Climate Change Fuel Cell Program

ChevronTexaco Fuel Cell Project

200 kW - PC25C Fuel Cell Power Plant
ChevronTexaco Park, San Ramon, California, USA

Final Report

Reporting Period December 19, 2001 through July 31, 2004

Mike Walneuski P.E.
Project Manager

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Chevron Energy Solutions Company
A Division of Chevron U.S.A. Inc.
345 California St. 32nd Flr
San Francisco, CA 94104

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Abstract

ChevronTexaco has successfully operated a 200 kW PC25C phosphoric acid fuel cell power plant at the corporate data center in San Ramon, California for the past two years and seven months following installation in December 2001. This site was chosen based on the ability to utilize the combined heat (hot water) and power generation capability of this modular fuel cell power plant in an office park setting. In addition, this project also represents one of the first commercial applications of a stationary fuel cell for a mission critical data center to assess power reliability benefits. This fuel cell power plant system has demonstrated outstanding reliability and performance relative to other comparably sized cogeneration systems.

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Executive Summary

In December of 2001 Chevron Energy Solutions had installed and commissioned a UTC Fuel Cells 200 kW PC25C phosphoric acid fuel cell at ChevronTexaco's corporate data center in San Ramon, California. This site was chosen based on the ability to utilize the combined heat (hot water) and power generation capability of this modular fuel cell power plant in a cogeneration application.

As an energy services provider, Chevron Energy Solutions undertook this project to demonstrate the technology and gain direct experience with the design and installation of stationary fuel cells for data center applications, as part of a longer-term effort to help commercialize the technology. In addition, the project enables Chevron Energy Solutions to monitor and test the technology, its operating efficiency and its interface with other power system components, in comparison with conventional power generation systems.

This report summarizes the operation of the fuel cell power plant during a two year and seven month period over which time this unit has demonstrated outstanding performance and reliability relative to other comparably sized cogeneration systems.

The availability factor of the fuel cell power plant has been 98.2% over its operating life. The Mean Time Between Forced Outages (MTBFO) was 3,538 hours resulting from 6 forced outages which totaled 226 hours over the period.

A Capacity Factor of 91.2% was achieved by this unit over this period. It should be noted that the maximum rated output of this fuel cell was never limited by auxiliary systems or load demand.

The electrical efficiency of the PC25C fuel cell started out at 42% and the cumulative electrical efficiency of the unit over the two year and seven month operating life, is currently at about 39%. At this rate of cell stack voltage degradation we expect that fuel cell will achieve the 37% electrical efficiency target that UTC guaranteed over the life of this cell stack, which estimated to be about 6 years for this power plant.

The total fuel utilization efficiency (overall power plant efficiency) during this period is 58.6%. This is based on achieving 38.6% electrical output and 19.7% thermal output. Thermal output includes both high and low grade heat use at the site. During this period the total useable thermal output from the fuel cell averaged 340 MBtu/hr based on heating demand which is about 38% of the available thermal energy produced by the fuel cell at this capacity factor.

This project also represents one of the first commercial applications of a stationary fuel cell for a data center. In May 2002 integration of switchgear was completed which added a Static Disconnect Switch (SDS) to demonstrate

operation of the fuel cell system in island mode or grid independent. In the event of a disruption on local utility lines, which also deliver power to the data center, the static disconnect switch ensures the fuel cell will continue to provide electricity to these critical data and retail transaction systems without interruption. Two grid interruption events have occurred where this benefits of this island mode capability was demonstrated.

The environmental benefits of displacing emissions from older dirtier power generating sources by operating the fuel cell power plant are significant. Based on the proven low emission rates from this fuel cell power plant the local air district has written a specific exemption in their regulations which reduces the duration for environmental permitting by 3 to 6 months enabling a shorter implementation period over other conventional cogeneration power plants.

Although the capital installation cost for this project was high given the complexity of interconnecting the fuel cell to electrical and mechanical systems in the basement of the data center building, many benefits have been realized that not only meet the ChevronTexaco's objective to gain experience but to help commercialize the technology through tours and information sharing efforts.

This project has proven that fuel cell power plants can be operated in an office park environment and provide enhanced power reliability benefits. The efficiency and reliability achieved from this fuel cell exceed other comparable cogeneration technology in this application. However, expected improvements in cell stack efficiency in parallel with reduced capital and maintenance costs must be achieved for this advanced power generation technology to be cost competitive in the market place.

Introduction

The scope of work of the project included design, permitting, installation, testing and commissioning of a UTC Fuel Cell (or International Fuel Cells - IFC) PC25C Fuel Cell Power Plant and Static Disconnect Switch (SDS) at the corporate data center building located in ChevronTexaco Park, San Ramon, California.

