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Stationary Fuel Cells Provide Power at a Remote Forest Service Ranger Station

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The first stationary fuel cell system in Wyoming and in the United States Department of Agriculture Forest Service was installed at historic Big Goose Ranger Station in the Bighorn National Forest during the summer of 2005. Acumentrics Corp. installed two 5-kilowatt solid oxide fuel cell units (figure 1) to provide electricity to two cabins, an office/shop, five trailer sites, and the station's drinking water and wastewater pumping systems. Hot water produced by the fuel cells helps heat one of the cabins at the remote ranger station high in the Big Horn Mountains.

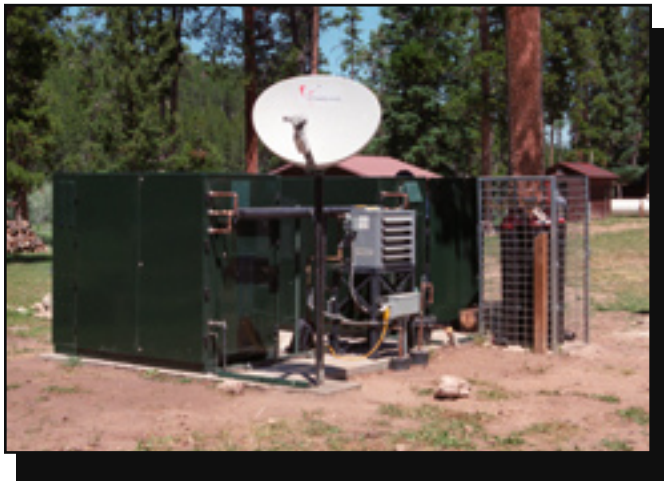

Figure 1—The completed fuel cell installation at Big Goose Ranger Station in Wyoming.

The U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC/CERL) provided the fuel cells. Through funding from ERDC/CERL and the U.S. Department of Energy's National Energy Technology Laboratory (NETL), the U.S. Department of Defense's Fuel Cell Test and Evaluation Center (FC*Tec*) performed the engineering for the fuel cell's installation. The Forest Service provided engineering for ancillary systems, construction administration and engineering, and the installation site. Additional grant funding was provided by the Propane Education and Research Council (PERC) and the U. S. Department of Energy's Federal Energy Management Program (FEMP). Montana-Dakota Utilities Co. provided support and meeting space.

Over the next few years, this field installation—a stand-alone system 7 miles from the nearest powerline and hours from the nearest fuel cell technician—will provide a unique demonstration of fuel cell performance. Hydrogen to power the fuel cells is reformed from propane, the only fuel readily available at the site. A new propane generator provides power if the fuel cells aren't working. The fuel cells will be shut down each

Highlights...

- Stationary fuel cells will probably be economical and reliable enough to be considered for power at remote Forest Service facilities in a few years.
- A number of Federal agencies and industry groups supported the installation of two 5-kilowatt stationary fuel cells at Big Goose Ranger Station high in the Bighorn Mountains of Wyoming.

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winter when the station is buried under snow and restarted each spring.

The fuel cells are monitored by a satellite uplink, allowing the relationships between electrical output and cogeneration of heat, day-to-day operation, and the efficiency of the fuel cells to be tracked remotely. The manufacturer can adjust the fuel cell system using this satellite uplink.

What We Did

In 2000, the Forest Service's technology and development engineering steering committee selected a project to install a demonstration fuel cell system that would investigate the advantages and problems of fuel cells and the circumstances under which fuel cells might be a viable power option for the Forest Service. The Missoula Technology and Development Center (MTDC) solicited Forest Service field units that would host a demonstration installation site.

Big Goose Ranger Station (figure 2), a seasonal work center, was selected by MTDC for the demonstration installation in 2001 because of the site's characteristics and the support and enthusiasm of Bighorn National Forest Engineer Anna Jones-Crabtree and Tongue District Ranger Craig Yancey. During the next 2 years, project leader Kathie Snodgrass secured funding from the partners listed above and worked with Bighorn National Forest grants and agreements specialist Margi Brayton Gray to execute the interagency and grant agreements.

