St Joachim and Anne Nursing Home CHP Verification Visit – September 17, 2015

CDH Energy was on site at St Joachim and Anne Nursing Home, located at 2720 Surf Ave, Brooklyn, NY on September 17, 2015 to perform field measurements of the CHP system temperatures and flows. The verification was performed to confirm the measurements collected by the Automated Logic control system (the Data Acquisition System or DAS) are accurate and can be used to calculate system performance.

The following are a summary of the observations collected during the site visit.

System Operation

During the site inspection, the CHP system was operating two of the three engine generators. The first CHP unit was running at 82.5 kW and the second unit was running at 80.5 kW. Figure 1 displays the system operation at the time of the inspection.

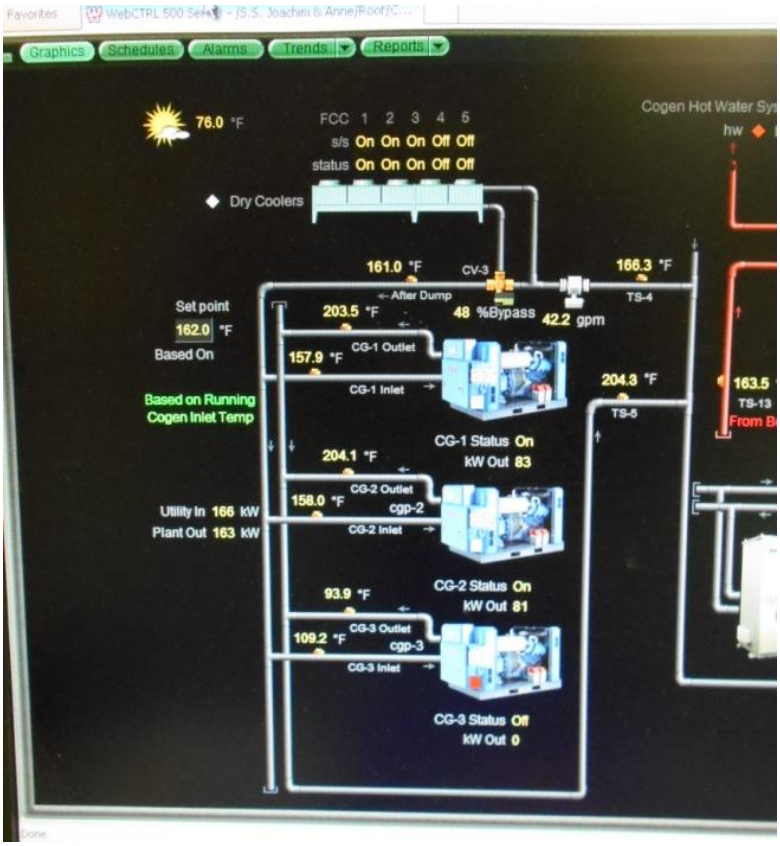

Figure 1. PLC Control Screen Diagram Showing CHP Units Status and Loop Measurements

CHP Loop Flow Measurements

The FM-1 flowmeter has been re-located to a straight run of pipe located between the CHP loop bridge piping and the dump radiator. The location has greater than 10-diameters on either side of the meter free of any fittings or pipe transitions, making it an ideal location for the meter.

The meter installed in this location is an Onicon F-1110 meter with a 4-20 mA output that is scaled for 0-375 GPM. Although this scaling is quite large compared to the typical flow in the CHP loop of 0 – 90 GPM, the meter was found to be accurate based on independent verification with the CDH Energy Fuji Portaflow C ultrasonic flow-meter.

