MEASUREMENT AND VERIFICATION PLAN

FOR

DG/CHP SYSTEM AT ULTRA FLEX
494 WORTMAN AVE, BROOKLYN, NY

revised
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Submitted to:

New York State Energy Research and Development Authority
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1. Introduction

Ultra-Flex is an industrial printing facility located in Brooklyn. The CHP system at Ultra-Flex includes three (3) 100-kW InVerde Engine Units from Tecogen that use permanent magnet generators with 480 VAC inverters to provide power output. The engines are capable of providing 125 kW peak and 100 kW continuous. The inverters, oil coolers, and associated electronics have their own small cooling loop and dry cooler (FLC-2). A heat rejection loop from the engine jacket and exhaust heat exchanger is the primary source of thermal output.

The engines are piped in parallel with integrated hot water loop (Figure 1). Heat recovered from the engine jacket and the exhaust gas heat exchanger is injected into hot water loop that serves the various thermal loads (Figure 2 and Figure 3). The system has been designed to accept 2 additional engines. The engine loop also includes a dump radiator (FLC-1) that is activated if water returning to the engine is too warm. For this system it is only expected to operate if the power requirements are temporarily larger than thermal loads.

The hot water from the engines is used to meet various thermal loads in this printing facility:

- 8 air handlers with fan coils (FC-1-2, 5-10) that supply warm air for process loads that include print dryers, laminating machines and printing presses (continuous year round load)
- 8 air handlers with fan coils (FC 11-18) for general space heating (seasonal load)
- two 30-ton, hot-water driven Yazaki chillers that provide seasonal space cooling in the plant (not installed as of September 2010)

The hot water flow through the 3 engines is about 90 gpm with a total output of 2,196 MBtu/h. The hot water flow in the main cogen loop is about 150-170 gpm. The cogen loop flow rate is controlled by a VSD that maintains the required differential pressure in the loop.

At full load the three generators will consume approximately 3,900 std cf/h of natural gas (1300 cf/h each).

The power output from the three engines feeds into one new electrical panel (CGDP) before being fed into the existing main facility distribution panel (MDP), as shown in Figure 4. The main parasitic loads on the CHP system are all fed from sub-panels HDP-CHP and MCC-1, which are connected to the CGDP panel. These parasitic loads include the dump radiators (FLC-1 and FLC-2), the cogen loop pumps (CGP-6 and CGP-7), the engine cooling water pumps (CGP-10 and CGP-11), and engine loop pumps (CGP-1 to CGP-3).

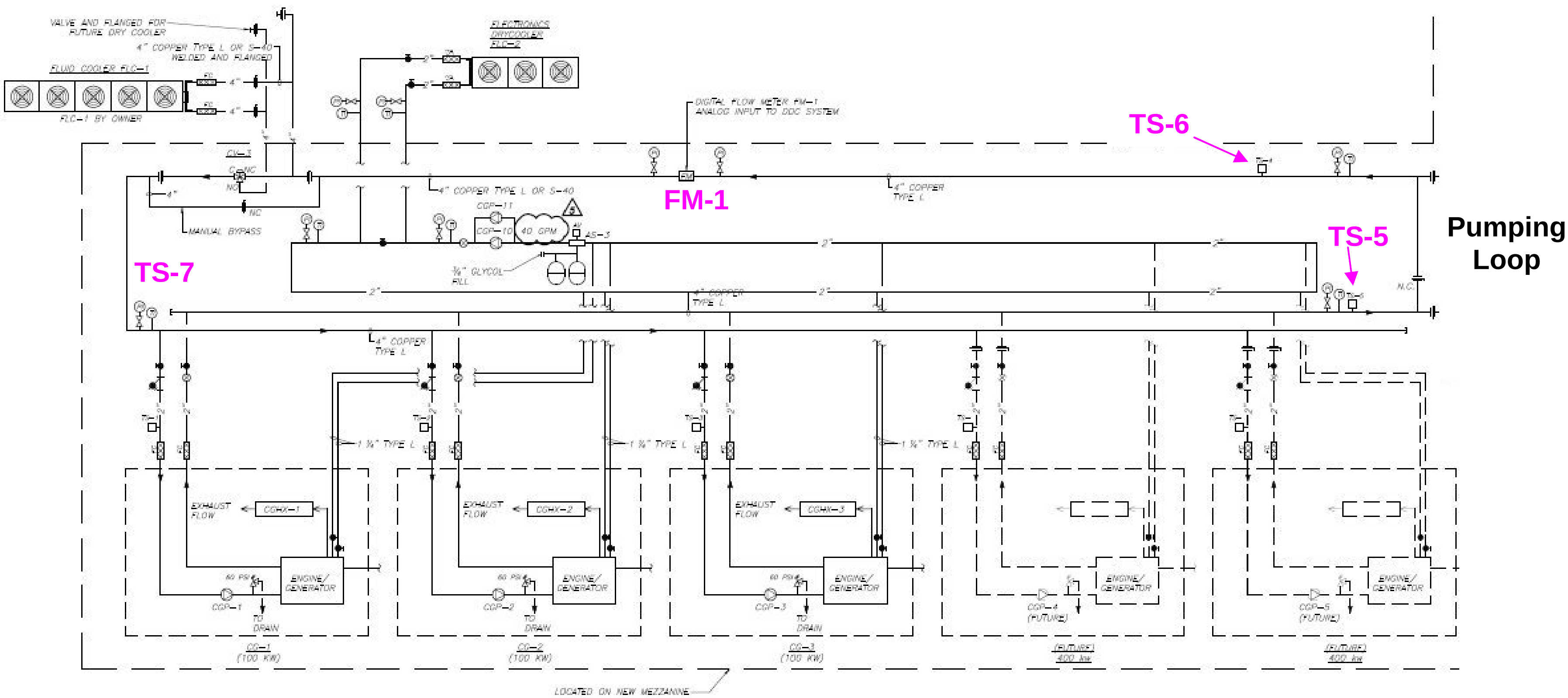

Figure 1. Schematic of Engine Loop (from Drawing M-301)

