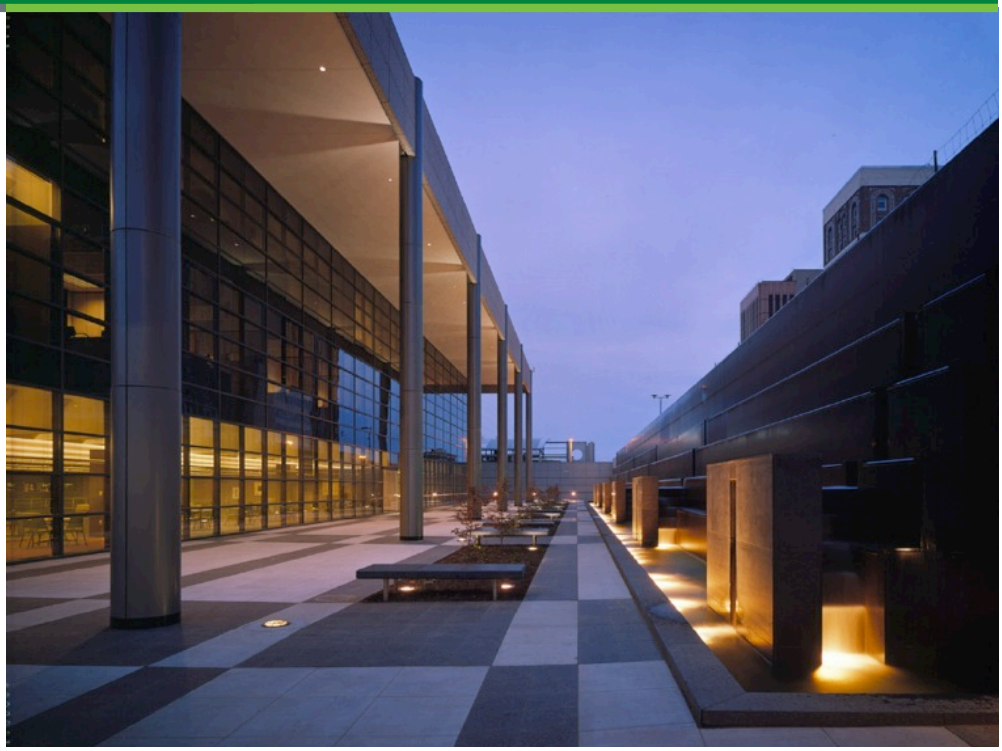
Case Study: Fuel Cells Increase Reliability at First National Bank of Omaha Technology Center

Fuel cells are a viable primary power choice for data centers—they generate highly reliable on-site power and useful thermal energy, and they can reduce greenhouse gas emissions by more than 50% compared to the baseline.[1] First National Bank of Omaha installed a fuel cell system in 1999 to provide primary power to its data center in Omaha, Nebraska. In more than 89,000 hours of operation through October 2009, the system is estimated to have reduced heating bills by more than $1 million. An independent third party verified that the designed total power system availability—including the use of four fuel cells, four rotary uninterruptible power supply systems (UPS), and other equipment—exceeded 99.9999%.[2]



Courtesy of First National Bank of Omaha

Background

Financial institutions rely on data centers to store, manage, and process digital data related to tasks such as securing check transactions and processing credit cards. The power supply to the data centers' computers must be free from surges, spikes and outages because an hour of downtime can cost millions of dollars in lost transactions.[5,6]

First National Bank of Omaha, a subsidiary of First National of Nebraska with locations in seven states, is one of the 50 largest banks in the U.S., serving almost 7 million customers nationwide. In 1998, First National built a 200,000 sq ft data center in downtown Omaha to process approximately 2.3 million credit card, banking, and ATM transactions/day.[7] Soon after construction was completed, the bank recognized that the electric grid would be unable to provide the power reliability that the center requires. During one particular grid outage, the backup generators failed to start and the timely processing of several million dollars of credit card transactions for a major U.S. retailer became problematic. The bank estimates that one hour of downtime is valued at $6 million.[8]

Project Planning and Evaluation

The Technology Center's primary power availability must match or exceed the availability of the computer system—a minimum of 99.9999%. Several alternatives were examined, and a 20-year lifetime economic analysis concluded that fuel cells were more economical than battery UPS systems, largely due to the latter's high maintenance and replacement costs, and an additional $28,000/year in cooling costs.

