

Case Study of Austin Energy's 200-kW Fuel Cell

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ABSTRACT

In the spring of 2001, Austin Energy decided to pursue a commercial fuel cell demonstration project to determine the issues involved with either a customer or the utility owning, installing, operating and maintaining this technology. A significant component of this project included understanding the issues associated with distributed generation connected to the local utility grid and how this would impact both the customer and the grid. An added benefit would be to provide a fuel cell education site that is accessible to other Austin Energy customers and the general public.

The site selected for the project is the city-owned Rebekah Baines Johnson Health Center, which houses the city health clinic. Because the Health Center had existing redundant 1,000,000 Btu per hour boilers for Heating, Ventilating, Air Conditioning, (HVAC) desiccant drying, and building heat along with a domestic hot water heater, the site presented an opportunity for using the waste heat generated by the fuel cell power plant in a combined heat and power application.

Using a federal grant of \$200,000 from the Climate Change Program administered by the U. S. Department of Defense, Austin Energy installed a 200-kW UTC Power Model PC25™C fuel cell. This fuel cell was the first in Texas to feed electric power into the utility grid. Commercial operation began July 2, 2002.

The issues to be worked through in many areas proved to be difficult, but doable, and many lessons have been learned along the way. The performance results have been impressive proving that this technology is not only technically viable in commercial applications but reliable as well.

The lessons learned from this project have proven valuable and a number of key issues will be shared in this paper. Included will be issues associated with site planning, permitting, and grid interconnection. Also, the fuel cell performance along with the operations and maintenance history will be discussed.

INTRODUCTION

Austin Energy is the nation's 10th largest municipally owned electric utility, serving the Capital city of Texas and a population of 840,000. Austin Energy owns 2,540 MW of generation fueled by natural gas, coal, and nuclear and over 100 MW of renewable sources under contract including wind, biogas and hydroelectric. The Austin Energy owned electric distribution system consists of 54 substations and more than 8,800 miles of underground and overhead lines.

Austin Energy is a recognized national leader in energy efficiency and "green energy" programs. The utility provides one of the most comprehensive energy efficiency programs in the nation with 20,000 customers annually making home energy efficiency improvements. Its green building program was the first in the nation and is credited for development of the first "green" rating system for both residential and commercial construction.

For several years Austin Energy has been involved in distributed generation on the local, state, and national levels for the purpose of seeking out the benefits of this emerging technology for the utility, customers, and the environment.

Because fuel cells hold promise of many benefits including a positive impact on the environment, Austin Energy has been keeping abreast of this emerging technology. In the spring of 2001, Austin Energy decided to pursue a fuel cell demonstration project to determine the issues involved with either a customer or the utility owning, installing, operating and maintaining this technology. An added benefit of this project would be to provide a fuel cell education site for customers and the general public.

On November 1, 2001 the Austin City Council approved the RBJ fuel cell project and on July 2, 2002 the RBJ fuel cell project began commercial operation.

A picture of the RBJ fuel cell site with RBJ Health Center in the

background can be found in Figure 1. A view of the fuel cell plant can be found in Figure 2.

FEDERAL GRANT

Austin Energy began a search for available supplemental funding and found an existing federal grant held by Logan Energy of Roswell, Georgia. The grant was part of the U. S. Congress Climate Change Fuel Cell Program. The Congress designated the U. S. Department of Defense (DOD) to act as grant administrator through the U. S. Army Tank-Automotive and Armaments Command Armament Research, Development and Engineering Center (TACOM-ARDEC), Picatinny Arsenal, N. J. Logan Energy remained the grant holder and permission was obtained from the DOD to change the site to RBJ Health Center in Austin. Through a contract with Logan Energy, Austin Energy would receive the proceeds from the grant in the amount of \$200,000 (\$1,000 per kilowatt). Requirements of the grant included:

- Prior to installation of the fuel cell, the recipient must identify the specific location of the power plant at the site.
- The recipient must assure that the power plant is installed and operated in accordance with all federal, state, and local regulatory requirements.
- The purchase of the power plant must include a 5-year maintenance contract. A copy of this contract must be provided before final payment of the grant is made.
- The recipient must submit a final technical report.
- The recipient must submit the required financial forms.

