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Fuel Cell Failure and Success: Big Goose Ranger Station and the Exit Glacier Nature Center

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A demonstration stationary fuel cell was installed at the remote Big Goose Ranger Station high in the Bighorn Mountains west of Sheridan, WY, during July 2005 (figure 1). The system provided electricity to two cabins, a combination office and shop, five trailer sites, and the site's drinking water and wastewater pumping systems. Hot water produced by the fuel cells heated one of the cabins. Unfortunately, the fuel cells weren't as reliable as expected, and they were removed in late September 2006.

This tech tip summarizes the Big Goose fuel cell project and explains what the Forest Service, U.S. Department of Agriculture, learned. The installation and first season's operation of the Big Goose fuel cells were discussed in the tech tip, "Stationary Fuel Cells Provide Power at a Remote Forest Service Ranger Station" (0673–2325–MTDC, *http://www.fs.fed.us/t-d/pubs/htmlpubs/htm06732325/* Username: t-d, Password: t-d).

Highlights...

- Remote Forest Service sites need to generate electricity quietly and without creating pollution.
- Fuel cells are quiet and don't pollute.
- A demonstration fuel cell system was installed at Big Goose Ranger Station in Wyoming and removed in 2006 because it did not perform reliably.
- A similar fuel cell system was installed at the Exit Glacier Nature Center in Kenai Fjords National Park, AK, where it is still performing reliably.
- Although fuel cells are becoming more reliable, they are still too costly for routine use by the Forest Service.

Figure 1—Two 5-kilowatt fuel cells were installed at Big Goose Ranger Station during the summer of 2005.

The Fuel Cell Project

Fuel cells produce electricity and hot water using a quiet, nonpolluting chemical process that is explained in the tech tip "Fuel Cells Are Coming" (0371–2307–MTDC,

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http://www.fs.fed.us/t-d/pubs/htmlpubs/htm03712307/ Username: t-d, Password: t-d). Big Goose Ranger Station was selected as the test site for a demonstration fuel cell project in 2001 by the Forest Service's Missoula Technology and Development Center (MTDC). The site embodies most of the characteristics that make it difficult to provide power to remote Forest Service sites. The Big Goose Ranger Station (7,800 feet elevation) is 7 miles from the nearest powerline. No technical support is available at the site or even within several hundred miles. The fuel cells had to be shut down each winter and restarted each spring. The fuel cells ran on hydrogen reformed from propane, the only fuel readily available at the site.

In 2002 and 2003 a team was assembled to design and implement the project. The project team included Forest Service personnel from MTDC, the Tongue Ranger District, the Bighorn National Forest, and the Rocky Mountain Regional Office. The U.S. Army Corps of Engineers Engineer Research and Development Center and the U.S. Department of Defense Fuel Cell Test and Evaluation Center provided funding for the fuel cells and provided fuel cell system engineering through Concurrent Technologies Corp.

Additional funding was provided by the Propane Education and Research Council, and the U.S. Department of Energy Federal Energy Management Program and National Energy Technology Laboratory. Acumentrics Corp. was selected to manufacture and install the fuel cells. The contract included a 2-year warranty. The general contractor was Engineering Procurement & Construction LLC. The total cost of the fuel cell system and associated work was nearly $500,000.

Construction began at Big Goose after snow melted on the mountain in 2004. All of the supporting work was completed during the summer of 2004, including installation of the backup propane generator. Because of a delay by the inverter supplier, the fuel cells couldn't be delivered and installed until July 2005.

The two 5-kilowatt fuel cell units were installed in July and August of 2005. When the fuel cells were operating, they provided quiet, pollution-free power for the station. The fuel cells at Big Goose were monitored and controlled by the manufacturer using a satellite uplink.

The Big Goose fuel cells produced power on less than half the days between installation in July 2005 and seasonal shutdown in September 2005. It was rare for the fuel cells to operate continuously for a full day. Problems that caused the system to shut down included:

- Carbon deposits in the fuel lines
- Oxidation on the fuel cell anodes
- Cell overheating that damaged the wiring
- Software control issues that made it impossible to shut the system down properly

These problems couldn't be detected or corrected remotely because a reliable satellite uplink connection couldn't be maintained. It may have been possible to avoid or quickly correct the fuel cells' functional problems if the satellite link had been reliable.