Figure 2—Big Goose Ranger Station after a late autumn snowstorm.

Rocky Mountain Region electrical/mechanical engineer Todd Michael worked closely with the engineers at FC*Tec* on system design. He also designed the solar sump-pump system that keeps the basement dry in the cabin that houses the hot water storage and expansion tanks (figure 3). The design included replacing the existing aging propane generator to provide reliable backup power, and replacing antiquated cabin wiring and appliances to improve safety and energy efficiency.

Figure 3—The hot water storage and expansion tanks are in the basement of one of the bunkhouse cabins.

Construction at Big Goose Ranger Station finally began after the snow melted off the site and access road in 2004. Contracting officer Noella Bond and facilities engineer Steve Quintana rode herd on the construction documents and construction work by general contractor Engineering, Procurement & Construction, LLC. Engineering technician Bruce Kjerstad and numerous other Rocky Mountain Region, Bighorn National Forest, and Tongue District employees assisted with the project. All of the supporting work was completed during 2004, including installation of the new backup propane generator. Unfortunately, because of a delay by a supplier, the fuel cells couldn't be delivered and installed until July 2005.

One of the two 5–kilowatt fuel cell units arrived, was installed, and operated perfectly during dedication of the system on July 21, 2005. Representatives of the funding partners, local residents, dignitaries, and the Forest Service fuel cell team

attended the dedication. After the dedication, Forest Service employees received operating instructions for the new system (figure 4). The second fuel cell unit arrived and was installed in early August. Unfortunately, satellite uplink and other electronic problems caused the system to experience more *down* time than *up* time during the summer of 2005. The system was winterized and shut down in late September. The manufacturer is confident that startup will go well in the spring of 2006 and that the electronics and uplink difficulties will be overcome.

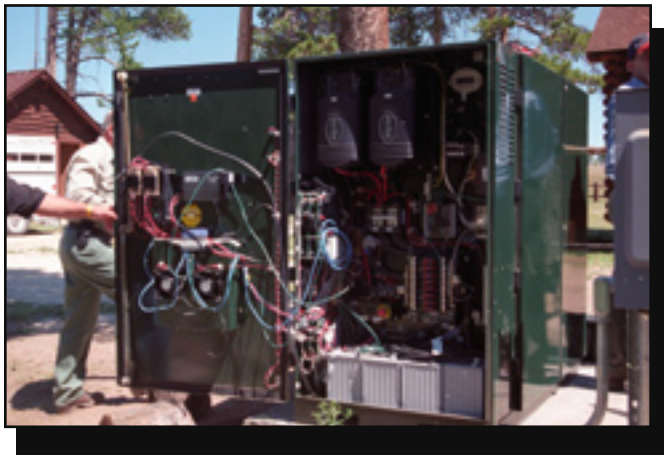

Figure 4—The Acumentrics Corp. provided information to Forest Service personnel so they would understand the basics of the components in the fuel cells and their operation.

Assuming the manufacturer is right, the experience and knowledge gained operating the demonstration fuel cells at Big Goose Ranger Station should prove valuable when fuel cell prices drop enough so they become economical for other remote installations.

How We Did It

FUNDING—

Because fuel cells in the 10-kilowatt size range were considerably more expensive than the Forest Service could afford, the project leader began looking for funding partners.

At a Distributed Energy Generation conference in Atlanta during 2002, connections were made with two partners, including our most substantial partner in the project, the ERDC/CERL Fuel Cell Team (*http://dodfuelcell.cecer.army.mil/*). The original primary contact was Michael Binder. When Binder retired, Nicholas Josefik became the contact. The ERDC/CERL Fuel Cell Team was interested in the project because it provided the opportunity to:

- Evaluate fuel cell operation at a remote, high-elevation site
- Fully review and compare all available fuel cells in the 5- to 10-killowatt range
- Evaluate the market for and state of development of small, stationary fuel cells

Other partners who contributed funding or technical assistance include:

