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City of Anaheim

Installation of 200 kW UTC PC-25 Natural Gas Fuel Cell At City of Anaheim Police Station

FINAL REPORT

February 2005 thru February 2006

DoD Climate Change Fuel Cell Program

US Army Corps of Engineers
Engineer Research and Development Center
Construction Engineering Research Laboratory

Anaheim Police Station, California

June 2006

Dina Predisik, Resource Programs Manager

Disclaimer

Abstract

The City of Anaheim Public Utilities Department (Anaheim) has been providing electric service to Anaheim residents and businesses for over a century. As a city in a high-growth region, identifying sources of reliable energy to meet demand is a constant requirement. Additionally, as more power generation is needed, locating generating stations locally is a difficult proposition and must consider environmental and community impacts. Anaheim believes benefits can be achieved by implementing new distributed generation technologies to supplement central plants, helping keep pace with growing demand for power. If the power is clean, then it can be delivered with minimal environmental impact.

Anaheim started investigating fuel cell technology in 2000 and decided a field demonstration of a fuel cell power plant would help determine how the technology can best serve Anaheim. As a result, Anaheim completed the project under this grant as a way to gain installation and operating experience about fuel cells and fuel cell capabilities. Anaheim also hopes to help others learn more about fuel cells by providing information about this project to the public. Currently, Anaheim has hosted a number of requested tours at the project site, and information about the project can be found on Anaheim Public Utilities' RD&D Project website.

The Anaheim project was completed in four phases including: research and investigation, purchase, design, and construction. The initial investigative phase started in 2000 and the construction of the project was completed in February 2005. Since acceptance and startup of the fuel cell, the system has operated continuously at an availability of 98.4%. The unit provides an average of about 4,725 kilowatt-hours a day to the Utilities' generation resources. Anaheim is tracking the operation of the fuel cell system over the five-year life expectancy of the fuel stack and will use the information to determine how fuel cells can serve Anaheim as power generators.

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Executive Summary

The Pilot Fuel Cell Project (Project) under this application is for the first fuel cell power generator installed by Anaheim. The Project includes one fuel cell installed at 8201 E. Santa Ana Canyon Road in the City of Anaheim in Orange County, California. The Project required the installation and interconnected to a three-story facility that serves as a Police Substation, Community Center, and will also include a Library by the end of 2006. The site contact is Bob Flores of the Anaheim Police Department at 714/765-3800. The Project Manager is Dina Predisik of Anaheim Public Utilities at 714/765-4182.

The fuel cell operates in parallel with the utility grid and is designed to operate in various modes along with an existing 125 kW backup diesel generator and 50 kW solar energy system. It is designed to run continuously to provide power to the facility and export excess power to the grid. Waste heat off of the fuel cell is recovered in a co-generation mode and is used for facility heating. The Project is funded, operated, and owned by Anaheim Public Utilities as part of the distributed generation fleet. The facility is billed for the power under City of Anaheim rates, and Anaheim Public Utilities pays for the natural gas fuel consumed by the fuel cell system.

The fuel cell used in the Project is a UTC Fuel Cells, LLC (UTCFC) PC-25 Model C, 200 kW/235 kVA phosphoric acid unit. It is a microprocessor-controlled, self-contained fuel cell based power generator that uses low-pressure natural gas for the fuel source. At the time of purchase approval by Anaheim, the UTC PC-25 was the only commercial fuel cell unit available on the market.

The Project was commissioned on February 9, 2005, and dedicated at the site on April 7, 2005. Since startup, the system has run continuously with the exception of two unscheduled outages and when maintenance is scheduled on the fuel cell system. In the first year of operation ending January 31, 2006, the fuel cell has produced 1,701,881 kWh.

1.0 Introduction

The City of Anaheim commissioned its very first fuel cell system on February 9, 2005. The fuel cell was installed as a demonstration project to help gain experience in operating and maintaining a fuel cell power generator. Under the project goals, Anaheim will evaluate the system performance and determine how fuel cells fit in the Utilities' generation fleet. The project was funded in part by the Department of Energy.

2.0 Name, Address and Related Company Information

City of Anaheim
201 S. Anaheim Boulevard
Suite 801
Anaheim, California 92805
714/765-4157

The City of Anaheim is the tenth largest city in California. It was settled in 1857 by a colony of German farmers and vintners. The city's name is a composition of "Ana" from the nearby Santa Ana river and "heim," German for home as the early settlers of Anaheim considered this location their "home by the river." Anaheim is in Orange County, California, and is located 28 miles southeast of Los Angeles. Based on the 2000 census, Anaheim's population is approximately 330,000.

Anaheim Public Utilities is Orange County's only customer-owned electric and water utility. It was founded in 1894 and currently sells in excess of three million megawatt-hours (MWh) per year with a historic system peak demand of 578 megawatts (MW). Anaheim Public Utilities' power supply comes from resources located in or near Anaheim and across the western United States. This power supply makes up 80% of Anaheim's need; the balance is obtained through a variety of power purchases.

The City of Anaheim governs under a city charter with a five-member City Council, Mayor, and City Manager. Anaheim Public Utilities is governed by the City Council which is responsible for determining policy for Utilities along with a seven-member Public Utilities Board. The Board acts as an advisory panel to the City Council on all Utilities matters. The Anaheim Public Utilities General Manager is responsible for all operations and reports to the City Manager.

3.0 Production Capability of the Manufacturer

UTC Power (UTC) is a unit of United Technologies Corp and formerly International Fuel Cells. UTC is a leader in fuel cell production and development for commercial, transportation, residential and space applications. UTC is the sole supplier of fuel cells for U.S. manned spaced missions and is a global leader in the development of fuel cells for transportation and power generation.

UTC Power is headquartered in South Windsor, Connecticut where the company has a facility for research, development, and manufacturing. UTC employs over 450 engineers, researchers, managers, and production workers.

Company Contact: James Lohneiss
Specialist, Customer Service
UTC Power
195 Governors Hwy.
South Windsor, CT 06074
(860) 727-2629
James.Lohneiss@UTCPower.com

4.0 Principal Investigator(s)

Name: Dina Predisik
Title: Resource Programs Specialist
Company: Anaheim Public Utilities
Phone: 714/765-4182
Fax: 714/765-4152
Email: dpredisik@anaheim.net

5.0 Host Facility Information

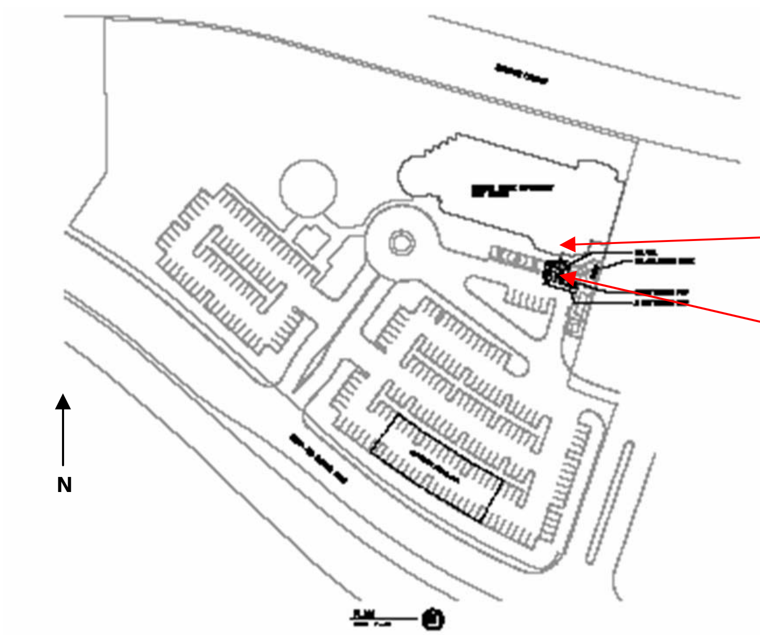
The fuel cell is installed at 8201 E. Santa Ana Canyon Road in Anaheim, California in the outside mechanical room of a three-story facility of approximately 12,077 square meters (170,000 square feet). The facility houses the Anaheim Police Department East Substation and facilities for the East Anaheim Community Center. In the past, the facility was a medical facility. Currently the facility is being renovated to include a new library to serve the community.

The facility is equipped with a 125 kW emergency diesel generator and a 50 kW solar energy system. The diesel generator protects a limited amount of emergency loads and the solar energy system, owned and operated by Anaheim Public Utilities, provides power to the grid through the facility. The historic peak demand of the facility is 280 kW with an average annual electric consumption of 1,366,262 kWh and natural gas consumption of 37,505 therms. Electricity is provided by Anaheim Public Utilities and the natural gas provider is Southern California Gas Company (a Sempra Energy Utility).

Prior to the Project completion, the site had a space heating system that utilized two 697,000 Btu/hour hydronic boilers. The design of the Project featured capturing the excess heat produced by the fuel cell to heat the facility. In this way, the system acts in a co-generation capacity.

Image 1: Anaheim Police Department East Substation, 8201 E. Santa Ana Canyon Road in 2000. The facility is currently used for a Police Department on floors 1-3, with the Community Center on the ground floor at the East side of the facility.

Community Center



Plan 2: The site plan for the installation of the fuel cell.