Fuel cell operation cost more than anticipated. The fuel cells were expected to be more fuel efficient than the old generator, but the two large propane tanks at the site had to be filled twice during the 2005 season instead of once, as was normal using the old generator. This was probably due to all the system problems.

Several tanks of purge gas were used during the 2005 operating season because of the numerous shutdowns. Purge gas is an inert gas that cleanses the fuel cell system of hydrogen and propane gases each time the system shuts down. Purge gas cost about $185 per tank.

The fuel cells were shut down for the winter in late September 2005 using the procedures required by the manufacturer. Despite repeated requests that the fuel cells be serviced during the spring and early summer of 2006, they were not.

Grant funding was only available through 2006. The Forest Service couldn't wait until 2007 for repairs because the normal budget wouldn't cover the cost of modifications to the fuel cells. The Big Goose fuel cell team finally decided that if repairs weren't made by the end of July 2006, there wouldn't be enough time left in the operating season for any useful evaluation of the system. The fuel cell system did not operate in 2006. The U.S. Department of Defense terminated the contract with Acumentrics on July 28, 2006.

During the last week of September 2006, a team from Concurrent Technologies Corp. dismantled the fuel cell system and restored the site (figure 2). The following work was completed:

- The fuel cells, batteries, communication system, and related items were removed. Because the fuel cells

didn't provide reliable power, they were of no use to the Forest Service. The Forest Service and the U.S. Department of Defense agreed to transfer ownership back to the manufacturer for analysis and for design improvements.

- The glycol and storage tanks for the heating system were removed from the basement of the cabin. The glycol was delivered to the ice rink in Sheridan, WY, for reuse.
- The radiator heating system in the cabin was modified to use water heated by the propane water heater rather than by the fuel cells.
- The water lines, propane lines, and conduit beside the concrete fuel cell pad were cut at ground level and capped. The concrete pad was left in place.
- The remote starter for the generator was rewired so it would work as it had before the fuel cell was installed.
- The sewer pump controls were rewired so the float system would operate when the generator was on.
- The transfer switch in the generator building was bypassed so that all electric supply wiring ran directly to the generator.
- The wires from the generator to the fuel cell pad were pulled back into the conduit and the conduit was capped. This leaves the electric lines in place in case the district wants to pursue energy generation alternatives in the future.

Figure 2—The fuel cells were removed from Big Goose Ranger Station in September of 2006.

Because the fuel cell system installation included a new propane generator, it was relatively easy to remove the fuel cell system and restore conventional power generation to the site. In fact, Big Goose has a better electrical system now than before the fuel cells were installed.

What We Have Learned

Stationary fuel cells in the 5- to 20-kilowatt size range that are not tied to the power grid were not as close to commercial viability as we believed when we began this project. All the systems we reviewed were still in the advanced experimental stage. As demonstrated by the operation of the fuel cell system at the National Park Service's Exit Glacier Nature Center in 2006 (see "Hope for the Future" below), at least some systems may now be reliable enough for use in remote settings. Stationary fuel cells that are tied to the commercial electric power grid and operate at a steady output around the clock are closer to commercial viability than fuel cells that are not tied to the grid.

To work well at remote, unattended Forest Service locations, fuel cells need to be more independent and sturdy than those installed at Big Goose. For remote use, fuel cells should run reliably without a phone link, satellite uplink, or complicated electronics. Links and electronics could be good tools for monitoring and making remote adjustments, but should not be required for basic operation.

The fuel cell team worked well, even though most of the technical work was led by partner members from another agency and a private contractor. The Forest Service would not have been able to accomplish this project without partners because of the high cost of the fuel cells. Forest Service units without partners probably shouldn't attempt installation of fuel cells until stationary fuel cell technology becomes fully commercial and the price drops.

Hope for the Future

Two years before the fuel cells were installed at Big Goose, a similar fuel cell system was installed at the Exit

Glacier Nature Center in Kenai Fjords National Park, AK (figure 3). The team leaders for the Exit Glacier and Big Goose fuel cell projects have compared notes and discussed operating issues several times since the fuel cell systems were installed. Based on those conversations, the Big Goose project leader believes that if the necessary repair work had been completed in 2006, the Big Goose fuel cells probably would have worked well in their second season.

Figure 3—This fuel cell (inset), similar to the model used at Big Goose, provides electricity reliably for the Exit Glacier Nature Center at Kenai Fjords National Park in Alaska.

