Addendum – Gateway CHP Verification and Commissioning

Location

Gateway Building
1 North Lexington Ave.
White Plains, NY 10601

Attendees

CDH Energy Corp. (CDH)	GI Energy
Hugh Henderson	Peter Falcier
Jeremy Wade	Curtis Knapper

Overview

CDH Energy was on site 12/01/2015 to verify and commission the instrumentation on the 2 MW cogeneration plant at the Gateway building in White Plains, NY. This Class A office building is located in downtown White Plains, adjacent to the White Plains Metro-North train station.

The main purpose of the site visit was to verify the location and installation of all the M&V sensors, perform field measurements to confirm the accuracy of the installed sensors, and take one time measurements where sensors were not installed.

M&V Sensor Locations and Installation

All sensors were identified in the field and compared to the annotated mechanical P&ID (Figure 3). Only one sensor was installed in a different location than shown on the P&ID drawing. The generator jacket water cooling flow (**FL1**) was not in the expected location, as shown in Figure 1.

All standalone flow meters were verified to be installed properly with the properly-sized pipe. The tags for **FL1** and **FL2** are shown in Figure 2.

We also reviewed the BTU Meters. The flow meter for the HHW BTU meter was not inserted into the pipe to the proper depth. When the flow meter was inserted another ¼ inch into the flow, the reading increased slightly to 600 GPM.

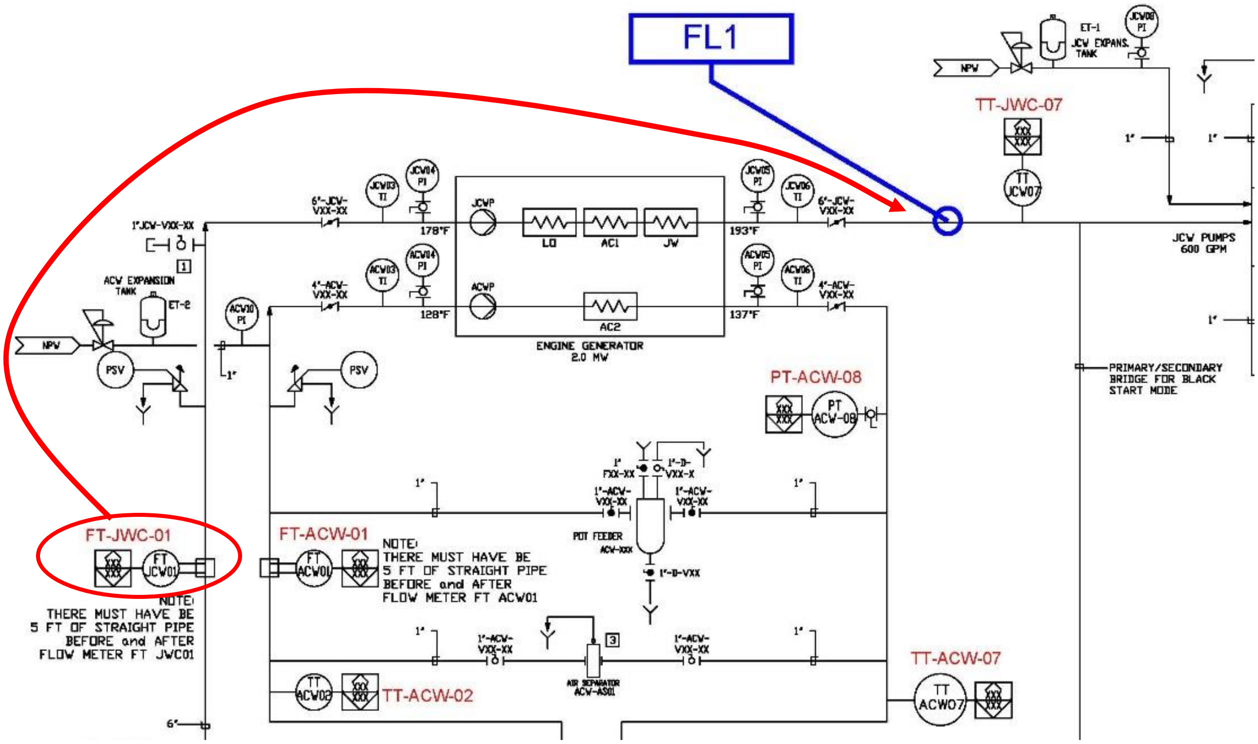
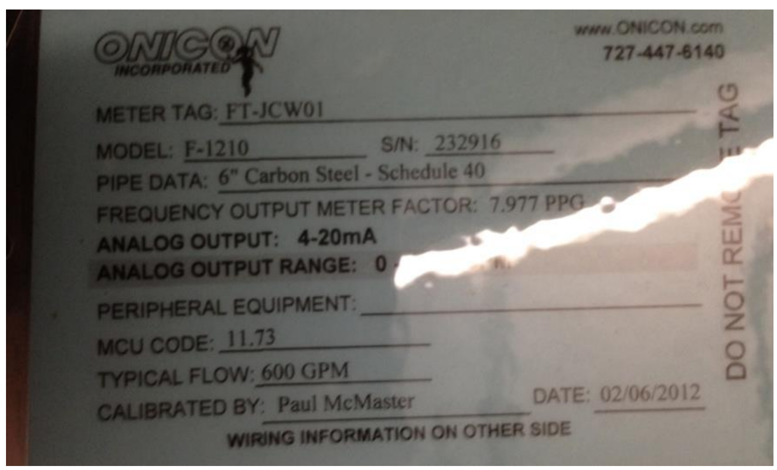
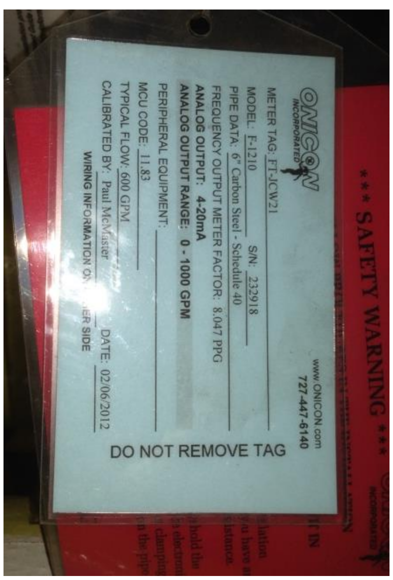