Community Center

Location of Fuel Cell

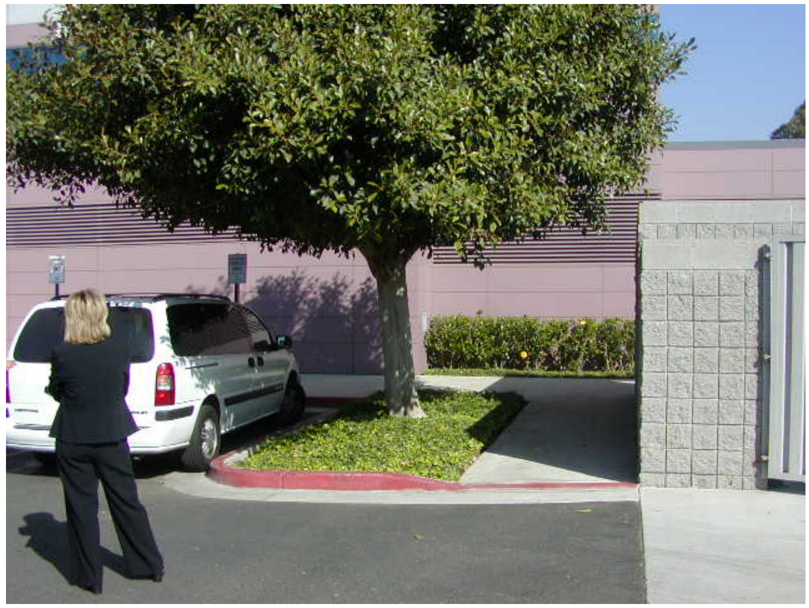


Image 2: Existing CMU wall that houses all the mechanical equipment and the 125kW emergency diesel generator. The fuel cell installation required the removal of the tree and the adjacent parking slot (non-handicap), and expanding the CMU wall to enclose the fuel cell and associated equipment.

Image 3: Interior of outside mechanical room showing existing original 697,000 Btu/hour hydronic boilers. At the time of this picture (October 5, 2002), the boiler on the left was out of service and the space heating was provided by the boiler on the right. The Project required the removal of the out-of-service boiler and the other boiler remains as a backup unit in case of heating system outages with the fuel cell.

6.0 <u>Experimental</u>

Under the goals of the Project, experimental methods were not used; instead, the Project requires field testing and verification of an operating fuel cell system. The system was designed and manufactured by UTC Fuel Cells, and as required by the Project, met Anaheim's size and commercial availability requirements. The fuel cell system is described more fully in Section 7.0 (Fuel Cell Installation) of this report. In particular, Table 2 of Section 7.0 addresses the specifications of the UTC PC-25 natural gas Fuel Cell System. More information can be found in the *200 kW On-Site Fuel Power Plant PC25™ Model C Installation Manual*, Copyright 2003, UTC Fuel Cells.

Though experimental methods were not addressed as part of the Project, data gathering and evaluation is required. From data that will be gathered over the five-year span of the Project, Anaheim will determine if the fuel cell under the Project is an appropriate technology for clean power generation in the City of Anaheim. The methods and materials used for this portion of the Project are described more fully in Section 10.0 (Data Acquisition System) of this report.

7.0 Fuel Cell Installation

The Project goal was for the installation and operation of a generating system in Anaheim that will help improve efficiency and reduce emissions within the region. The Project was to install a 200 kW fuel cell system at a police station/community center that would provide specific benefits including:

Community education – by locating the fuel cell at a police station and community center, awareness of clean power generation from the fuel cell and the 50 kW photovoltaic system on the rooftop of the facility will increase.

Emergency power – the fuel cell will provide the capacity to detect power anomalies and have the capability of being switched to supply backup power to the facility. The fuel cell system will potentially increase the amount of load that is protected in the event of an outage, which is crucial for a police station.

System efficiency – the waste heat will be utilized to tie into the space heating system of the facility in order to maximize the efficiency of the fuel cell system.

Interaction of multiple generating systems – the facility features a 50 kW photovoltaic system, a 125 kW emergency generator, and the 200 kW fuel cell generator. Part of the evaluation of performance will focus on the interaction of these systems.

Future deployment – based on the performance of the fuel cell and the future cost issues, Anaheim may seek to supplant diesel generators with fuel cells at select locations, such as office buildings, police stations, and libraries.

A Clean, Green Anaheim – the fuel cell integrates with existing programs that Anaheim has implemented, including green power purchases, a renewables curriculum for schools, energy efficiency rebates, microturbines, and electric transportation.

Recognition – Anaheim shares their experience with other municipalities and entities to help in their efforts to incorporate fuel cells in their respective businesses or territories.

Phase 1: The Project consisted of four phases including research and investigation, purchase, design, and construction. In the first phase, Anaheim conducted a preliminary siting study to determine a location for its first fuel cell installation. As a result of this phase, it was determined that only one fuel cell was beyond beta testing and commercially available to purchase, that being the UTC PC25. Upon this determination, Anaheim approved the purchase of the UTC PC25 to be located at the Anaheim Police Department East Substation in Anaheim Hills.

After the site was selected at 8201 E. Santa Ana Canyon Road, historic gas and electricity consumption was gathered for the site. Table 1 shows the totals gas and electric consumption, along with monthly and annual average, from February 2000 to June 2002.

	Natural Gas		Electricity	
	Therms	**Cost**	**kWh**	**Cost**
Total Consumption	95,292	$61,169	3,301,800	$322,833
Monthly Average	3,125	$2,185	113,855	$11,134
Annual Average	37,505	$26,215	1,366,262	$133,607

Table 1: Gas and Electricity Consumption at Project Site (8201 E. Santa Ana Canyon Road)

The UTC PC-25 specifications are shown in Table 2. Table 2 also indicates planned applications for the fuel cell use at the time of purchase.

Parameter	Specification	Application
Model	UTCFC PC25 Model C phosphoric acid fuel cell	
Power output	200 kW/235 kVA	Power supplied to the facility; excess power fed to utility grid
Electric configuration	480 VAC, 3 phase, 3 wire, 60 Hz	
Energy production	200 kW @ 8,322 hours/year (95% availability)	1.66 million kWh per year produced
Protection	AC over/under voltage AC voltage unbalance Abnormal frequency AC overcurrent AC current unbalance	
Heat output	700,000 Btu/hr 60°C (140 °F)	Used to tie into facility boilers for space heating
Efficiency	37% electrical only 87% electric and heat	
Fuel type	Natural gas	
Fuel consumption	1900 scf/hour (or 1.92 MMBtu/hour)	
Noise	62 dBA @ 9.174 meters (30 feet)	
Emissions, NOx	1 ppmv @ 15% O_2	
Dimensions	3.04m W x 5.49m L x 3.04m H (10’W x 18’L x 10’H)	
Weight	40,000 lb	
Warranty	Extended 5 year warranty	
Maintenance	5 year scheduled maintenance package	

Table 2: UTC PC-25 C System Specifications and Project Applications

Determining factors for the location of the Police Department East Substation was for backup power to be provided to the Police Substation, and enough space to house the system. At the East Substation facility there was enough space to retrofit a fuel cell system into the existing facility, and it would also provide additional backup power to the facility, along with the 125 kW diesel engine, if required.

Phase 2: Anaheim contracted with UTC for the provision of the fuel cell system and the design required for installing the system at the chosen location. In evaluating the UTC fuel cell against other fuel cell providers, it was determined that the UTC package was the only unit commercially available in its size range at the time. Other manufacturers were contacted, including Fuel Cell Energy, Ballard and Siemens as part of the evaluation. In addition, other fuel cell users were contacted and site visits were conducted. From these data points, Anaheim determined that the UTC package was best suited for the Project. As part of the purchasing process, Anaheim conducted an "Information Exchange" between Anaheim staff, including Utilities' protection technicians and electrical engineers, Facilities operators, and Building staff, and UTC technicians and designers. This meeting gave Anaheim staff an opportunity to ask questions about the fuel cell operations and specifications, make recommendations concerning interconnection and maintenance, and generally to get a firm understanding about the Project prior to working with a designer.

Because fuel cell technology, operation, and maintenance requirements were unfamiliar to Anaheim staff, a five-year warranty and maintenance agreement was reached with UTC. This requires scheduled quarterly maintenance by UTC during which time the fuel cell maintains its power, but is put into an idle mode. Once a year, the fuel cell goes through a five-day maintenance process which requires a complete shutdown of the system. As part of the purchase contract for maintenance of the fuel cell, Anaheim and UTC developed a Hazardous Materials Business Plan to handle the disposal of spent materials of the fuel cell. These generally amount to glycol, methanol, and various air filters. Under the Hazardous Materials Business Plan, UTC must log all materials for handling for acceptance by Anaheim. Anaheim then disposes of the materials under their existing requirements in compliance with the Department of Transportation.