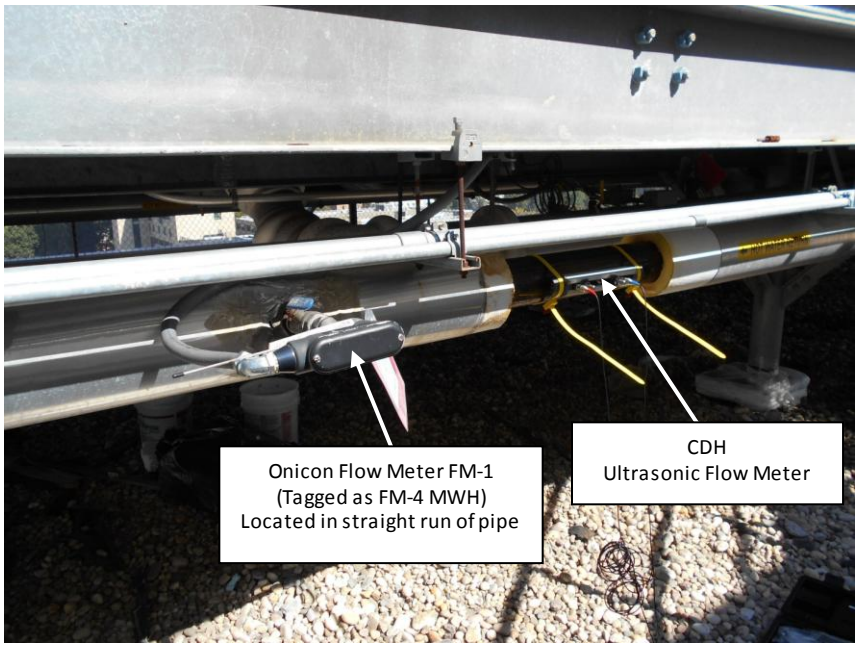

Figure 2. CHP Loop Flowmeter and Ultrasonic Flow Meter Verification Location - September 17, 2015

Flow measurements made with the CDH Energy Portaflow C ultrasonic flowmeter were compared to values recorded by the control system. The Onicon FM-1 meter readings were in reasonable agreement with the CDH ultrasonic meter. The CDH ultrasonic meter experienced occasional oscillations in flow due to air bubbles or other debris in the pipe. Based on the readings collected, no adjustment is recommended to the FM-1 reading.

Table 1. FM-1 Flow Meter Verification

CDH Ultrasonic Flowmeter (GPM)	ALC System (GPM)
44.7	46.8
46.8	46.7
42.4	46.7
44.6 (AVG)	**46.7 (AVG)**

CHP Loop Temperature Measurements

Measurements of the CHP loop supply temperature, return temperature, and return temperature downstream of the dump radiator were performed and compared to the values recorded by the control system. Manual temperature readings were taken with the CDH Fluke instrument and the ICE Fluke infrared meter.

Pipe surface measurement

Verification using other system instrumentation

Figure 3. Temperature Verification Techniques

The CHP loop supply temperature sensor (**TCLS**) is an insertion style temperature sensor and is designated as TS-5 on the M3.01 drawing. This sensor was observed to be installed in the proper pipe location and installed using a thermowell. The pipe surface temperature measurement agreed with both the DAS reading and the temperatures as indicated on the Tecogen units themselves. The infrared meter indicated slightly higher temperatures for reasons that are not clear, but since this elevate temperature is not supported by any other measurement, the IR meter reading will be ignored.

Table 2. TCLS Temperature Verification

Fluke Temperature Meter (pipe surface) (deg F)	Infrared Meter (pipe surface) (deg F)	DAS (deg F)	Tecogen 1 / 2 Leaving (deg F)
203.1	208	204.0	203.8 / 203.4
204.1	209	203.9	204.1 / 203.9
	206		
	210		
203.6 (AVG)	**208.2 (AVG)**	**204.0 (AVG)**	**204.0 / 203.7 (AVG)**

The CHP loop return temperature sensor (**TCLR1**) is an insertion style temperature sensor and is designated as TS-4 on the M3.01 drawing. This sensor was observed to be installed in the proper pipe location and installed using a thermowell. The pipe surface temperature measurement were substantially below the DAS readings, while the infrared meter indicated better agreement with the DAS sensors. Irregularities in the surface of the pipe are the likely cause of the poor surface temperature measurement.