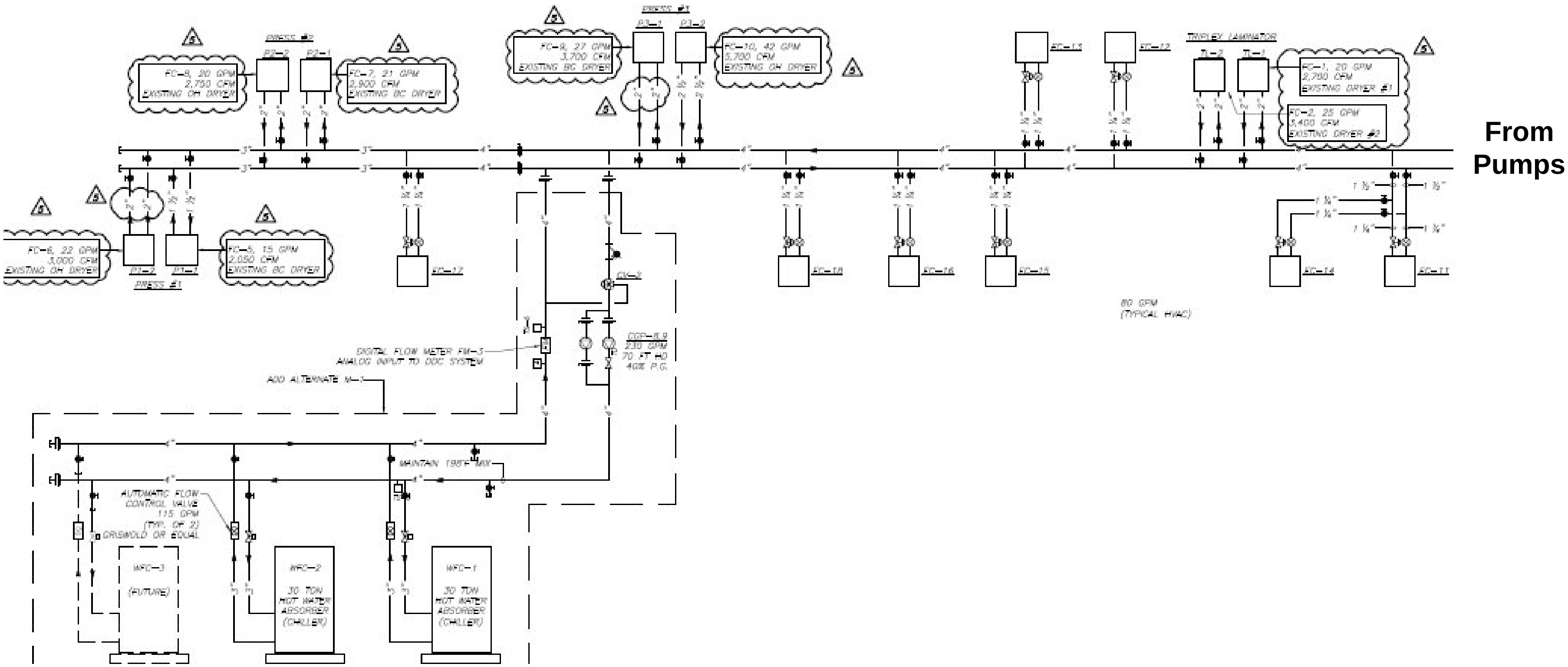

Figure 2. Schematic of Heat Recovery Loads (from Drawing M-301)

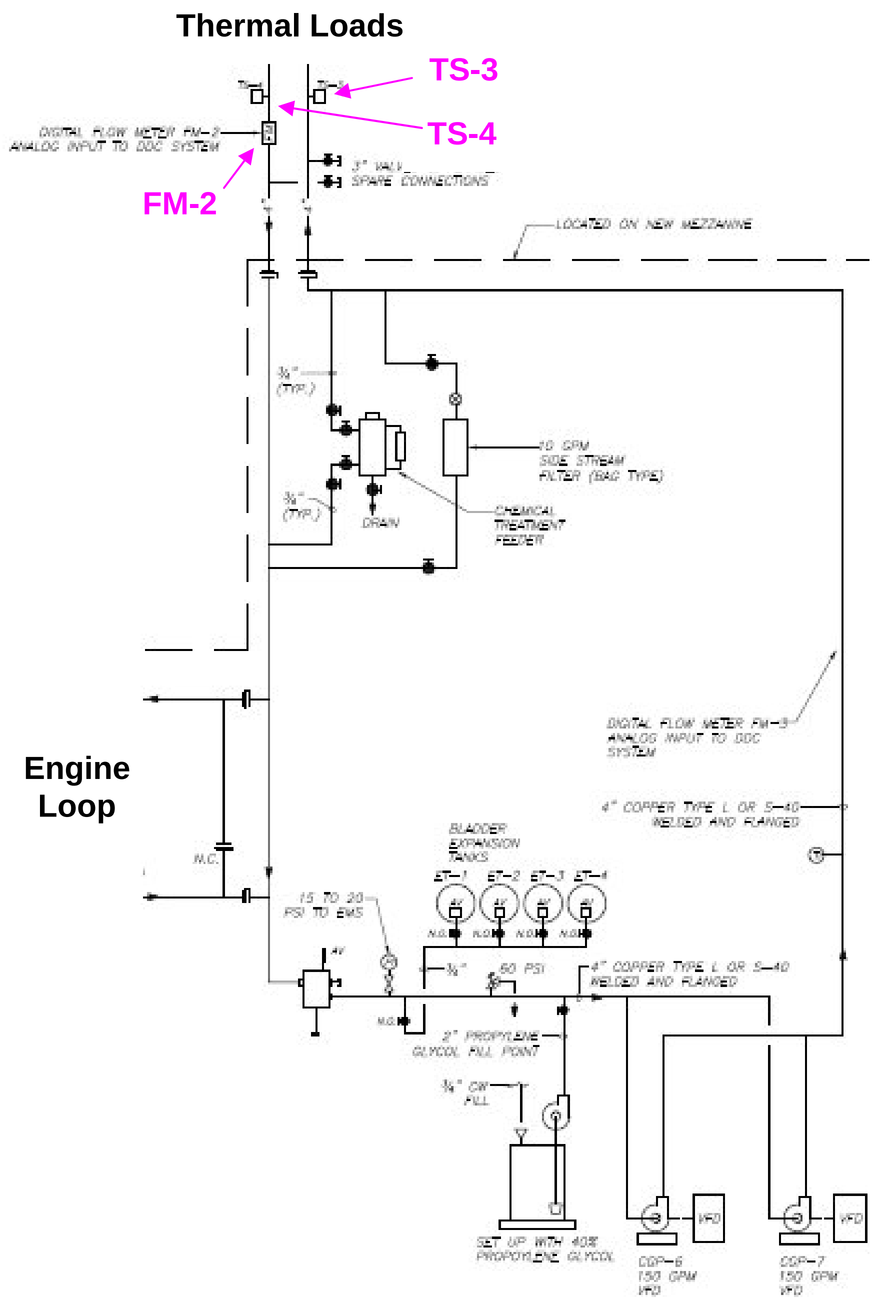

Figure 3. Schematic of Cogeneration Pumping Loop (from Drawing M-301)