Phase 3: Phase 3 of the Project was for UTC to provide the electrical, mechanical and structural designs to meet local utility and building code requirements in order to complete the construction of the Project. UTC sub-contracted with Kennedy/Jenks Consultants, a local engineering firm. Anaheim's design criteria included the following:

- Outdoor installation
- Installation to maintain the existing facility aesthetics
- Identification of loads that could be separated and allocated to the fuel cell
- The possibility of providing uninterruptible power to selected loads
- Blackstart capability in the event of a power outage
- Interfaces to facility's existing electrical and mechanical subsystems
- Heat recovery for use with existing boilers
- Coordination required with other existing generating sources
- Remote monitoring and control capability
- Protective relaying to comply with Anaheim's Interconnection Guidelines

As a first step in the Design Phase, a submeter test was performed on the electric loads in the building to determine which loads were suitable for re-routing to the fuel cell. From the results of the submeter testing, it was determined that lighting, plug loads, communications systems, forensic laboratory equipment, and the ventilations loads were appropriate loads to be located on the fuel cell subpanel. The load summary shown in Table 3 was developed by the designer after performing the submeter test at the Project site:

Item	Load Description	HP	FLA	KVA	PDF	PD FLA	PDKVA	ADF	AD FLA	ADKVA
1	Panel EM		72	57.4	1.1	79.2	63.1	0.8	63.36	50.5
2	MCC-A (Ventiliation)		10	8.0	1.1	11	8.8	0.8	8.8	7.0
3	DB-A (Misc. Lighting)		50	39.8	1.1	55	43.8	0.8	44	35.1
4	DB-B (Misc. Lighting and Ventilation)		25	19.9	1.1	27.5	21.9	0.8	22	17.5
	Total		**157**	**125.1**		**172.7**	**137.6**		**138.16**	**110.1**
1	Elevator	65	75	10.0	1.0	75	10.0	0.3	22.5	3.0
2	Chiller		90	10.0	1.0	90	10.0	0.7	63	7.0
	TOTALS		**322**	**145**		**338**	**158**	**224**	**120**	

Legend

FLA: Full Load Amps
KVA: Kilovolt Amps
PDF: Peak Demand Factor
PDKVA: Peak Demand KVA
PDFLA: Peak Demand FLA
ADF: Average Demand Factor
ADFLA: Average Demand FLA
ADKVA: Average Demand KVA

Table 3: Main Service Switchboard (Load Summary)

The modes of operation were also determined during the Design Phase as indicated in Table 4.

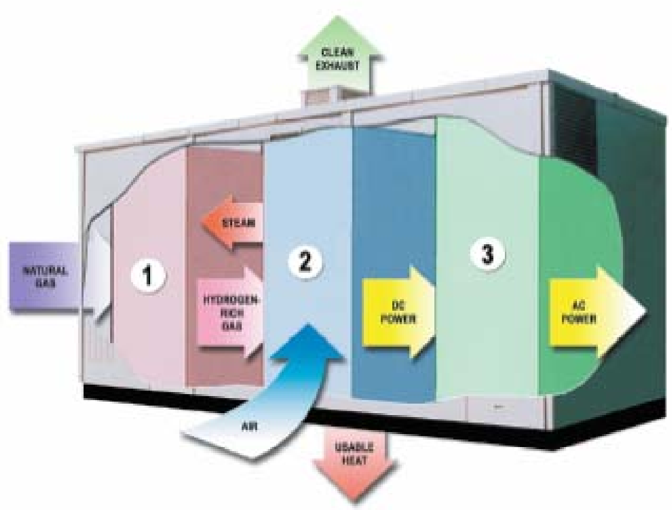
Condition	System Response		
	50 kW PV	**200 kW Fuel Cell**	**125 kW Diesel Generator**
Normal, Load < 250 kW	Generate power during sunlight hours (up to 50 kW), with net export to grid	Generate power continuously (200 kW), with net export to grid	Off
Normal, Load > 250 kW	Generate power during sunlight hours (up to 50 kW), with net import from grid	Generate power continuously (200 kW), with net import from grid	Off
Outage, Load 0 – 325 kW	PV inverter disconnects from grid	Fuel Cell disconnects from grid but is in idle mode; available for standby mode with reconfiguration of Kirk Key	Diesel Generator independently picks up primary loads within 125 kW capacity via transfer switch
Outage during Fuel Cell Annual Maintenance (not available for 5 days)	Generate power during sunlight hours (up to 50 kW), with net export to grid	Isolated from main panel - not available	Diesel Generator independently picks up primary loads within 125 kW capacity via transfer switch

Table 4: Modes of Operation for Fuel Cell Installation

Anaheim and UTC worked together throughout the design process to reach a design agreement for interconnection that would allow the fuel cell to give maximum benefit back to the community while operating in a safe and reliable manner. From the various design iterations, the final accepted design has the fuel cell operating continuously as long as the Utility grid is online. If the fuel cell "senses" any abnormalities from the Utility side, the fuel cell will disconnect from the grid and go into an idle mode. At the same time, a Schweitzer protective relay will disconnect the fuel cell further from the main buss, thus assuring no backfeed into the utility grid. If the fuel cell is to be used for backup power, the design calls for a kirk key interlock system to isolate the fuel cell from the utility grid while also providing power to one dedicated subpanel (F).

To understand the design requirements, a description of the operation of the UTC PC-25 at the Anaheim Police Station is helpful. The fuel cell is a power generator in the form of an electrochemical device. Unlike batteries, which are also electrochemical devices, fuel cells do not store the "fuel" used in the generation process. Instead, fuel cells are fed a constant flow of fuel. As fuel feeds the fuel cell, it produces electricity. Fuel cells continue to produce electricity as long as the fuel cell is fed.

The Anaheim Project requires natural gas as the fuel source for the fuel cell and functions as detailed in Image 4.



Natural gas is fed to a reformer **(1)** where hydrogen is extracted from the gas. This process requires heat and water, both supplied by the fuel cell system.

The fuel cell stack **(2)** is where the electrochemical process takes place. Hydrogen and air are combined in a process that produces DC power, water, and heat.

The power conditioning system **(3)** takes the DC power from the fuel cell stack and converts it into high quality AC output power.

Image 4: How the UTC PC-25 Fuel Cell System Works (source: UTC Power)

The fuel cell system is designed to be self-contained and uses most of the heat and water it produces in the power generation process. To accomplish this, the fuel cell system is designed with an on-board water treatment subsystem. The water produced in the generation process is treated in the system before it is recycled back into the fuel cell. If there is not enough recycled water available for the reforming process and the on-site potable water does not meet the specifications of the water used in the fuel cell, an external reverse-osmosis water treatment system is required to provide makeup water for the fuel cell. In the case of the Project in Anaheim, an R/O unit was required as part of the design.

One special consideration for the design called for all plumbing, with exception of drainage, to be run above ground. This was done as a way to limit the impact of the construction on a working facility. By putting all gas and conduit lines above ground, demolition of existing concrete and systems was reduced. Additionally, it was determined that if repairs were need for electrical conduit or hot water return and supply lines, above-ground installation would best serve future repairs. Because of the height of the wall (3.05-3.66 meters [10-12']), the above-ground lines were installed overhead to go over the wall. As a consequence, the cooling system was installed at a height higher than the actual fuel cell system requiring a pressurized cooling system instead of the conventional open-vented system normally used. The design consideration required including a glycol expansion tank with pressure valve off of the cooling tower.

The aesthetics of the site location was another design consideration that was taken into account. Prior to completion of the Project, the facility had an existing outside mechanical room surrounded by a twelve foot high CMU wall. The mechanical room can be seen from the street and the wall provides an amount of aesthetics to the facility. Additionally, the wall is a deterrent for vandalism. In order to tie the installed Project into the existing facility on an aesthetics level, the CMU wall was extended to enclose the fuel cell system and be hidden from view at street level.

To meet the operating needs of the Project, the design included the following specification Divisions:

<u>DIVISION 1</u>	**GENERAL REQUIREMENTS**
01010	Summary of Work and Contract Considerations
1190	Seismic Requirements for Contractor-Furnished and/or Installed Items
01300	Submittals
01650	Facility
<u>DIVISION 2</u>	**SITEWORK**
02705	Paving and Resurfacing
02775	Concrete Curb, Gutters, and Sidewalks
<u>DIVISION 3</u>	**CONCRETE**
03200	Reinforcing Steel
03300	Cast-In-Place Concrete
03350	Concrete Finishes
<u>DIVISION 4</u>	**MASONRY**
04220	Concrete Masonry Units
<u>DIVISION 5</u>	**METALS**
05500	Metal Fabrications (Miscellaneous Metal)
<u>DIVISION 8</u>	**DOORS AND WINDOWS**
08110	Hollow Metal Work
08358	Solid Metal Industrial Doors
08700	Finish Hardware
<u>DIVISION 9</u>	**FINISHES**
09960	Protective Coatings
<u>DIVISION 11</u>	**EQUIPMENT**
11001	General Equipment and Mechanical Requirements
11002	Electric Motor Drives
11211	Centrifugal Water Pumps

DIVISION 15	**MECHANICAL**
15050	Pipe, Valves, and Accessories

DIVISION 16	**ELECTRICAL**
16010	General Electrical Requirements
16110	Conduit, Raceway, and Fittings
16120	Low Voltage Wire and Cable
16130	Boxes
16140	Wiring Devices
16160	Panelboards
16180	Protective Devices and Switches
16450	Electrical Grounding

The fuel cell design was completed and approved by Anaheim in October 2003.

Phase 4: Phase 4 was for the installation, commissioning, and operations training for the Project. After the design plans were approved by the City of Anaheim Planning Department, Anaheim was able to move forward with the installation of the fuel cell. The public bid and contract process was managed by the City of Anaheim Public Works Department with Anaheim Public Utilities providing a Project Manager for the complete construction phase. The bid was awarded to Electro Serv Company January 2004 and Notice to Proceed was given April 16, 2004.

Image 5a-c: Construction started on April 19, 2004 with site preparation. This included the installation of the construction trailer, fencing around the construction site, and saw cutting the asphalt and concrete in preparation for demolition.

Image 5a: Construction trailer and security site.

Image 5b: Saw cut for removal of parking space.

Image 5c: Saw cut for asphalt demolition.

Image 8a-c: Construction progress shows demolition of site, including original walkway adjacent to CMU wall, tree removal, and removal of one parking space.

Image 8a: Demolition of original walkway and removal of tree.

Image 8b: Demolition of asphalt.

Image 8c: Demolition of original walkway adjacent to original CMU exterior wall (Project enclosed this CMU wall to install a new exterior wall).

