M&V Plan for DG/CHP System

Shore View Nursing & Rehabilitation Center

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Submitted to:

New York State Energy Research and Development Authority

17 Columbia Circle

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Submitted by:

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Introduction

All Systems Cogeneration, Inc. (ASC) has installed a combined heat and power (CHP) system at Shore View Nursing & Rehabilitation Center in Brooklyn, NY, a short-term, sub-acute, and long-term rehabilitation and nursing services center. The CHP system is based around one (1) INV-100 100 kW InVerde 100 cogen unit provided by Tecogen. The InVerde unit includes a natural gas-fired reciprocating V8 engine, water cooled permanent magnet generator, jacket water and exhaust heat recovery systems, and self-contained inverter in a sound attenuating enclosure. The unit can provide 100 kW of continuous power, 125 kW of peak power, and 700 MBtu/h of thermal output as hot water.

The CHP system contains a low temperature loop for domestic hot water (DHW) heating and an inverter cooling loop. The low temperature loop includes a heat exchanger (HX) for DHW loads and a dump radiator to remove excess heat. The generator cooling loop flows directly to a cooling radiator.

Monitoring System

A monitoring system was installed to measure the performance of the CHP system. The monitoring system is based around an Obvius AcquiSuite data logger. ASC provided and installed the flow meter, gas meter, and the parasitic power meter. CDH Energy (CDH) provided the temperature sensors and installed and commissioned the monitoring system. The critical monitored points to quantify the CHP system performance are listed in Table 1.

The total useful thermal output of the system (**QU**) is calculated using the measured temperatures across the DHW HX and flow measured by the flow meter (**FL**, **TLS**, **TLR1**). Heat rejected by a dump radiator is calculated using the flow and temperatures measured across the dump radiator (**FL**, **TLR1**, **TLR2**).

The generator gross power output ($\mathbf{WG_{GROSS}}$) is read directly from the cogen unit. The parasitic power (**WP**) is calculated using the current to the larger parasitic loads. The parasitic loads typically include: cogen loop pumps and fans. The system's total parasitic loads are subtracted from the gross power ($\mathbf{WG_{GROSS}}$) output to calculate the unit's net power (**WG**). Natural gas to the cogen unit (**FG**) is measured using a utility provided pulse meter.

Table 1. Monitored Data Points

Logger Channel	Data Point	Description	Eng Units	Instrument / Transducer	Output
MB-001	WG_GROSS	Gross Power Output	kWh	INVERDE Modbus Output	Modbus RTU
MB-002	WP	Parasitic Loads	kWh	Continental Controls Wattnode	Modbus RTU
-	WG	Net Power Output	kWh	-	Calculated
MB-001	WT	Total Building Import	kW	INVERDE Modbus Output	Modbus RTU
1	FG	Cogen Gas Consumption	cf	NGrid Utility Meter Pulse Output	Pulse
2	FL	Flow - Heat Recovery Loop	gpm	Onicon F-1111	4 - 20 ma
3	TLS	Temperature - Supply	ºF	Veris 10k Type 2 Thermistor	Resistance
4	TLR1	Temperature - after DHW HX	ºF	Veris 10k Type 2 Thermistor	Resistance
5	TLR2	Temperature - after Dump HX	ºF	Veris 10k Type 2 Thermistor	Resistance
-	QU	Total Useful Heat Recovery	MBtu	-	Calculated
-	QR	Rejected Heat Recovery	MBtu	-	Calculated

Sensor Details

- Temperature
  - Veris Industries – 4" Remote Probe 10K Type 2 Thermistor
- Water Flow
  - Onicon – F-1111 Insertion Style Impeller Flow Meter
- Gas Flow
  - National Grid Utility Pulse Meter

Data Logging System

CDH provided, installed, and wired an Obvius AcquiSuite data logger and temperature sensors. ASC provided and installed an Onicon flow meter for the low temperature loop and the gas meter and wiring. The data logger is connected to the internet via a Cradlepoint 3G cellular modem that will have a static IP address. The Obvius uploads data to CDH, that is then served up to the NYSERDA Data Integrator web site.

Data Analysis

Heat Recovery Rates

The heat recovery rates are calculated using the 1-minute data collected.

Total Useful Heat Recovery

$$QU = k \cdot \frac{1}{N} \cdot \sum FL \cdot (TLS - TLR1)$$

Rejected Heat Recovery

$$QR = k \cdot \frac{1}{N} \cdot \sum FL \cdot (TLR1 - TLR2)$$

"N" is the number of scan intervals included in each recording interval (e.g., with 1-minute data, N=60).

