Austin Energy’s

REBEKAH BAINES JOHNSON HEALTH CENTER

FUEL CELL PROJECT

Installation

Commercial Operation July 2, 2002

INTRODUCTION

Austin Energy (AE) is the nation's 10th largest municipally owned electric utility, serving the Capital city of Texas and a population of 840,000. AE 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 AE owned electric distribution system consists of 54 substations and more than 8,800 miles of underground and overhead lines.

Austin Energy and the city of Austin 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. It's 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.

PURPOSE

A fuel cell is a device that combines hydrogen fuel with oxygen from the air in an electrochemical process to produce electricity, heat, and water.

Since 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, AE 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.

On July 2, 2002 the RBJ Fuel Cell Project began commercial operation.

FEDERAL GRANT

A search for available supplemental funding discovered an existing federal grant held by Logan Energy of Roswell, Georgia. The grant funding was provided by 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, AE 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 UTC Model PC25C (formerly International Fuel Cell and ONSI). 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 UTC PC25C consists of two modules. The power module 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 due to 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 in a steam reforming process. Since 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 is expected to generate 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 UTC PC25C fuel cell are as follows:

- KW/KVA 200/235
- PHASE 3
- HZ 60
- VOLTS 480

- FUEL — Natural Gas 4 to 14 in. water
  1900 SCFH Nominal
- SOUND LEVEL — 62 Dba at 30 ft.
- AMBIENT TEMP. — -20°F to +110°F
- THERMAL ENERGY (CHP) — 900,000 BTU per hour @ 140°F
- POWER MODULE — 18' Long X 10' Wide X 10' High
  40,000 lbs.
- COOLING MODULE — 14' Long X 4' Wide X 4' High
  1,700 lbs.

MAINTENANCE

Routine scheduled maintenance requirements for the UTC PC25C fuel cell power plant:

ACTIVITY	4 TO 6 MONTHS (OPERATING)	ANNUAL (SHUTDOWN)	5 TO 10 YEAR 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

In order 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. Since 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 200kW fuel cell
- Opportunity for cogeneration
- Accessible to AE at all times
- Easy access for tours by the general public and interested customers
- AE 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 ft^2 building located near downtown Austin at 15 Waller Street.

As is typical of major cities, a site plan review was required by the city of Austin's Design Review and Inspection Department (DRID) before any construction permits could be obtained. Since 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: 1) The total area affected by construction must be less than 10,000 ft^2, and 2) The construction plan must contain less than 1,000 ft^2 of impervious cover.

Since 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 stormwater runoff from recharging the aquifer, Watershed Protection Regulations exist for the city of Austin. Projects with less than 1,000 ft^2 of impervious cover are exempted. The plans for installing the fuel cell at RBJ Health Center were drawn up to conform to these regulations.

As a normal step of the design review process, DRID required a drawing identifying the area affected by construction. The engineer provided a drawing with a line drawn around the entire construction zone, including the outdoor area for the equipment, excavation for underground piping and electrical runs, and the existing building mechanical room. The site plan exemption was rejected because the line drawn by the engineer included more that 10,000 ft^2 of total affected area and a full site plan review on the project was now required.

After further review of the affected area requirements, the definition of the affected area was found to require only the area of ground that would be disturbed by new construction. The engineer revised the drawing, eliminating the existing structures in the calculations, which resulted in the total affected area being under the 10,000 ft^2 threshold. The project now 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

Since the fuel cell would be connected to the electric grid, the Texas Commission on Environmental Quality (formerly the Texas Natural Resource Conservation Commission) required an air quality permit in accordance with A*ir 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: NOx emissions < .047 LB/MWH).
- NOx 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 Nox emissions < .035 LB/MWH).
- NOx emissions must be no more than .47 LB/MWH (Requirement: Generating capacity < 10 MW and operating more than 300 hours/year).
- NOx 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

Since 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 in order to determine code compliance for installation. A series of phone calls, meetings and discussions with the Fire Marshall's office were centered around 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 AE 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 AE 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 it is used by the fuel cell stack 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. Since 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. Since 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. At this writing, this curriculum is being developed by the Austin Fire Department.

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.

Since 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 AE 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, since the building operates 24 hours a day, seven days a 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 AE 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 to 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.

Since the PC 25C 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 PC 25C 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 all PC 25C fuel cell power plants worldwide 7days a week, 24 hours a day, including the RBJ Health Center fuel cell (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.