Figure 1. Actual Location of Flowmeter FL1



*Tag for **FL1***



*<< Tag for **FL2***

Figure 2. Flow Meter Tags for FL1 and FL2

Table 1. Data Points from Gateway SCADA System

Data Point	Point Name from P&ID	Description	Eng Units	Instrumentation
FG_ACC	FT-NG-14	Volume - CHP Gas Use	CF	Con Edison Utility Pulse Meter on CHP
FG_INT	FT-NG-14	Volume - CHP Gas Use (per interval)	CF	
WT_KW		Power - Total Building	kW	Import + Generator
WT_ACC		Energy - Total Building	kWh	
WCON		Energy - Total Con Edison Import	kWh	Import on all 3 meters
WCON_KW		Power - Total Con Edison Import	kW	
WC20		Energy - Con Edison Import Service 1	kWh	Con Ed Utility Meter
WC20_KW		Power - Con Edison Import Service 1	kW	
WC05		Energy - Con Edison Import Service 2	kWh	Con Ed Utility Meter
WC05_KW		Power - Con Edison Import Service 2	kW	
WC23		Energy - Con Edison Import Service 3	kWh	Con Ed Utility Meter
WC23_KW		Power - Con Edison Import Service 3	kW	
WG_GROSS_KW		Power - Gen Set Gross Output	kW	Engine Controller
WGEN_ACC		Energy - Gen Set Gross Output	kWh	SATEC Meter
WGEN_INT		Energy - Gen Set Gross Output (per interval)	kWh	
WGEN		Energy - Gen Set Gross Output (per interval)	kWh	
WTOT_E_ACC		Energy - Total Power Converter Output	kWh	Sum of WC1 + WC2 + Wc3
WTOT_E_KW		Power - Total Power Converter Output	kW	
WC1_KW		Power - Power Converter 1 Output	kW	Eaton IQ250
WC1_ACC		Energy - Power Converter 1 Output	kWh	
WC2_KW		Power - Power Converter 2 Output	kW	Eaton IQ250
WC2_ACC		Energy - Power Converter 2 Output	kWh	
WC3_KW		Power - Power Converter 3 Output	kW	Eaton IQ250
WC3_ACC		Energy - Power Converter 3 Output	kWh	
WTOT_B_KW		Power - Total On-Board Converter Output	kW	
WCONV1_KW		Power - PC1 On-Board Converter Output	kW	
WCONV2_KW		Power - PC2 On-Board Converter Output	kW	
WCONV3_KW		Power - PC3 On-Board Coverter Output	kW	
WCI1_KW		Power - Power Converter 1 Metered Input	kW	Eaton IQ250 (does not work)
WCI1_ACC		Energy - Power Converter 1 Metered Input	kWh	
WCI2_KW		Power - Power Converter 2 Metered Input	kW	Eaton IQ250 (does not work)
WCI2_ACC		Energy - Power Converter 2 Metered Input	kWh	
WCI3_KW		Power - Power Converter 3 Metered Input	kW	Eaton IQ250 (does not work)
WCI3_ACC		Energy - Power Converter 3 Metered Input	kWh	
FL1	FT-JCW-01	Flow - Jacket Cooling Water after Engine	gpm	Onicon F-1210
FL2	FT-JCW-21	Flow - Jacket Cooling Water after HX-01	gpm	Onicon F-1210
TLR1	TT-JCW-15	Temperature - Jacket Cooling Water after HRSR	°F	
TLR2	TT-JCW-17	Temperature - Jacket Cooling Water after Abs Chiller	°F	
TLR3	TT-JCW-20	Temperature - Jacket Cooling Water after HX-01	°F	
TLR4	TT-JCW-22	Temperature - Jacket Cooling Water after Bypass	°F	
TLR5	TT-JCW-02	Temperature - Jacket Cooling Water after Jacket Water HX	°F	
HHW_Q		Energy - Heating Hot Water Recovered Heat from HX-01	MMBtu/h	Onicon System 10 BTU Meter
HHW_FL	FT-HHW-04	Flow - Heating Hot Water (Load Side of HX-01)	gpm	
HHW_TLS	TT-HHW-05	Temperature - Heating Hot Water HX-01 Inlet (supply)	°F	
HHW_TLR	TT-HHW-03	Temperature - Heating Hot Water HX-01 Outlet (return)	°F	
CHW_Q		Energy - Chilled Water Heat Absorption	Btu/h	Onicon System 10 BTU Meter
CHW_FL	FT-CHW-01	Flow - Chilled Water	gpm	
CHW_TLS	TT-CHW-02	Temperature - Chilled Water Supply to Chiller	°F	
CHW_TLR	TT-CHW-03	Temperature - Chilled Water Return from Chiller	°F	
TGS	TT-EX-01	Temperature - Exhaust Gas before HRSR (supply)	°F	
TGR	TT-EX-02	Temperature - Exhaust Gas after HRSR (return)	°F	
TAO		Temperature - Outdoor Ambient Dry Bulb	°F	
TWBO		Temperature - Outdoor Ambient Wet Bulb	°F	
RHO		Relative Humidity - Outdoor Ambient	%RH	
FGEN		Flow - CHP Gas Use from Gen Set	cfm	
FGEN_INT		Volume - CHP Gas Use from Gen Set (per interval)	CF	
PFGI		Pressure - Gas Before Regulator	psi	
PFGO		Pressure - Gas After Regulator	psi	
TFGO		Temperature - Gas After Regulator	°F	
FB_ACC		Volume - Facility (Boiler) Gas Use	CF	
FB_INT		Volume - Facility (Boiler) Gas Use	CF	