- **Federal Energy Management Program (FEMP)**
  Web site: *http://www.eere.energy.gov/femp/*
  (Find your FEMP regional office at: *http://www.eere.energy.gov/femp/about/regionalfemp.cfm*.)
  Primary contact: Randy Jones

- **Fuel Cell Test and Evaluation Center (FC*Tec*)**
  Web site: *http://www.fctec.com/index.asp*
  Operated by Concurrent Technologies Corp.
  Primary contacts: Robert Unger, Scott Kenner, Scott Bedont, and Larry Shirey

- **Montana-Dakota Utilities Co.**
  Web site: *http://www.montana-dakota.com/*
  Primary contact: John Delvo

- **National Engineering Technology Laboratory (NETL)**
  Web site: *http://www.netl.doe.gov/*
  Primary contact: Mark Williams

- **Propane Education & Research Council (PERC)**
  Web site: *http://www.propanecouncil.org/*
  Primary contacts: Larry Osgood, Greg Kerr, and John Kerekes

Finding partners isn't always easy, and it sometimes involves serendipity. Sometimes partners can be found by chatting with participants at local workshops or national conferences.

The FEMP document, *Distributed Energy Resources: Sources of Financial Assistance and Information*, contains Web links to potential partner organizations and programs. This document is available on the Forest Service's internal computer network at: *http://fsweb.wo.fs.fed.us/eng/facilities/2004_doe_funding.htm*. Other information on funding can be found at: *http://www.eere.energy.gov/femp/services/project_facilitation.cfm*. Local utility companies and State energy offices also may be interested in becoming partners or they may be aware of other opportunities. State energy office contacts are listed at: *http://www.eere.energy.gov/state_energy_program/seo_contacts.cfm*.

The final funding for the project was:

ERDC/CERL	
Fuel cell system	$245,000
Construction	$37,500
Design	$25,000
NETL	
Design	$50,000
PERC	$75,000
FEMP	$30,000
Forest Service Rocky Mountain Region	
Construction	$4,800
Design	$5,000
Bighorn National Forest	
Construction	$2,500
Agreements, contract administration, and construction engineering	$12,000
MTDC	
Coordination and partnerships	$8,000
TOTAL	***$494,800***

That's a lot of money. In contrast, replacing the aging propane generator would have cost the Bighorn National Forest only about $25,000. Constructing a commercial powerline over 7 miles of difficult terrain to the site would have cost about $175,000 (figure 5). Detailed cost estimates were not calculated for renewable energy systems. Geothermal, hydropower, and wind resources are not practical at Big Goose Ranger Station. A solar energy system for the site probably would cost around $100,000.

Figure 5—Supplying commercial electrical power to Big Goose Ranger Station would have required stringing 7 miles of powerline through extremely rugged terrain. This picture shows the closest power pole to the station.

AGREEMENTS—

At the request of ERDC/CERL, a master memorandum of agreement (MOA) between ERDC/CERL and the Forest Service was executed as part of this project. The MOA allows any Forest Service unit to use a work order to partner with ERDC/CERL on future fuel cell projects. ERDC/CERL is interested in projects that will advance fuel cell design, operation, and fuel flexibility to enable fuel cell use for military applications, as well as for applications in remote areas and developing countries without access to natural gas or other fuel infrastructure. Electronic copies of the MOA with ERDC/CERL, a sample work order, and the agreements with the other partners are on the Forest Service's internal computer network at: *http://fsweb.wo.fs.fed.us/eng/programs/facilities/sus_green/partners.htm*.

Allow plenty of time to work out an agreement with another agency or organization. Each organization and agency has its own requirements. It can be difficult to reach agreement on language. An agreement that must be signed at a higher level takes a while to work through all the layers of approvals. Some-

times it's tough to track down signing officials. For instance, work began on the ERDC/CERL agreement in November 2002. The Chief of the Forest Service signed it in January 2004. On the other hand, the quickest agreement took only a couple of months to complete.

