# Fuel Cell Demonstration at the U.S. Coast Guard Air Station Cape Cod

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ABSTRACT

The U.S. Coast Guard installed one of the first fuel cells in the New England region, with funding from the Green Power Initiative of the Renewable Energy Trust (administered by the Massachusetts Technology Collaborative), the U.S. Department of Defense's (DOD's) Climate Change Fuel Cell Program, and KeySpan Energy. Beginning in 1998, the Federal Energy Management Program (FEMP) and the U.S. Army Corps of Engineers' Construction Engineering Research Laboratory (CERL) provided technical assistance in the form of project economics, analysis, and site selection.

The 250-kW fuel cell combined heat and power plant is located at the U.S. Coast Guard Air Station Cape Cod in Bourne, Massachusetts. The prime contractor, PPL Corporation, was responsible for all engineering and design work. FuelCell Energy of Danbury, Connecticut, was responsible for the manufacture, delivery, and installation of the fuel cell.

Fuel cells produce electricity through an electrochemical reaction rather than combustion. While currently more expensive to purchase than conventional power-generating equipment, fuel cells provide efficient, reliable power with minimal emissions. (For more information on fuel cells, see FEMP's Federal Technology Alert, "Natural Gas Fuel Cells" at www.eere.energy.gov/femp/pdfs/FTA_natgas_fuelcell.pdf).

## BACKGROUND

Air Station Cape Cod is one of the largest U.S. Coast Guard air stations on the East Coast, providing support for both fixed-wing aircraft and helicopters for search and rescue, maritime law enforcement operations, and other missions. Its crews protect life and property from the Canadian border to Long Island, New York, and provide logistical support for offshore lighthouses in New England.

The U.S. Coast Guard R&D Center wanted to demonstrate that fuel cells were capable of providing power to important operational units during adverse conditions (in the midst of ice storms, blizzards, or other outages). They also wanted a location logistically close to the R&D Center (in Groton, Connecticut), and Air Station Cape Cod proved to be a perfect location.

Fuel cells also have numerous potential benefits, including independence from the electric grid, environmentally friendly power generation, high quality power free from fluctuations and noise, and reliable emergency power. In addition, they can be a cost-effective power supply alternative.

In addition to electric power, the fuel cell provides additional heat for domestic hot water for the bachelor's quarters and an associated galley. The fuel cell currently provides pre-heat for galley dishwashers for the building, and at full 250-kW design output, could also provide space heating for the entire building.

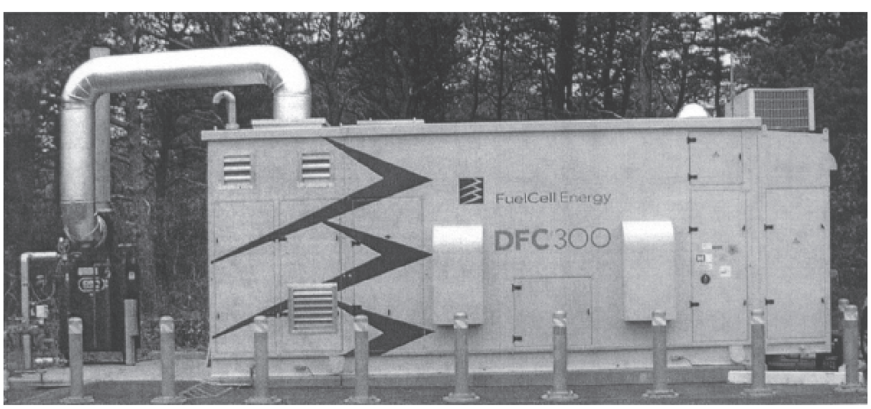


**Figure 1. Fuel cell combined heat and power plant located at the U.S. Coast Guard Air Station Cape Cod in Bourne, Massachusetts.**

PROJECT SUMMARY

The Coast Guard began investigating the use of fuel cells in 1998 based on energy objectives implemented in 1997 that directed the Coast Guard to realize a 20% reduction in facility energy costs from 1995 levels by 2005. The objectives further mandated Coast Guard facilities to "minimize the use of petroleum fuels in all its facilities and platforms… through investments in engineering." The U.S. Army Construction Engineering Research Laboratory (CERL) and its subcontractor Science Applications International Corporation (SAIC) investigated a number of potential locations for a fuel cell at a shore facility, and ultimately Air Station Cape Cod was chosen.

The main benefits of fuel cells used in combined heat and power applications such as this are the relatively low cost electric power and the hot water provided from the waste heat. Fuel cells also provide a major benefit in grid-independent or emergency power source applications, offering an alternative when a site cannot or does not want to be connected to the utility grid.

The fuel cell at Air Station Cape Cod is a Model DFC®300 manufactured by FuelCell Energy. It is rated at 250 kW and fueled by natural gas. This installation was one of the first of its kind installed by FuelCell En-


**Figure 2. Air Station Cape Cod—the largest Coast Guard station on the east coast.**

ergy. The complete fuel cell system also includes a heat exchanger to capture waste exhaust heat for use in the galley. An anti-islanding or reverse power relay prevents power from being exported to the grid.