Image 9a-c: Plumbing work for the heat recovery, water supply, and drain system started May 3, 2004.

Image 9a: Drains that will be integrated into concrete slab, and rebar for CMU footing.

Image 9b: Trenching and support for CMU footing; existing chiller lines.

Image 9c: Rebar for CMU wall footing.

Image 10: Receiving the UTC PC-25 fuel cell system and R/O from the UTC manufacturing plant in Connecticut on July 13, 2004; both units were placed for temporary storage in the construction security area.

Image 11: Placing the fuel cell system required a crane to remove the plant from the truck and place it in a temporary location at the construction security site.

Image 12: Since the cooling tower would be mounted on newly constructed concrete slabs, it was also placed at the same temporary location as the fuel cell system until the concrete work was complete.

Image 13: Pouring concrete for CMU wall footing.

Image 14: Construction of CMU wall (June-July 2004).

Image 15: Completed CMU wall and slab (August 2004). On the southwest wall there are two podium slabs for the new circulation pumps that were installed as part of the heat-recovery system. The pumps circulate some of the heat coming off of the fuel cell to heat the facility.

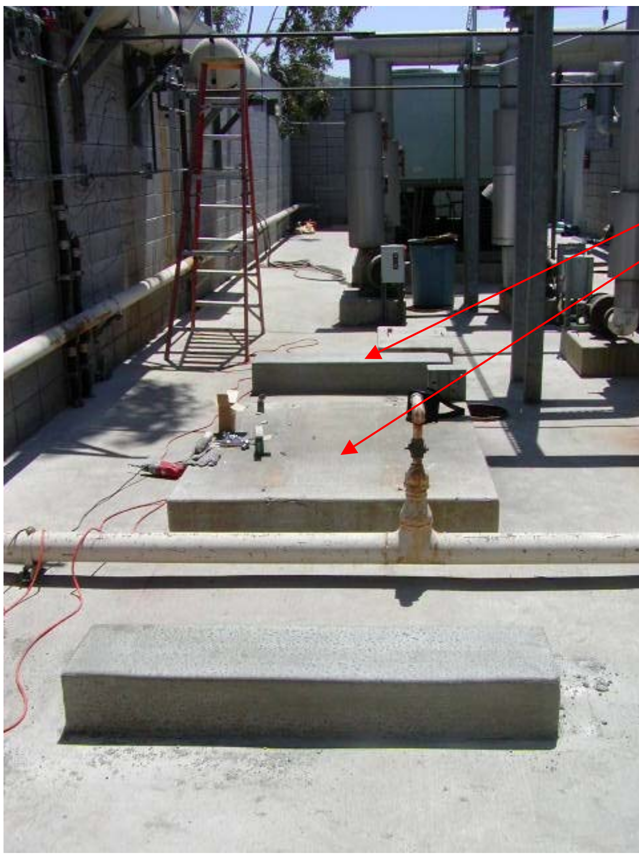


Image 16: Podium slabs for mounting the cooling tower. Prior to the Project, an out-of-service boiler was located at this space (see Image 3). As part of the Project scope, the boiler was removed leaving one boiler remaining on standby as a backup unit. The fuel cell system provides all of the heat required to heat the facility.

Image 17: Repositioning the fuel cell from the temporary site to the permanent position (May 21, 2004).

Image 18: Lifting the fuel cell over the CMU wall into its permanent enclosure.

Image 19: All new conduit and piping associated with the Project was installed above-ground and mostly overhead. This photo shows the 10.16 cm (4 inches) power conduit, with protective relay conduit to the disconnect and the panel relay to the fuel cell 1.91 cm (3/4 inches), and conduits for telecomm and controls.

Image 20: Conduit uses a UniRack system to support the overhead installation.

Image 21: 2.54 cm (1 inch) and 1.91 cm (¾ inches) conduit for the phone wire, controls, and power to the cooling tower.

Image 22: AC disconnect outside the fuel cell system (normally open at MD-2) provides protection in case the system is switched to backup power

Image 23: AC disconnect on the fuel cell system (MD-1) is normally closed during normal operation.

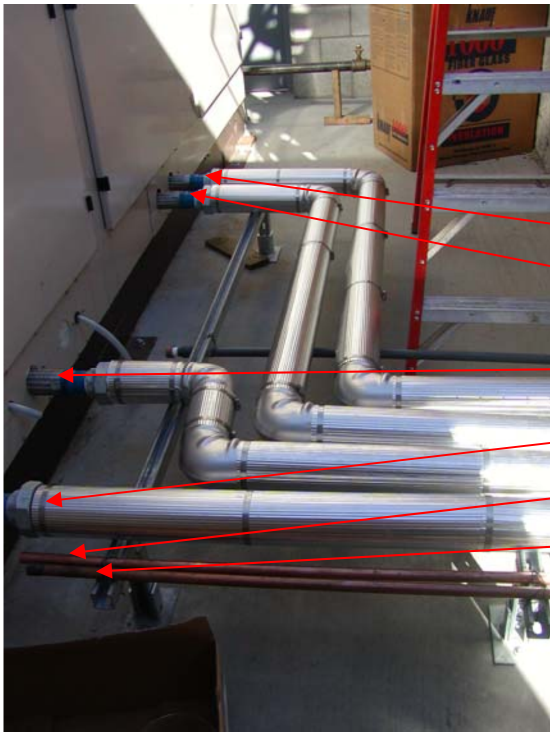


Image 24: Plumbing lines into and out of the fuel cell system:

Image 25: Two new 3-horsepower hot water return pumps were installed to recover the heat off of the fuel cell system and pump it into the facility space heating system. One pump is for backup only; only one pump is required for daily operations.

Image 26: A Nimbus N-Series Reverse-Osmosis system is used to treat water in case makeup water is required in the power generation process.

Image 27: The fuel cell system operates on a pressure rating of 10.16-35.56 cm (4-14 inches) water. The existing gas pressure into the facility was in the 10.16-22.86 cm (4-9 inches) water range with the boilers operating at 6 inches. As a result, the gas pressure needed to be increased and regulators were installed before the back-up boiler and before the fuel cell. This image shows the new service to the fuel cell and the new regulator.

Image 28: The cooling system was installed at a height higher than the actual fuel cell system requiring a pressurized cooling system instead of the conventional open-vented system normally used. This installation choice required the inclusion of a glycol expansion tank with pressure valve off of the cooling tower.

Image 29: The cooling tower is a three fan-cooled module that receives power directly from the fuel cell; the glycol off of the fuel cell ties into the cooling tower (5.08 cm [2 inches] copper tubing) and further to the expansion tank (2.54 cm [1 inch] copper tubing).

Image 30: The Hot Water Supply/Return lines intersect the original facility heating lines providing heat off of the fuel cell to the facility.

Image 31: Completed project shows the fuel cell to the left of the hot water return pumps. A roll-down door at the front of the fuel cell keeps the site secure. The fuel cell runs continuously at an average peak of 198 kW.

It is Anaheim's goal to manage the operation and maintenance of the fuel cell installed under this Project, and identify if and how the technology works within Anaheim's generation requirements. Anaheim has integrated training Utilities' staff in the technology, installation, maintenance, operation, and safety issues as part of the overall Project goals. Upon startup of the fuel cell, training was conducted for Utilities staff, including field technicians, electrical engineers, and designers. This training will be ongoing as Anaheim's expectation is that fuel cells are an option for future power generation in the area.

8.0 Electrical System

Appendix Attachment B is a copy of the single line diagram (E-2 of the Project plans) showing how the fuel cell is connected to the facility and utility grid. The fuel cell is connected to the grid at a 400 amp breaker on the main distribution panel (MSA) on circuit 100. Between the disconnect at the fuel cell (MD-1) and the 400 amp breaker on the main buss is a Schwietzer relay that was installed as a protection device on circuit 101 as required by Anaheim.

On the facility side, the fuel cell is connected to a 400 amp breaker at distribution panel F on circuit 103. When the fuel cell operates in standby mode, the fuel cell provides dedicated power for plug loads and some lighting to the facility at this breaker. All necessary emergency loads are handled by the125kW diesel backup generator at distribution panel EM.

The Sequence of Operations for the fuel cell system electrical generation is as follows:

Normal Operation

The fuel cell will normally provide power to dedicated loads, panel “A”, panel “B”, panel “F”, and MCC-A, at a maximum output of 200kW. Any excess power generated by the fuel cell will be supplied to the (E) main distribution board “MSA” in parallel with the utility grid. The key interlock is normally located at the (N) 400A circuit breaker in (N) distribution panel “F”.

Upon loss of utility power:

- The fuel cell will sense the loss of utility power and disconnect from the grid.
- The Schweitzer Relay will sense the loss of utility power and also provide a signal to the fuel cell to assure the fuel cell disconnects from the grid.
- The fuel cell will operate in a grid independent idle mode; no loads will be supported by the grid independent idle mode output of the fuel cell. This is due to the key interlock 400A breaker which is connected to the fuel cell and panel “F.”
- The key interlock at panel “F” will normally be in the open position so no power from the fuel cell will reach panel “F” in normal operation.

Upon restoration of utility power:

- The Schweitzer Relay will detect that utility power has been restored and send a signal to the fuel cell automatically; this will allow the fuel cell to operate in parallel with the grid.
- The fuel cell, sensing the utility power has been restored and the signal from the Schweitzer Relay, will switch modes of operation and synchronize with utility power.
- If the grid has been lost for an extended period of time greater than a customer preset “maximum time allowed to reconnect” (TDCUST3 located on the fuel cell’s LDT screen #073 -- presently set at 30,000 seconds or approximately 8 hours), the fuel cell will stay in the idle mode once utility power is restored. In this case, operator intervention is required to restore fuel cell to grid connected mode. The operator will reset the “mode” selection on LDT operations screen #001 from IDLE to “Grid Connect”. Anaheim has provisions in the existing maintenance and extended warranty contract with UTC Power for UTC to restore service to the fuel cell remotely when necessary and appropriate.

