Quarterly Report No. 3

King County Fuel Cell Demonstration Project

Quarter 1, 2005

Prepared for

US EPA

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Background

This Quarterly Report for the King County Fuel Cell Demonstration Project is intended to provide information regarding the experience gained from the operation of the fuel cell as well as performance data. The Quarterly Reports will be submitted throughout the two-year demonstration period, April 2004 – April 2006. The project has two objectives:

(1) Demonstrate molten carbonate fuel cell technology can be adapted to use anaerobic digester gas as a fuel source; and
(2) Achieve a nominal plant power output target of 1 MW (net AC) using either digester gas or natural gas/scrubbed digester gas.

The participants in this project are:

- King County
- FuelCell Energy Inc. (FCE)
- U.S. Environmental Protection Agency (EPA)
- CH2M HILL
- Brown and Caldwell
- Hawk Mechanical

In cooperation with the U.S. Environmental Protection Agency (US EPA) and FuelCell Energy Inc., King County is sponsoring the world's largest demonstration project of a molten carbonate fuel cell (MCFC) using digester gas; the fuel cell's nominal capacity is one megawatt (MW). A portion of the waste heat from the fuel cell exhaust will be integrated into the existing heat distribution system, offering further efficiency. CH2M Hill and Brown and Caldwell are assisting King County in the coordination and management of the overall project. CH2M HILL and Brown and Caldwell have direct responsibility for monitoring and reporting of project status, design and utility interface requirements, assistance during construction, start-up, testing, and operation, and analysis and reporting of the results of the demonstration project.

Review of Fuel Cell Performance

The fuel cell began operating in Quarter 2 of 2004. This report covers Quarter 1 of 2005 (Q1-2005).

Quarter 1 2005 Summary

The fuel cell operated on both digester gas and natural gas. The waste heat recovery unit (WHRU) ran intermittently during the quarter. Water and digester gas tests were performed for the first time during the demonstration period. Due to sulfide breakthrough, the SulfaTreat® media used for digester gas treatment was replaced. The transition of the fuel cell operation and maintenance from FCE to King County occurred. FCE completed the King County staff classroom training. The fuel cell rated output was derated two percent on March 3, 2005, dropping the rated base output from 1 MW to 980 kW maximum output. The deratings will continue every 6 months.

The fuel cell operated primarily on digester gas. There were several occasions, however, where the fuel cell was forced to operate on natural gas; two occasions were due to failure of digester gas flow element, and the remainder were due to divert events associated with the treatment plant's gas scrubbing system. A chronology of operations is shown below.

- January 15 – January 29: operated on natural gas due to digester gas flow element failure
- March 28 – March 31: operated on natural gas due to digester gas flow element failure
- March 30 – April 1: changed out SulfaTreat® media
- 11 divert events forced operation on natural gas for approximately 200 hours
- Incorporated fuel trim control logic and verified proper operation

Description of Three Gas Supplies

The fuel cell has three gas supplies, as described below.

- **Gas 1** = Natural Gas from King County (KC): Anaerobic digester gas from KC that has been scrubbed on-site to pipeline quality gas.
- **Gas 2** = Natural Gas from Puget Sound Energy (PSE): Natural gas supplied by the local gas utility, PSE.
- **Gas 3** = Raw Digester Gas: Unscrubbed anaerobic digester gas from the digester gas scrubber header.

An input flow of approximately 147 cubic feet per minute (cfm) is required from gases 1 and 2 to achieve the fuel cell rated output, while approximately 227 cfm is required from gas 3 to achieve the rated output.

Major Activities During Reporting Period

The major activities that occurred during the reporting period were:

- Fuel cell output derating
- Changes to water for digester gas compressor
- Potential new gas supply
- Carbonyl sulfide vessel start-up challenges

Fuel Cell Output Derating

The fuel cell output is derated periodically over its life to maximize life of the stacks. The derating is scheduled to occur every six months. The derating is based on a linear derating of 10% over an assumed three-year life. The fuel cell derating schedule is shown below.

Start of operation:	100% rated = 1 MW
6 months:	98% of beginning of life (BOL) = 980 kW
12 months:	96% of BOL = 960 kW
18 months:	94% of BOL = 941 kW
24 months:	92% of BOL = 922 kW
30 months:	90% of BOL = 904 kW

The first two percent derate (20kW) to 980kW maximum output was completed on March 3, 2005 after the first six months of operation. The next scheduled derate of 20kW will be early September 2005 based on continuous operation.

Changes to Water for Digester Gas Compressor

Currently the cooling water for digester gas compressor is reuse water or city nonpotable water (C2) when the reuse water system is not in operation. The water flow to the compressor is approximately 5 gallons per minute (gpm).

To save money, the water source will be changed to disinfected secondary effluent (C3). C3 was used originally to cool the digester gas compressor, but significant biofouling in the compressor required frequent compressor cleaning. Manual strainers were installed to mitigate the biofouling, but they had to be cleaned several times a day. The new C3 water will come from a location that has an automatic strainer. Strained C3 water is used in other compressors on the plant site, so it is not expected to cause a problem. No biofouling agent (e.g., sodium hypochlorite) will be added as it is corrosive and the compressor is constructed from carbon steel.