Finding the Right Fuel Cell

Fuel cells generate electricity with an electrochemical reaction rather than by burning fuel. The tech tip, *Fuel Cells are Coming*, has information about the different types of fuel cells and how fuel cells work. It is available in print from MTDC publications (phone: 406–329–3978) or electronically at: *http://www.fs.fed.us/t-d/pubs/htmlpubs/htm03712307/* (Username: t–d, Password: t–d).

The design team was challenged to find a fuel cell system that would meet the needs of Big Goose Ranger Station. Based on information from fuel cell manufacturers, the partners originally assumed that it would be possible to purchase a commercially available fuel cell. We soon discovered that most manufacturers were still in the late product development stages and whatever model was chosen would be a precommercial product at best. After assurances from the manufacturers that their products worked reliably in long-term operational tests, we decided to forge ahead.

The following operational requirements made it difficult to find a fuel cell that would work at the site:

Grid independence—A number of manufacturers produce 5- or 10-kilowatt models, but almost all of them are designed to be connected to the commercial power grid. Fuel cells that are tied to the grid operate around the clock, feeding extra electricity back into the power grid.

Rapid on and off—For fuel efficiency and economy, Big Goose Ranger Station requires a system that can power up and down rapidly, depending on demand. Peak electricity use is during the morning and evening. Normally, crews stationed at Big Goose are out in the field all day.

Winter shutdown—The system also must be able to survive being shut down for the winter during extremely cold temperatures. Almost all of the available 5- or 10-kilowatt fuel cells use a proton exchange membrane (PEM), which can be ruined if it is exposed to freezing temperatures. When PEM fuel cells are operating, they generate enough heat to prevent them from freezing, but a large amount of propane would be required to keep PEM fuel cells from freezing over the winter at Big Goose Ranger Station.

Propane—The only fuels readily available at Big Goose are propane and cordwood. Few fuel cells use propane and none use cordwood. Most propane that is readily available contains various amounts of sulphur and sometimes other substances that can poison the chemical reaction. Highly refined propane is available in some locations, but is quite expensive.

Oxygen—The air is significantly thinner at 7,800 feet than at sea level. Most fuel cells are designed for operation at or near sea level. Because fuel cells use oxygen from the air when converting hydrogen into electricity, the lower oxygen levels at high elevation could reduce performance or cause the fuel cell system to shut down.

No babysitting—Unlike virtually all previous stationary fuel cell installations, no technical personnel are available at Big Goose Ranger Station to adjust or repair the fuel cells if they need attention. The nearest electrician is in Sheridan, WY. When road conditions are good, travel time between Sheridan and the ranger station is 2 hours. When road conditions are poor, the trip can take half a day. No technicians skilled in solid-oxide fuel cell maintenance were available in Wyoming.

The design team finally settled on a package system of two solid oxide 5-kilowatt fuel cells made by Acumentrics Corp. as the best choice for Big Goose Ranger Station. The solid-oxide fuel cells use a hard ceramic material instead of a plastic or liquid electrolyte, allowing them to withstand freezing temperatures. While power-up and power-down isn't instantaneous for any fuel cell, a battery bank charged while the fuel cells are running provides power during the short time it takes the fuel cells to go from idle to full power production. The batteries also provide power for surge loads up to 20 kilowatts. We originally

thought that the fuel cells would shut off when there was no power demand, but later discovered that a 500-watt idle load was required.

The Acumentrics Corp. fuel cells can use the standard propane delivered by Farmer's Co-op with no problems. Fans supplied with the fuel cells for Big Goose Ranger Station ensure that enough oxygen is available. The manufacturer was confident the fuel cells would not require frequent maintenance, and that the manufacturer's technicians would be able to perform adjustments remotely using a satellite uplink.

Interestingly, the Park Service installed the same model for use at the Kenai Fjords Exit Glacier Visitor Center in Alaska during 2003. The design team and manufacturer were able to improve the Big Goose installation based on some issues that surfaced during the first season of operation at Exit Glacier.