If the fuel cell is not available due to maintenance services:

- The manual disconnect switch “MD-1” shall be opened.
- Main disconnect switch “MD-2” will remain closed.
- The key interlock at the (N) 400A circuit breaker in (N) distribution panel “F” shall be confirmed open so that there is no power feedback to the fuel cell from panel “F”.
- The key interlock to the (E) 400A circuit breaker in (E) main distribution board “MSA” shall be confirmed closed.
- The existing main distribution board “MSA” will provide power to dedicated loads.

Upon completion of maintenance services, main disconnect switch “MD-1” shall be closed to restore electric utility power to the fuel cell.

Backup Operation

The fuel cell is capable of providing backup power to panel "F" upon loss of utility grid. In this situation, the fuel cell will immediately switch to grid independent idle mode and not be connected to any dedicated loads as described above. In order to for the fuel cell to provide backup power to panel "F":

- The disconnect switch at "MD-2" shall be opened.
- The key interlock at panel "MSA" shall be removed and inserted in the in the key interlock at the 400A breaker at panel "F".
- The breaker at panel "F" shall be closed.
- At the fuel cell operator panel, the fuel cell "GI" mode selection shall be switched. At this point, load is added to the fuel cell. Anaheim has made provisions with UTC for assistance to activate backup power startup when necessary and appropriate.
- When grid power is restored and the fuel cell is no longer required for backup power, the fuel cell will return to normal Grid Connected operation as long as the grid has been restored within the operator adjustable "TDCUST3" (maximum time to allow reconnect) on operator LDT screen display #073.

If the grid outage has been an extended period in excess of the fuel cell's "TDCUST3" time, the fuel cell will not automatically return to normal operation. Operator intervention is required. On LDT operations screen #001, reset to mode of operation from IDLE to "Grid Connect" mode in order to restore the fuel cell to normal "grid connect" mode

In order to restore panel "F" to have grid power as primary source:

- The breaker shall be opened at panel "F".
- The key interlock shall be removed at panel "F" and inserted at panel "MSA".
- The breaker at panel "MSA" shall be closed.
- The disconnect switch "MD-2" at fuel cell shall be closed.

9.0 Thermal Recovery System

Appendix Attachment C is a copy of the process and instrumentation diagram for the hot water and fuel cell system (P-1 of the Project plans) showing how the fuel cell is connected to the facility heating system. Recovered heat from the fuel cell is used in the existing hot water space heating system. A heat recovery loop circulates water through the heat exchanger of the fuel cell. The heat exchanger provides between 275,000 and 500,000 BTU/hr of heat depending upon the operation duration of the fuel cell installed in the Project. The fuel cell is designed to provide the full amount of recovered heat any time there is flow in the heat recovery loop.

The Sequence of Operations for the fuel cell system heat recovery system is as follows:

When the fuel cell is operating:

- Heat Recovery Pump (HRP-01) will be controlled by the hot water return temperature.
- When the hot water return temperature falls below 130°F, the pump will start. Water from the hot water return will circulate through the fuel cell high-grade heat exchanger.
- When the temperature reaches 140°F, HRP-01 will stop.

- If the heat from the fuel cell is insufficient to meet Site heating loads, the existing boiler (700,000 BTU/hr gas-fired) will be used to provide further heat.
- If the return temperature drops to 125°F, the boiler and associated Hot Water Pump P-4 will start.
- The boiler will continue to operate until the return temperature reaches 135°F; at that point, the boiler and P-4 will stop.

<u>When the fuel cell is not operating:</u>

- HRP-01 will be taken out of auto operation and not be available for use.
- HRP-02 will be in manual standby as a backup to the existing boiler and its associated pump (P4).
- The boiler will operate (as above) to heat the facility.

<u>Standby Pump (HWR-02)</u>

Heat Recovery Pump HRP-02 is configured for manual standby. If HRP-01 cannot operate, it will be shutdown manually, and HRP-02 will be put online manually to operate in its place. HRP-02 is also a backup pump for P-4 that serves the boiler.

Because the heating system at the Police Substation altered facility operations, UTC developed a "Modes of Operation" table for Anaheim Facilities staff. The table assists staff in determining how valves and pumps should be configured (open or closed, off or on) for different modes of operation for the fuel cell. To keep the operations consistent, the new valves (1-13) have metal tags indicating the corresponding valves to modes of operation. Additionally, the table is accessible on site in case operations change on the fuel cell system.

VALVE NUMBER					1	2	3	4	5	6	7	8	9	10	11	12	13
EQUIPMENT	Pump #1	Pump #2	Boiler Pump	Boiler													
MODE #1	ON	OFF	ON	ON	O	O	O	C	C	C	C	O	O	O	C	C	C
MODE #2	OFF	ON	ON	ON	C	C	C	O	C	C	O	O	O	O	C	C	C
MODE #3	ON	ON	OFF	ON	O	O	O	C	O	O	C	O	O	O	O	O	O
MODE #4	ON	ON	OFF	OFF	O	O	O	C	O	O	O	C	O	O	O	C	C

Mode #1: In this mode, Pump #1 is taking a portion of the HHWR water from the building and preheating it to a maximum of 71°C (160°F). It then returns it to the HHWS down stream of the boiler. The boiler pump and boiler are available. If the HHWR return to the boiler drops below 59°C (130°F), the boiler will come on and heat the water up to 71°C (160°F).

Mode #2: In this mode, Pump #2 is running and performing the same operation as Pump #1in Mode #1.

Mode #3: In this mode, Pump #1 and Pump #2 are running. The boiler pump is off. Pump #1 is performing the same function as in Mode #1. Pump #2 in this mode is taking place of the boiler pump and satisfying the flow switch in the boiler so it is available if needed. The boiler will operate in the same manner as in Mode #1.

Mode #4: In this mode, Pump #1 and Pump #2 are running. The boiler pump and boiler are unavailable and the only source of heat is from the fuel cell. Pump #1 is supplying all of the heat to the building. Pump #2 is being used as a boost pump to circulate water through the system.

Table 5: Fuel Cell/HVAC Modes of Operation

10.0 Data Acquisition System

The control software on the UTC PC-25 is controlled remotely using a program called RADAR. RADAR stands for Remote Automated Diagnostics and Data Acquisition and Recording and it is a computer aided diagnostics tool to monitor the operation of UTC fuel cell systems. RADAR was developed by UTC and it provides the means for remotely retrieving power plant operating data over a local phone line. The collected information is stored in a central computer database or in a laptop computer. A menu driven user interface provides access to current and historical data for assessing power plant performance. The RADAR application is integrated with MS ACCESS and follows standard Windows conventions.

The diagnostic interface program ties to a database in UTC's facilities and is used by UTC operations and service personnel to operate the Power Plant. In this way, the power plant is operated and monitored on a 24-hour basis by UTC Power in their Connecticut offices per the agreement with Anaheim. On a daily basis, the database "calls" the power system modem and compares operating values onsite with configuration limits. The data is emailed to UTC 24-Hour Response Line and notifies the operations personnel if any data is out-of-line. If there are values that are not inline with the configuration limits, operations personnel examine the data for occurrences and respond appropriately.

The diagnostic interface allows the following general function interactivity:

- Power plant operations: Allows start/stop of the plant, operating mode setting, load mode setting, relighting of reformer, shutdown latch reset, alarm reset.
- Power plant events history: Displays event history.
- Plant data (real time): Graphically displays real--time data on main and sub screens.
- Rolling memory data: Graphical displays stored data on main and sub screens.
- Trend menu: Displays trend data on a graph.
- Overrides (3 screens): Allows manual operation of power plant equipment and operating sequence control.
- System setting: Allows the settings of accumulation parameters, shutdown, alarm conditions, data communication, etc and operation of PCS protection reset, etc.
- Control parameters: Allows setting of various power plant control parameters.

There are a number of system parameters data points accessible through RADAR that are used by UTC operations including the following:

- Hydro-Desulfurizer catalyst bed temperature
- Primary reformer temperature
- Backup reformer temperature
- Motor compartment ventilation air inlet temperature
- Cell stack fuel inlet temperature (anode inlet)
- Primary steam separator (ACC400) temperature
- Backup steam separator (ACC400) temperature
- HEX400 cold side (glycol) exit temperature
- Cell stack coolant inlet temperature
- Polisher (DMN440) inlet temperature
- Hydro-Desulfurizer (preox section) temperature
- Hydro-Desulfurizer (preox section) exit temperature

- High grade heat thermal control valve exit temperature
- Motor compartment ventilation air exit temperature
- Not used in CTC power plant
- Natural gas inlet temperature
- Steam separator (ACC400) water level
- DC voltage of top half of stack
- DC voltage of bottom half of stack
- Actual steam ejector (EJT010) position
- Requested natural gas valve position
- Actual cathode air valve position
- Reformer burner air flow
- Instantaneous cell stack DC current
- Natural gas flow venture (FE012) exit pressure
- Uncorrected natural gas flow
- Requested propane valve position
- Uncorrected propane flow
- Dispatched power request from external power control
- Water tank (LT450) water level
- Requested steam ejector position
- Glycol pump variable speed drive output (0% to 100%)

For Anaheim, RADAR is used to call the fuel cell system to get historical data. The data is downloaded monthly over a phone line, exported to Excel, and compiled to ascertain a trend addressing peak power output, energy output, and natural gas consumption. This data is used to determine how well the fuel cell system is working and if it is meeting its performance standards. Monthly, Anaheim collects data that includes: date and time of read, AC volts, fuel consumption totals, kilowatts AC net, kilowatts DC, and megawatt-hours net.