The k-factor is the product of the density and specific heat of the heat transfer fluid. The heat transfer fluid for the high temperature loop is expected to be a water glycol mixture, which has a k-factor of $480\ \mathrm{Btu/h \cdot gpm \cdot °F}$ at an operating temperature of 180°F.

Calculated Quantities

The net power output from the CHP system (**WG**), is defined as the gross output of the generator (**WG_{gross}**) minus the measured parasitic loads (**WP**).

The net total efficiency of the CHP system, based on the higher heating value of the fuel, is defined as:

$$TE_{net} = \frac{QU + 3{,}413 \cdot WG}{HHV_{gas} \cdot FG}$$

Where:

QU	-	Useful heat recovery (Btu)
WG	-	Net generator output (kWh)
FG	-	Generator gas consumption (Std CF)
HHV_{gas}	-	Higher heating value for natural gas (~1,032 Btu/CF)

Addendum – Shore View

Location

Shore View Nursing & Rehabilitation Center
2865 Brighton 3rd Street
Brooklyn, NY 11235

Site Contact

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- CDH was on site 1/27/2016 to install and commission the instrumentation on the 100 kW Tecogen Inverde INV-100.
- All Systems Cogeneration (ASC) was on site the week of 6/20/2016 to replace the reciprocating engine in the cogen unit after a catastrophic failure.
- ASC was on site 7/1/2016 to add an additional booster pump.
- ASC was on site 2/15/2017 to relocate the flow meter.
- CDH was on site 2/22/2017 to verify Onicon flow meter.

Summary

CDH provided the data logger, enclosure, communications, current sensors, and temperature sensors. ASC provided and installed the flow meter and gas meter. ASC installed the CDH enclosure and performed all the necessary wire pulls and provided 120V power to the enclosure. CDH terminated wiring to the data logger and to the sensors. The M&V enclosure is located in the north east corner of the boiler room near the DHW heat exchanger.

Monitored Data Points

Logger Channel	Data Point	Description	Eng Units	Instrument / Transducer	Output
MB-001	WG_GROSS	Gross Power Output	kW	INVERDE Modbus Output	Modbus RTU
MB-001	WG_ACC	Energy - Gross Generator Output	kWh	INVERDE Modbus Output	Modbus RTU
MB-001	WG_INT	Energy - Gross Generator Output per Interval	kWh	INVERDE Modbus Output	Modbus RTU
-	WP	Power - Parasitic Loads	kW		Calculated
-	WG	Net Power Output	kW	-	Calculated
1	FG	Cogen Gas Consumption	cf	NGrid Utility Pulse Meter	Pulse
2	FL	Flow - Heat Recovery Loop	gpm	Onicon F-1111	4 - 20 ma
3	TLS	Temperature - Supply	^{0}F	Veris 10k Type 2 Thermistor	Resistance
4	TLR1	Temperature - after DHW HX	^{0}F	Veris 10k Type 2 Thermistor	Resistance
5	TLR2	Temperature - after Dump HX	^{0}F	Veris 10k Type 2 Thermistor	Resistance
6	IFANS	Current - Dump Fans	A	Veris H921	4 - 20 ma
-	QU	Total Useful Heat Recovery	MBtu	-	Calculated
-	QR	Rejected Heat Recovery	MBtu	-	Calculated

Verification

Flow

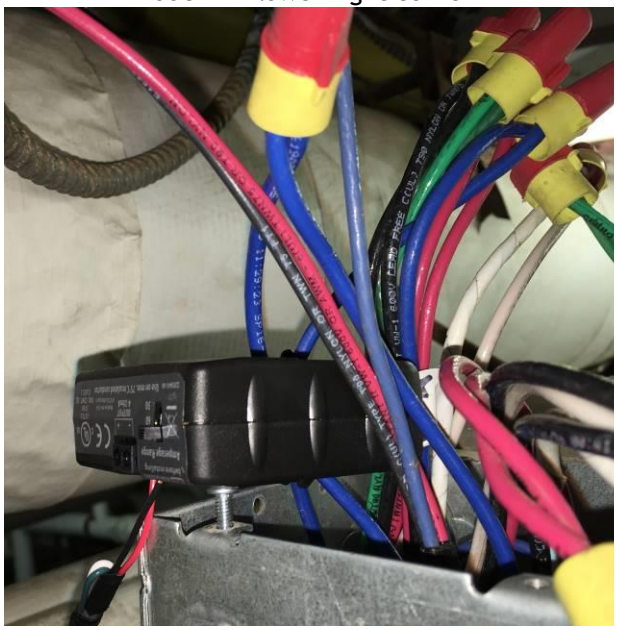
The heat recovery loop was verified using a Fuji Electric, transit-time, ultrasonic flow meter.