Both Big Goose Ranger Station and the Exit Glacier Nature Center receive extreme winter weather and don't operate then. Both locations use propane fuel. However, unlike Big Goose, Exit Glacier is at sea level, and its fuel cell system is housed indoors. More significantly, the operation of the Exit Glacier fuel cell system does not depend on satellite or phone communication with the manufacturer. Adjustments and most repairs are made by Park Service or contracted technicians. Components of the fuel cell system are shipped back to the manufacturer if extensive repairs or modifications are needed.

The system at Exit Glacier was installed in 2003. After installation, the system didn't run properly because it had been damaged during shipping. The system was returned to the manufacturer for repairs before being reinstalled in 2004, the first full operating season.

The system ran 340 hours during 2004, but several problems prevented it from operating most of the time. After that season, the system was shipped back to the manufacturer and the steam reformer was replaced with a C-POX (catalytic partial oxidation) fuel reformer. The Big Goose fuel cell system was built with the C-POX fuel reformer and a few other improvements that had also been made to the Exit Glacier fuel cell system.

In 2005, the Exit Glacier fuel cell system ran 850 hours during the season, but still was down numerous times because of software problems, wildly varying load profiles, and inverter problems. The problems were similar to those experienced at Big Goose, which also had problems with the satellite uplink.

After the 2005 season, the Exit Glacier fuel cell unit was again shipped back to the manufacturer—this time for modifications to the software and fuel cell stacks that improved efficiency and performance. The water system pumps operated by the fuel cell were modified to have "soft starts," decreasing the instantaneous electrical load. Similar modifications were not made to the Big Goose system.

After the fuel cell unit was returned to Exit Glacier in July 2006 and the batteries were replaced, it ran for more than 1,100 continuous hours. The system was still running perfectly when it was shut down for the winter. The system started in 2007 with just one hitch—a burned-out fuse. The project team leader expects the 2007 operational season to be as uneventful as the 2006 season.

The Big Goose fuel cell system probably would have worked well if the manufacturer had been able to perform the necessary work during the summer of 2006. It is disappointing that this installation didn't meet expectations. The continued successful operation of the fuel cell at Exit Glacier demonstrates that fuel cell installations may soon be feasible at remote Forest Service sites.

Keeping Up With Fuel Cell Developments

The following Web sites are updated frequently with the latest information about fuel cells. Readers also are

encouraged to search other Internet sites or publications that may address their specific interests:

- Fuel Cells 2000 *http://www.fuelcells.org/*
- Fuel Cell Works *http://www.fuelcellsworks.com/news1.html*
- National Fuel Cell Research Center *http://www.nfcrc.uci.edu/*

To contact partners in the Big Goose fuel cell project:

- **U.S. Army Corps of Engineers Engineer Research and Development Center and the U.S. Department of Defense's Fuel Cell Test and Evaluation Center**

  Web site: *http://www.dodfuelcell.com/*

  Primary contact: Nicholas Josefik

- **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.html)*

  Primary contact: Randy Jones

- **Fuel Cell Test and Evaluation Center (FCTec)**

  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

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About the Author

Kathleen Snodgrass came to MTDC as a project leader in 2001. She graduated from Washington State University in 1974 with a Bachelor of Science degree in architectural studies, then spent about 10 years in highway design and construction with the Idaho Division of Highways. She began her career with the Forest Service in 1984. Kathie worked in facilities, landscape architecture, land line, and general engineering on the Nez Perce National Forest for about 10 years. She was the forest's facilities architect for about 7 years before coming to MTDC.

Library Card

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The first stationary fuel cell system in Wyoming and in the Forest Service was installed at Big Goose Ranger Station in 2005. The fuel cells were removed in late September 2006 because the system did not perform reliably. This tech tip summarizes the Big Goose fuel cell project and explains what the Forest Service learned from it. The National Park Service successfully used a similar fuel cell at the Exit Glacier Nature Center in Kenai Fjords National Park, AK.

Keywords: Alaska, Big Horn Mountains, Bighorn National Forest, distributed energy production, electricity, energy sources, Exit Glacier, facilities, green power, hot water, hydrogen, National Park Service, propane, Wyoming

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Electronic copies of MTDC's documents are available on the Internet at:

http://www.fs.fed.us/eng/t-d.php

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 networks at:

http://fsweb.mtdc.wo.fs.fed.us/search/

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