Potential New Gas Supply

Discussions were held on whether or not to construct a new digester gas pipeline to directly serve both the boiler and the fuel cell. The new gas line would come from the digesters directly, and would not be impacted by the PSE divert events, which return Gas 1 back to the Gas 3 header and rapidly increase the methane content. The higher methane gas cannot be used by the boiler, and the rapid change in methane content causes the fuel cell to trip to natural gas. Once the divert event is over, it takes approximately six hours to transfer the fuel cell fuel source back to digester gas.

The new pipeline would be complicated to construct, as it would require tapping into the suction side of the digester mixing compressors. All four digesters would be needed to ensure a sufficient gas supply for both the boiler and fuel cell, with one digester out of service for cleaning. Construction cost would be high, safety would be a concern, and additional instrumentation would be required. In addition, not divert events would occur after the cogen facility is in operation (construction to be completed in the fall of 2005) since all the gas will be used on site and none will need to meet the PSE specifications. For these reasons, the new pipeline does not appear to be necessary. The final decision on whether or not to construct a new pipeline is tabled until after the cogen facility is in operation and the new energy contracts have been negotiated with PSE. The energy contracts will dictate how often the turbines will run, which will dictate how often the boiler will run (e.g., only when the turbines do not run). The fuel cell will run at all times.

Carbonyl Sulfide Vessel Start-Up Challenges

The construction of the carbonyl sulfide (COS) removal vessel, which will be a pretreatment process for Gases 1 and 2, was completed in Q4 of 2004. The vessel media was ordered by King County on April 26, 2005 and is expected to be shipped in May. At the end of Q1-2005 the vessel was not yet in operation.

Performance of Power Plant Components

This section describes the performance of the individual fuel cell power plant components.

King County Scrubbed Digester Gas Treatment System (Gas 1)

The Binax gas scrubbing system had a total of 11 diverts while operating on digester gas during Q1, forcing operations on natural gas (Gas 2 or Gas 3) for approximately 200 hours.

Natural gas samples were taken from the desulfurizer inlet, desulfurizer A outlet, and desulfurizer B outlet on February 3 and March 18, 2005. The gas flows in series through desulfurizer A and then desulfurizer B. The natural gas contained approximately 96% methane, 3% carbon dioxide, 7,000 ppmV nitrogen, and 400 ppmV of oxygen. The sulfur results are shown in Table 1. Approximately 1,500 ppbV of total sulfur was detected from the inlet natural gas, but no sulfur was detected from the outlet of either desulfurizer A or B, which means that the media has not reached its adsorption capacity. The media was not replaced.

Table 1 - Desulfurizer Gas Test Results (February 3, 2005 and March 18, 2005)

Volatile Sulfur Compounds (VSC, ppbV v/v)	**Desulfurizer A**	**Desulfurizer B**	**Inlet on Feb 3**	**Inlet on March 18**
Hydrogen Sulfide (H_2S)	n/d	n/d	n/d	n/d
Carbonyl Sulfide (COS)	n/d	n/d	n/d	n/d

Sulfur Dioxide (SO_2)	n/d	n/d	n/d	n/d
Methyl Mercaptan (MESH)	n/d	n/d	n/d	n/d
Ethyl Mercaptan (ETSH)	n/d	n/d	n/d	n/d
Dimethyl Sulfide (DMS)	n/d	n/d	n/d	n/d
Isopropyl Mercaptan (IPM)	n/d	n/d	550	1,500
t-Butyl Mercaptan (TBM)	n/d	n/d	924	600
n-Propyl Mercaptan (NPM)	n/d	n/d	n/d	n/d
Thiophene (THT)	n/d	n/d	n/d	n/d
unknown sulfur compounds	n/d	n/d	n/d	n/d
Total Sulfur	**no sulfur detected**	**no sulfur detected**	**1,475**	**2,100**

* All sulfur compounds calibrated with 538ppbV DMS standard gas

Natural Gas Treatment System (Gas 2)

The system did not operate on this gas during the quarter.

Digester Gas Treatment System (Gas 3)

As previously mentioned there were two separate cases of digester gas flow element failure, once on January 15 and another on March 28. After each event, new flow elements were installed after consultation with vendor and site visits by vendor technicians. An evaluation of the failed element in January (by the vendor) was inconclusive in determining a root cause. After the second failure, it is believed that water is condensing and collecting in the coriolis flow element. As a result of the March 28 failure, in addition to installing another coriolis flow element, the coriolis element itself will be heat traced and a redundant thermal mass flow element will be installed. Testing will occur when modifications are complete (expected to occur in early May).

Digester gas samples were taken from anaerobic digester gas (ADG) polisher A outlet, ADG polisher B outlet, ADG SulfaTreat® outlet and Natural Gas Inlet on February 14, 2005. The gas flows in series through the SulfaTreat®, polisher A and polisher B.
The three outlet samples contained approximately 63% methane and 37% carbon dioxide, with less than 2,000 ppmV of nitrogen. The outlet gas from both polishers A and B contained no volatile sulfur compounds, while the SulfaTreat® outlet sample contained less than 200 ppbV of unidentified heavy sulfur compounds.

On March 18th, 2005, King County staff took another sample of the digester gas. The samples were taken from inlet, SulfaTreat® outlet, ADG polisher A outlet and ADG polisher B outlet. The results are summarized below in Table 2. Based on this sample the SulfaTreat®

media was changed out by King County personnel on March 30 and 31. A gas leak check of the vessel was performed on April 1.