Because the incumbent system used relatively low-cost coal as its primary fuel supply, the economic analysis showed that primary power from the electric grid costs less than fuel cell system power. However, the grid's lower reliability could cost the bank more in downtime losses than the savings gained by using grid power. Independent reliability analysis has shown that the Technology Center's total fuel cell system—including the four fuel cells, rotary UPS systems, and backup generators—could surpass their reliability needs by providing an unmatched availability of 99.9999% measured against independent failures. While simple payback is typically calculated based on energy savings for an installation such as this, the bank decided to install the fuel cell system not for energy cost savings but for savings resulting from reduced downtime and increased customer satisfaction.

System Configuration

The data center system comprises four 200 kW UTC Power phosphoric acid fuel cells (PAFC) in a high-availability primary power system configured by

Project Summary

Location	First National Bank of Omaha Technology Center, Omaha, Nebraska	
Primary Objective	Reliable primary power supply	
Incumbent Technology	Grid electricity/emergency generators, lead acid batteries/UPS system, and gas-fired furnaces	
System and Manufacturer	Primary power to four rotary UPS units provided by four phosphoric acid fuel cells rated at 200 kW, for a total capacity of 800 kW. Total system including rotary UPS units supplied by Sure Power Corporation. (The original fuel cell manufacturer was UTC Power, acquired by ClearEdge Power in 2013.)	
Fuel Cell Start Up Date	February 1999	
Fuel Supply	Two separate natural gas grid distribution sources for redundancy	
Operating Hours	More than 89,000 hours (May 1999 to October 2009)	
Availability	99.9999%	
Efficiency (Lower Heating Value)	Electrical Efficiency	37.6% (at end of 89,000 hours)[3]
	Thermal Energy Recovered	9.5 Billion Btus (10,000 GJ)/year[3]
	Overall Fuel Cell Efficiency	55.4% (thermal and electrical)
Benefits	Use	Provides primary power, backup power, and heating and cooling for critical credit card processing operations. In the winter, thermal energy is also used for melting snow.
	Cost Savings	$107,000/year from recovering fuel cell waste heat[4]
	Emissions Avoided by Displacing Grid Electricity, Metric Tons	CO_2: 29,800, NO_x: 130, SO_x: 190
	Emissions Avoided by Using Fuel Cell Heat to Displace Gas-Fired Furnaces, Metric Tons	CO_2: 8,000 (the displaced gas-fired furnaces are assumed to emit negligible amounts of NO_x and SO_x—so no savings are shown)
	Total Emissions Avoided from Displacing Grid Electricity and Utilizing Fuel Cell Thermal Energy, Metric Tons	CO_2: 37,800, NO_x: 130, SO_x: 190 (sum of emissions in previous two rows)
System Cost (after $800,000 Government Grant)	$680,000/fuel cell, $3.2 million for the four fuel cells and rotary UPS systems (excludes installation costs and backup generators)	

Sure Power Corporation. The system also includes four rotary UPS units, backup generators, as well as two electric feeds and two natural gas distribution supplies. Only two of the four fuel cells are required at any one time to support the center's 340 kW critical load, which includes the computer mainframe, peripheral computers, and servers. The other two fuel cells generate an additional 400 kW for non-critical loads and serve as backup to the critical load system. The redundant nature of the system enables routine maintenance without affecting critical loads and provides additional protection against power interruptions. The secondary system also produces supplemental electricity that is sold to the Omaha Public Power District (OPPD) when the electric grid reaches peak load at a rate of about $0.135/kWh (based on 2008 rates).