11.0 Fuel Supply System

The fuel supply for the Project comes from commercial grade natural gas supplied by Southern California Gas Company. Since there was existing natural gas service to the facility, the Project tied-into the service and ran additional service to the fuel cell system. This required increasing the gas service to 5 pounds per square inch and installing regulators on both the fuel cell side and the facility side of the service. The facility gas account is under a GN-10 Core rate schedule and Anaheim wanted to stay on this schedule after the Project was completed since non-Core rate schedules have additional monthly services charges. An application was required by Southern California Gas and Anaheim had to show how the usage at the facility would not exceed 20,800 therms a month. Since startup of the unit, the fuel cell has averaged 13,100 therms per month.

12.0 Program Costs

Item	Description	Cost
Purchase	One UTC PC-25C 200kW fuel cell generator system and R/O water treatment system; includes taxes, shipping, personnel training, and first year maintenance (includes all materials required for operation of fuel cell unit except natural gas and water), warranty and monitoring costs for one year	$897,660.00
Design	Engineered drawings, construction specifications, plan check approval, installation instructions,	$62,990.00

	facility metering final test report, configuration plan options report for fuel cell system	
Installation	Transporting, handling and installing the fuel cell system including related heat recovery equipment, electric and nitrogen supply systems, interconnecting pipes, valves and controls, and all structural requirements including concrete, asphalt, and enclosure wall.	$263,985.75
Performance Monitoring/Maintenance	Four-year extended warranty and maintenance (four annual payments) for quarterly and annual maintenance on system, emergency call-out response, and monitoring of system	$215,000.00
TOTAL		**$1,439,635.75**

Table 6: Project Installation and Maintenance Costs

Table 6 shows the direct costs of completing the Project including the commitment to extended warranty and maintenance over the expected lifespan of the fuel stack (five years).

Fixed Operating Cost: Anaheim's annual agreement with UTC for the extended warranty, maintenance and monitoring of the fuel cell system includes all variable operating costs (consumables) with the exception of natural gas and water. Since the agreement calls for payment of these materials, the costs are fixed; costs are $53,750/year as indicated in Table 6. Consumables include: nitrogen, glycol, activated charcoal, mixed resin, air and water filters.

Variable Operating Cost ($/kWh): The only variable cost of operating the Project is for natural gas at approximately eight cents per kilowatt-hour ($.08/kWh).

Fuel Costs ($/MMbtu): Based on gas bills for the period February 2005 through January 2006, fuel costs are $8.98/MMbtu.

Local Area Fuel Price: Natural gas to the fuel cell system is purchased through a commercial account with Southern California Gas Company; the account is not a secured long-term contract. Therefore, the gas delivered is through Southern California Gas Company's purchase on the commodity market at the delivery point. This commodity purchase is made monthly by Southern California Gas Company, and as a consequence, the gas price used at the Project site varies from month to month.

Cost for natural gas from February 2005 to January 2006 ranged from $0.68 to $1.23 per therm and averaged $0.92 per therm.

Local Area Electricity Price: Anaheim Public Utilities provides electricity to the Project site. Since both the site and Anaheim Public Utilities are part of the City of Anaheim, the site is on a City rate that is used for all City of Anaheim facilities. The average rate for electricity at the Project site is $0.09 per kilowatt-hour; there are no demand charges under the city facility rate.

13.0 Operational Data and Results

The Project was completed as a way to test and understand a fuel cell power generator as a pilot program. As such, one of the Project goals was to maintain the status quo at the Project site in an effort to tie the fuel cell operations seamlessly into the existing site operations. This includes the electric and gas consumption bills handled by the Facilities Department. The fuel cell does not provide electricity to the facility. Instead, it is a power generator for the Utilities Department, and the power used from the fuel cell by the facilities is billed, at the City rate, to the facility. In the same way, the facility is not responsible for the purchase of the natural gas to feed the fuel cell; this is paid for by Utilities.

Table 7 shows the fuel cell operating data for the first year of operation of the fuel cell at 8201 E. Santa Ana Canyon Road. The values were obtained through the onboard RADAR software system described in Section 9.0 in this report. The fuel cell system has meters for both the MWh power production, natural gas consumption in standard cubic feet, and operating time for the fuel cell; these values are all cumulative. RADAR also records all outages at the site, both scheduled and unplanned.

- Availability was derived as a ratio between of the total operating hours of the fuel cell and the total amount of hours the fuel cell was capable of running if it ran without interruption.
- Capacity factor was derived as a ration between the total energy produced over the time period and the total energy that was capable of being produced had the fuel cell run without interruption.
- Electrical Efficiency was derived as a ratio between the energy produced in kilowatt-hours and the fuel required to produce the electricity in kilowatt-hours (requiring conversion from therms to kWh).

Fuel Cell Operating Data					
Rated Fuel Cell Capacity	**200**	**kW**	**Fuel Usage (LHV)**	**1.5602744 e+10**	**Btus**
Total Operating Hours	**8,482**	**hrs**	**Thermal Heat Recovery**	**N/A**	**Btus**
Total Time in Period	**8,616**	**hrs**	**Heat Recovery Rate**	**N/A**	**Btus/hr**
Availability	**98**	**%**	**Heat Rate**	**9,136**	**Btus/kWh**
Total Energy Produced	**1,701,881**	**kWe-hrs**	**Electrical Efficiency**	**37**	**%**
Average Electric Output	**198**	**kW**	**Thermal Efficiency**	**N/A**	**%**
Peak Electric Output	**200**	**kW**	**Total Thermal Heat Recovery**	**N/A**	**Btus**
Capacity Factor	**99**	**%**			

Table 7: Fuel Cell Operating Data (February 2005 through end of January 2006)

Table 8 shows the annual gas and electricity consumption at the facility prior to the fuel cell site installation. The values were gathered from billing data from Anaheim Public Utilities for electric consumption and Southern California Gas for natural gas consumption. The natural gas data was received in therm units and was converted to MMBtus.

Site Parameters Prior to Fuel Cell Installation				
Month	Total Monthly Site Electrical Usage kWe-hrs	Peak Site Electrical Usage kW	Total Monthly Site Fuel Usage (LHV) MMBtu	Peak Site Fuel Usage (LHV) MMBtu/day
Feb-04	86,000	160	449	16
Mar-04	99,200	180	383	12
Apr-04	92,400	180	374	12
May-04	100,600	180	283	9
Jun-04	107,800	180	344	11
Jul-04	110,800	180	219	7
Aug-04	75,600	160	17	1
Sep-04	101,000	220	16	1
Oct-04	107,400	200	278	9
Nov-04	85,600	180	409	14
Dec-04	105,800	220	381	12
Jan-05	95,699	207	489	16

Table 8: Site Parameters Prior to Fuel Cell Installation (February 2004 through end of January 2005)

Table 9 shows the gas and electricity consumption at the facility for one year after the fuel cell was installed at the Project site. The values were gathered from billing data from Anaheim Public Utilities for electric consumption and Southern California Gas for natural gas consumption. The natural gas data was received in therm units and was converted to MMBtus. The fuel cell was commissioned and started on February 9, 2005, so a partial bill was attributable to the fuel cell operation only.

Site Parameters During Fuel Cell Installation				
Month	Total Monthly Site Electrical Usage kWe-hrs	Peak Site Electrical Usage kW	Total Monthly Site Fuel Usage (LHV) MMBtu	Peak Site Fuel Usage (LHV) MMBtu/day
Feb-05	19,102	221	1,114	40
Mar-05	272	136	1,575	51
Apr-05	1	1	1,369	46
May-05	19,049	226	1,296	42
Jun-05	9	7	1,385	46
Jul-05	759	25	1,599	52
Aug-05	770	33	1,461	47
Sep-05	304	63	1,543	51
Oct-05	352	101	1,568	51
Nov-05	10	5	1,428	48
Dec-05	1	2	1,510	49
Jan-06	2	2	1,751	56

Table 9: Site Parameters After Fuel Cell Installation (February 2005 through end of January 2006)

From the billing data, the electricity use from the Utilities grid was reduced by 96% while the natural gas consumption was increased by 380%. February 2005 shows a peak of 221kW which was reached prior to the fuel cell being commissioned. In the same way, two outages occurred at the fuel cell in May 2005 thus explaining the peak of 226kW in May when the fuel cell was not operating.

Table 10 shows the scheduled and unplanned outages at the fuel cell site. Though the fuel cell is scheduled for a three to four-day annual maintenance, the reporting timeframe does not include the first annual maintenance that was performed on the fuel cell February 13, 2006. The first unscheduled outage occurred on May 17, 2005 and was rectified on May 19. This occurrence was due to a bad gas flow sensor on the fuel cell unit. The sensor was replaced and power was restored on May 19 for a complete outage of 51 hours. The second unscheduled outage occurred on May 24, 2005 and was rectified on May 27. The outage occurred due to a field operation error that caused a glycol leak on the cooling loop. The leak was repaired and the cooling loop put back in service; power was restored on May 29 for a complete outage of 60 hours.