Table 2 - Hydrogen Sulfide Concentrations in Digester Gas Pre- and Post-Treatment

Test Date	Polisher B Outlet	Polisher A Outlet	SulfaTreat® Outlet	ADG Inlet **
12 Feb05	3.5*	11*	70*	
14 Feb05***	ND	ND	<200 ppb total S	
18 Mar05	1*	5.5*	11,000*	220,000
21 Mar05	2*	3*	600*	150,000
* Measured using Jerome meter. ** Measured using Sensidyne tube. ***Lab analysis.				

Fuel Cell Stack

Fuel cell continues to operate as expected.

Waste Heat Recovery Unit

In January, the waste heat recovery unit was officially commissioned. It is designed to run when the fuel cell is generating power, not under hot standby conditions. When given the permissive signal from the fuel cell, the waste heat recovery system works as designed. When the permissive is taken away, the waste heat recovery blower shuts down. The hot water loop pumps, control valves, and blower are all automatic; design criteria are shown below.

Settings:

- Blower speed: 55 hertz
- High Temp Loop Control Valve open to 92%
- Low Temp Loop Control Valve open to 93%
- Incoming water temperature from main system in tunnel: 130ºF (actual is about 136ºF)
- Outgoing boiler water temperature: 160ºF (actual is about 154ºF, so change in temp = 18ºF)
- Incoming air temperature to boiler: 675ºF (actual is about 580ºF)
- Outgoing air temperature from boiler: 240ºF (change in temp = 340ºF)

Very little heat was recovered during this quarter. The system frequently tripped at 650ºF approximately every 20 minutes. The fuel cell would shut off to protect from back draft. The temperature set point was adjusted to 580ºF and the waste heat recovery system now operates as intended.

The contractor (Hawk Mechanical) provided training to King County staff on the WHRU system in March.

Mechanical Balance of Plant (MBOP)

Systems performed as expected, with various components requiring some corrective maintenance. See the Maintenance Items section.

Electrical Balance of Plant (EBOP)

System performed well with no failures throughout the quarter.

Humidifier Water Treatment System

The treated water coming off the water treatment system for the gas humidifier was sampled and analyzed for total hardness and total chlorine on February 1, 2005. The total hardness was measured 0.1 mg/L, with a minimum detectable limit (MDL) of 0.1 mg/L. The total chlorine was 0.05 mg/L with a MDL of 0.05 mg/L.

Electrical and Thermal Efficiency

All efficiency calculations are based on a lower heating value (LHV) of 900 BTU/ft^3 for natural gas and 548 BTU/ft^3 for digester gas. The efficiency calculations are done at full load under standard conditions and include parasitic loads. Variations in ambient temperature and elevation do impact the fuel cell performance and efficiency.

Efficiency is measured in seven ways, as shown in Table 3. Defined as electrical efficiency, measurements 1 through 4 represent how much electricity is produced as a function of inlet gas supply; measurements 5 through 7 represent the thermal efficiency, which takes into account the electricity produced and the waste heat recovered. The efficiency values reported for the power plant include parasitic power demands, as well as the inversion from DC to AC. Currently, only electrical efficiency values are available, as the waste heat recovery system did not begin operation until the second quarter of 2005.

Highly accurate efficiency calculations require the use of flow meters calibrated to greater accuracy than the fuel cell power plant has. Therefore, efficiency values will differ depending on the method used to obtain gas flow information and electrical output data. The efficiency calculations presented here have an estimated ± 2-3% variance.

Spot readings were taken at the digester gas compressor in order to calculate Efficiency 3. During 100 percent power (1,000 kW), the compressor and other components on the skid draw 49.7 Amps of 3-Phase AC @ 497 V, Power Factor of 1.00, totaling 42.7 kW. At 2 percent derated 100 percent power conditions (980 kW) new readings were taken and the compressor and other components on the skid draw 46.5 Amps of 3-Phase AC @ 497 V, Power Factor of 1.00, totaling 40 kW.

The parasitic loads are shown below. The digester gas has an additional load for the gas compressor of about 40 kW, for a total loss of 152 kW.

Gas Type	Balance of Plant Loads (kW)	Transformer/ Inverter Losses (kW)	Total Parasitic Losses (kW)

Natural gas	53	37	90
Raw digester gas	75	37	112

The unit is limited to 1,090 kW; thus, minus the balance of plant loads and transformer /inverter losses for natural gas (90 kW) = 1,000 kW.

The efficiency is typically slightly higher for digester gas than natural gas because the fuel cell runs cooler and less air is needed for cooling. Figure 8 shows a graph of efficiency over the past year of operation. All efficiency numbers reflect operation at full power, and include the total parasitic losses described above. Availability is the total time the fuel cell was able to operate when a gas supply was available.

Graphical results from efficiency measurements 1 and 2 are shown in Appendix A. These measurements come from logging devices in the fuel cell power plant.