FL	Ultrasonic (gpm)	Onicon (gpm)
	22.3	20.6
	22.2	20.7
	22.2	20.9
	22.2	20.9
	22.4	21.0
	22.5	20.8
	22.6	20.9
	22.5	20.9
	22.6	20.7
Avg.	22.4	20.8

Site Photos

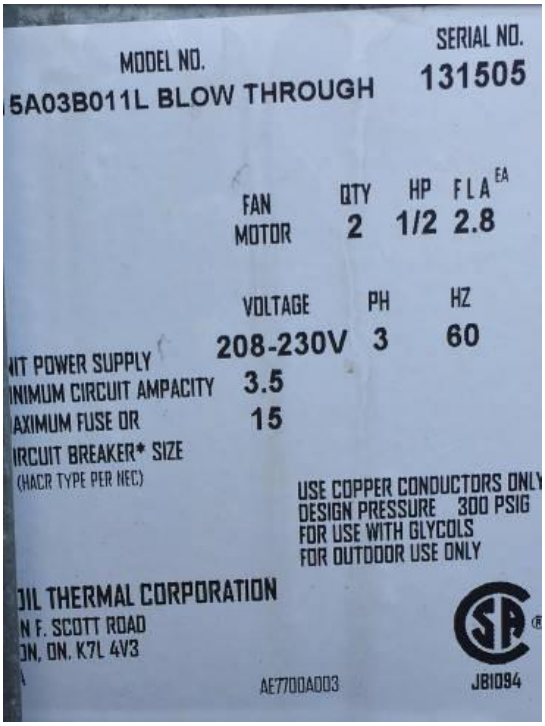
CDH M&V enclosure with Cradlepoint cellular modem in lower right corner

Tecogen InVerde 100 CHP Cogeneration Unit



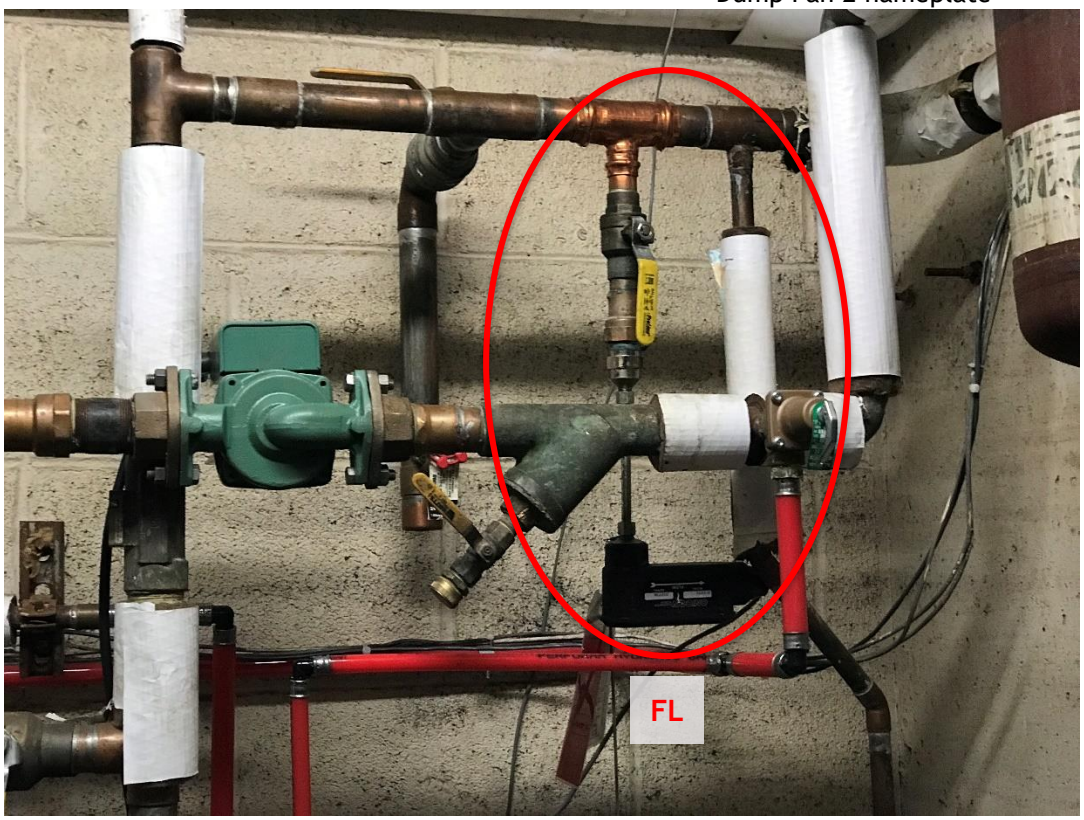
Veris H921 Analog CT measuring both dump radiator fans (**IFANS**)