Fuel Cell Outages		
Mean Time Between Failure	**4,241**	**hrs**
Total Scheduled Outages	**0**	
Mean Time of Scheduled Outages	**0**	**hrs**
Total Unscheduled Outages	**2**	
Mean Time of Unscheduled Outages	**56**	**hrs**

Table 10: Fuel Cell Outages (February 2005 through end of January 2006)

14.0 Milestones/Improvements/Lessons Learned

For the City of Anaheim, this demonstration is ongoing for the five year life expectancy of the fuel cell stack. The greatest milestone achieved is the completion of the Project and successful operation of the fuel cell system to date.

Modifications did not occur in the design or construction phases of the Project but have occurred for the operation of the fuel cell. Since the thermal recovery system ties into the existing heating system at the facility, City of Anaheim Facility staff was given training and a scope of work matrix described in Section 7.0, Table 5, to assist in changing the operating parameters if necessary. Otherwise, the Project was installed as planned.

The challenges of the Project focused on a few key issues. First, the technology was unfamiliar to Utilities. Concerns about back-feeding the Utilities' grid and any potential negative issues associated with back-feeding had to be reviewed a number of times. The site chosen for the installation was a good site because it was an agreed-to site. Otherwise, it provided many challenges because of the small space, the aesthetic issues, and existing site conditions. Additionally, understanding how the system works and Utilities' staff reaching a comfort level concerning operations is ongoing. The Project is still in the very early stages of operation and there may be more issues that arise as the system gets older or if the system is ever put in a backup power operation mode.

Finally, the Project does not make the best use of the fuel cell technology as is apparent in Table 7. Instead of simply recovering the heat off of the fuel cell to heat the facility, using high grade heat off of the fuel cell for another application, such as to an absorption chiller, would increase the electrical efficiency. Particularly since the climate zone necessitates cooling the facility more than heating the facility. In addition, installing a BTU meter would be a helpful tool for measurement and verification. In looking at opportunities for future fuel cell generation sites in the City of Anaheim, consideration will be given to new construction with appropriate space and significant cooling loads.

15.0 Conclusions/Summary

The Pilot Fuel Cell Project is the first opportunity for the City of Anaheim to install and operate a fuel cell power generator. Anaheim is facing the challenges of supplying reliable power to a growing population, while also meeting clean power generation goals. Anaheim sees distributed generation technologies as one possible solution to supplementing central power plants. Along with solar energy, another form of distributed generation technology, fuel cells offer clean power generation; and this is essential to the region. The Project is a way to test and determine if, and at what level, fuel cells serve Anaheim.

The 200 kW UTC PC-25C fuel cell generator was installed at an Anaheim Police Substation and commissioned on February 9, 2005. Since that date, the fuel cell has operated continuously with minimum downtime.

Total cost for the Project is $1,439,635.75. This includes construction design, purchase of the fuel cell and R/O unit (shipping and handling), complete installation and approval, commissioning, five-year warranty, maintenance (quarterly and annual maintenance and all associated materials), personnel training.

16.0 References

None

APPENDIX

Kennedy/Jenks Consultants

Engineers & Scientists

32001 - 32nd Avenue South, Suite 100
Federal Way, Washington 98001
253-874-0555 (Seattle)
253-927-8688 (Tacoma)
FAX 253-952-3435

19 July 2006

Ms. Dina Predisik
Resource Programs Manager
City of Anaheim Public Utilities Department
201 South Anaheim Boulevard, Suite 801
Anaheim, California 92805

Subject: UTC 200 kW Fuel Cell Project
Sheet E-2 – Electrical Single Line Diagram
Sheet P-1 – Process & Instrumentation Diagram
K/J 026148.00

Dear Dina:

Per your request, this letter serves as written authorization for the City of Anaheim to use the above referenced design plans in Anaheim's final Technical Report to the Department of Energy.

If you have any questions, please call us at (253) 874-0555.