The ChevronTexaco Park corporate headquarters is a large complex that contains 13 multi-story office buildings, a cafeteria and central plant that provides chilled water throughout the campus. Each of the buildings uses natural gas for heating. There is no other cogeneration power plant currently installed at this facility, but two emergency generators provide backup power. The total load for the ChevronTexaco Park complex ranges from 4.3 to 6.5 MW.

The Fuel Cell power plant is designed to produce electrical power (200 kW/235 kVA, 480V, 3 phase) from natural gas fuel through an electrochemical process. This power plant will offset between 25% and 50% of the corporate data center building load and about 5% of the total electrical load of the entire ChevronTexaco Park complex.

The electrical, mechanical and control systems for this project were sized and configured to allow for expansion for a future second fuel cell at the site. However, this additional fuel cell power plant has not yet been installed.

Although the fuel cell power plant is capable of providing up to 900,000 Btu per hour of hot water at full electrical output, the existing thermal loads in the data center building would only utilize about 38% of this available heat energy. Piping, pumps and control systems were installed to connect the building high and low temperature hot water systems to the fuel cell to enable thermal heat recovery.

<u>Equipment Description and Location</u>

The Fuel cell power module (10'H x 10'W x 13'L) was installed on the East Side of data center on a foundation designed for seismic zone 4 which includes a trench to route piping and electrical conduit into the basement for connection to the existing system equipment. The site required over excavation and recompaction of the soil to install a foundation adequate to support the 10 Ton fuel cell power module. A pad for nitrogen supply cylinders to purge the hydrogen in the cell stack on start/stop was installed adjacent to the fuel cell and a perimeter fence and gate designed to match the existing structure provided security for the outdoor site.

The Cooling Module, a forced air fluid cooler which rejects unused heat from the closed loop cooling system to the ambient air, was installed in the building exhaust air duct, located in the basement, to reduce ambient noise levels in the office park area. A make-up water treatment system (dionized water) and a 500 gallon (1,893 Liter) storage tank, sized for two units, were installed in the basement mechanical room for initial fuel cell start-up and during prolonged periods of operation at high temperature.

Heat Recovery Systems

The fuel cell power plant provides a high-grade heat option. This high-grade heat option produces up to 450,000 Btu/hr @ 250 degree F (107 C) pressurized high-grade hot water and a minimum 450,000 Btu/hr 140 degree F (46 C) of low-grade hot water at rated power. If less than the available high-grade heat is recovered, the remaining heat will be available for recovery at the standard temperature. The hot water heat recovered from the fuel cell is supplied to the building heating and domestic hot water systems to reduce the fuel usage of these existing appliances.

The high temperature hot water from the power plant is used to supplement the existing hot water heating system by preheating the feed water to the boiler. The hot water heating system is utilized during the summer months for humidity control and during the winter months for space heating.

The low temperature hot water form the fuel cell is used for domestic water heating in this building. A double walled stainless steel heat exchanger is provided internal to the fuel cell for the domestic potable water-heating loop.

The two heat recovery systems use an injection loop piping design and have redundant pumps (for a future fuel cell) and are instrumented with direct reading and transmitting pressure, temperature and flow devices.

Electrical Interconnection

The fuel cell power plant is electrically connected to the "West Bus" 600V load center through a step up transformer and switchgear. Initially the fuel cell was connected to a spare feeder breaker and operated grid connected only providing a constant 200kW. In April 2002, a high speed Static Disconnect Switch (SDS) and Site Management Controller (SMC) was installed to enable the automatic seamless transfer to grid independent fuel cell operating mode and pickup the load (~185 kW) on the data center UPS feed bus and return transfer automatically to grid connect generating mode upon sensing of a stable utility power supply. The SMC will perform load-sharing dispatch between power plants in the event another fuel cell is installed in the future.

A motor control center (480V, 600A) was installed in the West Bus Control Room to provide power to auxiliary pump motors and controls. It was necessary to install active harmonic filters to reduce the existing harmonic current distortion in the 600V electrical system to achieve full rated power output from the fuel cell in island mode operation when running grid independent.

The electrical interconnection agreement with the local Utility (PG&E) required installation of a separate external protective relay and additional electrical “type” testing of the unit (since this fuel cell was not UL certified). A stand-by service agreement was also required by the Utility for this power plant.