Notes: Shaded Points are used in Data Integrator Database

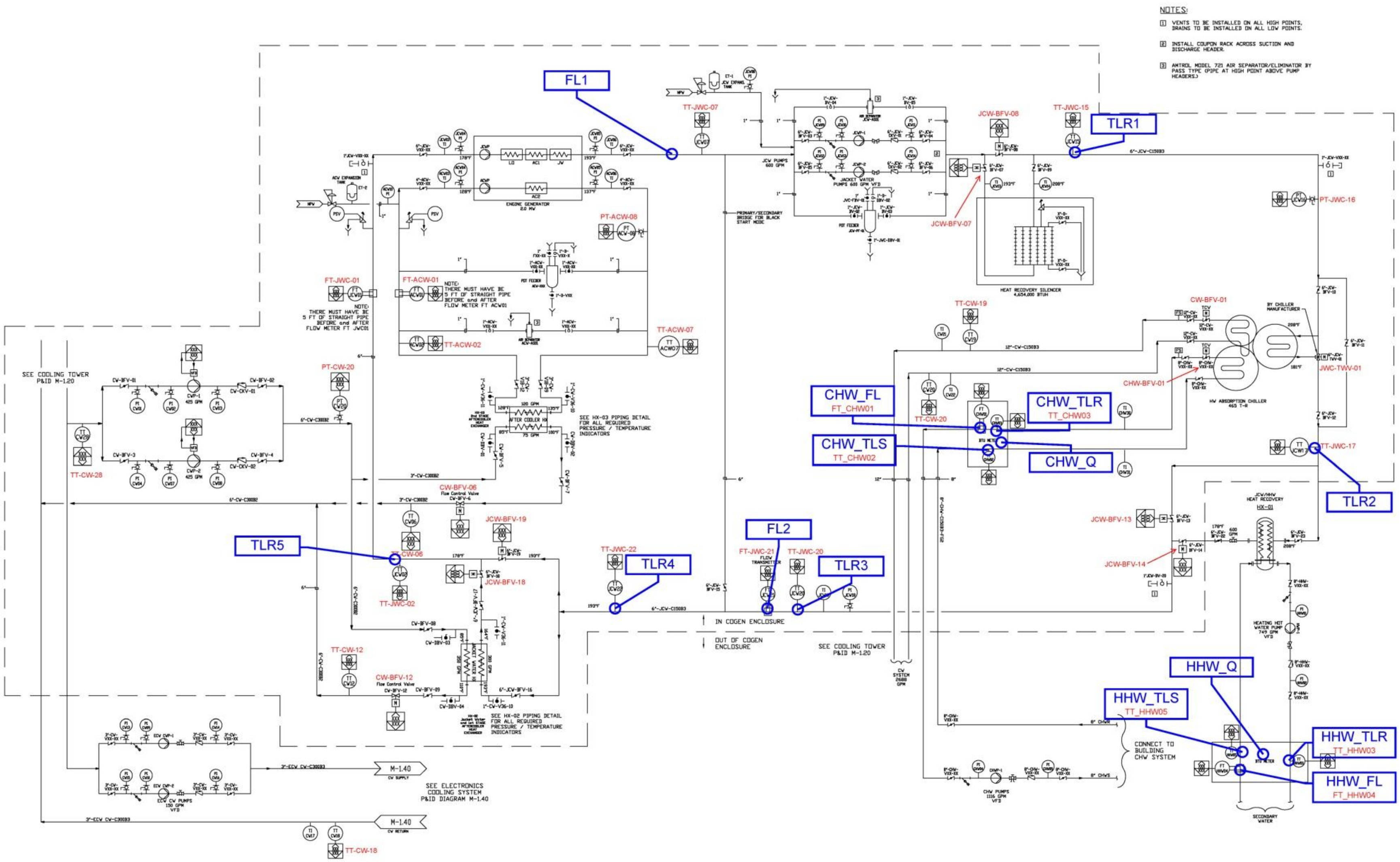


Figure 3. Piping Schematic with Monitored Data Points Shown

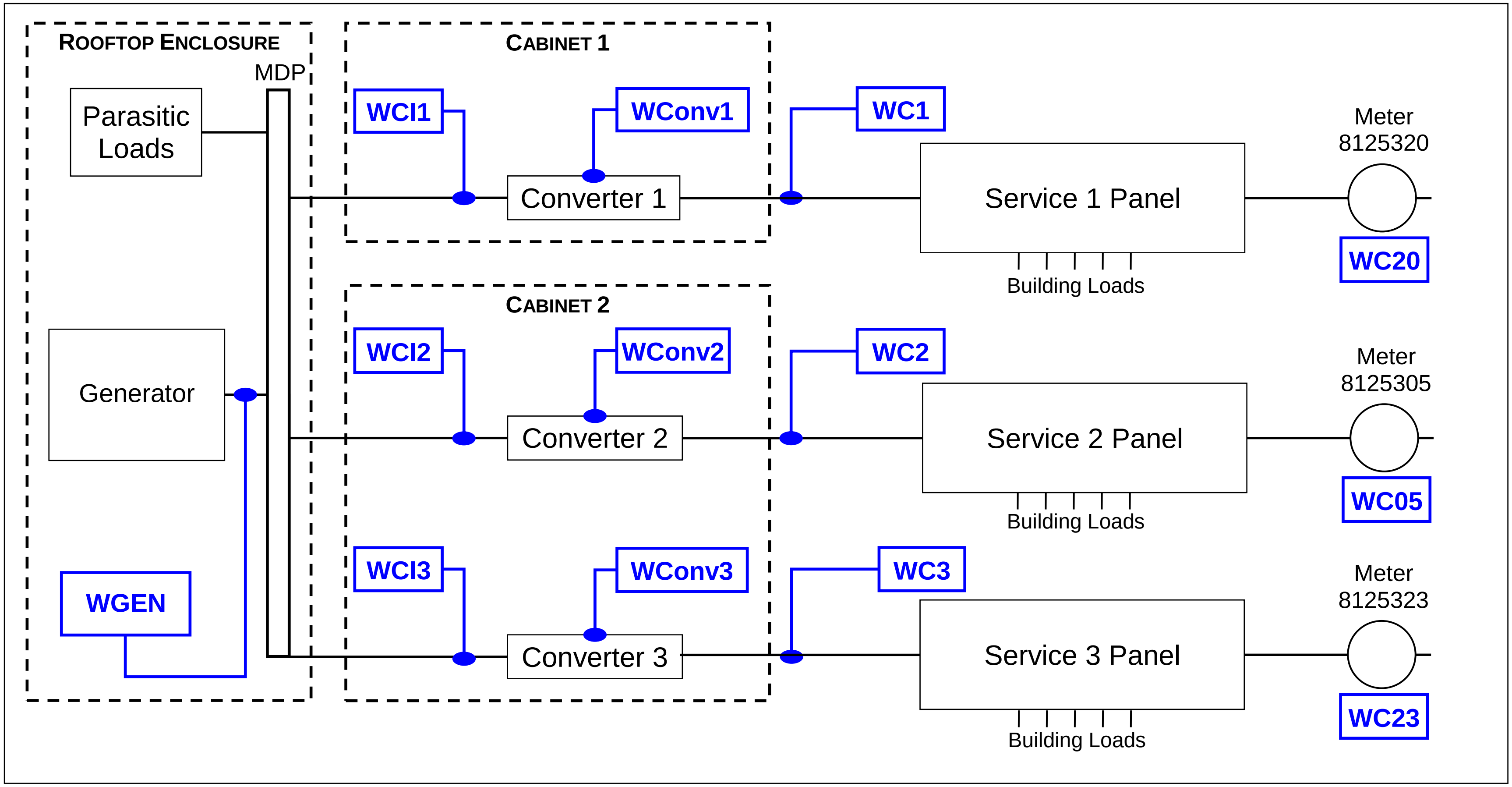


Figure 4. Electrical One-Line with Monitored Data Points Shown

Calculations to Determine Quantities of Interest for the NYSERDA CHP Website

CHP Website Variables	Required Calculations
WPARA: Parasitic Power Use (kW)	= **15.2**
WG_kW: Net Power Output (kW)	= **WC1_kW + WC2_kW + WC3_kW** or = **WTOT_e_kW**
WG: Net Energy Output (kWh)	= (**WC1_kW** + **WC2_kW** + **WC3_kW**) x 0.25 or = **WTOT_e_kW** x 0.25
FG: Engine Gas Consumption (CF) (Uses interval data)	= **FG_INT**
QHR: Useful Heat Recovery (Btu/h) ABS Chiller Heat: HX01 Heat:	When CHW_Q > 0 then: = **490** x **FL2** x (**TLR1** – **TLR2** **– 2.8**) Else: = **HHW_Q**
QD: Unused Heat Recovery (Btu/h)	= **490** x **FL1** x (**TLR4** – **TLR5**)
WT: Utility Power Consumption (kWh) (Uses interval data from Con Ed meter)	= (**WC20_kW** + **WC05_kW** + **WC23_kW**) x 0.25 or = **WCON_kW x 0.25**
FB: Building Gas Consumption (CF) (Uses interval data)	= **FB_INT**

Note: Values in green discussed below in the Field Measurements and Verification section

Field Measurements and Verification

Loop Temperatures

While onsite, we observed a period when both HX-01 and the absorption chiller readings were not in operation. Table 2 shows the cogen loop (JWC) temperatures that were recorded under no load conditions. The jacket water supply temperature (**TLR1**) after the exhaust heat recovery system consistently reported as 2.8°F higher temperature than the other temperatures during this condition. Therefore we will apply a - 2.8°F offset to **TLR1** for any heat recovery calculations.