FUEL CELL

The fuel cell power plant installed at RBJ Health Center is a 200 kW phosphoric acid fuel cell manufactured by United Technologies Corporation, the UTC Model PC25TMC fuel cell. This fuel cell was chosen because it was found to be the only commercially available fuel cell that met all the requirements of the DOD grant.

The PC25TMC fuel cell consists of two modules. The power mod-

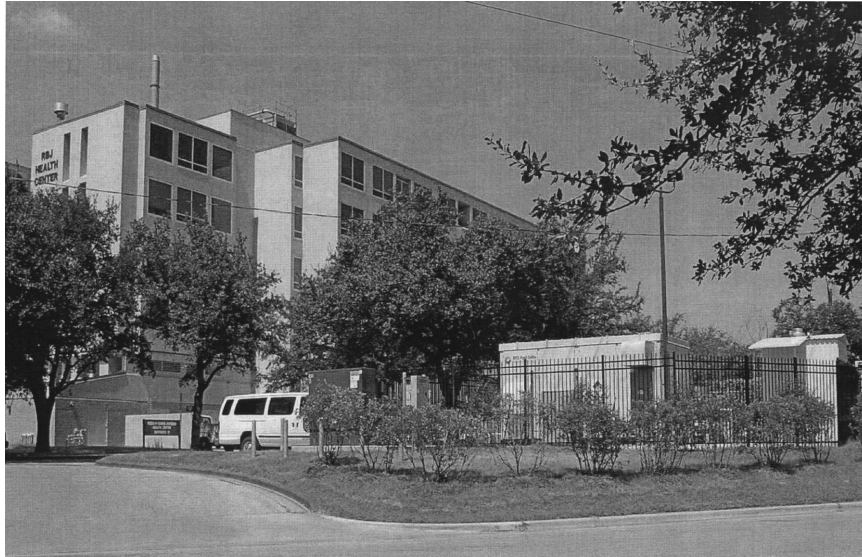


Figure 1. RBJ Health Center with the PC25TM in the Foreground



Figure 2. PC25TM Fuel Cell at RBJ Health Center

ule converts natural gas fuel into alternating-current electric power. A separate cooling module rejects excess heat generated by the power module.

The power module contains a fuel processor. Pure hydrogen is not currently feasible for direct use in fuel cells because of the high costs associated with production and storage along with safety issues that need to be resolved. As a result, the power module uses an onboard fuel processor to extract hydrogen from natural gas through a steam reforming process. Because the fuel cell stack operates at 350°F, water produced by the electrochemical process is in the form of steam and is recovered for use in the reformer.

As a safety precaution, a nitrogen purging system automatically purges all hydrogen out the exhaust stack in the event the fuel cell power plant shuts down for any reason.

Below about 85°F ambient temperature, the fuel cell generates more water than is required by the power plant processes and the excess is discharged as water vapor into the atmosphere through the fuel cell exhaust. Above 85°F ambient temperature, makeup water is required and is supplied through an automatic makeup system using reverse osmosis technology.

The fuel cell stack generates direct-current electric power that is sent through a power conditioner contained in the power module and converted to 480 volt, 3-phase alternating-current electric power. The RBJ fuel cell generates over 1,500,000 kWh per year into the Austin Energy electric grid.

Additional equipment to support the fuel cell power plant includes electrical connections to the electric power grid (including safety devices), piping and control system to the building for combined heat and power, nitrogen supply and connection, connection to the natural gas distribution main, and electrical and piping connections between the cooling module and power module.

The factory technical specifications for the PC25™C fuel cell can be found in Table 1.

MAINTENANCE SCHEDULE

The factory recommended scheduled maintenance for the UTC PC25™C fuel cell can be found in Table 2.