Natural Gas Interconnection

The fuel cell power plant operates on pipeline natural gas delivered at pressures between 4 to 14 inches of water (0.010 to 0.036 kg/sq cm). A underground tap line was be installed to the fuel cell from the 5 psi (3,515 kg/sq cm) gas main located in the roadway 100 feet (30.5 M) South of the data center building. A gas pressure regulator and a Utility approved gas meter were installed along with a separate high accuracy gas flow meter for power plant performance monitoring.

An agreement was executed with the local Utility (PG&E) to discount the delivery cost of natural gas for the fuel cell power plant under Tariff Schedule G-COG, Gas Transportation Service to Cogeneration Facilities.

Control System & Telemetry

An integrated instrumentation and control system was installed for monitoring and control of the power plant, heat recovery and auxiliary systems. A PC based man-machine-interface (MMI) work station was installed in the electrical control room with data acquisition software to record and annunciate alarm conditions, calculate energy usage and power plant performance. A communications interface to connect with the existing Building Management Control System provides remote monitoring of alarms to the facility control room. A separate electric meter will be supplied to connect with the site Energy Management System (EMS) for custody transfer of energy data.

Telephone connections to fuel cell power module required connection of a dedicated analog telephone line with direct long distance access for IFC to gather data from the power plant during the warranty and service agreement period.

Permitting

The fuel cell is exempt from Bay Area Air Quality Management District permitting. Based on the proven low emission rates from the fuel cell power plant the air district has written a specific exemption in their regulations which reduces to duration for environmental permitting by 3 to 6 months over other types of conventional cogeneration power plants. City planning and building department approvals, including review by local fire department did not require any onerous conditions or resolution of any environmental impact issues to obtain the construction permits required for the project.

Construction

Chevron Energy Solutions was responsible to develop and design the project, and coordinate construction. Construction was contracted to companies retained for projects at the ChevronTexaco Park based on the extensive level of integration required with existing operating systems in the data center building.

The Fuel Cell was commissioned on December 19, 2001 and operated until late-March 2002 when it was shut down to install the SDS Switchgear. Following extensive SDS load bank testing and functional verification of the Island Mode Operation of the Fuel Cell Power Plant it was returned to service in mid-May 2002. It has been in operation since then with an overall availability of 98.2%

Experimental

The following are the objectives for the ChevronTexaco Fuel Cell Project installed at ChevronTexaco Park in San Ramon, California.

- Demonstrate that advanced power generation technologies can provide combined heat and power with a higher electrical efficiency and lower emissions than other cogeneration technologies.

- Demonstrate that fuel cell power plants are a quiet, energy efficient, and environmentally clean source of power that can be installed and operated directly inside a large office park complex.

- Gain experience with the design, installation, testing and operation of a commercial Fuel Cell power generation system.

- Determine the reliability of the Fuel Cell power generation technology and the capability to provide primary power in the event of a power outage.

Standard instrumentation and methods will be used for measurement and assessment of data necessary to evaluate performance of the power plant system.

Results and Discussion

The following sections provide details about the results of the first two years and seven months of operation of the ChevronTexaco Fuel Cell Project installed at ChevronTexaco Park in San Ramon, California. The discussion will focus on the power plant installation, commissioning, performance, reliability, cost, and operational issues relative to the project objectives.

Installation

The design and permitting phase of the project was started in March 2001 and took about six months before city planning and building department permit approvals were obtained. Construction, which took about three months, started in September 2001 on underground systems required to pour foundations needed to set the fuel cell power plant in mid-November 2001. The mechanical systems (gas fuel, water and thermal hot water), electrical and instrument/control systems were installed connected by mid-December 2001.

Commissioning

Initial start-up of the fuel cell power plant was performed over about a one week period. Utility witness testing and approval of the protective relay system took two days before the power plant could be paralleled to the electric grid. Overall the startup went well and the Fuel Cell Power Plant was generating power on December 19, 2001. A six-day operational acceptance test was performed from December 28, 2001 to Jan 3, 2002.

SDS System

On March 27, 2002 the fuel cell power plant was shutdown to install the Static Disconnect Switchgear (SDS). The high speed Static Disconnect Switch (SDS) and Site Management Controller (SMC) was installed to enable the automatic seamless transfer to grid independent fuel cell operating mode and pickup the load (~185 kW maximum) on the data center UPS feed bus and return transfer automatically to grid connect generating mode upon sensing of a stable utility power supply. Following extensive SDS testing and verification of the Island Mode Operation of the Fuel Cell Power Plant it was returned to service on May 14, 2002.

This SDS commissioning activity completed the construction and commissioning scope for the project.