The fuel cells provide primary power to four rotary UPS units that maintain the center's critical electrical system. Two separate gas grid distribution sources furnish natural gas to the fuel cells. Two 1,250 kW diesel generators provide primary backup power to the fuel cells and ultimately to the UPS units, and two independent utility feeds from the Omaha Public Power District provide secondary backup power. The UPS units, which employ flywheels, store mechanical energy that is converted as needed to electrical energy using electric generators. These UPS units provide a seamless transition between power sources by providing up to 40 seconds of power—enough time for the fuel cells to reconfigure or generators to start.

The fuel cells produce heat that is captured by integral heat exchangers in each

Fuel cells (right) and gas regulators (left) installed at the First National Technology Center.

Courtesy of First National Bank of Omaha

control system and to provide hot water to coils beneath the sidewalks that melt snow. During the summer months the heat is used as part of the air conditioning system. In this case, building air is chilled to a low temperature to remove moisture and then the cool air is reheated with fuel cell waste heat to bring its temperature into the comfort range. Sure Power Corporation estimates that approximately 9.5 billion Btus of heat are recovered every year with an estimated value of $107,000/year.[3,5]

Installation

First National's fuel cell system was one of the largest indoor installations in the world. The bank also became the first entity permitted to operate in parallel with the local utility, Omaha Public Power. At the start of the project, there were challenges in coping with Nebraska's unusually high concentration of nitrogen in the natural gas supply, which compromises the performance of fuel cell stacks. A scrubber was installed on the natural gas supply system to reduce the nitrogen content and limit fuel cell damage.

Maintenance

The Technology Center's in-house technicians were trained by the original manufacturer, UTC Power, at its Connecticut headquarters to manage operations and perform nearly all routine fuel cell maintenance; the company's technicians repair only major components. Routine maintenance is completed at scheduled intervals, typically quarterly and annually depending on individual component requirements, and the redundancy of the system allows each fuel cell to be offline for maintenance without disrupting operations. The fuel cell manufacturer provides continuous monitoring, which enables potential maintenance issues to be addressed before problems arise. Proactive maintenance and coordination between the fuel cell manufacturer and the Technology Center has resulted in a fuel cell system that is easy to maintain and operate.

UTC Power PC25C fuel cells installed in the basement of First National Bank of Omaha's Technology Center in Omaha, Nebraska.

Courtesy of First National Bank of Omaha

Cost of System

Each fuel cell cost $680,000, with the system capital cost of the four fuel cells and four rotary UPS systems (excluding diesel generators and installation costs) totaling $4.0 million. With an $800,000 grant ($200,000/fuel cell) from the U.S. Department of Defense's Climate Change Fuel Cell Program, the net system cost totaled $3.2 million. The Investment Tax Credit for fuel cells was not in place when this project was undertaken. It is estimated that the Technology Center saves $107,000/year by recovering waste fuel cell heat for use in building heating and cooling systems.

Project Results

First National has reduced its energy costs by selling electricity to the utility and using waste fuel cell heat, and benefited from the exceptional (99.9999%) availability of its fuel cell system. Since the system began operating in 1999, the Technology Center has never experienced a system shutdown. Once, an accidental interruption in service by the natural gas supplier shut down the fuel cells. However, due to the redundant design of the backup systems, critical loads were not affected.

The fuel cell CHP system emits much less CO_2, SO_x and NO_x compared to grid electricity produced from fossil fuel-burning power plants in the Upper Midwest grid region.[9] In addition, by using fuel cell waste heat for heating and cooling, the data center avoids carbon emissions associated with gas-fired furnaces. It is estimated that approximately 38,000 MT of CO_2, 130 MT of SO_x and 190 MT of NO_x have been avoided since initial startup of the fuel cells from May 1999 through October 2009.

For More Information

For more information, visit http://www.hydrogenandfuelcells.energy.gov.

References and Notes

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