Table 3 - Efficiency Measurements

Efficiency Measurement	Components	Where Calculated on Flow Chart	Value Q1-05	How Calculated
1	Power plant operating on natural gas	C/A	40-45%	electricity out /natural gas in
2	Power plant operating on digester gas	C/B	46-47%	electricity out /digester gas in
3	Power plant operating on digester gas (with digester gas skid losses)	C/(B+F)	40-47%	electricity out/(digester gas in + compressor power in)
4	Fuel stack only	H/G	No data yet available	fuel cell stack DC power out /gas to the fuel cell stack
5	With heat recovery on natural gas	(C+D)/A	No data yet available	(electricity out + heat recovered)/natural gas in
6	With heat recovery on digester gas	(C +D)/B	No data yet available	(electricity out + heat recovered)/digester gas in
7	With heat recovery on digester gas (with digester gas skid losses)	(C+D)/(B+F)	No data yet available	(Electricity out +power used for skid + heat energy recovered)/Total fuel in

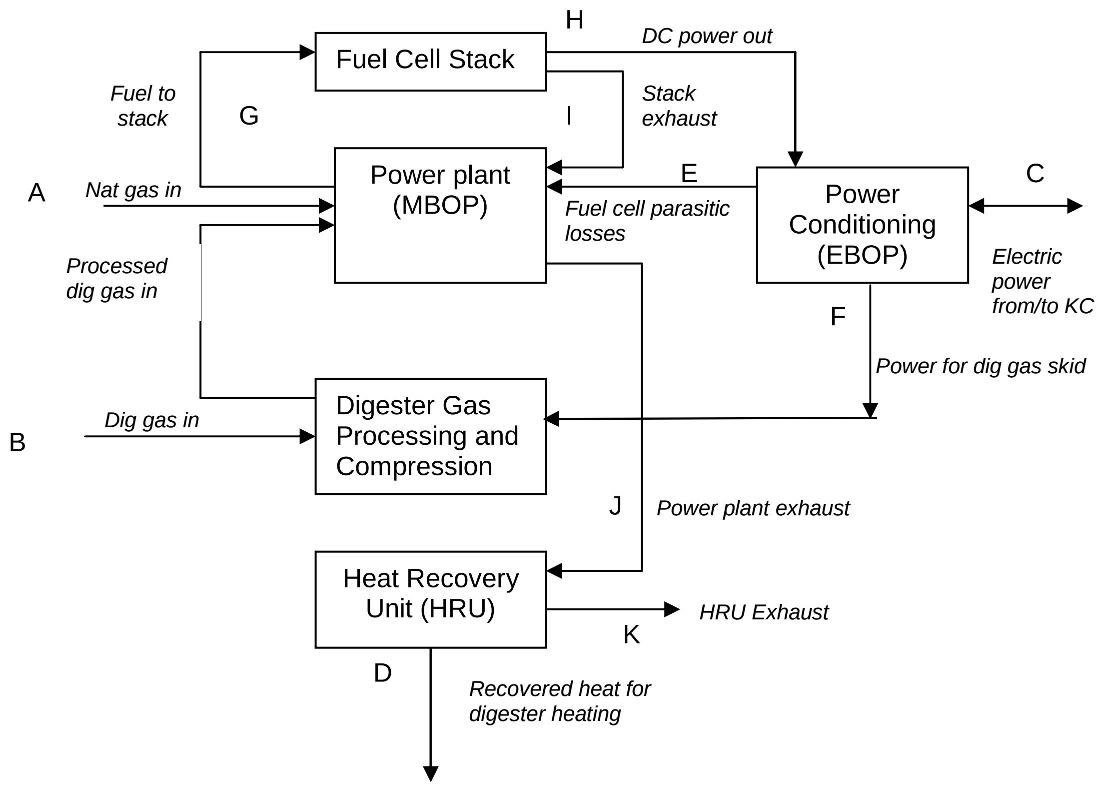


Figure 1 – Process Flow Diagram

Performance Summary

One measure of the fuel cell's performance is availability, or the percentage of time the fuel cell actually operates relative to the amount of time gas supply was available. For this quarter, the operation time was evaluated from January 3rd, 2005 through March 31st, 2005.

During Q1-2005 the fuel cell operated 93.7 percent of the time it was available. 2,058 hours were spent with the fuel cell in either Hot Standby or Power Generation modes; 2,058 hours were spent generating power, and 1.855 million kWh were generated.

Additional measures of the fuel cell's performance are summarized in Table 4 and Table 5. Table 4 is for natural gas and Table 5 is for digester gas.

Table 4 - Fuel Cell Performance Summary on Natural Gas

Year	2004		2005				2006	
Parameter	**Q2 and Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**
Run time (hours)	1,897	970	730					
Power generated (kWh)	1.4M	0.593M	0.697M					
Availability	93%	100%	100%					
Shutdown	7%	0%	0%					
Efficiency*	43%	43%	42%					

*Efficiency Measurement 1 from Table 3

Table 5 - Fuel Cell Performance Summary on Digester Gas

Year	2004		2005				2006	
Parameter	**Q2 andQ3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**
Run time (hours)	313	490	1,270					
Power generated (kWh)	78,664	357,000	1.158M					
Availability	65%	95%	90%					
Shutdown	35%	6%	10%					
Efficiency**	44%	44%	43%					

**Efficiency Measurement 2 from Table 3

Performance Goals and Metrics

Seventeen performance goals and metrics were established with King County and FCE. They are described below in Table 6, with the results from Q1-05.