Table 2. Temperature and Flow Readings Around the JWC Loop

Readings for JCW Loop under No Load Conditions				
Cain HRSR (°F)	**TLR1 (°F)**	**TLR2 (°F)**	**TLR3 (°F)**	**FL2 (gpm)**
200.0	202.8	199.8	200.0	601.0
	202.9	199.7	200.0	603.0
	202.7	199.9	199.9	602.0

Loop Flow (FL2)

We used a handheld Doppler flow meter to measure the fluid velocity to confirm **FL2**. The results are reported in Table 3 and Figure 5 shows the measurement location. In this case the fluid was 200°F, though the flow meter head can only reliably measure the fluid velocity at temperatures less than 180°F (this may have had a modest impact on accuracy).

The velocity to volumetric flow rate conversion is: $GPM = 2.45 \times ID^2 \times FPS$
Where:

- GPM is Gallons per Minute
- ID is the Inside Diameter of the pipe (6" Carbon Steel Pipe ID is 6.065")
- FPS is Feet per Second.

Table 3. Jacket Water Flow Measurements Using a Doppler Flow Meter

Doppler Flow Meter		**Onicon Flow Meter FL2 (FT-JWC-21)**
FPS	GPM	GPM
5.3	478	596
5.4	487	
5.5	496	
5.6	505	
5.7	514	

The flow rate indicated by the Doppler flow meter is 100 gpm lower than the Onicon meter.

Initially, we tried to use the Fuji transit time ultrasonic flow meter on **FL2**, but were unable to get a signal. Transit time flow meters require clean fluid. In this case debris or excessive air bubbles may have made it difficult for transit time meter to work.

Figure 5. Jacket Water Supply (right) and Return (left) Pipes in the Chiller and HRSG Container

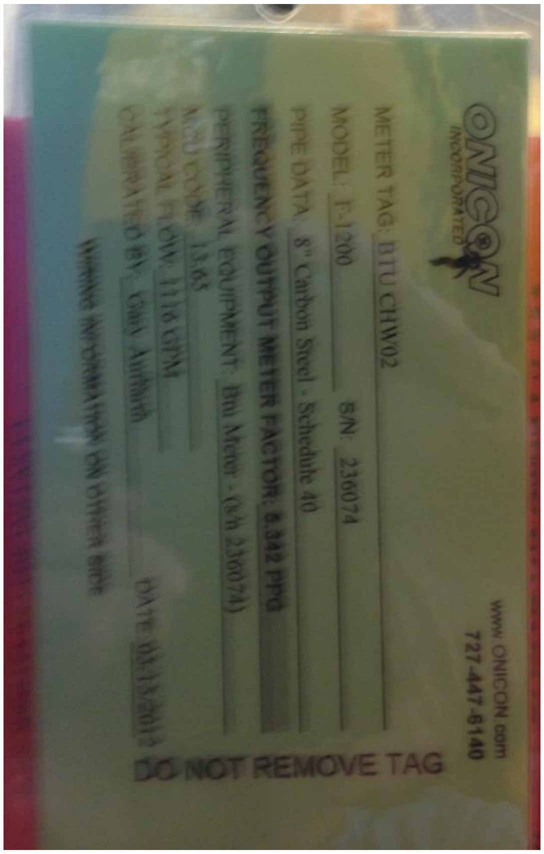
Impact of Swapped BTU Meters

We determined that the BTU Meters on the HHW and CHW loops were swapped. The BTU meter in the HHW location expected a design flow of 1116 gpm – which is the expected flow for the CHW Loop. Figure 6 shows the flow meter and BTU Meter tags for both locations.

Table 4 compares the expected or design information on the meter tag to the actual data for each location. The meter intended for the chilled water loop (BTU CHW02) was installed in the HHW loop instead. Fortunately, the pipes were 6 inch schedule 40 steel in each location. While the flows were different than intended, in both cases the resulting velocity was within the range of 3 to 30 ft/s required for ±1% meter accuracy.