Table 1. PC25TMC Fuel Cell Technical Specifications

kW/kVA	200 kW/235 kVA
Phase	3 phase
Hertz (Hz)	60 Hz
Voltage	480 volts
Fuel	Natural gas at 4 to 14 inches water pressure 1,900 standard cubic foot per hour nominal
Sound Level	62 Dba at 30 ft.
Ambient Temperature	-20°F to +110°F
Thermal Energy for CHP	900,000 Btu per hour at 140°F
Power Module Dimensions	18 ft long x 10 ft wide x 10 ft high
Cooling Module Dimensions	14 ft long x 4 ft wide x 4 ft high

Table 2. PC25TMC Fuel Cell Maintenance Schedule

Activity	4 to 6 months (operating)	Annual (shutdown)	5 to 10 years Overhaul (shutdown)
Replace water treatment system beds and filters	X	X	
Replace air filters	X	X	
Inspect pressure vessels		X	
Check relief valves		X	
Check and service motor bearings		X	
Clean water tank		X	
Fuel cell stack			X
Fuel processor			X

SITE

To glean as much information as practical from both the customer and utility views, specific site selection criteria were put into place to ensure adequate controls and access for the project. Because the project would extend well past installation to include operating, monitoring,

and maintaining the fuel cell as well as other activities such as public tours, these controls and access would need to continue for the life of the installation. With these considerations in mind, the site selection criteria included:

- A commercial type building suitable for a 200 kW fuel cell
- Opportunity for cogeneration
- Accessible to Austin Energy at all times
- Easy access for tours by the general public and interested customers
- Austin Energy electric grid interconnection compatible.

After careful consideration, only city-owned sites were considered feasible to adequately meet all the expectations of this project. The resulting site search led to the city health clinic at the Rebekah Banes Johnson Health Center, a five-story, 50,000 ft² building located near downtown Austin at 15 Waller Street.

As is typical of major cities, the city of Austin's Design Review and Inspection Department (DRID) required a site plan review before any construction permits could be obtained. Because DRID had never seen a stationary commercial fuel cell installed in Austin before, considerable effort was required in matching up the fuel cell project with existing city site plan criteria.

Based on the idea that a fuel cell is a piece of equipment, a site plan review exemption was requested. To qualify for an exemption, several conditions had to be met including:

- The total area affected by construction must be less than 10,000 ft²
- The construction plan must contain less than 1,000 ft² of impervious cover

Because the fresh water supply for much of central Texas, including Austin, is supplied by underground aquifers, the city has ordinances regulating access and use of the aquifers. To ensure that new construction does not prevent storm water runoff from recharging the aquifer, watershed protection regulations exist for the city of Austin.

Projects with less than 1,000 ft² of impervious cover are exempted. The plans for installing the fuel cell at RBJ Health Center were drawn

up to conform to these regulations.

In the end the project met the qualifications for a small project site plan review, and after all plans were submitted and reviewed, the project was determined by DRID to qualify for a site plan review exemption.

The installation of the fuel cell at RBJ Health Center met existing city zoning requirements.

All other permitting issues, including environmental and building permits, were routinely resolved within existing guidelines and did not prove to be a burden.

The entire site plan review process, including design drawing, submittal, review, and exemption approval was about three months in length.

AIR PERMIT

Because the fuel cell would be connected to the electric grid, the Texas Commission on Environmental Quality (TCEQ, formerly the Texas Natural Resource Conservation Commission) required an air quality permit in accordance with *Air Quality Standard Permit for Electric Generation Units, effective date June 1, 2001*. The air permit was obtained in about two weeks with no cost, and required merely submitting a Form PI-1S. The requirements applicable to the fuel cell are:

- Construction could not begin prior to written approval by the TCEQ executive director.
- The fuel cell must be registered with the TCEQ.
- Permit registration fees were waived (Requirement: NO_x emissions < 0.047 lb/MWh).
- NO_x emissions must be certified in lb/MWh and displayed on the nameplate of the fuel cell (a nameplate was affixed to the fuel cell certifying certify NO_x emissions < 0.035 lb/MWh).
- NO_x emissions must be no more than 0.47 lb/MWh (Requirement: Generating capacity < 10 MW and operating more than 300 hours/year).