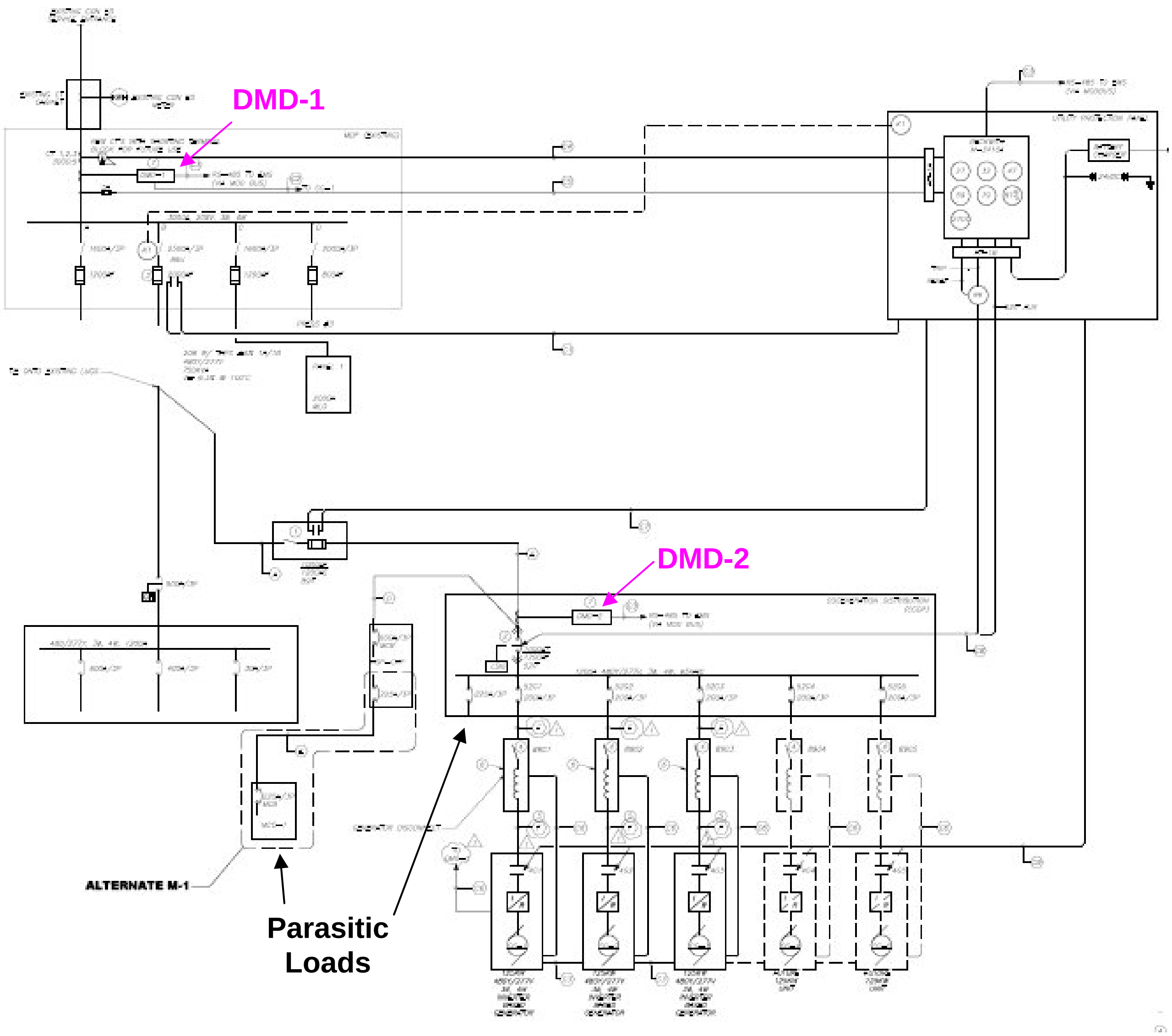

Figure 4. One-Line Schematic of Electrical Interconnection (from Drawing E-301)

2. Monitoring Points

The ALC control system at the site will be used for data collection. Table 1 lists the monitored points that will be used to characterize the performance of the CHP system. The table lists the original drawing information as well as the identifying information from the ALC control system. Specifications on the sensor/transducer, the expected engineering units, and the CDH point name (will be used in the data analysis section) are also given.

Table 1. List of Monitored Data Points to be Collected

No.	Drawing Tag Name (see pics)	ALC Exp:Num	Expected ALC Point Name	Manufacturer / Model #	Description	CDH Point Name	Eng Units
1	DMD-2		CGDP Power Meter - Real Power (kW)	Eaton 250/260 (shark 100)	Generator Power Output	WG_kw	kW
2	DMD-2		CGDP Power Meter - Energy Forward (kWH)	Eaton 250/260 (shark 100)	Generator Energy Output	WG	kWh (cum)
3	DMD-1		MDP Power Meter - Real Power (kW)	Eaton 250/260 (shark 100)	Generator Power Output	WT_kw	kW
4	DMD-1		MDP Power Meter - Energy Forward (kWH)	Eaton 250/260 (shark 100)	Generator Energy Output	WT_kw	kWh (cum)
5			Engines Gas Use (cu ft/hr)	Roots 16M175 Meter (16,000 CF/h)	Generator Gas Input	FG	cf/h
6	FM-1	3:11	Flow Rate	Onicon F-1210 (0-280 gpm)	Engine Loop Flow Rate	FM1	gpm
7	TS-5	3:1	CGWS Temp	ALC Thermistor	Engine Loop Supply Temp	TS5	F
8	TS-6	3:2	CGWR Temp	ALC Thermistor	Engine Loop Return Temp	TS6	F
9	TS-7		Engines Inlet Temp	ALC Thermistor	Engine Loop Return (after FLC)	TS7	F
10	FM-2	3:12	Flow Rate	Onicon F-1210 (0-280 gpm)	Engine Loop Flow Rate	FM2	gpm
11	TS-3	3:15	CGWS Temp	ALC Thermistor	Cogen Loop Supply Temp	TS3	F
12	TS-4	3:16	CGWR Temp	ALC Thermistor	Cogen Loop Return Temp	TS4	F
13		0:2	P-6 SPEED	signal to VSD	CGP-6 pump Speed	VP6	hz
14		0:4	P-7 SPEED	signal to VSD	CGP-7 pump Speed	VP7	hz
15				ALC Thermistor	Outdoor Temperature	TAO	F

Figure 5 and Figure 6 are screen shots from the ALC system showing the locations of the measured points in the system. The sensor identification data from the drawing has also been added.