Table 6 – Performance Goals and Metrics

Performance Goal	Metric	Q1-05 Result
1. Deliver high quality and quantity gas to the fuel cell	Acceptable gas supply >95% of the time. Digester gas Btu content between 550 and 610 Btu/standard cubic foot (scf) @ 4 to 7 in water column (w.c.); 50 to 100°F	One of three gas sources has been available 100% of the time
2. Produce energy as designed on natural gas and digester gas	Produce 15,000 MWhrs gross power for 2-year test period. Prorate to later half of test after plant normalized after first 6-9 months. 1 MW net. Parasitic electric loads for natural gas and digester gas to be measured during testing. Full power = 140 scfm natural gas and 230 on digester gas	Approx 2,000 MWhrs gross power generated during quarter 1. Prorated out to 2 years is 16,000 MWhrs. 1 MW net met on both natural gas and digester Full power on natural gas is 135 scfm and 230 scfm on digester gas.
3. Produce minimal noise and equipment interferences	60 decibels (dBA) at a distance of 100 feet from fuel cell pad (70 dBA at a distance of 10 feet)	To be measured in Q2 2005
4. Produce energy at a minimal cost	0.2 full time equivalents (FTEs) – Operations 0.2 FTEs – Maintenance 0.1 FTEs – Miscellaneous Cost of energy to produce 1 kWh of power < $0.10 (energy off the grid $0.05, but a premium is paid for green power)	More FTEs used during transition from FCE to KC operations and maintenance staff
5. Produce minimal air emissions – natural gas and digester gas (LSG/ADG[1])	CO < 10 ppmV NOx < 2 ppmV NMHC < 1 ppmV	Met in Q2 2004 on natural gas. Not tested this quarter. Planned test in Q2 2005 on digester gas.
6. Produce wastewater/drain water with no adverse impacts to the treatment plant	Water treatment system brine Cooling water Condensate	Water tested had acceptable water quality.
7. Operate fuel cell on a continuous basis	Downtime for maintenance and troubleshooting limited to 20 hours/week (remain at hot standby condition) Availability of > 80% Run 85% of the time at full net power for 2	Quarter 1 total downtime was 136 hours which averages to < 12 hrs/week. Note that

Performance Goal	Metric	Q1-05 Result
	years. Determine frequency of downtime and length of time out of service	a small percentage of this time was actually spent on maintenance or troubleshooting. During Quarter 1 there were 7 trips and approx. 20 hours downtime for each trip.
8. Operate fuel cell efficiently	45.0% efficiency on natural gas 45.0% efficiency on digester gas	Efficiency = 42% on natural gas and 43% on digester gas.
9. Manage system with ease remotely	Monitor and control system through SCADA at the operations building at FCE's office in Danbury, CT	Remote monitoring done successfully.
10. Remove hydrogen sulfide effectively from digester gas	Remove hydrogen sulfide to < 10 ppmV on inlet gas	Polisher exhaust < 10 ppmV
11. Reasonable costs to dispose of solid waste	SulfaTreat® system lasts for 0.6 years before replacement Carbon systems (both natural gas and digester gas systems) last for 0.3 years before replacement Fuel cell lasts for 3 years before replacement Preconverter catalyst lasts for 5 years before replacement Oxidizer catalyst lasts for 5 years before replacement Exhaust gas polisher lasts for 5 years before replacement Deoxidizer catalyst lasts for 5 years before replacement Fuel cell not negatively affected by digester gas Deactivated catalysts (from preconverter, oxidizer, deoxidizer and exhaust gas polisher) (recover precious metals)	SulfaTreat® media replaced at end of quarter after approx 6 months of use on digester gas. Disposed of on-site for landscaping. No cost for disposal.
12. Recover heat successfully	Recover 1.4M Btu /hr of heat (13,800 lbs gas/hr) 650°F out of stack	No energy recovered this quarter.
13. Achieve output turndown	25% to 100%	Done in Q2 2004.
14. Achieve output ramp	0.5 kW/min (cold start)	Done in Q2 2004 and

Performance Goal	Metric	Q1-05 Result
rate		every time ramp up.
15. Meet design service life	10,000 hours (1.15 years)	Not measured yet. As of March 31, 2005, the fuel cell has operated for 5,700 hours with no problems or performance degradation
16. Able to restart from a trip	Trip recovery to back on load in approximately 10 hours	Done in Q2 2004.
17. Able to quickly start	Hot start in 10 hours (standby to rated output)	Done in Q2 2004.

[1] Digester gas = LSG =ADG = Low pressure sludge gas = anaerobic digester gas

Operations and Maintenance

Operations and maintenance began to transfer this quarter from FCE to King County. In March, King County assigned a lead operator (Senior in Charge) to the fuel cell - Lewis Canada. Lewis will spend half his time at the fuel cell, and half at the cogeneration facility once it is started up in the fall.

Training

Hands-on training of the King County O&M staff by FCE occurred during January and February. Hands on training required operators to have completed the week long classroom portion of training and then spend 40 hours with a FCE employee in the control room and plant while meeting all requirements of the Operator qualifications card. A total of 7 people completed this training.

Operations

The responsibility of filling in the daily operations checklists was transferred from FCE to King County in March. The checklist can be performed on hardcopy or with a handheld personal digital assistant (PDA). The responsibility for first response to plant alarms began to be turned over to King County Operations in February.

Preventive Maintenance

The responsibility for performing preventive maintenance (PM) activities was transferred from FCE to King County in February. Detailed maintenance information is provided later in the report.