- NO_x emissions must be re-certified every 16,000 hours (not to exceed 3 years). This must be done by either third party testing, or by following a manufacturer maintenance program certified for continued compliance.
- Records must be maintained for operating hours.
- Records must be maintained for maintenance and/or testing to document re-certification of emission rates.

FIRE CODES

Because the fuel cell at RBJ Health Center was the first commercially sited fuel cell in Austin, the city Fire Marshall's office needed answers to several questions to determine code compliance for installation. A series of phone calls, meetings and discussions with the Fire Marshall's office were centered on three main issues: life safety, hazardous materials, and fire.

Life Safety

The original plan included connecting the fuel cell to the distribution circuits within the health clinic providing primary power to the building with the Austin Energy electric grid as backup. The circuits involved would fall under local and national regulations for life safety. In the end, connecting to the building distribution circuits proved technically unfeasible (see Technical Issues section) and the fuel cell was connected to the Austin Energy distribution grid. This eliminated life safety issues.

Hazardous Materials

Hazardous materials contained in the fuel cell included hydrogen, phosphoric acid, and catalyst.

To power the fuel cell, hydrogen is extracted from natural gas in the reformer section of the power plant and sent to the cell stack. This hydrogen is generated as the fuel cell stack uses it and virtually all the hydrogen is converted into water in the process with only trace amounts going to atmosphere. In the event of a shutdown of the fuel cell, any hydrogen remaining in the power plant system is immediately and automatically purged using nitrogen. Because the fuel cell power plant

is outdoors, no protection was required other than the existing power plant equipment.

Phosphoric acid is used as an electrolyte in the fuel cell stack. The acid is absorbed in a thin carbon plate in each fuel cell and remains suspended through capillary action. The total volume of phosphoric acid in the fuel cell stack is about 500 lb. Because the phosphoric acid remains suspended within the fuel cell carbon plates, it was classified as a solid hazard. However, the fuel cell assembly configuration provides for secondary containment of the acid.

Catalyst is used in the fuel processor to extract hydrogen from natural gas. The catalyst is not routinely handled on site and is changed out at the 40,000-hour (5 years) maintenance outage.

Fire

After reviewing the fuel cell power plant and its components, the need was seen for the development of a fuel cell curriculum for firefighter training. The Austin Fire Department developed this curriculum.

TECHNICAL ISSUES

The RBJ Health Center peak electric demand is about 300 kilowatts. Service to mechanical room equipment (HVAC, chillers, motors, etc.) is 208 volts. A 450-kilowatt Generac diesel generator set is used for backup power.

Because the fuel cell produces only 200 kilowatts of power, it does not have capacity to meet the entire building peak load demand of 300 kilowatts. In view of this, an engineering review of the building was conducted with the goal of connecting the fuel cell to provide primary power to the health clinic building life safety circuits only, while sending excess capacity to the Austin Energy grid. The review revealed that life safety circuits were connected to all four of the building distribution panels and renovating the building wiring to accommodate this goal proved too costly for this project.

An engineering review was then conducted with the goal of connecting the fuel cell to the building main distribution circuit to operate continuously at full capacity. This would allow all 200 kilowatts of power to flow from the fuel cell to the building in parallel with the grid during periods when building load exceeded the fuel cell capacity. Also,

this would allow power to flow back into the grid during periods when the fuel cell capacity exceeded the building load.

There were several major hurdles to overcome. The engineering review revealed that addition of the fuel cell would increase the available fault current in the building distribution system beyond the capability of the installed building switchgear. Upgrading the equipment proved to be fraught with problems. The area where the distribution equipment renovation would occur has extremely limited space, requiring removal of the old equipment prior to installation of the new (this proved impractical, because the building operates 24 hours per day, 7 days per week). Overcoming these issues proved too costly to be practical for this project and this goal was abandoned.

During the engineering design review, consideration was given to running the fuel cell in parallel with the backup generator during emergency conditions. This review concluded that operating the backup generator and the fuel cell in parallel would result in major electric harmonics problems and would not work.