We confirmed with Onicon that the expected fluid was water for each BTU meter. The chilled water loop likely has water (without glycol) since it is directly connected to the main chilled water system. Similarly, the load-side hot water piping connects directly into the building's space heating system which should use pure water.

HHW BTU Meter (BTU CHW02)



HHW Flowmeter Tag

CHW BTU meter (BTU CHW01)

Figure 6. BTU Meters at HHW and CHW Locations

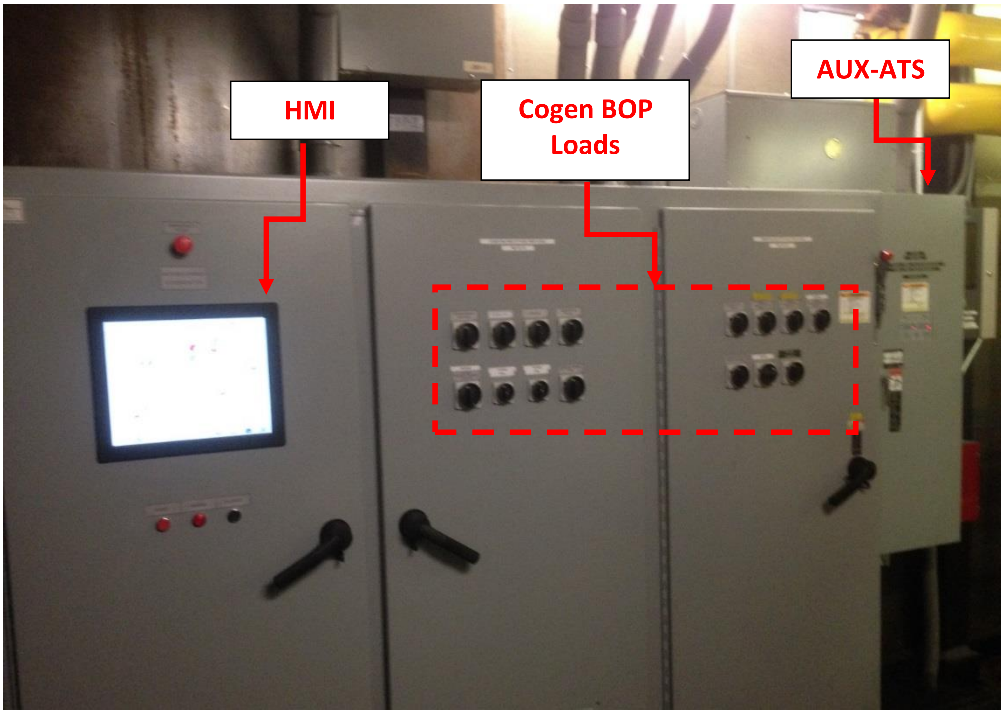
Table 4. Comparing Tag (Design) and Actual Flow Readings

				Design / Meter Tag			Actual / Measured		
Loop	**Serial No**	**Fluid**	**Meter Tag**	**Flow (gpm)**	**Pipe Diam (in)**	**Velocity (ft/s)**	**Flow (gpm)**	**Pipe Diam (in)**	**Velocity (ft/s)**
HHW	236074	Water	BTU CHW02	1116	8	7.1	600	8	3.8
CHW	232911	Water	BTU CHW01	749	8	4.8	1150	8	7.3

Notes: Actual velocities are all within the ±1% accuracy limit of 3 to 30 ft/s

Parasitic Panels and Electrical Arrangement

The Cogen BOP panel (Figure 7) can be fed from an automatic transfer switch (ATS) that uses two sources. The “normal” source for automatic transfer switch (AUX-ATS) was intended to be the generator bus (52AUX). In an emergency, the BOP panel can be fed from the EMCCP-2 emergency panel. However, the staff reported that AUX-ATS is always set to “emergency” source, as shown in Figure 8. The “emergency” source is fed from the utility during normal operating times. The original monitoring plan intended to capture net power output from the inverters, since the parasitic power was supposed to be on the generator bus.