Maintenance Items

Ongoing corrective maintenance items included the following:

- #2 Instrument Air Dryer: Excessive blow-down of air occurred due to over temperature from previous operating conditions that have since been corrected.
- Level switches 821/822 Anaerobic Digester Gas Knockout Drum: The level switches are not reliable and are currently removed awaiting installation of new switches during upcoming outage planned in July.
- Oil Filter: Slight oil leaks on two components associated with the high efficiency oil filter on the digester gas compressor discharge. These leaks have been fixed.
- Divert Alarms: Numerous false alarms indicating that communications between KC instruments related to Divert signals and the fuel cell distributed control system (DCS) were generated from the "watchdog" timer.
- Fire Detector: The fire detector caused a trip due to inadvertent operation (no fire). This sensor has caused previous false indications, in working with the vendor we had thought the problem was solved. The sensor has been replaced and has been wired directly to the DCS rather than the fire panel so we can better monitor its performance.

- Water Flow Control Valve: A momentary loss of communications with the water flow control valve initiated a trip. The digital valve controller has been replaced and has been evaluated by the vendor. They found nothing wrong with the component. Vendor representatives have monitored at the DCS and found that the circuit is not overloaded. At this point valve is operating properly with no communications problems.

Media Types

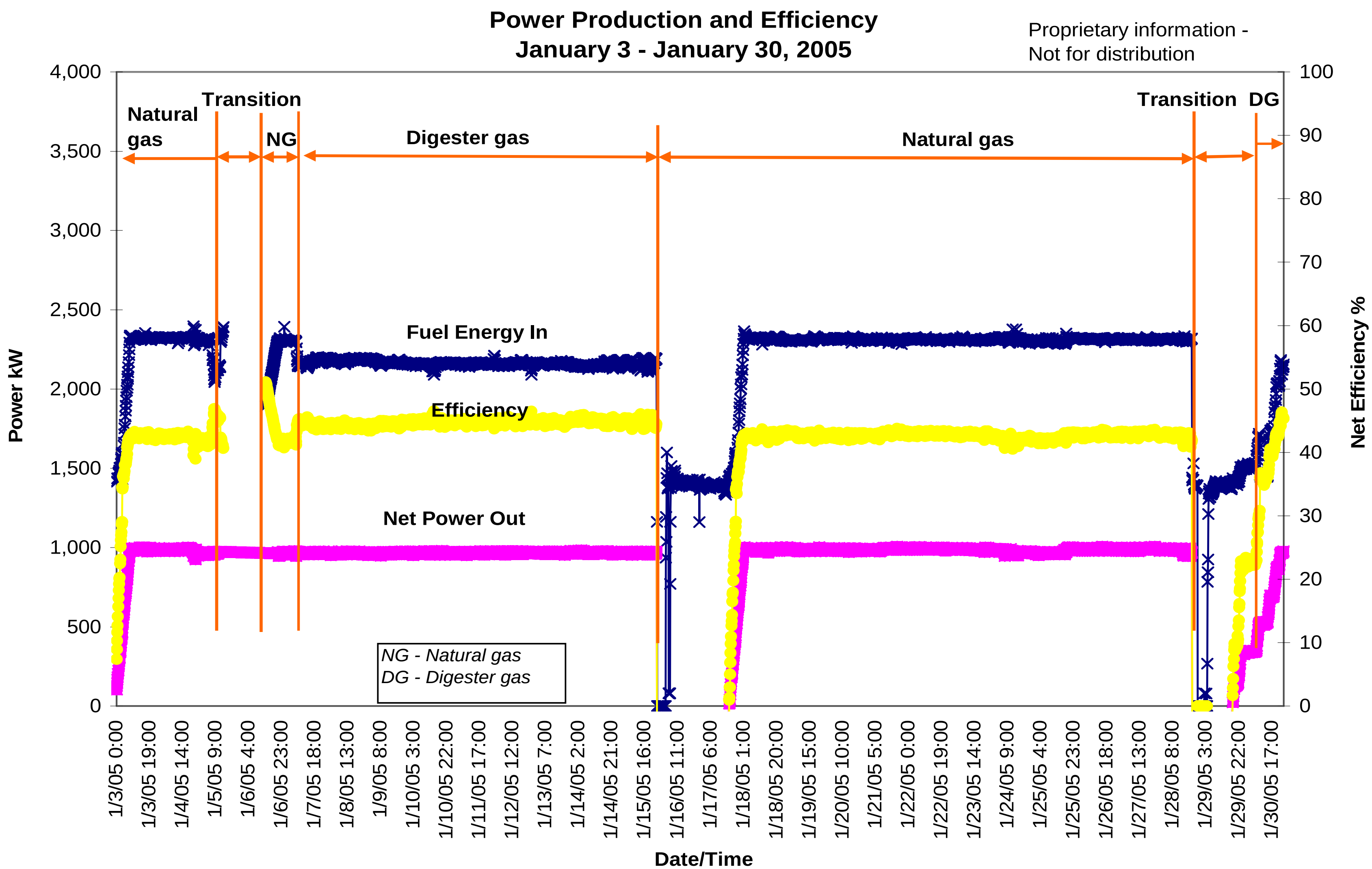
Several different types of media are used for gas and water treatment. The media types, expected life are described below in Table 7. The only media that has been replaced to date is the SulfaTreat®.