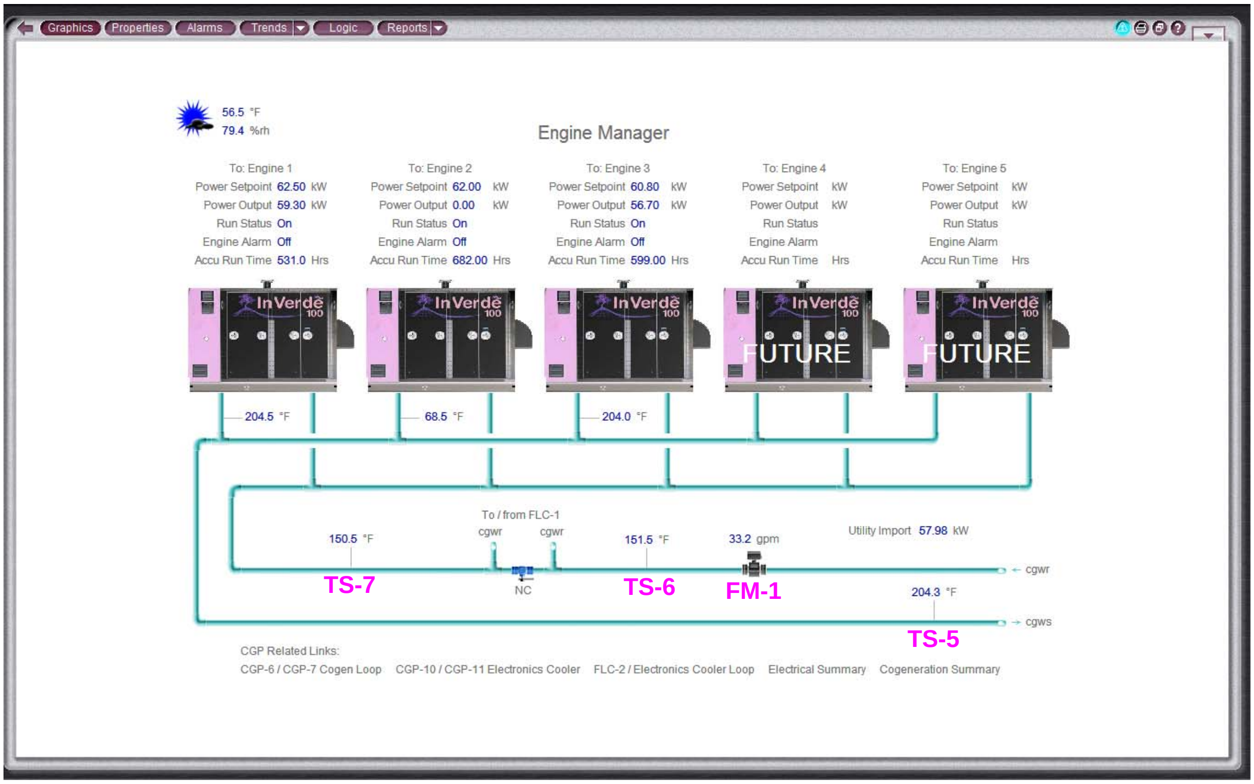

Figure 5. Screen Shot of "Engine Manager" from ALC Control System

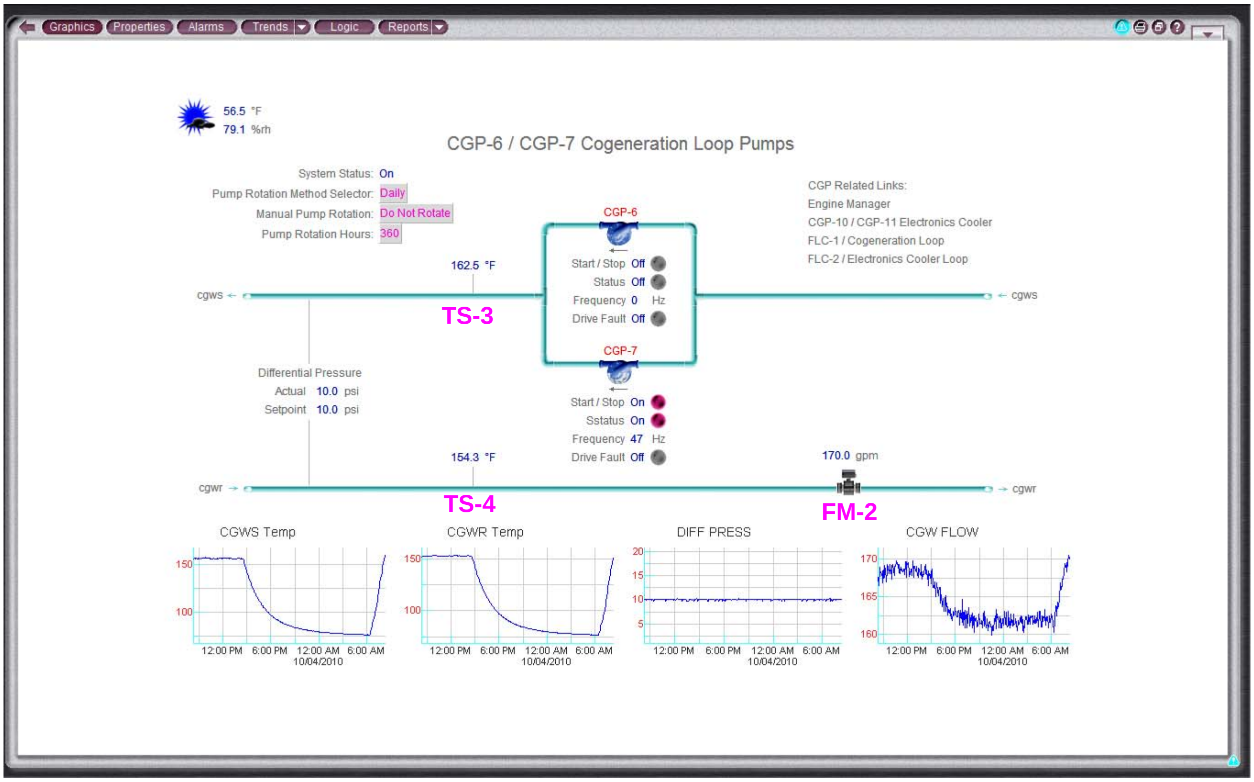

Figure 6. Screen Shot of "Cogen Loop" from ALC Control System

Temperature Sensors

The temperature sensors are BAPI thermistor probes installed in thermowells. Several of the thermistors are shown in Figure 7.

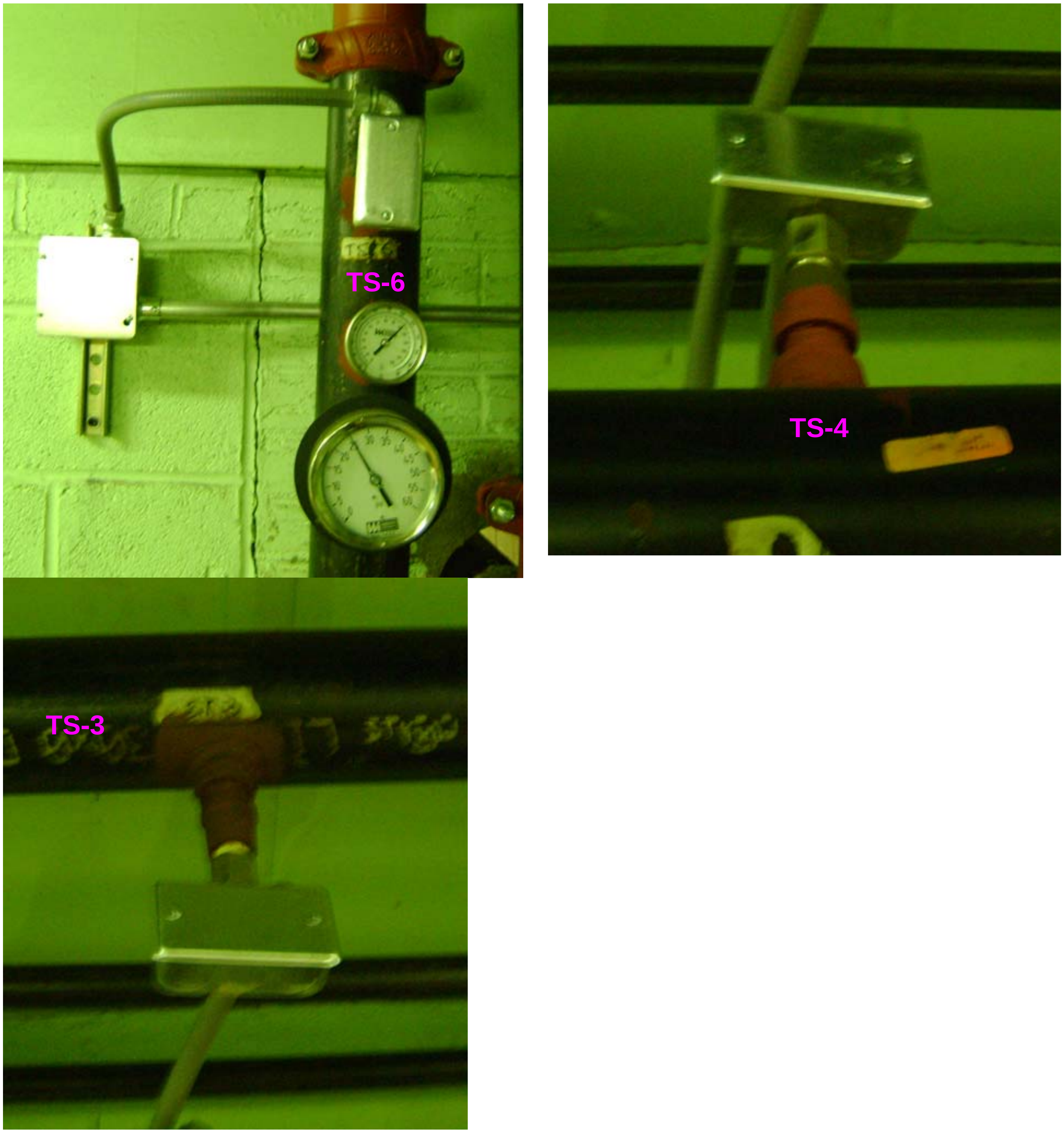

Figure 7. Thermistor Sensors Installed in 4 inch Steel Piping

Fluid Flowmeters (FM-1, FM-2)

The hot water flowmeters are Onicon model F-1210 dual-turbine insertion meters. Each flowmeter is inserted into the 4-inch line through a 1-inch ball valve. Both were calibrated for a range of 0 to 280 gpm. The typical flow (used for calibration) was 150 gpm. Since the flow through the engine loop is expected to range from 30 to 90 gpm (for 1 to 3 engines), the accuracy for the engine loop is not expected to be as good as for the cogen loop, where expected flow is closer to 150 gpm.