After engineering reviews of the building distribution system were completed, a decision was made to interconnect the fuel cell directly to the utility electric grid at the high side of the building main transformer. Although this proved to be a disappointment from a goal standpoint, the engineering exercises proved very valuable because Austin Energy now understands the issues and solutions for interconnecting fuel cells to building electrical systems.

ELECTRIC GRID INTERCONNECTION

The RBJ Health Center fuel cell is the first fuel cell in the state of Texas to be interconnected and feeding into the electric grid. At the point of interconnection, the Austin Energy distribution feeder is 12,475 volts.

As is typical with most electric utilities, any electric generator that is connected to the Austin Energy electric grid must install utility-grade interconnection control and protection devices that are provided by vendors well experienced in utility-grade equipment with a proven history known to Austin Energy. Included in this equipment are protective relays designed to completely and quickly disconnect the generator from the electric grid in case of an electric excursion caused by either the generator or the grid. An excursion can be caused by such events as

over- or under-voltage, over- or under-frequency, harmonic distortion, etc. This equipment must operate correctly to ensure the safety of electric grid equipment and personnel.

Because the PC25TMC was equipped with an integrated control and protection scheme designed and installed by the fuel cell manufacturer, Austin Energy required additional protective relays. A Model 351 Protective Relay was purchased from Schweitzer Engineering Laboratories, Inc. and installed.

The Texas Public Utility Commission has outlined a process for pre-certification of distributed generation, including fuel cells, in their Distributed Generation Interconnection Manual. The PC25TMC installed at RBJ Health Center was not pre-certified.

CONTROLS/COMMUNICATIONS

The RBJ Health Center fuel cell runs unmanned with remote communications access and control capability. This allows for considerable flexibility in monitoring and controlling the fuel cell.

The fuel cell is monitored and can be controlled via phone line from the Domain District Cooling Plant owned by Austin Energy (located in north Austin). The Domain plant serves as a central dispatch base when the need arises to call out technicians for emergencies.

The UTC fuel cell factory in South Windsor, Connecticut monitors Austin Energy's PC25TMC fuel cell power plant 7 days per week, 24 hours per day via a dedicated phone line. This also allows factory control of the fuel cell if necessary.

The fuel cell can also be accessed via phone line by remote computers equipped with the proper software and security access. A laptop computer is used to access the fuel cell remotely or can be plugged directly into the fuel cell control system.

Should the fuel cell shut down for any reason, the fuel cell will notify the designated on-call person by pager.

COGENERATION

Because of the economic and environmental benefits, cogeneration is a major driver in the Austin Energy distributed generation program.

Cogeneration (also known as combined heat and power or CHP) is the process of capturing waste heat resulting from generating electricity and using this energy in beneficial ways, such as producing steam and domestic hot water, and to augment boilers. The result is higher energy efficiencies that not only reduce the cost of generating energy, but also provides environmental benefits because less fuel is required for the total energy generated (electricity and usable heat). In effect, the CHP thermal energy is "free fuel" because the same amount of natural gas is consumed by the fuel cell to make electricity with or without CHP. Because no natural gas is consumed in the CHP thermal energy cycle, no emissions are generated. At the same time, existing boiler and water heater fuel supplies are reduced or displaced entirely by the CHP process, thus reducing or eliminating their emissions. Based on the energy produced versus the input energy of the fuel (fuel Btu/kW), traditional central power plants have electrical efficiencies of about 30% to 35%, with state-of-the-art combined cycle units in the 50% to 55% range. The UTC fuel cell has the potential of 85% CHP efficiency if all the waste heat were captured and used.

One goal of the RBJ fuel cell project is to study the real world benefits of CHP. Producing approximately 900,000 Btu/hr of usable thermal energy (waste heat), the PC25TMC fuel cell has great potential for CHP.

The fuel cell power plant contains two external hot water loops. The cooling loop carries rejected excess heat from the fuel cell to the cooling module. The CHP thermal loop supplies thermal (heat) energy to the Health Center building.