Table 3. TCLR1 Temperature Verification

Fluke Temperature Meter (pipe surface) (deg F)	Infrared Meter (deg F)	DAS (deg F)
155.4	165.1	166.2
153.1	166.1	166.3
154.3 (AVG)	**165.6 (AVG)**	**166.3 (AVG)**

The CHP loop return temperature sensor after the dump radiator (**TCLR2**) is an insertion style temperature sensor that was added after system construction. This sensor was observed to be installed in the proper pipe location and installed using a thermowell. The pipe surface temperature measurement were substantially below the DAS readings, while the infrared meter indicated better agreement with the DAS sensors. Again, irregularities in the surface of the pipe are the likely cause of the poor surface temperature measurement.

Table 4. TCLR2 Temperature Verification

Fluke Temperature Meter (pipe surface) (deg F)	Infrared Meter (deg F)	DAS (deg F)
151.9	158	161
152.3	160	162.1
150.9	157	161.9
152.1 (AVG)	**159 (AVG)**	**161.6 (AVG)**

Overall, the system temperature readings collected by the DAS are reasonably bounded by either pipe surface temperature readings, infrared measurements, and corroboration with other system temperature sensors. No adjustment to the reported system temperatures is recommended.

Power Measurements

The parasitic power meter is installed on the entire MCC-1 panel board (Figure 4) that contains a mixture of CHP parasitic and non-parasitic loads. CDH Energy performed one time measurements on these loads to assess the typical level of non-CHP parasitic loads measured by this meter (Table 5), and to verify accuracy of the WPAR meter. The WPAR meter was within 1 kW of the sum of the one time measurements.

Figure 4. MCC-1 Containing CHP Parasitic and Non-parasitic Loads

Table 5. One-Time Power Measurements – MCC-1 Parasitic Load Panel

Tag	Description	Total Motor Size (HP)	Power (kW)	Measurement Type (Measured / Calc'd from Amps)	CHP Parasitic?
FLC-1	Electronics Cooling - Inverde 1	3	OFF	N/A	Yes
FLC-2	Electronics Cooling - Inverde 2	3	1.98	Calc'd from Amps @ 0.85 PF	Yes
FLC-3	Electronics Cooling - Inverde 3	3	2.19	Calc'd from Amps @ 0.85 PF	Yes
FLC-5	Cogen HW Fluid Cooler	15	4.45	Calc'd from Amps @ 0.85 PF	Yes
CGP-5	CHP Loop Pump	10	2.76	Calc'd from Amps @ 0.85 PF	Yes
CGP-6	CHP Loop Pump	10	OFF	N/A	Yes
CGP-7	Absorber HW Pump	7.5	5.90	Measured	Yes
CGP-8	Absorber HW Pump	7.5	OFF	N/A	Yes
CWP-1	Chilled Water Chiller Pump	7.5	4.60	Measured	No
CWP-2	Chilled Water Chiller Pump	7.5	OFF	N/A	No
CWP-3	Chilled Water Secondary Loop	15	OFF	N/A	No
CWP-4	Chilled Water Secondary Loop	15	3.75	Calc'd from Amps @ 0.85 PF	No
CDP-1	Condenser Water	25	11.60	Measured	No
CDP-2	Condenser Water	25	OFF	N/A	No
HWP-1	HX-1 HW Pump	5	OFF	N/A	Yes
HWP-2	HX-1 HW Pump	5	2.08	Calc'd from Amps @ 0.85 PF	Yes
CT-1	Cooling Tower	10	0.92	Calc'd from Amps @ 0.85 PF	No
	MCC-1 Total Power (kW)		40.23		
	MCC-1 Observed Power at Meter (kW)		41.00		
	Total Non CHP Parasitics (kW)		**20.86**		

Figure 5. WPAR Meter Reading

The CGDP meter that records the total output of the CHP system was observed to vary from the sum of the CHP unit electrical outputs by a factor of 2.0. This issue has been documented as far back as June 2011.

Table 6. CGDP Reading vs Tecogen Output Readings

CGDP Reading (kW)	Inverde 1 Output	Inverde 2 Output	Inverde 3 Output	CHP Total
82.1 kW (164.1 kW with multiplier of 2.0)	82.5 kW	80.5 kW	0 kW	162.5 kW

The control system has been updated to provide the sum of the Inverde output as the gross power production for the CHP plant, in place of the CGDP reading in the daily report provided. The sum of these engine output was compared to the historic CGDP meter reading for the past three months (Figure 6). No substantial difference is noted between the data provided in the reports. Gross power reported by the DAS from 9/17/2015 forward will be the sum of the Inverde outputs.