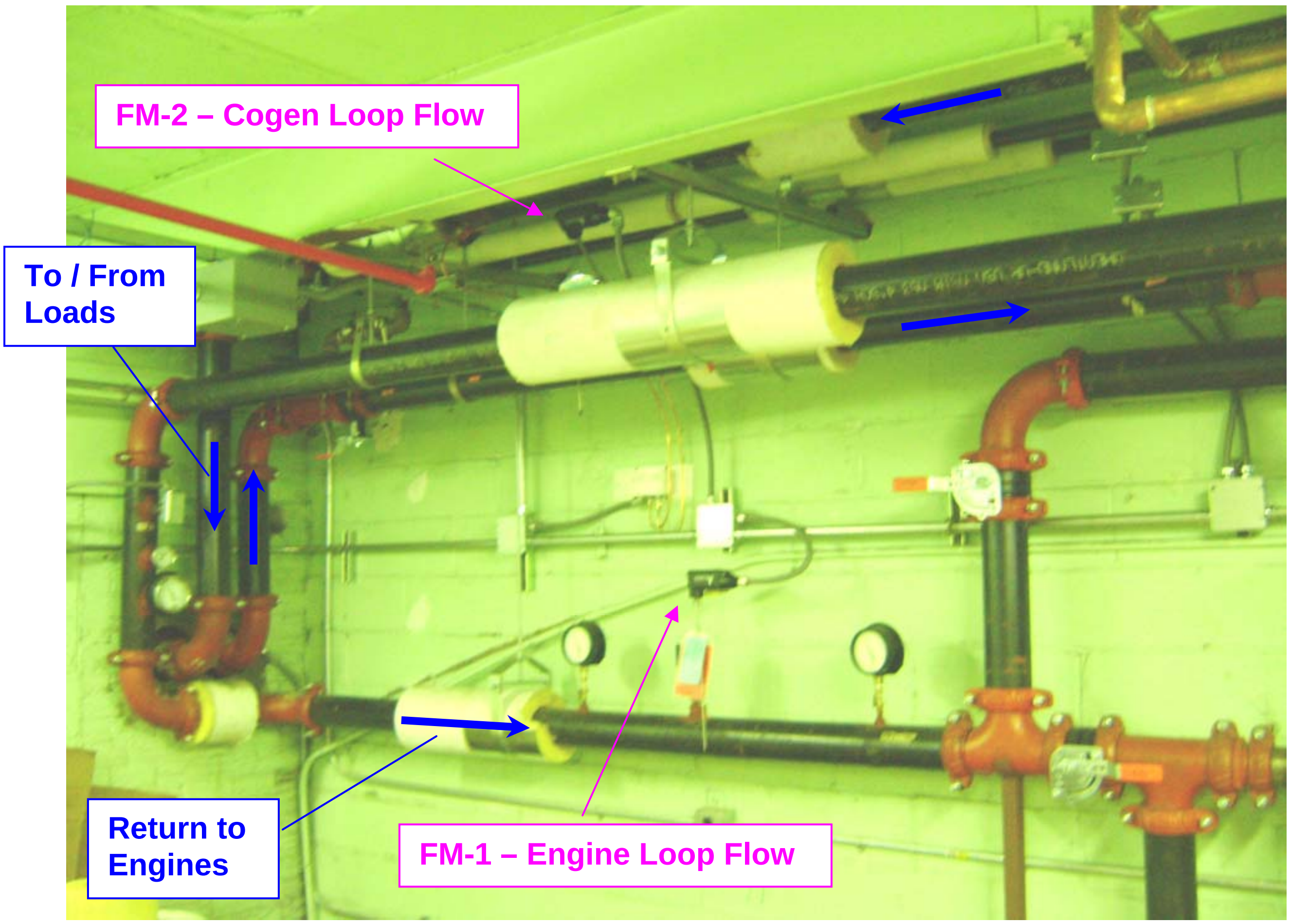

Figure 8. Photo of Flow Meter Locations

Calibration tag for FM-1 (engine loop)

Flow meter on cogen loop (FM-2)

Figure 9. Onicon Flowmeter Details

Engine-Generator Power Output (WG)

The power output of the 3 engine-generator units is consolidated into one feed in panel CGDP (see Figure 4). The power produced by the 3 engines – net of parasitic power consumption in panels MCC-1 and HDP-CHP – is measured by a revenue graced power meter (Eaton 250/260). The same meter is also used to measure facility power import from the utility.

MDP Power Meter (Facility Import)

Combined Generator Output (CGDP)

Figure 10. Power Meters for Generator Output and Total Facility Power

Engine-Generator Gas Input (FG)

There is one Roots rotary gas meter measuring the combined gas use of the CHP system. The meter has been installed and was connected to the ALC system about December 16, 2010. This Roots 16M175 meter has a max rating of 16,000 CF/h.

	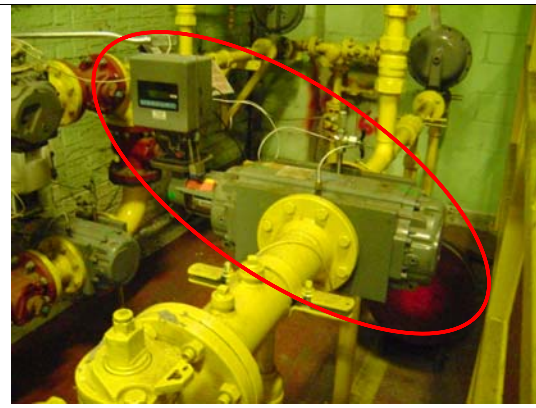
Engine-Generator Enclosure	Engine Gas Meter (pulse output to ALC)

Figure 11. Generator Enclosure and Gas Meter Location

Data Logging Equipment

The ALC control system will be used transfer 5-minute or 15-minute data to CDH each night by email. The ALC system will be setup to email the data listed in Table 1 at a regular time each night as a time-stamped CSV file. The file should include the previous few days of data (e.g., 3-4 days).

Verification

Once the data collection process is established, CDH Energy staff will come on-site and use our hand held meters to confirm proper readings are being collected.

3. Data Analysis

Heat Recovery

The amount of useful heat recovery for this system can be calculated 2 different ways: 1) using the flow-delta T for the engine loop, or 2) using the flow delta-T for the cogeneration loop. Both methods are summarized below.

Useful heat recovery	QUc =	K·FM2·(TS3-TS4)	cogen loop
	QUe =	K·FM1·(TS5-TS6)	engine loop

The flow meter FM2 is expected to operate more frequently near its calibration point, therefore **<u>we will use QUc as primary measurement of useful heat recovery</u>**. The measurement QUe will be used as a check. The factor K will be determined based on the fluid in the loops, which is expected to be a glycol-water mix (K ~ 488 Btu/h-gpm-°F for pure water at 180°F; approximately 459 for 40% glycol). CDH will use a Hygrometer to estimate the glycol concentration if required.