The Health Center mechanical room contains two (redundant) natural-gas-fired 1,000,000 Btu/hr boilers for HVAC and heating, and a 100-gallon domestic water heater. Hot water from the fuel cell power plant heat exchanger is pumped directly into the two boilers through the CHP thermal loop. However, building codes required installation of a double-walled heat exchanger between the fuel cell CHP thermal loop and the domestic water heater to prevent cross-contamination.

A simple, but important, finding of this project is the fact that rated CHP efficiencies of the fuel cell can be realized only if the thermal energy is fully utilized. This fact is demonstrated by analysis of the existing building thermal heat load.

The total gas requirement for the RBJ Health Center boilers is seasonally affected and ranges from about 150,000 Btu/hr in the summer to about 750,000 Btu/hr in the winter (on a monthly average). The total

fuel cell CHP efficiency fluctuates accordingly with the result being that the building is unable to use all the available heat produced. Of the approximately 7.8 million Btu of thermal energy expected to be generated by the fuel cell per year, less than one-fourth of that amount is needed to meet the building heat load.

PROJECT MILESTONES

Project Milestones can be found in Table 3.

Table 3. Project Milestones

Date	Milestone
11/1/2001	The Austin City Council approves the RBJ fuel cell project
1/8/2002	Purchase order released to UTC
1/8/2002	Project kickoff meeting
1/8/2002	Site development planning begins
4/19/2002	Site plan exemption granted
4/24/2002	Building permits granted
4/24/2002	Construction begins
5/13/2002	Fuel cell delivered to site
6/7/2002	Completed 8 hour test run for DOD grant
7/2/2002	Fuel cell on line

CONTRACTOR

A contract for turnkey installation was successfully negotiated and a purchase order was released to United Technologies Corporation (UTC) on January 8, 2002.

On January 8, 2002 a project kickoff meeting and site visit were conducted and the project entered the engineering phase. UTC sub-sub-contracted DMJNH+N for site engineering and project management and DPR Construction for construction.

Among the issues to be resolved were:

- Zoning
- Site planning

- Building codes
- Permitting (air emissions, wastewater)
- Installation drawings
- Hazardous material requirements
- Electric grid interconnection
- Fuel contract
- Controls/communications
- Environmental waste
- Security

COST

Included in the cost of the RBJ Health Center fuel cell are:

- Fuel cell plant
- Cooling module
- Nitrogen manifold
- Reverse osmosis unit and building
- Piping and controls for cogeneration
- Double-walled heat exchanger for domestic water heating
- Grid interconnection protective relays
- Grid connect transformer
- Metering
- Engineering
- Site planning and preparation

The RBJ Health Center fuel cell was installed at a total cost of approximately \$1.2 million, or \$6,000 per kilowatt. Taking the \$200,000 federal grant into consideration, the installed cost to Austin Energy was \$5,000 per kilowatt. Included in the RBJ Health Center installation were added costs associated with making provisions for public access and tours. Through available government programs, it is possible to install a UTC fuel cell power plant for a lower cost in many applications.

Traditional natural-gas-fired central power plants are currently installed for \$450-\$550 per kilowatt. While Austin Energy does not believe fuel cells will replace central power plants anytime soon, the cost comparison does reinforce the fact that fuel cells are very expensive. However, fuel cells present opportunities that can offset the cost differential.

A significant value that fuel cells bring is in health benefits. The toxic air emissions produced by a natural gas powered fuel cell are negligible and are a fraction of those produced by other forms of generation. Of particular note is the fact that the toxic emissions produced are well below air emission standards set anywhere in the world, including those standards that have planned reductions in coming years. Additionally, recovered waste heat is used to actually offset natural-gas-fired boilers and water heaters, thus reducing the toxic air emissions they produce.

Also, the recovered heat energy produced by CHP provides economic value by reducing the costs associated with fuel, operation, and maintenance of boilers and water heaters.

Fuel cells configured to provide primary power to carry the entire load of a building while using the local electric grid as backup can eliminate the need for on-site diesel generators. The National Fire Prevention Association has even approved the elimination of backup diesel generators for life safety circuits with approved configurations of fuel cells using local electric grid power for backup. This not only adds significant economic value, but also adds health benefits by eliminating the toxic emissions associated with on-site diesel generators.