All computer systems are configured to access the fuel cell for control or can merely access and monitor the data without affecting the controls.

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 AE 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" since the same amount of natural gas is consumed by the fuel cell to make electricity with or without CHP. Since 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 modern combined cycle units in the 50% to 55% range. The UTC PC25 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 UTC PC25 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 will be needed to meet the building heat load.

Since the fuel cell generates heat in excess of the needs of the RBJ Health Center building, the use of other thermally activated technology could be employed to increase the CHP efficiency. For example, an assessment has been conducted to determine the feasibility of utilizing available waste heat currently being rejected to the cooling module to drive an absorption chiller that will augment the building air conditioning system, thus driving up the CHP efficiency of the fuel cell. The assessment suggests that enough heat is produced by the fuel cell to provide the existing building heat load while also supporting a 20 to 30 ton absorption chiller.

PROJECT MILESTONES

11/1/01	The Austin City Council Approves the RBJ Fuel Cell Project
1/8/02	Purchase Order released to UTC
1/8/02	Project kickoff meeting
1/8/02	Site development planning begins
4/19/02	Site plan exemption granted
4/24/02	Building permits granted
4/24/02	Construction begins
5/13/02	Fuel cell delivered to site
6/7/02	Completed 8 hour test run for DOD Grant
7/2/02	Fuel cell on line and commercial

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-subcontracted 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 PC25 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 any 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 a great opportunity to capture these real world benefits.

COST REDUCTION OPPORTUNITIES

During the course of the RBJ Health Center project, several opportunities for future cost reduction were identified, including:

- Integrated Cooling Module
- Fuel Cell Water Balance
- Equipment Footprint
- Grid Interconnection Pre-certification
- Site Plan Exemption
- Cogeneration Integrated

Since fuel cell technology development is progressing at a very rapid pace, all these issues are being resolved and should not be viewed as barriers to the mass implementation of fuel cells. In reality, these issues are a natural technical progression in the evolution of fuel cells and are included in this report for the purpose of recording the efforts of fuel cell manufacturers and early adopters to underscore the importance of real world demonstration projects. This highlights the value of these projects in moving fuel cell technology from the research & development phase through the transition to market development.

Integrated Cooling Module: The UTC PC25C requires a cooling module, 14' long X 4' wide X 4' high. Integrating the cooling module into the fuel cell power plant would reduce the costs associated with the equipment footprint, piping, and associated site work. This integration is expected in the next generation of fuel cells that are scheduled to be available in the near future.

Fuel Cell Water Balance: The UTC PC25C provides for automatic water makeup for operation above the plant balance point temperature. The balance point is the ambient temperature at which the power plant condenses the exact amount of water needed to meet process requirements. Above the balance point temperature (approximately 85°F), water must be added to the system. Since the power plant requires ultra-pure process water, a reverse osmosis unit is required for makeup water to extend the maintenance cycle of the water treatment system. When water balance is achieved throughout the full operating ambient temperature range, the reverse osmosis unit becomes unnecessary and associated costs are eliminated.

Equipment Footprint: The PC 25C footprint (without the cooling module, hydrogen manifold, or reverse osmosis unit) is 18'L X 10'W X 10'H. This size is too large for the available space in many commercial applications. Advances in technology and design are expected to bring down the fuel cell footprint in the near future.

Grid Interconnection Pre-certification: Fuel cell grid interconnection equipment can be pre-certified by the process in the Texas Public Utility Commission *Distributed Generation Interconnection Manual.* Much work went into this manual and the process outlined in its pages clears the path for mass implementation of fuel cells. Pre-certification eliminates the cost of additional utility-grade relays required by electric utilities.

Site Plan Exemption: Time and cost could be greatly reduced with adoption of a standard site plan review exemption for fuel cells meeting certain requirements (see SITE section). This would reduce the number of engineering drawings needed for the review process and would shorten the timeline for the project. Through a combination of education and demonstration projects, this issue can be easily resolved.

Cogeneration Integration: The PC 25C is equipped with integrated heat exchangers and piping necessary for cogeneration (CHP). External flanges are provided for easy attachment to the CHP host piping. However, neither the control system nor a circulating pump is included for the CHP system. This requires engineering, equipment, and installation costs to be added to the project. A CHP circulation/controls system integrated into the fuel cell power plant could reduce these costs. This is not a complicated technical hurdle for fuel cell technology and should be easily resolved as CHP applications are found.