The fuel cell was sized to meet anticipated site loads. For this reason, no attempt was made to provide for exporting power to the grid. This approach provided a lower cost project (as a result of avoidance of additional utility interconnection requirements). However, the result of this decision combined with lower-than anticipated site loads has led to a situation where the fuel cell must be operated at less than full load to ensure that power is not exported to the grid. To date, the production set point of the fuel cell has been maintained between 150 kW and 180 kW.

The entire project cost to date is $1.8 million, including all site work and the first year's maintenance costs. The Coast Guard covered approximately 59% of the cost, with 22% paid by the Massachusetts Technology Corporation, 14% by DOE, and the remaining 5% paid for by KeySpan Energy. Subsequent year's maintenance and repair costs are still being negotiated with FuelCell Energy.

The most significant regularly scheduled maintenance item is replacement of the fuel cell stack. The original fuel cell stack is anticipated to last 3 to 5 years, with subsequent stacks lasting 5 to 7 years (as a result of recent technology improvements). The stack replacement cost is estimated to be around $300,000 to $350,000. Total maintenance costs will also depend on the level of service chosen by the site, with FuelCell Energy offering a variety of plans ranging from minimal coverage and response to complete service and round-the-clock response.

Heat is recovered from the fuel cell via a high-efficiency heat exchanger that is used to heat domestic hot water to 140°F (60°C). The 140°F water serves the galley dishwasher, where it is heated to wash temperature by a supplemental system. The remaining hot water is mixed with make-up water to a temperature of 120°F (49°C) and distributed throughout the barracks. It is believed that once the fuel cell is operating at its full 250-kW design capacity, there will be sufficient heat to provide hot water for the space heating system that serves the facility.

## BENEFITS

In its first 12 months of operation, the fuel cell had an average operating availability of 96.2%—above its first year's expected design availability. The fuel cell produced a total of 1,392 MWh of electricity during the year. Of the total production, 1,250 MWh powered Air Station Cape Cod building loads. The remaining 142 MWh powered the internal fuel cell loads.

Over the same period, an estimated 1,832 million Btus of recovered heat have been utilized for domestic hot water use. This has offset the purchase of nearly 26,300 ccf of natural gas. Total operating expenses for the period were $146,435, while total system savings were $170,300, resulting in a total net savings of $23,865.

The fuel cell at Air Station Cape Cod provided emergency power to the barracks and galley during a number of short grid outages in 2003. A more significant test of its emergency capability was made in September 2003, when the fuel cell was operated in a totally grid independent mode as a precaution against a potential loss of commercial power during a hurricane. Fortunately, the storm passed to the west of Cape Cod, but the fuel cell operated as designed during the period and proved its worth as an independent power source. Although Cape Cod was not affected by the great utility blackout in the Northeast on August 14-15, 2003, the fuel cell is poised to demonstrate its value in case of a major utility outage.

## LESSONS LEARNED

The most significant lesson learned is that site loads must be accurately determined prior to the design of a fuel cell project. Had the loads been determined more accurately, more buildings could have been connected to the fuel cell or provisions made to export power.

A second lesson learned is that the benefits of a fuel cell system are very dependent on the relative costs of purchased electricity and natural gas. If the cost of natural gas rises more quickly than the cost of purchased electricity (as at Cape Cod Air Station), the economics of a fuel cell change. Although savings are being realized, they are not as large as originally expected. It is possible that in the future, natural gas prices may rise such that it is more economical for the site to purchase electrical power than generate it.

A third lesson learned is that fuel cell maintenance costs (restacking and preventative maintenance) can be significant. While the first year's maintenance was included in the original procurement for this fuel cell,