Table 7 – Water and Gas Treatment Media

Unit Name	Gas/Water Treated	Media Type	Media Product	Expected Life (months)	Quantity Needed Per Event (lb)
Cold Gas Desulfurizer	Natural gas (Gases 1 and 2)	Activated carbon	Englehard CNG-1	6	560
		Activated carbon	Norit RGM-3 9Cu impregnated carbon	6	308
		Activated alumina	Englehard CNG-2	6	1,456
Humidifier Water GAC Filter	City Water (C1)	Granular activated carbon	Calgon Filtrasorb 400	as req'd	4
Humidifier Water Twin Softeners		Water softener resin	TBD	as req'd	6
Humidifier Water GAC Filter, JelCleer, and Water Softeners		Quartz media bed	US Filter high quality silica quartz	as req'd	TBD
SulfaTreat® Vessel	Digester Gas (Gas 3)	SulfaTreat® media	SulfaTreat® media	9	18000
Digester Gas Polishers		Potassium permanganate impregnated (KOH) activated carbon	Type SG-PH, Granular 6x12 mesh	3 - 6	12000
Digester Gas Polishers		absorbent media	Straight chain carbon (non impregnated)	3 - 6	1600

Appendices

A – ENERGY EFFICIENCY AND OUTPUT DATA



Power Production and Efficiency
January 3 - January 30, 2005
Proprietary information -
Not for distribution
Power kW
Net Efficiency %
Date/Time
Natural gas
Transition
NG
Digester gas
Natural gas
Transition
DG
Fuel Energy In
Efficiency
Net Power Out
NG - Natural gas
DG - Digester gas
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
100
90
80
70
60
50
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30
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1/30/05 17:00

Figure A1

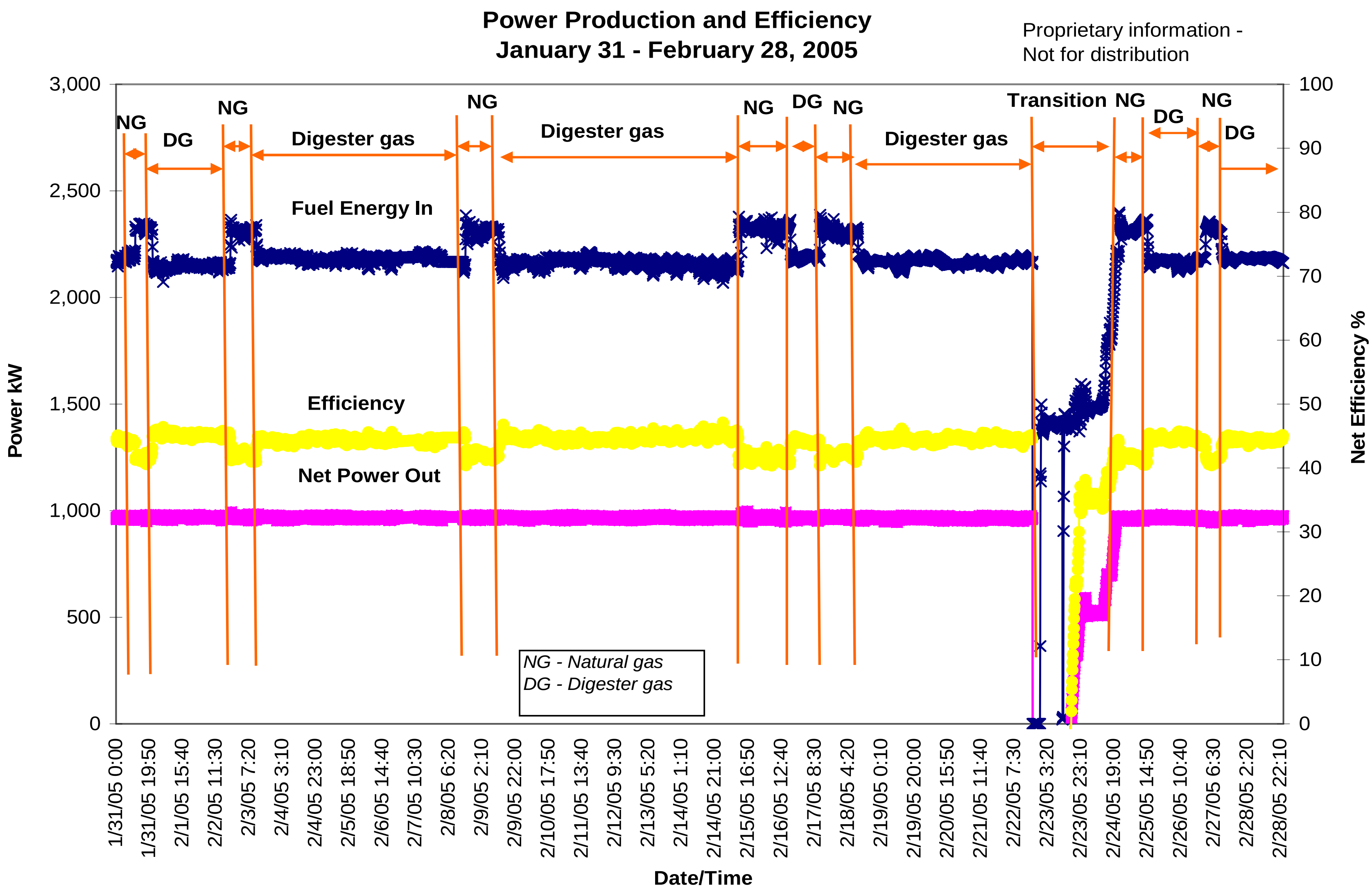
Power Production and Efficiency
January 31 - February 28, 2005
Proprietary information -
Not for distribution
Power kW
Net Efficiency %
Date/Time
Fuel Energy In
Efficiency
Net Power Out
NG
DG
Digester gas
Transition
NG - Natural gas
DG - Digester gas