Reliability and Capacity Factors

The critical reliability factors for this project were defined as: Mean Time Between Forced Outages (MTBFO), and; Availability Factor (AF). The capacity factor is representative of the electric generation output capability of the power plant. Each of these factors are defined below based on power generation system definitions from the Gas Technology Institute (GTI) and Utility standards:

Mean Time Between Forced Outages (MTBFO): Measures the nominal time between unscheduled forced outages. Where:

$$MTBFO = \frac{\text{Service Hours (SH)}}{\text{Number of Forced Outages (FO)}}$$

Availability Factor (AF): Measures on a percent basis, the unit's "could run" capability, impacted by planned and unplanned maintenance. Where:

$$AF\ \% = \frac{\text{(PH - Scheduled Outage Hours -Forced Outage Hours) x 100}}{\text{Period Hours (PH)}}$$

Capacity Factor (CF): Measures on a percent basis, the actual unit electric generation produced compared to maximum possible generation that could have been produced. Where:

$$CF = \frac{\text{Actual Electric generation (kWh)}}{\text{Unit Maximum Rated Capacity (kW) * Period Hours (PH)}}$$

The Mean Time Between Forced Outages (MTBFO), Availability Factor (AF) and Capacity Factor (CF) for the Fuel Cell Power Plant over the past two years and seven months of operation are shown in Table 1 below:

Table 1 - Reliability & Capacity Factors

Period	Number of Forced Outages	Mean Time Between Forced Outages (MTBFO)	Availability Factor (AF)	Capacity Factor (CF)
Year 2002	4	1732	98.9 %	83.7 %
Year 2003	2	4300	98.2 %	96.6 %
Jan-July 2004	0	5879	97.3 %	95.2 %
Total Over Life	6	3538	98.2%	91.2%

Note: MTBFO and AF calculations exclude Schedule Outage Hours when power plant was shut down between 3/27/02 - 5/14/02 for SDS Installation.

Availability Factor

The availability factor of the fuel cell power plant has been 98.2% over its operating life. The availability of this fuel cell is significantly better than that of comparably sized small natural gas reciprocating engine cogeneration units which range from 90 to 95% availability based on our experience on other projects.

Capacity Factor

The data in Table 3 shows that over the operating life of the unit the achieved a Capacity Factor of 91.2%. The rated capacity of the fuel cell power plant is 200 kW gross. This capacity factor data reflects the operation of the fuel cell at lower loads when curtailment was necessary for various reasons (such as testing) during the operating life of the power plant. It should be noted that the maximum rated output of this fuel cell was never limited by auxiliary systems or load demand.

Mean Time Between Forced Outages

Over the operating life of the fuel cell power plant there have been six (6) forced outage events that have impacted MTBFO, see Table 2 below. The most frequent problem was three inverter related shutdowns that were eventually traced to a faulty inverter boost pole. This boost pole was replaced in December 2003 and no subsequent inverter shutdowns have occurred since. Two events in 2002 occurred when the temperature control valve TCV 400 became stuck (hung up) due to a loose brake module on the actuator. The TCV 400 valve actuator brake was replaced and has not caused any further outages.

The extensive instrumentation and remote data acquisition capabilities on the fuel cell power plant have enabled UTC technicians to diagnose and resolve equipment problems through remote access telecommunications from the factory. The duration of the forced outages has been minimized as a result of this capability since in most cases technicians can restart the unit after the alarm or outage remotely without making a service visit to the site. The power plant will automatically dial out and notify the factory upon an alarm condition, prompting investigation, which minimizes the level of effort required of the local operators.

Table 2 below is a description of the Forced Outage events causing the power plant shutdown over the past two years and seven months of operation.

Table 2 - Forced Outage Shutdown Events

Forced Outage Event Description	Date - Time	FOH
Inverter related shutdown. DC Link pumped up during Load share excursion.	5/20/2002 12:58 PM	69.5
Temperature Control valve TCV400 hung up restarted with no issue.	6/5/2002 8:36 PM	23.7
Inverter DC Link Over Voltage shutdown while trying to go to load. Restarted and running in Load share configuration.	7/24/2002 6:06 PM	14.9
Temperature Control valve TCV400 hung up restarted with no issue.	8/14/2002 2:42 PM	6.0
Inverter DC Link Over Voltage shutdown occurring during a grid outage. Many issues with Multi Unit Load Sharing.	2/6/2003 11:54 AM	43.4
Inverter shutdown. Replaced boost pole on inverter unit.	12/10/2003 7:23 AM	68.8

Performance Statistics

The following section will discuss the performance and efficiency results over the past two years and seven months of operation of the fuel cell power plant in addition to a comparison of site parameters before and after installation of the project.