The non-useful or rejected heat recovery will be determined using the following calculation:

Non-Useful or Rejected heat recovery QR = K·FM1·(TS6-TS7)

Calculated Quantities

For this site, the <u>net</u> power output from the engine generators will be measured by the power transducer in the CGDP panel, so

WNET = WG

The fuel conversion efficiency of the CHP system, based on the lower heating value of the fuel, will be defined as:

$$FCE = \frac{QUc \cdot \Delta t + 3{,}412 \cdot (WNET)}{LHV_{gas} \cdot FG}$$

where:	QUc	-	Useful heat recovery (Btu/h)
	WNET	-	Net generator output (kWh)
	FG	-	Generator gas consumption (Std CF)
	Δt	-	1/12 hour for 5-minute data
	LHV_{gas}	-	Lower heating value for natural gas (~905 Btu per CF)

The FCE can be calculated for any time interval. When converting to daily, monthly, or annual values, each value is summed and then the formula is applied:

$$FCE = \frac{\sum^{N} QU \cdot \Delta t + 3412 \cdot \sum^{N} (WNET)}{LHV_{gas} \cdot \sum^{N} FG}$$

Where N is equal to the number of intervals in the period of interest.

Appendix A

Mapping of Data from Raw Data File

The data file report.csv is emailed to CDH Energy each night. The headers in the file identify each column. The table below indicates the Mapping between the raw file and the CDH data point names.

CDH Variable Name	Header Name in Raw Data File (before Nov 29, 2010)	Header Name in Raw Data File (starting Nov 29, 2010)	Header Name in Raw Data File (gas mtr fixed, Dec 16)
WG		CGDP Energy (kWh)	
WG_kw	Plant Power Output (KW)	CGDP Power (kW)	
WT		MDP Energy (kWh)	
WT_kw	Utility Import (kW)	MDP Power (kW)	
FG	Plant Total Gas Use (scf)	Engines Gas Use	Engines Gas Use (cu ft/hr)
FM1		Engines Flow (gpm)	
TS5		Engines CGWS Temp	
TS6		Engines CGWR Temp	
TS7	Engines Inlet Temp	Engines Inlet Temp	
FM2		Main CGW Flow (gpm)	
TS3		Main CGWS Temp	
TS4		Main CGWR Temp	
VP6		CGP-6 Speed (Hz)	
VP7		CGP-7 Speed (Hz)	
TAO		OA Temp	
THR	CGW Entering Temp		
THS	CGW Leaving Temp		
FH	CGW Flow (GPM)		
TDS	FLC-1 Entering Temp		
FD			
QD	Total Heat Rejected (BTU)		
QWG	Plant Electrical Output (BTU)		
QT	Plant Thermal Output (BTU)		
ET	Plant Efficiency		

ALC Datapoint List

Point List

Location: Ultra Flex / 975 Essex Street / Mezzanine / Engine Manager **Run Date: 9/2/2010 11:30:10 AM**

Filters: Physical points

Location	Equipment	Name	Type	Offset / Polarity	Exp:Num	I/O Type
/Ultra Flex/975 Essex Street/Mezzanine						
	Engine Manager					
		CGWR TEMP	BAI	0	3:2	Thermistor
		CGWS TEMP	BAI	0	3:1	Thermistor
		EG-1 ENT TEMP	BAI	0	3:5	Thermistor
		EG-1 LVG TEMP	BAI	0	3:6	Thermistor
		EG-2 ENT TEMP	BAI	0	3:7	Thermistor
		EG-2 LVG TEMP	BAI	0	3:8	Thermistor
		EG-3 ENT TEMP	BAI	0	3:9	Thermistor
		EG-3 LVG TEMP	BAI	0	3:10	Thermistor
		FLOW RATE	BAI	0	3:11	0-20 mA
		EG-2 ENAB HOA	BBI	normal	1:2	H-O-A Status Feedback
		EG-3 ENAB HOA	BBI	normal	1:3	H-O-A Status Feedback
		EG-1 ENAB HOA	BBI	normal	1:1	H-O-A Status Feedback
		EG-1 ALARM	BBI	normal	1:2	Dry Contact
		EG-1 STATUS	BBI	normal	1:1	Dry Contact
		EG-2 ALARM	BBI	normal	1:4	Dry Contact
		EG-2 STATUS	BBI	normal	1:3	Dry Contact
		EG-3 ALARM	BBI	normal	1:6	Dry Contact
		EG-3 STATUS	BBI	normal	1:5	Dry Contact
		CGP Signal	BAO	0	1:8	Electrical 0-10 Volt
		EG-2 ENABLE	BBO	normal	1:2	Relay / Triac Output
		EG-1 ENABLE	BBO	normal	1:1	Relay / Triac Output
		EG-3 ENABLE	BBO	normal	1:3	Relay / Triac Output

Point List

Location: **Ultra Flex / 975 Essex Street / Mezzanine / CGP-6 / CGP-7 Cogeneration Loop Pumps** **Run Date: 9/2/2010 11:32:16 AM**

Filters: **Physical points**

Location	Equipment	Name	Type	Offset / Polarity	Exp:Num	I/O Type
/Ultra Flex/975 Essex Street/Mezzanine						
	CGP-6 / CGP-7 Cogeneration Loop Pumps					
		CGP-6 FDBK	BAI	0	0:2	0-20 mA
		CGP-7 FDBK	BAI	0	0:5	0-20 mA
		CG Sys Press	BAI	0	3:14	0-20 mA
		CGW FLOW	BAI	0	3:12	0-20 mA
		CGWR Temp	BAI	0	3:16	Thermistor
		CGWS Temp	BAI	0	3:15	Thermistor
		DIFF PRESS	BAI	0	3:13	0-20 mA
		P6 VFD Fault	BBI	normal	0:3	Binary Input
		P7 VFD Fault	BBI	normal	0:6	Binary Input
		P-1 RUN	BBI	normal	0:0	Binary Input
		P-2 RUN	BBI	normal	0:0	Binary Input
		Pump 6 Status	BBI	normal	0:1	Binary Input
		Pump 7 Status	BBI	normal	0:4	Binary Input
		P-6 SPEED	BAO	0	0:2	Electrical 0-10 Volt
		P-7 SPEED	BAO	0	0:4	Electrical 0-10 Volt
		Pump 6	BBO	normal	0:1	Relay / Triac Output
		Pump 7	BBO	normal	0:3	Relay / Triac Output

Point List

Location: **Ultra Flex / 975 Essex Street / First Floor / MDP Power Meter** **Run Date: 9/2/2010 11:40:06 AM**

Filters: **BACnet points**

Location	Equipment	Name	Type	Offset / Polarity	Exp:Num	I/O Type
/Ultra Flex/975 Essex Street/First Floor						
	MDP Power Meter					
		3 Phase Apparent Power (kVA)	BAV			
		3 Phase Reactive Power (kVAR)	BAV			
		Apparent Energy (KVAh)	BAV			
		Apparent Power Phase A (kVA)	BAV			
		Apparent Power Phase B (kVA)	BAV			
		Apparent Power Phase C (kVA)	BAV			
		Current Phase A	BAV			
		Current Phase B	BAV			
		Current Phase C	BAV			
		Energy Forward (kWH)	BAV			
		Energy Net (kWH)	BAV			
		Energy Reverse (kWH)	BAV			
		Frequency	BAV			
		Neutral Current	BAV			
		Phase A-B Voltage Setpoint	BAV			
		Phase A-C Voltage Setpoint	BAV			
		Phase B-C Voltage Setpoint	BAV			
		Power Factor	BAV			
		Power Factor Phase A	BAV			
		Power Factor Phase B	BAV			
		Power Factor Phase C	BAV			
		Reactive Energy Lag (KVARh)	BAV			
		Reactive Energy Lead (KVARh)	BAV			
		Reactive Energy Net (KVARh)	BAV			
		Reactive Power Phase A (kVAR)	BAV			
		Reactive Power Phase B (kVAR)	BAV			
		Reactive Power Phase C (kVAR)	BAV			
		Real Power (kW)	BAV			
		Real Power Phase A (kW)	BAV			
		Real Power Phase B (kW)	BAV			
		Real Power Phase C (kW)	BAV			
		Voltage Phase A-B	BAV			
		Voltage Phase A-C	BAV			
		Voltage Phase A-N	BAV			
		Voltage Phase B-C	BAV			
		Voltage Phase B-N	BAV			
		Voltage Phase C-N	BAV			
		Maintenance	BBV			
		Phase A-B High Voltage Alarm	BALM			
		Phase A-B Low Voltage Alarm	BALM			
		Phase A-C High Voltage Alarm	BALM			
		Phase A-C Low Voltage Alarm	BALM			
		Phase B-C High Voltage Alarm	BALM			
		Phase B-C Low Voltage Alarm	BALM			

