up to 6,000 ft Noise: < 65 dBA @ 1 meter
Fuel	Natural Gas



Building 115

Research Facility

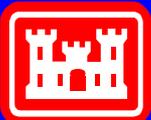
- Site Supports
 - Laboratory Facility
 - Destructive Testing Facility
- Historical Average Demand
 - 5400 kW-hrs/Month
- 3 Fuel Cells
 - January 18, 2002



Building 110

Manufacturing Facility

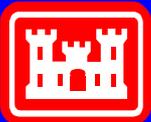
- **Site Supports**
 - Heavy Machining
 - Telecommunication Equipment
- **Historical Average Demand**
 - 5400 kW-hrs/Month
- **3 Fuel Cells**
 - January 18, 2002



Quarters 19

Officer's Quarters

- **Site Supports**
 - Historic Building
 - 4 Family Residences
- **Historical Average Demand**
 - 3400 kW-hrs/Month
 - Excess Power Exported to Local Grid
- **4 Fuel Cells**
 - January 15, 2002



Installation Challenges

- **Electrical Interconnection**
 - **Interconnection Review**
 - **\$20,000 - \$40,000**
 - **2 - 4 Months**
 - **Decline Interconnection Review**
 - **Arsenal's Jurisdiction**
- **Underground Natural Gas Piping Location**
 - **Inaccurate As-Built Drawings**
 - **Perform Hand Digging**
- **Water Pressure**
 - **NYS Board of Health Requires Back Flow Preventors**
 - **System Requires 40psi**
 - **Install Booster Pump**



Installation Challenges

- **Fuel Cell Placement**
 - Inaccessible by Fork Truck
 - Redesign Placement Procedure
 - New Lifting Fixtures
 - Utilize Crane
- **Power Quality**
 - Voltage Fluctuation
 - +/- 5 to 10 Volts RMS on A, B, C Phases
 - Exceed Inverter Anti-Islanding Set Points
 - Fuel Cells Enter Anti-Islanding Sequence
 - Re-Tap Local Transformer



Operation Challenges

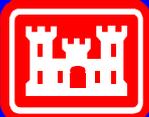
- **Water Quality**
 - 11-12 Grains Hardness
 - Change DI Filters 2x/Month
 - Place Scale-Inhibiting Cartridges Above DI Filters
- **Extreme Temperatures**
 - Winter Temperatures Reached -10°F
 - Internal Temperature Switch
 - Shut-Down Unit to Protect Internal Controls
 - Reset Conservative Temperature Setting
- **Coolant Pump Failure**
 - Create Pump Retrofit Kit



Watervliet Arsenal Performance Summary

January 18, 2002 – January 21, 2003

System No.	Total Run Hours	Total Hours	Availability (%)	Capacity Factor (%)	Total Energy Produced (kWe-hrs AC)	Average Output (kW)	Electrical Efficiency (%)
Site 1 Performance Matrix							
B95	8032	8894	90.3%	44.0%	19578	2.44	22.8%
B96	7946	8911	89.2%	44.4%	19761	2.49	23.5%
B97	8412	8845	95.1%	48.4%	21407	2.54	23.6%
B98	8103	8888	91.2%	46.4%	20617	2.54	23.4%
Site 2 Performance Matrix							
B100	8467	8837	95.8%	50.8%	22446	2.65	24.7%
B102	8283	8856	93.5%	51.1%	22635	2.73	24.8%
B103	8667	8844	98.0%	51.1%	23723	2.74	26.4%
Site 3 Performance Matrix							
B104	8382	8844	94.8%	48.8%	21566	2.57	23.6%
B105	8194	8769	93.4%	48.9%	21449	2.62	24.8%
B106	8520	8856	96.2%	49.7%	21993	2.58	23.9%

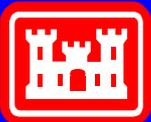


Watervliet Arsenal Performance Summary

(10 units)

January 15, 2002 – January 21, 2003

- Total Run Time 83,006 hrs
- Availability 93.8%
- Capacity Factor 48.5%
- Total Electric Output 215,174 kWh
- Average Output 2.59kW
- Electrical Efficiency 24.1%



Watervliet Arsenal

Program Costs

January 15, 2002 – January 21, 2003

- Electrical Cost \$.077/kW-hr
- Natural Gas Cost \$ 0.35/Therm
- Fleet Natural Gas Usage 30,294 Therms
- Fleet Electrical Production 214,555 kW-hrs

- Fleet Natural Gas Cost \$10,602.90
- Electrical Savings \$16,520.74
- Total Savings \$ 5,917.84



Watervliet Arsenal Program Highlights

- System B103
 - 100% Availability Final 4.5 Months
 - 98.8% Availability Final 11.5 Months
- System B98
 - 6742 Cell Stack Run Hours
- System B104
 - 7056 Cell Stack Run Hours



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