Table 3 below summarizes the annual comparison of the electric and fuel use of the entire ChevronTexaco Park Site in 2001 before installation of the fuel cell and in years 2003 through July 2004 during operation of the fuel cell. The same before and after comparison is shown using data on a monthly basis in Table 4 and 5 below. The yellow highlighted cells in the monthly data in Tables 4 and 5 represent maximum or peak electric use or generation and peak gas usage for each annual period.

The data in Table 3 show that the total electric use at the entire site was reduced or offset by the electric generation produced by the fuel cell power plant. It should be noted that fuel cell generation as a percent of total site electric use ranged from 4% to 7% and the fuel cell gas use as percent of total site gas use ranged from 11% to 25% during the two year and seven month operating period. The total gas use data for the entire site includes gas used by the fuel cell power plant.

Table 3 – Annual Site Electric & Gas Use Before and After Installation of Fuel Cell Power Plant System

Period	Total Electric Use Entire Site (kWh)	Peak Electric Use Entire Site (kW)	Total Gas Use Entire Site (MMBtu)	Peak Gas Use Entire Site (MMBtu per day)	Fuel Cell System Total Generation (kWh)	Fuel Cell System Total Fuel Use (MMBtu)	Fuel Cell System Peak Generation (kW)
Before Installation							
2001	31,453,901	6,354	69,822	301	0	0	0
After Installation							
2002	29,958,610	6,024	90,152	360	1,435,195	12,755	198
2003	30,607,173	6,540	99,926	355	1,674,826	14,878	200
Jan-Jul 2004	16,994,187	5,784	59,422	359	920,739	8,663	200

Table 4 – Monthly Site Electric & Gas Use AFTER Installation of Fuel Cell Power Plant System

Period *After Installation*	**Total Electric Use Entire Site (kWh)**	**Peak Electric Use Entire Site (kW)**	**Total Gas Use Entire Site (MMBtu)**	**Avg Daily Gas Use Entire Site (MMBtu per day)**	**Fuel Cell System Total Generation (kWh)**	**Fuel Cell System Total Fuel Use (MMBtu)**	**Fuel Cell System Peak Generation (kW)**
Jul-04	1,810,731	5,640	6,353	205	121,317	999	163
Jun-04	2,837,520	5,784	7,063	235	147,620	1,344	200.0
May-04	2,520,618	5,772	7,955	257	147,460	1,322	198.2
Apr-04	2,355,210	5,496	8,062	269	102,663	1,279	142.6
Mar-04	2,636,985	5,520	8,890	287	145,450	1,403	195.5
Feb-04	2,383,665	4,674	9,970	344	126,450	1,173	181.7
Jan-04	2,449,458	4,842	11,130	359	129,779	1,142	174.4
Dec-03	2,318,889	4,896	10,992	355	123,280	1,049	165.7
Nov-03	2,369,643	5,598	9,152	305	145,771	1,269	200.0
Oct-03	2,505,303	5,868	7,126	230	147,461	1,342	198.2
Sep-03	2,845,503	6,036	6,260	209	152,265	1,353	211.5
Aug-03	2,677,356	6,540	6,405	207	136,453	1,225	183.4
Jul-03	2,780,421	6,384	6,289	203	147,591	1,338	198.4
Jun-03	2,724,333	6,132	6,831	228	134,987	1,251	187.5
May-03	2,536,071	5,976	7,932	256	140,792	1,222	189.2
Apr-03	2,340,582	5,412	9,453	315	142,469	1,252	197.9
Mar-03	2,529,678	5,514	9,553	308	141,413	1,282	190.1
Feb-03	2,428,221	4,950	9,792	350	129,205	1,122	192.3
Jan-03	2,551,173	5,202	10,141	327	133,139	1,175	179.0
Dec-02	2,246,112	4,854	10,798	348	146,980	1,337	197.6
Nov-02	2,443,680	5,118	8,432	281	142,588	1,224	198.0
Oct-02	2,319,741	5,898	6,652	215	133,739	1,210	179.8
Sep-02	2,708,452	5,802	4,997	167	142,499	1,246	197.9
Aug-02	2,541,189	5,994	5,332	172	146,700	1,339	197.2
Jul-02	2,662,953	6,024	5,495	177	143,966	1,298	193.5
Jun-02	2,715,705	6,006	5,846	195	119,628	1,006	166.2
May-02	2,480,154	5,766	6,723	217	73,948	654	99.4
Apr-02	2,668,995	6,078	7,624	254	(11,254)	113	(15.6)
Mar-02	2,478,900	5,256	8,904	287	127,291	1,058	171.1
Feb-02	2,325,405	4,980	8,205	293	126,122	1,072	187.7
Jan-02	2,367,324	4,800	11,145	360	142,988	1,199	192.2