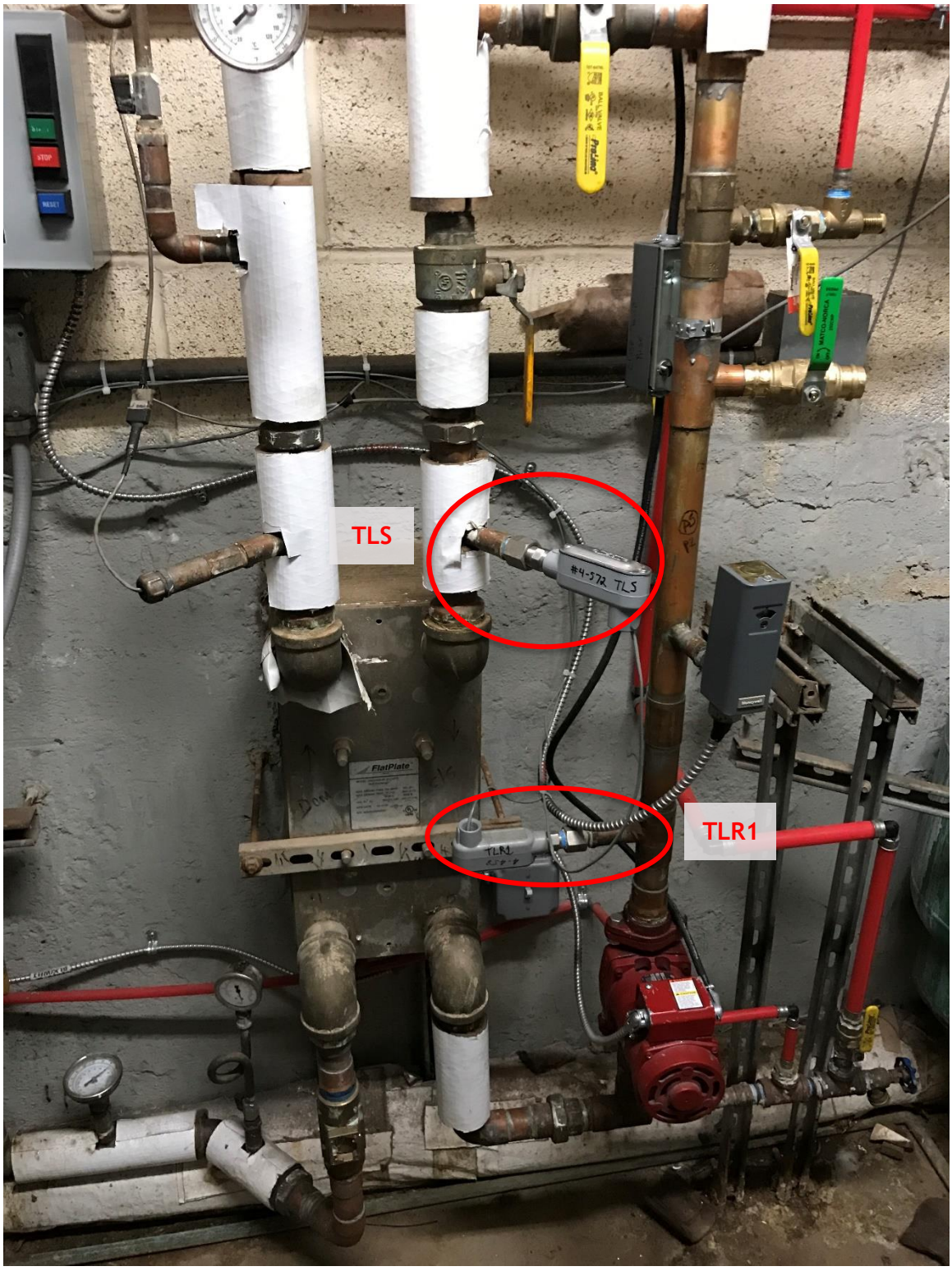
GE Roots Meter with 100CF/pulse pulse output (**FG**)



Dump Fan 1 nameplate

Dump Fan 2 nameplate





Two (2) temperature sensors (**TLS**, **TLR1**)

Temperature sensor after the dump radiator (**TLR2**)