Point List

Location: Ultra Flex / 975 Essex Street / Mezzanine / CGDP Power Meter **Run Date: 9/2/2010 11:35:15 AM**

Filters: BACnet points

Location	Equipment	Name	Type	Offset / Polarity	Exp:Num	I/O Type
/Ultra Flex/975 Essex Street/Mezzanine						
	CGDP Power Meter					
		3 Phase Apparent Power (kVA)	BAV			
		3 Phase Reactive Power (kVAR)	BAV			
		Apparent Energy (KVAh)	BAV			
		Apparent Power Phase A (kVA)	BAV			
		Apparent Power Phase B (kVA)	BAV			
		Apparent Power Phase C (kVA)	BAV			
		Current Phase A	BAV			
		Current Phase B	BAV			
		Current Phase C	BAV			
		Energy Forward (kWH)	BAV			
		Energy Net (kWH)	BAV			
		Energy Reverse (kWH)	BAV			
		Frequency	BAV			
		Neutral Current	BAV			
		Phase A-B Voltage Setpoint	BAV			
		Phase A-C Voltage Setpoint	BAV			
		Phase B-C Voltage Setpoint	BAV			
		Power Factor	BAV			
		Power Factor Phase A	BAV			
		Power Factor Phase B	BAV			
		Power Factor Phase C	BAV			
		Reactive Energy Lag (KVARh)	BAV			
		Reactive Energy Lead (KVARh)	BAV			
		Reactive Energy Net (KVARh)	BAV			
		Reactive Power Phase A (kVAR)	BAV			
		Reactive Power Phase B (kVAR)	BAV			
		Reactive Power Phase C (kVAR)	BAV			
		Real Power (kW)	BAV			
		Real Power Phase A (kW)	BAV			
		Real Power Phase B (kW)	BAV			
		Real Power Phase C (kW)	BAV			
		Voltage Phase A-B	BAV			
		Voltage Phase A-C	BAV			
		Voltage Phase A-N	BAV			
		Voltage Phase B-C	BAV			
		Voltage Phase B-N	BAV			
		Voltage Phase C-N	BAV			
		Maintenance	BBV			
		Phase A-B High Voltage Alarm	BALM			
		Phase A-B Low Voltage Alarm	BALM			
		Phase A-C High Voltage Alarm	BALM			
		Phase A-C Low Voltage Alarm	BALM			
		Phase B-C High Voltage Alarm	BALM			
		Phase B-C Low Voltage Alarm	BALM			

Point List

Location: **Ultra Flex / 975 Essex Street / Mezzanine / CGP-10 / CGP-11 Electronics Cooler Loop Pumps** **Run Date: 9/2/2010 11:34:13 AM**

Filters: **Physical points**

Location	Equipment	Name	Type	Offset / Polarity	Exp:Num	I/O Type
/Ultra Flex/975 Essex Street/Mezzanine						
	CGP-10 / CGP-11 Electronics Cooler Loop Pumps					
		ECGWR TEMP	BAI	0	3:4	Thermistor
		ECGWS TEMP	BAI	0	3:3	Thermistor
		CG1	BBI	normal	0:0	H-O-A Status Feedback
		CG1	BBI	normal	0:0	H-O-A Status Feedback
		CGP-10 STATUS	BBI	normal	0:7	Binary Input
		CGP-11 STATUS	BBI	normal	0:8	Binary Input
		CGP-10	BBO	normal	0:5	Relay / Triac Output
		CGP-11	BBO	normal	0:6	Relay / Triac Output

Point List

Location: Ultra Flex / 975 Essex Street / Roof / FLC-2 \ Electronics Cooler Loop **Run Date: 9/2/2010 11:36:50 AM**

Filters: Physical points

Location	Equipment	Name	Type	Offset / Polarity	Exp:Num	I/O Type
/Ultra Flex/975 Essex Street/Roof						
	FLC-2 \ Electronics Cooler Loop					
		CGWR TEMP	BAI	0	2:11	Thermistor
		CGWS TEMP	BAI	0	2:10	Thermistor
		CG1	BBI	normal	0:0	H-O-A Status Feedback
		FAN1 STATUS	BBI	normal	2:7	Binary Input
		FAN 1	BBO	normal	2:7	Relay / Triac Output

Point List

Location: **Ultra Flex / 975 Essex Street / Roof / FLC-1 \ Cogeneration Loop** **Run Date: 9/2/2010 11:36:18 AM**

Filters: **Physical points**

Location	Equipment	Name	Type	Offset / Polarity	Exp:Num	I/O Type
/Ultra Flex/975 Essex Street/Roof						
	FLC-1 \ Cogeneration Loop					
		CG INLET TEMP	BAI	0	0:12	Thermistor
		CGWR TEMP	BAI	0	2:9	Thermistor
		CGWS TEMP	BAI	0	2:8	Thermistor
		FLC-1 BYPSS POS	BAI	0	2:15	0-10 Volt
		FLC-1 BYPSS POS	BAI	0	2:16	0-10 Volt
		CG1	BBI	normal	0:0	H-O-A Status Feedback
		CG1	BBI	normal	0:0	H-O-A Status Feedback
		CG1	BBI	normal	0:0	H-O-A Status Feedback
		CG1	BBI	normal	0:0	H-O-A Status Feedback
		CG1	BBI	normal	0:0	H-O-A Status Feedback
		CG1	BBI	normal	0:0	H-O-A Status Feedback
		FAN1 STATUS	BBI	normal	2:1	Binary Input
		FAN2 STATUS	BBI	normal	2:2	Binary Input
		FAN3 STATUS	BBI	normal	2:3	Binary Input
		FAN4 STATUS	BBI	normal	2:4	Binary Input
		FAN5 STATUS	BBI	normal	2:5	Binary Input
		FAN6 STATUS	BBI	normal	2:6	Binary Input
		FLC-1 BP VLV	BAO	0	2:8	Electrical 0-10 Volt
		FAN 1	BBO	normal	2:1	Relay / Triac Output
		FAN 2	BBO	normal	2:2	Relay / Triac Output
		FAN 3	BBO	normal	2:3	Relay / Triac Output
		FAN 4	BBO	normal	2:4	Relay / Triac Output
		FAN 5	BBO	normal	2:5	Relay / Triac Output
		FAN 6	BBO	normal	2:6	Relay / Triac Output

Point List

Location: **Ultra Flex / 975 Essex Street / Mezzanine / Engine 1** **Run Date: 9/2/2010 11:31:21 AM**