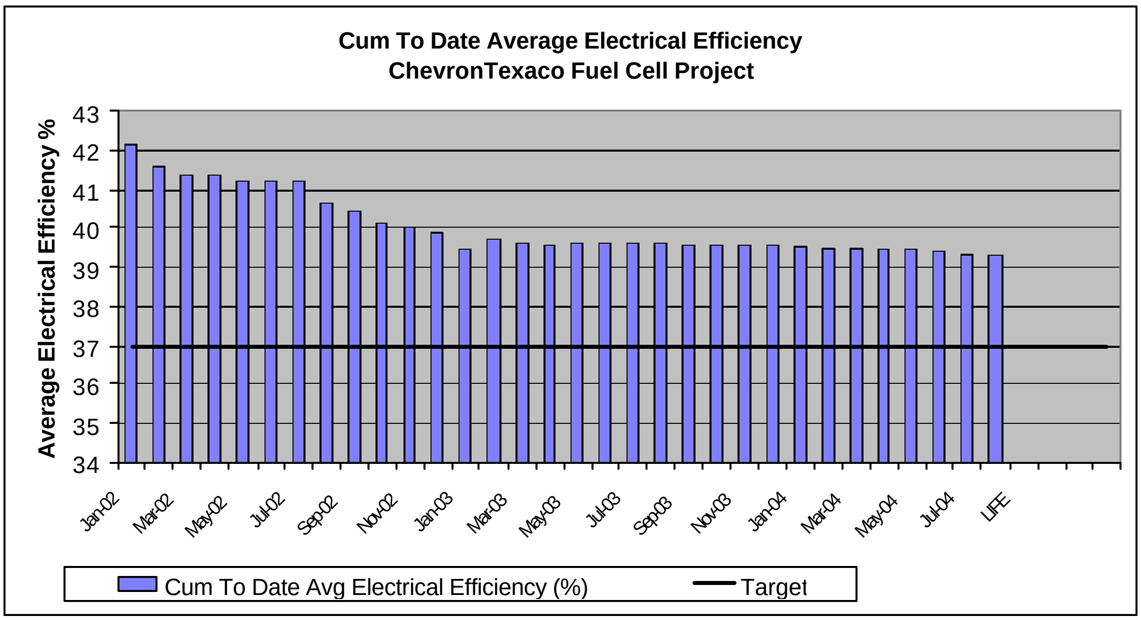
Table 5 – Monthly Site Electric & Gas Use BEFORE Installation of Fuel Cell Power Plant System

Period *Before Installation*	**Total Electric Use Entire Site (kWh)**	**Peak Electric Use Entire Site (kW)**	**Total Gas Use Entire Site (MMBtu)**	**Avg Daily Gas Use Entire Site (MMBtu per day)**	**Fuel Cell System Total Generation (kWh)**	**Fuel Cell System Total Fuel Use (MMBtu)**	**Fuel Cell System Peak Generation (kW)**
Dec-01	2,337,165	5,100	8,728	282	0	0	0
Nov-01	2,419,758	5,748	6,196	207	0	0	0
Oct-01	2,584,891	6,270	4,576	148	0	0	0
Sep-01	2,487,267	6,354	3,453	115	0	0	0
Aug-01	2,437,680	5,892	3,289	106	0	0	0
Jul-01	2,599,098	5886	3,332	115	0	0	0
Jun-01	2,547,903	6102	3,851	120	0	0	0
May-01	2,549,178	6258	4,196	127	0	0	0
Apr-01	2,359,359	5946	7,449	257	0	0	0
Mar-01	2,232,171	5946	7,670	264	0	0	0
Feb-01	2,101,771	4356	7,751	242	0	0	0
Jan-01	2,430,336	4728	9,331	301	0	0	0

Electrical Efficiency

The graph below is a plot of the cumulative electrical efficiency of the fuel cell power plant over the two year and seven month operating life, which is currently at about 39%. The electrical efficiency started out at 42% which may be slightly higher than previous versions of the PC25C fuel cell because UTC provided 4 additional cell stack modules in this upgraded unit.

During he first year of operation the electrical efficiency of the cell stack dropped about 2.5%, which we understand is normal degradation for this type of fuel cell. During the following 19 months of operation the cell stack electrical efficiency has only dropped another ¾ %. At this rate of degradation we expect that fuel cell will achieve the 37% electrical efficiency target that UTC guaranteed over the life of this cell stack, which is estimated to be about 6 years for this project.