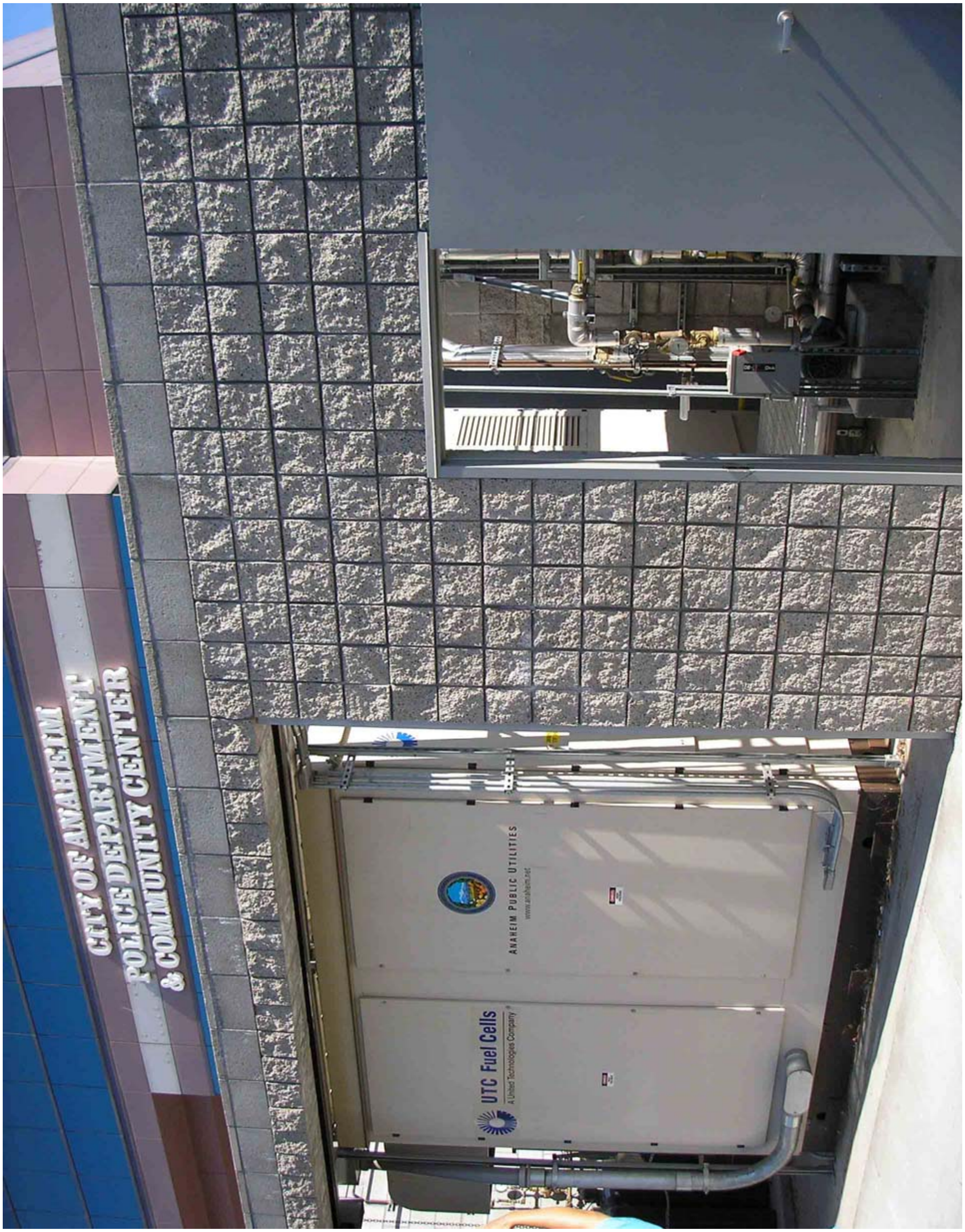
Very truly yours,

KENNEDY/JENKS CONSULTANTS

Jeff M. Foray, P.E.
Project Manager

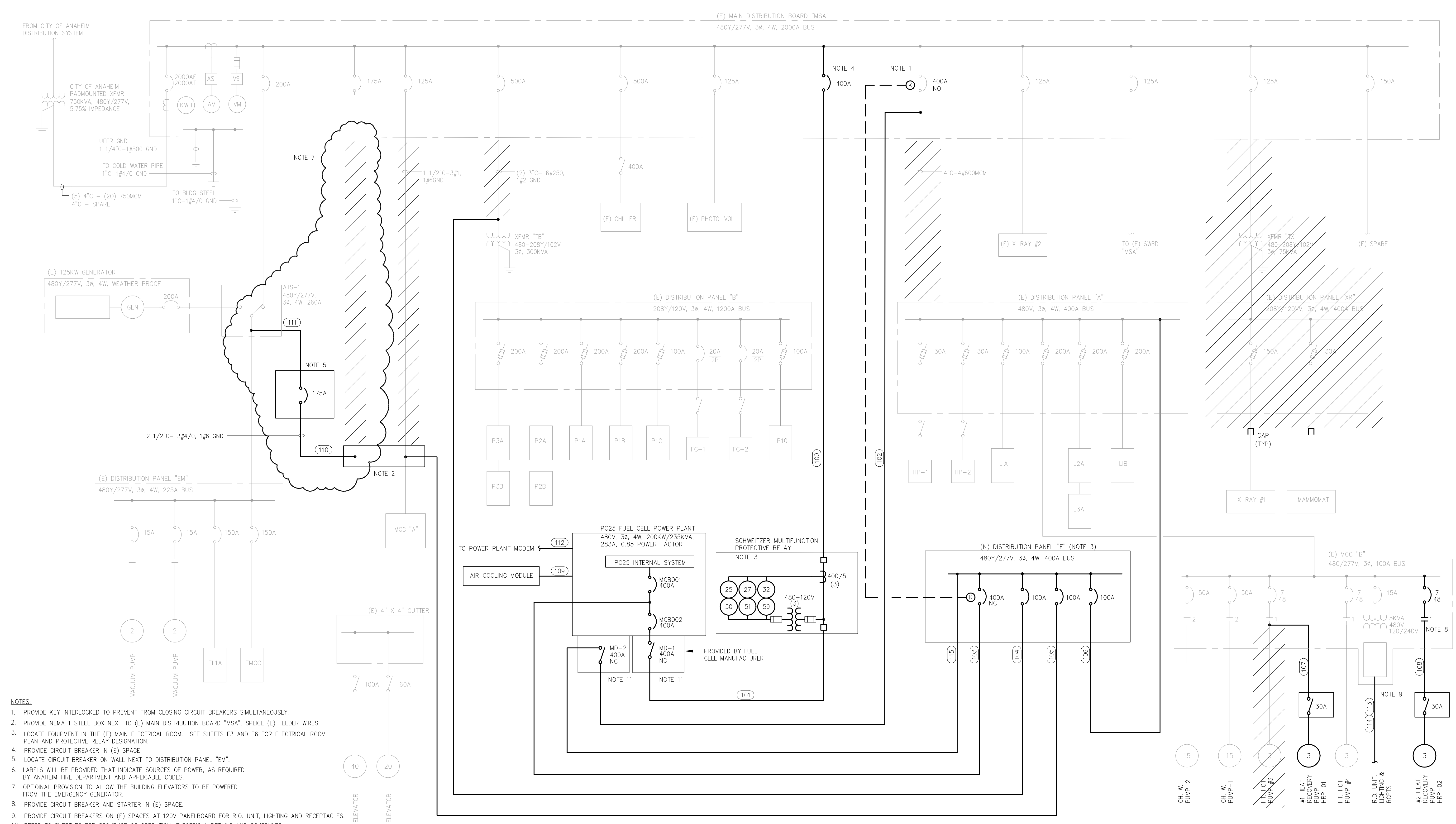
Attachment A

Completed 200kW Fuel Cell Project at
8201 E. Santa Ana Canyon Road, Anaheim, California



Attachment B

Electrical Single Line Diagram (E2)



NOTES:

1. PROVIDE KEY INTERLOCKED TO PREVENT FROM CLOSING CIRCUIT BREAKERS SIMULTANEOUSLY.
2. PROVIDE NEMA 1 STEEL BOX NEXT TO (E) MAIN DISTRIBUTION BOARD "MSA". SPLICE (E) FEEDER WIRES.
3. LOCATE EQUIPMENT IN THE (E) MAIN ELECTRICAL ROOM. SEE SHEETS E3 AND E6 FOR ELECTRICAL ROOM PLAN AND PROTECTIVE RELAY DESIGNATION.
4. PROVIDE CIRCUIT BREAKER IN (E) SPACE.
5. LOCATE CIRCUIT BREAKER ON WALL NEXT TO DISTRIBUTION PANEL "EM".
6. LABELS WILL BE PROVIDED THAT INDICATE SOURCES OF POWER, AS REQUIRED BY ANAHEIM FIRE DEPARTMENT AND APPLICABLE CODES.
7. OPTIONAL PROVISION TO ALLOW THE BUILDING ELEVATORS TO BE POWERED FROM THE EMERGENCY GENERATOR.
8. PROVIDE CIRCUIT BREAKER AND STARTER IN (E) SPACE.
9. PROVIDE CIRCUIT BREAKERS ON (E) SPACES AT 120V PANELBOARD FOR R.O. UNIT, LIGHTING AND RECEPTACLES.
10. REFER TO SHEET E6 FOR SEQUENCE OF OPERATION, ELECTRICAL DETAILS AND SCHEDULES.
11. THE MANUAL DISCONNECT SWITCH SHALL BE VISIBLE, ACCESSIBLE AND LOCKABLE OUTSIDE THE FUEL CELL.

SINGLE LINE DIAGRAM
SCALE: NONE

NO.	REVISION	DATE	BY

SCALES
0 — 1"
0 — 25mm
IF THIS BAR IS NOT DIMENSION SHOWN, ADJUST SCALES ACCORDINGLY.

DESIGNED TIW/CCI
DRAWN CCI
CHECKED TIW

ANAHEIM POLICE STATION EAST
ANAHEIM, CALIFORNIA
PILOT FUEL CELL PROJECT

UTC Fuel Cells
A United Technologies Company

Kennedy/Jenks Consultants
SEATTLE, WASHINGTON

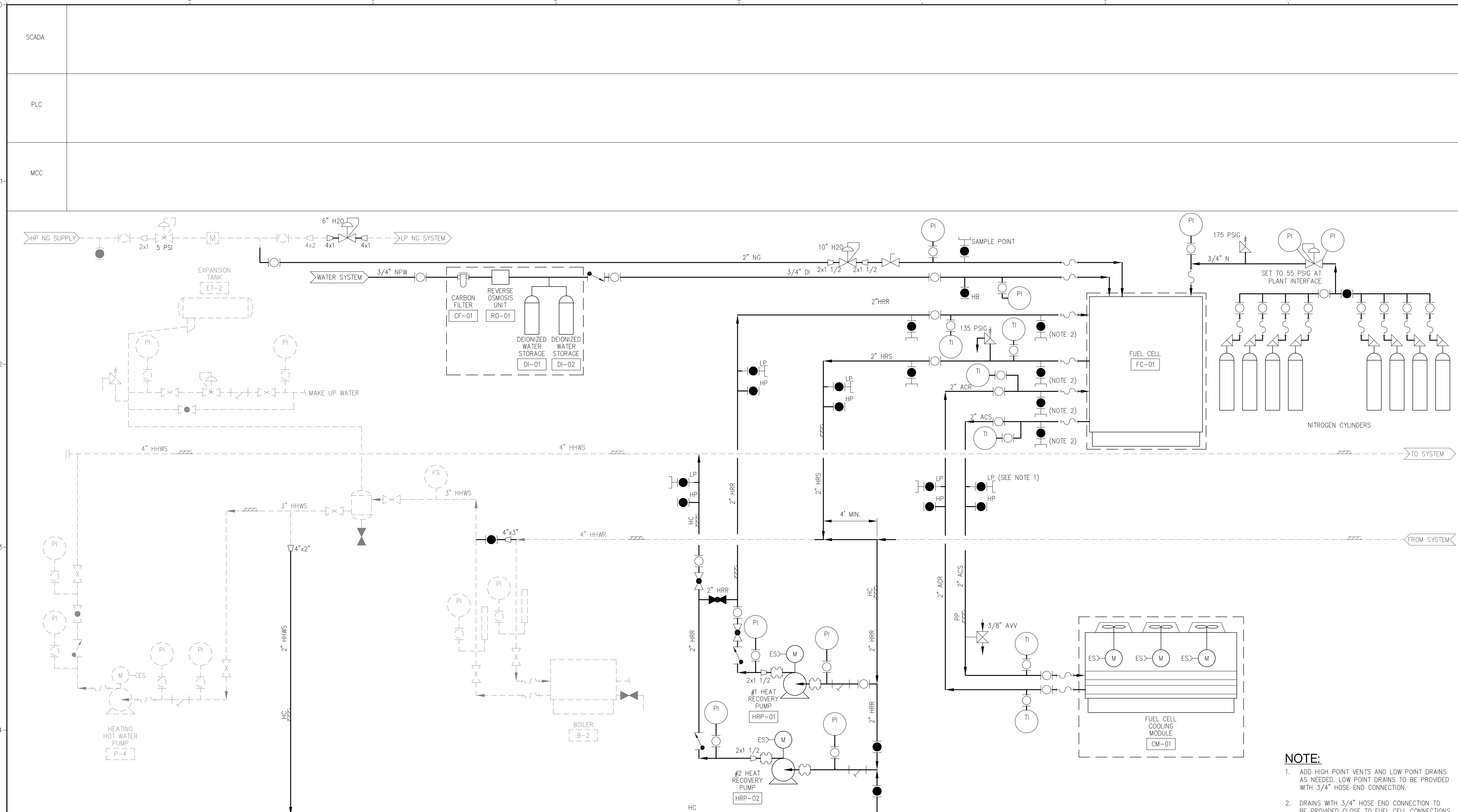
DRAFT FINAL

ELECTRICAL SINGLE LINE DIAGRAM

FILE NAME 021648.00-E02
JOB NO. 026148.00
DATE MAY, 2003
SHEET E-2 OF 20

Attachment C

Process & Instrumentation Diagram (P-1)



NOTE:

1. ADD HIGH POINT VENTS AND LOW POINT DRAINS AS NEEDED. LOW POINT DRAINS TO BE PROVIDED WITH 3/4" HOSE END CONNECTION.
2. DRAINS WITH 3/4" HOSE END CONNECTION TO BE PROVIDED CLOSE TO FUEL CELL CONNECTIONS.

VENDOR SUPPLIED

USE OF DOCUMENTS

NO.	REVISION	DATE	BY

SCALES

0 — 1"

0 — 25mm

IF THIS BAR IS NOT DIMENSION SHOWN, ADJUST SCALES ACCORDINGLY.

DESIGNED MLV/LMM

DRAWN LMM

CHECKED JMF

ANAHEIM POLICE STATION EAST
ANAHEIM, CALIFORNIA
PILOT FUEL CELL PROJECT

UTC Fuel Cells
A United Technologies Company

Kennedy/Jenks Consultants
SEATTLE, WASHINGTON

DRAFT FINAL

PROCESS & INSTRUMENTATION DIAGRAM HOT WATER AND FUEL CELL SYSTEMS

FILE NAME 026148.00-P01

JOB NO. 026148.00

DATE MAY, 2003

SHEET P-1 OF 20