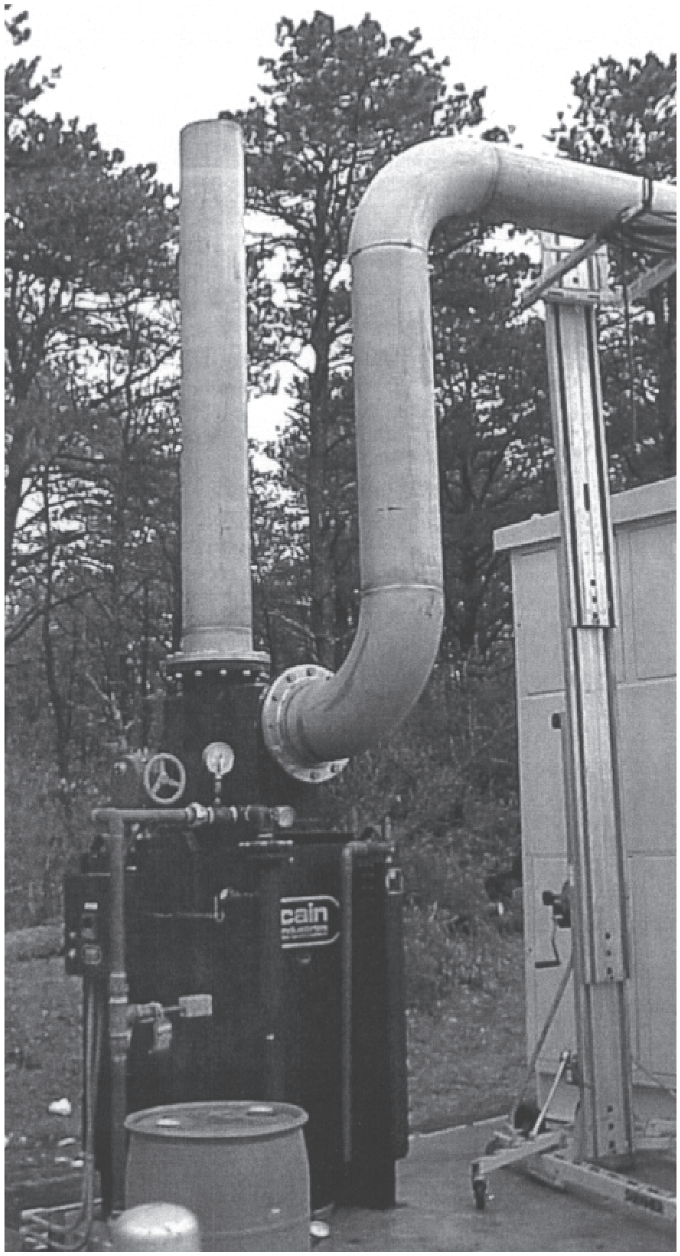


**Figure 3. High-efficiency heat exchanger for domestic hot water production.**

negotiations are still under way between the Coast Guard and FuelCell Energy over future maintenance costs. Long-term maintenance costs should be considered and negotiated prior to procurement of a fuel cell.

## LOOKING AHEAD

The most significant barrier to a more successful operation of the Air Station Cape Cod fuel cell is the inability to operate at full power. The fuel cell power generation is limited because the excess power cannot be exported to the grid. The Coast Guard has just received funding for the design and installation of the utility interconnection needed to overcome this barrier. Coast Guard personnel are also working with their utility to reach agreement on export of excess energy. Air Station Cape Cod has recently procured and installed a Btu meter, which will facilitate quantifying the savings associated with waste heat recovery.

For those interested in periodic updates on this fuel cell, monthly reports on the status of the fuel cell and production statistics, see the following two URLs:

- www.uscg.mil/systems/gse/energy/FuelCell/Fuel-Cell-Consolidate-Status-Report-2003.pdf, and
- www.uscg.mil/systems/gse/energy/FuelCell/Fuel-Cell-Consolidate-Status-Report-2004.pdf

**Acknowledgments**

The authors would like to thank Lieutenant Commander Christopher Lund of the U.S. Coast Guard Research and Development Center in Groton, CT for his input and comments on this case study. The authors would also like to acknowledge the efforts of Dave Cleveland for his role as "fuel cell champion" (now retired) at Air Station Cape Cod and Paul King, FEMP representative, Northeast Regional Office, U.S. Department of Energy, who also supported this project.

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## ABOUT THE AUTHORS

**Mark Halverson** is a senior research engineer in the Energy Science and Technology Directorate at the Pacific Northwest National Laboratory. For the past 15 years, Mark has supported building energy code and energy efficiency programs. Recent activities include development of consensus and Federal standards, energy code training, analysis of energy savings associated with codes and standards, facilitation of energy saving performance contracts, and measurement and verification. He is currently supporting DOE's Building Energy Codes Program and Federal Energy Management Program. He works closely with ASHRAE's SSPC 90.1, is a member of ASHRAE's Code Interaction Subcommittee, and is a member of the FEMP M&V team. Mark has a Master of Science Degree in chemical engineering from the University of Washington and a Bachelor of Science Degree in chemical engineering from Montana State University. He is a registered Professional Engineer in the state of Washington and a Certified Energy Manager.

**Bill Chvala** (pronounced Koala, like the bear) is a senior research engineer in the Energy Science and Technology Directorate at the Pacific Northwest National Laboratory. He first came to PNNL in 1991 to work on energy performance evaluations of office equipment, building HVAC equipment, and lighting. Since then, he has been involved in numerous metering, data collection, demand-side management (DSM), and load-shedding projects. Previously he worked briefly for a public electric utility and rural electric cooperative. Bill's specialties include field data collection, utility data and rate analysis, and energy performance evaluations for Federal facilities and large military installations. Bill manages the Federal Energy Management Program (FEMP) Technical Assistance activities at PNNL which provides of guidance, design review, technology evaluation, energy project development, and other short-term assistance to Federal agencies. Bill is also active in PNNL's long-standing program with the U.S. Army, helping them understand energy consumption on an installation level and identifying potential energy projects, fuel switching opportunities, load-shedding, and other operations improvements.

**Shawn Monique Herrera** is a project manager with the U.S. Department of Energy, Federal Energy Management Program (FEMP) in Washington, D.C. Shawn works on the distributed energy resources and technical assistance projects. Before joining FEMP in May 2000, Shawn worked for the U.S. Department of Energy in Nevada. She managed several energy management projects for several years. She holds a Bachelor of Science Degree in electrical engineering.