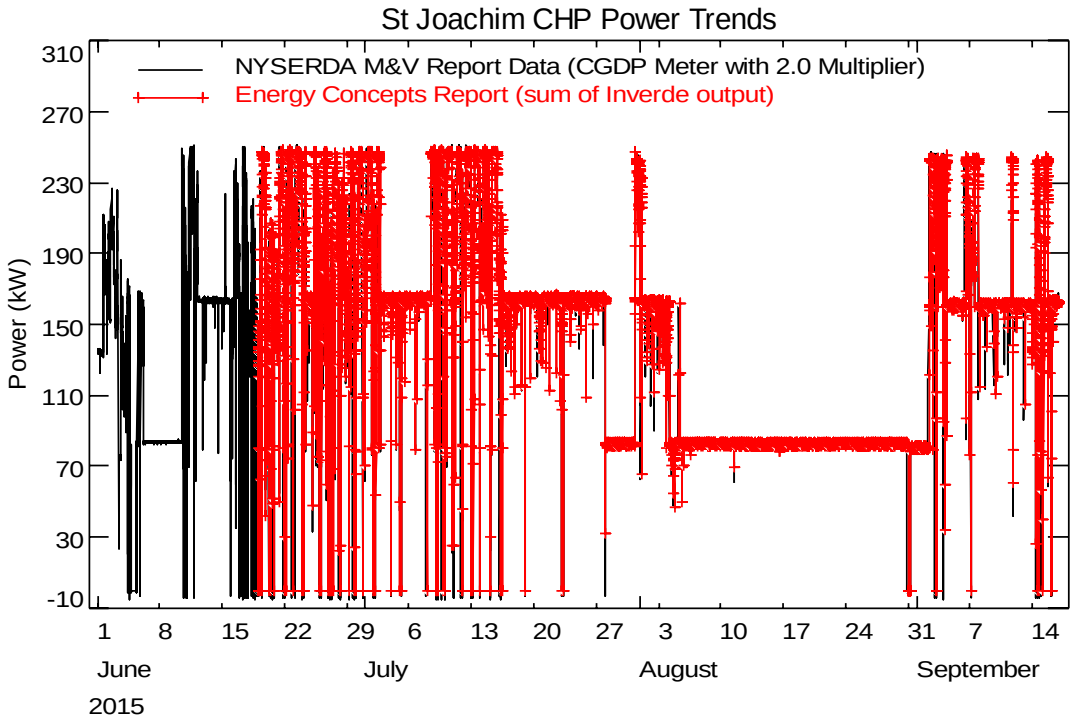

Figure 6. Comparing Data from NYSERDA M&V Report to Energy Concepts Monthly Report

CHP Gas Flow

The gas meter was clocked for a short duration and the gas rate was calculated and compared to the value provided in the report file. The on-screen display of the gas flow was not correct (indicating 35 CFM continuously). The meter is reporting correctly.

Table 7. Gas Meter Reading

Time	Gas Meter Reading (CF)	DAS Report Value (CF)
1:06 PM	68,549,500	
1:13 PM	68,549,743	
7 minutes	243 (2,083 CFH)	2,100 CFH

Conclusions

All sensors and delivered data values for the CHP system at St Joachim are reporting correctly. An adjustment to the historic and on-going parasitic power measurement is required to remove energy consumption from components that are not located on the CHP HW side of the system.

Using the readings from the DAS, and adjusting for the parasitic power correction, the system displayed a CHP fuel conversion efficiency (FCE) of 68.5% LHV during the site visit.

Table 8. FCE Calculation – Coincident Readings from DAS

Gross Power (kW)	163.0
Parasitic Power (CHP only) (kW)	20.1
Net Power (kW)	142.9
Heat Recovery (Mbtu/h)	815.2
Gas Consumption (CFH)	2,100.0
FCE elec (gross) (% LHV)	29.3%
FCE CHP (net) (% LHV)	68.5%