Fuel cells, properly configured, can provide all the power needs of a building and can continue to do so when the local electric grid suffers an outage.

This is by no means an exhaustive added value analysis for fuel cells, but is presented to demonstrate two things. First, on-site fuel cells and central power plants provide distinctly different values to the electric power grid and should not be viewed as competing entities, but rather as complementary value streams for the grid. Second, while the cost of on-site fuel cells will probably continue to be significantly higher than central power plants, the gap does not need to be closed entirely. However, to realize the true value of on-site fuel cells, the values as presented here need to be quantified and understood. Projects such as the RBJ Health Center fuel cell provide an opportunity to capture these real world benefits.

THREE-YEAR OPERATING SUMMARY

The reliability of the fuel cell has far exceeded Austin Energy's expectations throughout its three-year history. The system has been on-line over 95% of the time, including startup.

While the PC25™C fuel cell has the potential for 85% total CHP efficiency, the total efficiency of the RBJ fuel cell has been less than 40%. This is caused by two factors: 1) The RBJ Health Center building can use less than one fourth of the heat generated, by the system, and 2) There have been occasional outages on the CHP delivery system to the building at times when electricity continued to be generated.

The RBJ fuel cell has experienced several outages from disturbances in the electric grid. Occasionally, the grid has experienced an outage and tripped the fuel cell. On other occasions the fuel cell has momentarily discontinued sending power to the grid because of voltage unbalance on the grid feeder line. In these instances, the inverter simply stopped the flow of electricity to the grid for a short period of time (20 to 28 cycles) while the imbalance was corrected. The ability of the PC25™C fuel cell to do this prevents the unit from tripping, while protecting both the unit and the grid.

During its history, the RBJ fuel cell has experienced two forced outages because of a glycol coolant leak in the inverter requiring replacement of the inverter modules. In each case the outage time was about three weeks.

Also during its history, the CHP system has experienced two forced outages. During both outages, the fuel cell continued to generate electricity. This was possible because the CHP piping and the CHP control system are not integral to the PC25™C fuel cell, but use a heat exchanger for the interface. The outages were caused by leaks in the copper piping running underground between the fuel cell and the CHP interface located in the building mechanical room.

The three-year performance highlights of Austin Energy's PC25™C fuel cell are summarized in Table 4.

Resources

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Austin Energy: www.austinenergy.com

United Technologies, Inc.: www.utcfuelcells.com/fuelcells/index.shtm

Logan Energy: www.loganenergy.com

U. S. Department of Defense: www.dodfuelcell.cecer.army.mil/pafc/in-cex.php4

Texas Department on Environmental Quality: www.tceq.state.tx.us

Texas DG Interconnection Manual: www.dsireusa.org/documents/Incentives/TX10Ra.pdf

Sweitzer Engineering Labs, Inc.: www.selinc.com

Table 4. Performance Highlights of the RBJ Fuel Cell

Description	Highlight
Total hours on line	25,081 hours
Total electricity generated	4,949,000 kWh
Total Energy delivered to Health Center	5,386 million Btu
Electric Efficiency	29%
Total CHP efficiency	39%
Planned outages	156 hours
Unplanned outages	990 hours
Derated hours	769 hours
Availability factor	95.49%
Gross capacity factor	94.21%

ABOUT THE AUTHOR

Larry Alford has over 30 years of experience in the electric utility industry and for the past four years has been the Manager of Distributed Generation at Austin Energy. Mr. Alford is responsible for on-site distributed generation and CHP projects. He led the successful effort to install the first commercial fuel cell in Austin, which was the first fuel cell in Texas to feed power into the local electric utility grid. He served on the Fuel Cell Advisory Committee for the Texas State Energy Conservation Office's Fuel Cell Initiative. He has also served on the advisory panel for The Texas Leadership Consortium for Curriculum Development. Mr. Alford attended Texas A&M University—Kingsville. Mr. Alford may be contacted at larry.alford@austinenergy.com.