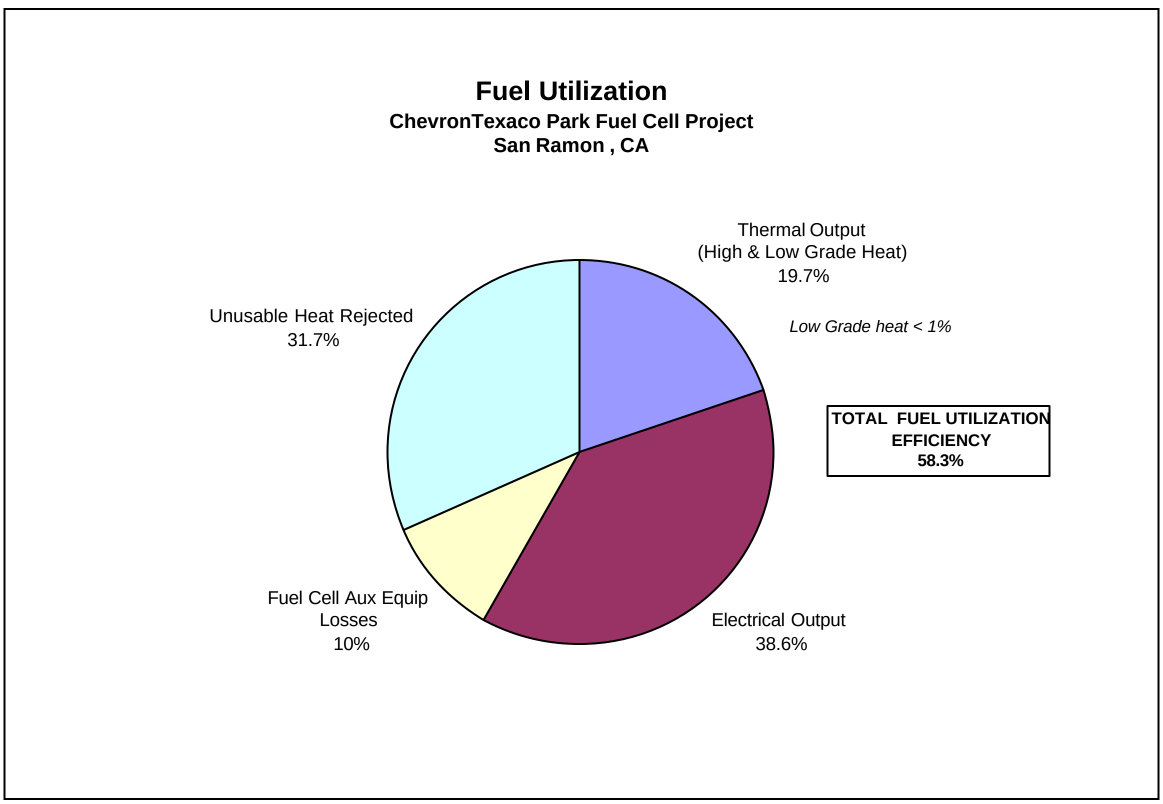
It should be noted that loss in fuel cell electrical efficiency over time is offset by additional thermal energy production as a result of cell stack degradation.

Thermal Output

The Fuel Utilization Chart below presents data gathered during the past year of operation (through July 2004) for the Fuel Cell Power Plant System at Chevron Texaco Park. Thermal output is measured for both high and low grade heat use, net electrical power is metered and fuel cell auxiliary equipment losses have been estimated based on manufactures data.

The total fuel utilization efficiency (overall power plant efficiency) during this period is 58.6%. This is based on achieving 38.6% electrical output and 19.7% thermal output. Thermal output includes both high and low grade heat use at the site. High grade heat is used for preheating boiler feedwater supplied for heating and cooling loads in the building. The low grade heat output from the fuel cell is utilized for domestic water heating which has minimal demand in this building or less than 1% of the thermal output.

During this period the total useable thermal output from the fuel cell was 2,960 MMBtu. This useable thermal output averaged 340 MBtu/hr based on demand during this period which is about 38% of the available thermal energy produced by the fuel cell at this capacity factor. Consideration has been made to pipe this additional low grade hot water to another building on the site to recover this available heat energy that is currently being rejected to atmosphere in the cooling module.



Cost

The cost of the ChevronTexaco Fuel Cell Project and the economic data for operations over the past two years and seven months is presented in the tables below.

The capital investment for this project is shown in Table 6 below. Investment costs were offset by the grant from the D.O.E. Climate Change Fuel Cell Program and a rebate from the Self Generation Incentive Program (SGIP) sponsored by the California Public Utilities Commission.