Figure A2

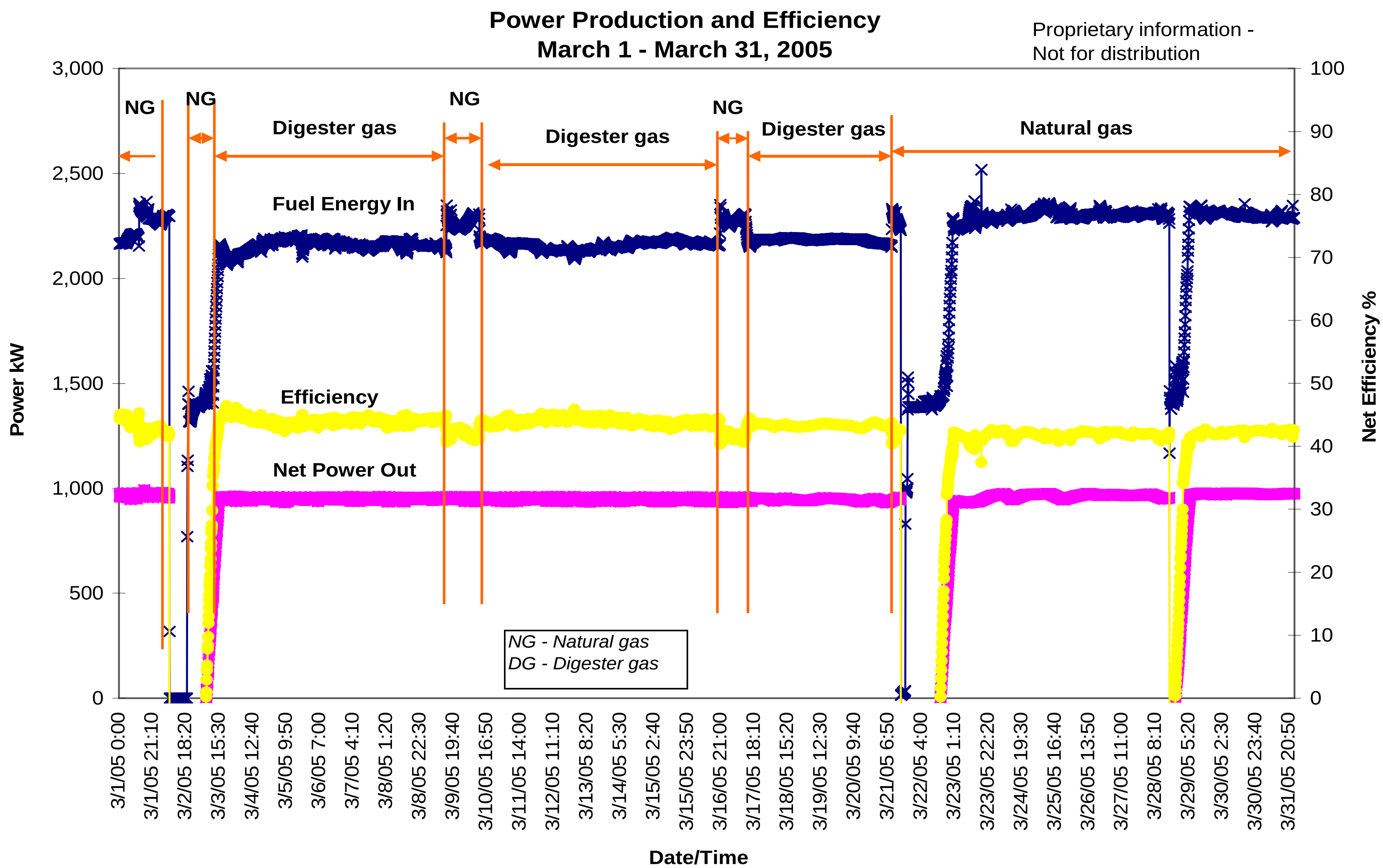
Power Production and Efficiency
March 1 - March 31, 2005
Proprietary information -
Not for distribution
Power kW
Net Efficiency %
3,000
2,500
2,000
1,500
1,000
500
0
100
90
80
70
60
50
40
30
20
10
0
NG
NG
NG
NG
Digester gas
Digester gas
Digester gas
Natural gas
Fuel Energy In
Efficiency
Net Power Out
NG - Natural gas
DG - Digester gas
3/1/05 0:00
3/1/05 21:10
3/2/05 18:20
3/3/05 15:30
3/4/05 12:40
3/5/05 9:50
3/6/05 7:00
3/7/05 4:10
3/8/05 1:20
3/8/05 22:30
3/9/05 19:40
3/10/05 16:50
3/11/05 14:00
3/12/05 11:10
3/13/05 8:20
3/14/05 5:30
3/15/05 2:40
3/15/05 23:50
3/16/05 21:00
3/17/05 18:10
3/18/05 15:20
3/19/05 12:30
3/20/05 9:40
3/21/05 6:50
3/22/05 4:00
3/23/05 1:10
3/23/05 22:20
3/24/05 19:30
3/25/05 16:40
3/26/05 13:50
3/27/05 11:00
3/28/05 8:10
3/29/05 5:20
3/30/05 2:30
3/30/05 23:40
3/31/05 20:50
Date/Time

Figure A3