What We Have Learned So Far

Fuel cell technology is not going to work well for remote Forest Service applications until the operation package is more robust than was demonstrated during the first partial season of operation at Big Goose Ranger Station. The fuel cells shut down every time there was a glitch in the satellite uplink or electronics, which happened with alarming frequency. For remote use, the fuel cells need to run independently, without the necessity for an uplink or complicated electronics. The uplink and electronics are a good tool for monitoring and remote adjustments, but fuel cells that depend on these systems for basic operation are not suitable for remote locations. These problems may be resolved during the second season of operation.

The Tongue District reported that the fuel cells produced power less than half of the days between the system's installation in July and its seasonal shutdown in September 2005. Operational and reliability issues included:

- Batteries became deeply discharged. An error caused the batteries to continue powering a fan after the fuel cells quit producing power because the satellite uplink failed. They had to be removed from the site and hooked to a commercial battery charger in Sheridan. The batteries are needed for the satellite uplink, without which the fuel cells will not produce electrical power.

- Low cell voltage caused a fault on one unit. The cause of this problem is unknown.

- The satellite phone dialed a random unknown number instead of the number for Acumentrics Corp., preventing Acumentrics Corp. from making adjustments remotely. This problem was corrected.

- The district reported that the two large propane tanks at Big Goose Ranger Station had to be filled twice during the 2005 season instead of just once, which would have been normal. Accurate figures on propane use weren't available at the time of publication.

- Purge gas is an inert gas that cleanses the fuel cell system of hydrogen and propane gases each time it shuts down. Purge gas is expensive; around $185 per tank. Several tanks of purge gas were used because of many unexpected shutdowns during the 2005 operating season, an unanticipated addition to operating costs.

The performance of the fuel cells was disappointing during the first season at Big Goose Ranger Station. However, the forest and district are optimistic that the supplier can correct the problems, allowing Big Goose Ranger Station to enjoy the clean, quiet, efficient heat and power that the fuel cells should be producing. Another tech tip will provide an update after the second season of operation.

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Steve Quintana, Bighorn National Forest
Craig Yancey, Bighorn National Forest, Tongue Ranger District

About the Author

Kathleen Snodgrass came to MTDC as a project leader in 2001 from the Nez Perce National Forest, where she had been the facilities architect for about 7 years. She had worked in facilities, landscape architecture, land line, and general engineering on the Nez Perce National Forest for about 10 years, and had also spent about 10 years in highway design and construction with the Idaho Division of Highways after graduating from Washington State University in 1974 with a bachelor's degree in architectural studies.

Library Card

Snodgrass, Kathleen. 2006. Stationary fuel cells provide power at a remote Forest Service ranger station. Tech Tip 0673–2325–MTDC. Missoula, MT: U.S. Department of Agriculture Forest Service, Missoula Technology and Development Center. 8 p.

Describes the selection, installation, and first season of operation for the first stationary fuel cells used in the National Forest System. The two 5-kilowatt fuel cells were manufactured by Acumentrics Corp. They were designed to run on propane and to survive freezing temperatures when they were turned off. Historic Big Goose Ranger Station, where the fuel cells were installed, is at 7,800 feet in the Big Horn Mountains of Wyoming, 7 miles from the nearest powerline and hours from the nearest fuel cell technician. The project involved the cooperation of several Federal agencies and industry groups. During the first season of operation, the fuel cells' performance was disappointing. Problems are being corrected in hopes that the system will work better during the second season.

Keywords: Big Goose Ranger Station, Big Horn Mountains, Bighorn National Forest, electricity, equipment evaluation, facilities, fuel cells, green power, historic, hot water, propane, Wyoming

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Single copies of this document may be ordered from:

USDA Forest Service, MTDC
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Electronic copies of MTDC's documents are available on the Internet at: *http://www.fs.fed.us/t-d* (Username: t-d, Password: t-d).

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Forest Service and Bureau of Land Management employees can search a more complete collection of MTDC's documents, videos, and CDs on their internal computer network at: *http://fsweb.mtdc.wo.fs.fed.us/search*.

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