Main Panel

Left Hand Side

Right Hand Side

Figure 7. The Cogen Balance of Plant (BOP) Panel

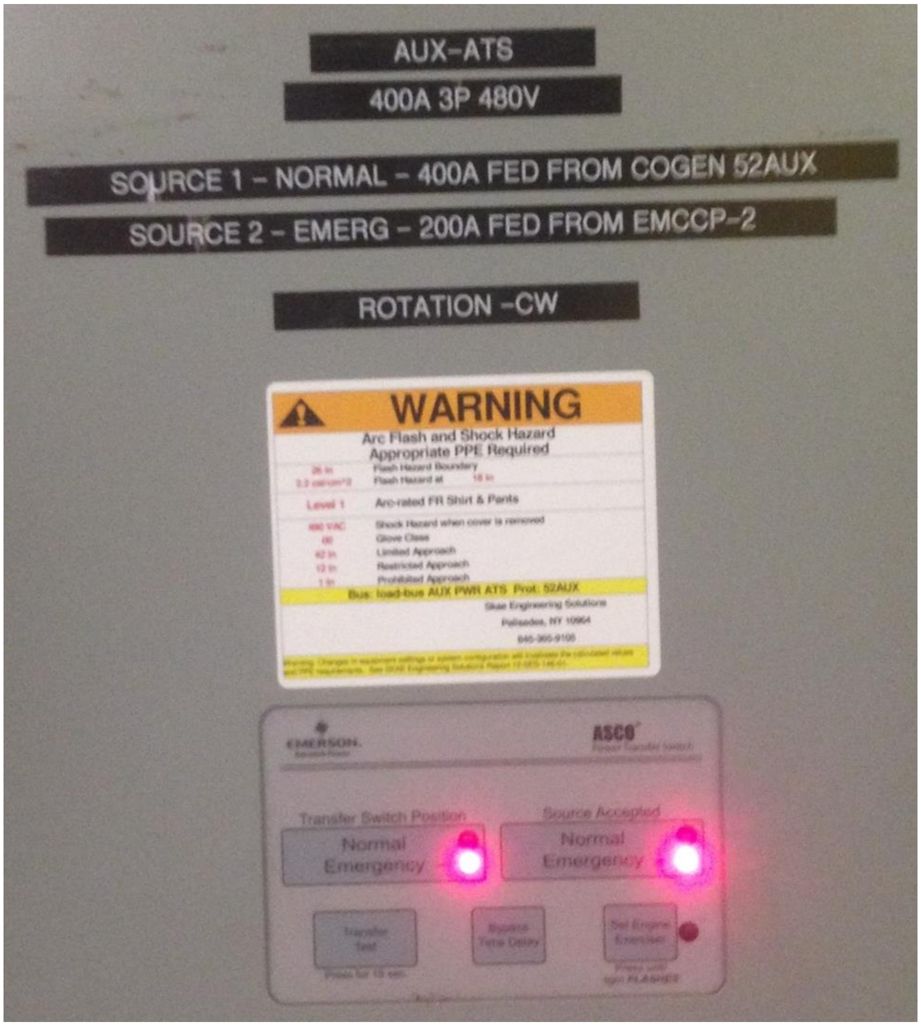


Figure 8. AUX-ATS Switches the Cogen BOP Panel Between Normal (Generator) and Emergency Sources

Therefore, we must now separately account for parasitic power. The parasitic power in the Cogen Balance of Plant (BOP) Panel was measured with a hand-held Fluke power meter. The results are given in Table 5.

Table 5. Parasitic Power Measurements in Cogen Aux Panel EMCCP-2

w/o Cooling Tower Fan	w/ Cooling Tower Fan
15.2 kW	20 kW

This measured parasitic load of 15.2 kW (w/o the Tower) will be applied to the Cogen output. The Cogen BOP loads include the equipment shown in Figure 7 and Table 6.

Table 6. Cogen Balance of Plant Loads

Transformer Sub-Feed	Ventilation Fan #2 (OFF)
Cogen-PP-1	**Cooling Water Pump #1**
[Absorption] Chiller (OFF)	**Cooling Water Pump #2**
Ventilation Fan #1 (OFF)	**Engine Jacket Water Cooling Pump #1**
Engine Jacket Water Cooling Pump #2	Cooling Tower Basin Heater (OFF)
Purge Fan	**SPARE**
Purge Fan	**Crankcase Ventilator**
Cooling Tower Fan (OFF)	

Notes: Bold items are included in 15 kW.