Filters: **BACnet points**

Location	Equipment	Name	Type	Offset / Polarity	Exp:Num	I/O Type
/Ultra Flex/975 Essex Street/Mezzanine						
	Engine 1					
		Active Alarm #	BAV			
		Analog Voltage	BAV			
		Average Current	BAV			
		Average Power	BAV			
		Average Volts	BAV			
		Barometric Absolute Pressure	BAV			
		Battery Voltage	BAV			
		C1 Current	BAV			
		C2 Current	BAV			
		C3 Current	BAV			
		Catalyst Intlet Temperature	BAV			
		Catalyst Outlet Temperature	BAV			
		Enclosure Temperature	BAV			
		Exhaust Temperature	BAV			
		Frequency	BAV			
		Fuel Valve Position	BAV			
		Gas Usage	BAV			
		Generator Inlet Temperature	BAV			
		Generator Outlet Temperature	BAV			
		Heat Output	BAV			
		Logic Voltage	BAV			
		Manifold Absolute Pressure	BAV			
		O2 Sensor mV	BAV			
		Oil Temperature	BAV			
		Power Leg 1	BAV			
		Power Leg 2	BAV			
		Power Leg 3	BAV			
		Present Power Setpoint	BAV			
		RPM	BAV			
		Total Energy	BAV			
		Total Heat	BAV			
		Total Hour Meter	BAV			
		Total Starts	BAV			
		V1 Voltage	BAV			
		V2 Voltage	BAV			
		V3 Voltage	BAV			
		Water Inlet Temperature	BAV			
		Water Outlet Temperature	BAV			
		Alarm LED	BBV			
		Alarm Status	BBV			
		Engine Starter Relay	BBV			
		Gas \ Ignition Relay	BBV			
		Pump Relay	BBV			
		Run LED	BBV			
		Shutdown LED	BBV			
		Startup LED	BBV			
		Status	BBV			
		CG-X Analog Fault Alarm	BALM			
		CG-X Boost Fault Alarm	BALM			
		CG-X Break Resistor Temperature Alarm	BALM			
		CG-X CAN Bus Comms Fail Alarm	BALM			

Location	Equipment	Name	Type	Offset / Polarity	Exp:Num	I/O Type
		CG-X Catalyst Temperature Alarm	BALM			
		CG-X Contactor Fault Alarm	BALM			
		CG-X Crank Failiure Alarm	BALM			
		CG-X Current Imbalance Alarm	BALM			
		CG-X Current Mode Fault Alarm	BALM			
		CG-X Customer Alarm	BALM			
		CG-X DC Bus Low Fault Alarm	BALM			
		CG-X DC Overvoltage Fault Alarm	BALM			
		CG-X Emergency Stop Alarm	BALM			
		CG-X Emergency Stop Alarm	BALM			
		CG-X Emissions Fault Alarm	BALM			
		CG-X Exhaust Temperature Alarm	BALM			
		CG-X Filter Contact Fault Alarm	BALM			
		CG-X Generator Cooling Alarm	BALM			
		CG-X High Connect Time Alarm	BALM			
		CG-X High Coolant Temperature Alarm	BALM			
		CG-X High Cooldown Time Alarm	BALM			
		CG-X High Enclosure TemperatureAlarm	BALM			
		CG-X High Frequency Alarm	BALM			
		CG-X High Generator Current Fault Alarm	BALM			
		CG-X High Inlet Water Temperature Alarm	BALM			
		CG-X High Oil Temperature Alarm	BALM			
		CG-X High Power Alarm	BALM			
		CG-X High Voltage Alarm	BALM			
		CG-X High Water Pressure Alarm	BALM			
		CG-X High Water Temperature Alarm	BALM			
		CG-X Ignition Power Fail Alarm	BALM			
		CG-X Inverter Temperature Fault Alarm	BALM			
		CG-X Logic Voltage Fault Alarm	BALM			
		CG-X Low Catalyst DT Alarm	BALM			
		CG-X Low Coolant Temperature Alarm	BALM			
		CG-X Low Enclosure Temperature Alarm	BALM			
		CG-X Low Frequency Alarm	BALM			
		CG-X Low Oil Level Alarm	BALM			
		CG-X Low Oil Pressure Alarm	BALM			
		CG-X Low Oil Temperature Alarm	BALM			
		CG-X Low Power Alarm	BALM			
		CG-X Low Thermal Load Alarm	BALM			
		CG-X Low Voltage Alarm	BALM			
		CG-X Low Water Pressure Alarm	BALM			
		CG-X Microgrid Board Fault Alarm	BALM			
		CG-X Oil P Switch Fail Alarm	BALM			
		CG-X Output Voltage Fault Alarm	BALM			
		CG-X Overcurrent Fault Alarm	BALM			
		CG-X Overload Fault Alarm	BALM			
		CG-X Overspeed Alarm	BALM			
		CG-X Phase Rotation Fault Alarm	BALM			
		CG-X Power Supply Fault Alarm	BALM			
		CG-X Protection Relay Input Alarm	BALM			

Location	Equipment	Name	Type	Offset / Polarity	Exp:Num	I/O Type
		CG-X SA Operation Fault Alarm	BALM			
		CG-X SKiiP1 Fault Alarm	BALM			
		CG-X SKiiP2 Fault Alarm	BALM			
		CG-X SKiiP3 Fault Alarm	BALM			
		CG-X Starting Failiure Alarm	BALM			
		CG-X Underspeed Alarm	BALM			

Addendum - Ultraflex
975 Essex Street
Brooklyn, NY 11208-5443

Site Contact:
Chris Volney
Energy Concepts
718-483-0505

- Website data begins September 2^{th}, 2011
- CDH on site to verify meters and readings June 21^{th} 2011

Verification – June 21th

Site Information:

Piping	steel
size	4"
diameter	4.5"
wall	.237"
Glycol reading	50%
multiplier	0.4518

Multiplier is based on the measured glycol content of the water used by the system and is used as the value of k in the equation for heat transfer.

Power:

	Fluke (kW)	Generator Reading (kW)	Database (kW)
10:18	269.3	271.9	
10:24	269.4	271.5	271.5
avg	269.35	271.7	
%diff	0.79	0.07	

	Facility Import	
	Meter (kW)	Database (kW)
10:30	135	145.9

Gas:

	Gas Meter		Database
	Meter (ccf)	diff (cfm)	(cfm)
10:31	165247	58.139535	58.8
10:54	165261		
11:14	165272		

Recovered Heat:

	Handheld	Database	ALC
TS3 (F)		224	226
TS4 (F)	210	211.6	210.9
FM2 (gpm)	167.5	156.8	167.0
Q (MBTU/h)	1211.1	878.4	1139.3

Q = k*FM2*(TS3-TS4)
k = .4518

The calculation of Q for the handheld measurements uses the temperature from the ALC system recorded at the time of the measurement. (both are instantaneous readings, the database is a 15 average)

Table 1. List of Received data points

CDH ID	File Header V1	File Header V2	File Header V3
WG		CGDP Energy (kWh)	
WG_kw	Plant Power Output (KW)	CGDP Power (kW)	
WT		MDP Energy (kWh)	
WT_kw	Utility Import (kW)	MDP Power (kW)	
FG	Plant Total Gas Use (scf)	Engines Gas Use	Engines Gas Use (cu ft/hr)
FM1		Engines Flow (gpm)	
TS5		Engines CGWS Temp	
TS6		Engines CGWR Temp	
TS7	Engines Inlet Temp	Engines Inlet Temp	
FM2		Main CGW Flow (gpm)	
TS3		Main CGWS Temp	
TS4		Main CGWR Temp	
VP6		CGP-6 Speed (Hz)	
VP7		CGP-7 Speed (Hz)	
TAO		OA Temp	
THR	CGW Entering Temp		
THS	CGW Leaving Temp		
FH	CGW Flow (GPM)		
TDS	FLC-1 Entering Temp		
FD			
QD	Total Heat Rejected (BTU)		
QWG	Plant Electrical Output (BTU)		
QT	Plant Thermal Output (BTU)		
ET	Plant Efficiency		