Table 6 – Capital Investment and Funding

Capital Investment	**Cost**
Capital Fuel Cell Power Plant	$ 950,000
Installation Cost	$ 1,513,000
Total Capital Cost =	$ 2,463,000
External Funding	
DOE Grant	$ 200,000
CPUC SGIP Rebate	$ 500,000
Total Funding =	$ 700,000
Total Project Cost =	$ 1,763,000

The high installation cost for this project reflects the complexity of interconnecting the fuel cell to electrical and mechanical systems in the basement of the data center building and includes all costs except the capital investment cost for the static disconnect switch (SDS). The SDS design procurement, installation and testing of this power reliability equipment were not included in the costs above. The cost for this additional SDS work was a total of more than $800,000.

The actual cost and savings for the first two years and seven months of operation of the fuel cell power plant system are shown in Table 7 below.

Table 7 – Cost and Savings

Period	2002	2003	Jan-July 2004
Fuel Cell Net Generation (kWh)	1,435,195	1,674,826	920,739
Avg Elec Cost ($/kWh)	0.12	0.12	0.11
Avg Gas Cost ($/MMBtu)	4.08	6.19	6.66
Depreciated Capital Cost	$ 192,167	$ 214,797	$ 138,222
Fuel Cost to Generate (Variable)	$ 51,994	$ 92,145	$ 57,679
Operations & Maintenance Cost (Fixed)	$ 28,592	$ 28,867	$ 23,744
Capital for Replacement Cell Stack	$ 50,000	$ 50,000	$ 50,000
Savings Electric Cost - Generation Offset	$ (78,571)	$ (208,272)	$ (101,548)
Savings Gas Cost - Thermal Offset	$ (10,398)	$ (17,193)	$ (11,365)
Annual Cost Total	$ 133,783	$ 160,344	$ 156,732
Variable Costs - Fuel (mils/kWh)	3.62	5.50	6.26
Fixed Costs - Depreciation, O&M (mils/kWh)	1.99	1.72	2.58

Total annual operating costs for the fuel cell have increased over the past two years primarily caused by natural gas price fluctuation despite the fact that utility electric rates (PG&E E20P) have declined. These operational costs plus the depreciation expense associated with the capital investment in the project result in a power plant that would not be competitive if economics were the only criteria.

Included in the annual cost is capital investment for a future fuel cell stack replacement estimated to cost about $300,000. This cell stack replacement would occur at six year intervals over the life of the power plant and would be performed during an annual overhaul.

Conclusion

Over the past two years and seven months the 200 kW PC25C phosphoric acid fuel cell power generation system has operated successfully at ChevronTexaco's corporate data center in San Ramon, California. This advance technology cogeneration power plant continues to run reliably and efficiently and provides a clean source of power for this facility.

As an energy services provider, Chevron Energy Solutions undertook this project to demonstrate the technology and gain direct experience with the design and installation of stationary fuel cells for data center applications, as part of a longer-term effort to help commercialize the technology.

In an effort to further the technology development, the benefits of lessons learned from this combined heat and power application of a fuel cell system are realized through: implementation in other cogeneration projects installed by Chevron Energy Solutions; communication within ChevronTexaco Corporation and groups developing alternative energy sources; feedback to IFC the equipment manufacturer for consideration in their next generation of fuel cell power plants, and; site tours and information sharing efforts to build awareness within the energy industry and the educational, business and government communities.

This project represents one of the first commercial applications of a stationary fuel cell for a mission critical data center. This has allowed ChevronTexaco to evaluate fuel cell power technology along side more traditional power quality and generation technologies (rotary UPS systems and diesel generator systems) to really understand fuel cell technology advantages and disadvantages while providing incremental improvement to the existing system reliability of this facility.

This successful demonstration proved that modular fuel cell power plants are a quiet, energy efficient, and environmentally clean source of power that can be installed quickly and operated directly inside a large office park complex. Demonstration of this and other applications of fuel cell power technology will build awareness and hopefully drive competition in the effort to expand and shape the future of distributed generation systems.

Although currently this fuel cell power technology is not as cost competitive as other conventional cogeneration systems, continued validation of the benefits through programs, such as this, should yield competitive advanced power generation technology that more effectively utilize our limited resources and result in climate change for an improved environment.

Photo Gallery

Setting the PC25C Fuel Cell Power Module on foundation outside the corporate data center building at ChevronTexaco Park

PC25C Fuel Cell Power Plant in operation providing 200kW to corporate data center at ChevronTexaco Park