M&V Plan for DG/CHP System

Elbee Gardens Apartments

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Submitted to:

New York State Energy Research and Development Authority

17 Columbia Circle

Albany, NY 12203-6399

Submitted by:

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Facility:

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Staten Island, NY 10304

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Introduction

All Systems Cogeneration, Inc. (ASC) is installing a combined heat and power (CHP) system at the Elbee Gardens Apartments in Staten Island, NY, a multifamily, section 8 apartment building. The CHP system will be based around one (1) INV-100e+ 100 kW InVerde 100e+ cogen unit provided by Tecogen. The cogen 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 will contain two (2) separate water loops; a low temperature loop for domestic hot water (DHW) heating and a high temperature steam loop. The low temperature loop includes a heat exchanger (HX) for DHW loads and a cooling radiator to remove excess heat. The high temperature loop boosts the condensate temperature going to the boiler. The inverter cooling loop flows directly to a cooling radiator.

Monitoring System

A monitoring system will be installed to measure the performance of the CHP system. The monitoring system is based around an Obvius AcquiSuite data acquisition server (DAS). CDH Energy (CDH) will provide the DAS, cellular modem for communications, flow meter, current sensors for measuring parasitic power, and temperature sensors. ASC will provide a pulse output from the Utility gas meter to the CDH M&V enclosure, and CDH will install and commission 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 the flow measured by the flow meter (**FJW**, **TJWS**, **TJWR1**) as well as the measured output from the high temperature loop BTU meter (**FEX**, **TEXS**, **TEXR**). Heat rejected by a dump radiator is calculated using the flow and temperatures measured across the dump radiator (**FJW**, **TJWR1**, **TJWR2**). There is no dump radiator on the high temperature loop.

The generator gross power output ($\mathbf{WG_{GROSS}}$) is read directly from the cogen unit. The parasitic power (**WP**) is calculated using the sum of the measured dump fan currents (**IFC1**, **IFC2**) and

assumed constant pump loads. The parasitic loads usually include cogen loop pumps and fans. The total parasitic load is subtracted from the gross power (**WG_{GROSS}**) output to calculate the unit's net power (**WG**). Natural gas to the cogen unit (**FG**) will be measured using the Utility gas meter with a pulse output.

Table 1. Monitored Data Points

Data Point	Description	Eng Units	Instrument / Transducer
WG_GROSS	Gross Power Output	kW	INVERDE Modbus Output
WG_ACC	Energy - Gross Generator Output	kWh	
WG_INT	Energy - Gross Generator Output per Interval	kWh	
WP	Power - Parasitic Loads	kW	Calculated
WG	Net Power Output	kW	Calculated
FG	Cogen Gas Consumption	cf	NGrid Utility Meter Pulse Output (100CF/pulse)
FJW	Flow - Jacket Water Heat Recovery Loop	gpm	Onicon F-1111
TJWS	Temperature - JW Supply	^{0}F	Veris 10k Type 2 Thermistor
TJWR1	Temperature - JW after HX1	^{0}F	Veris 10k Type 2 Thermistor
TJWR2	Temperature - JW after FC-1	^{0}F	Veris 10k Type 2 Thermistor
FEX	Flow - High Temp Exhaust Heat Recovery Loop	gpm	Badger BTU Meter
TEXS	Temperature - EX Supply	^{0}F	
TEXR	Temperature - EX Return	^{0}F	
IFC1	Current - Cooling Fan 1	A	Veris H921
IFC2	Current - Cooling Fan 2	A	Veris H921
QJW	Jacket Water Heat Recovery	MBtu	Calculated
QEX	High Temp Exhaust Heat Recovery	MBtu	Calculated
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 (low temp loop)
  - Badger Meter Series 380 self-contained temperature sensors (high temp loop)
- Water Flow
  - Onicon – F-1111 Insertion Style Impeller Flow Meter (low temp loop)
  - Badger Meter Series 380 Inline Impeller Flow Meter (high temp loop)
- Gas Flow
  - Utility Gas Meter with 100cf/pulse, Pulse Output

Data Logging System

CDH will provide, install, and wire the DAS, cellular modem, flow meter, current and temperature sensors. ASC will provide the pulse output from the utility gas meter. The DAS will connect to the internet via the cellular modem with a static IP address. The DAS will upload data to CDH, who serves it 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 50% water glycol mixture, which has a k-factor of $452\ \mathrm{Btu/h \cdot gpm \cdot °F}$ 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:

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

Where:

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

Addendum – Shore View

Location

Elbee Garden Apartments
1950 Clove Road
Staten Island, New York 10304

Site Contact

Gregg Giampaolo
All Systems Cogeneration
1595 Ocean Avenue, Suite A12
Tel (631) 750-6060
all-systems@att.net

- CDH was on site 6/21/2017 to install all M&V instrumentation and setup communications.
- CDH was on site 10/24/2017 for final M&V instrumentation verification

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 to the enclosure. CDH terminated wiring to the data logger and to the sensors. The M&V enclosure is located on the south west wall of the CHP room just inside the entrance to the room.

Monitored Data Points

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TEXS	Temperature - EX Supply	ºF	
TEXR	Temperature - EX Return	ºF	

Verification

Flow

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

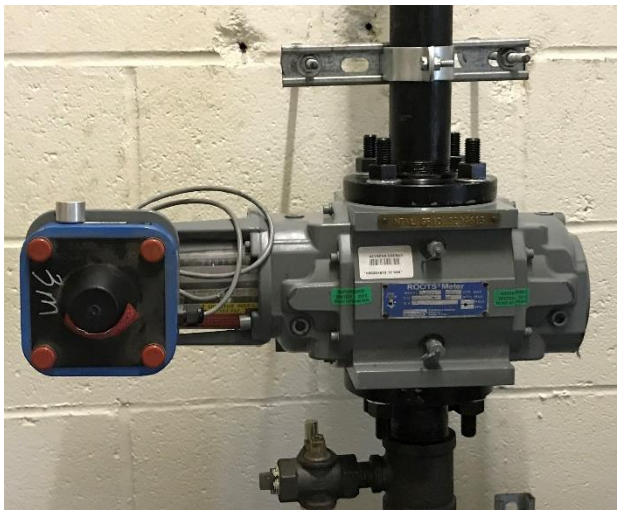
FL	Ultrasonic (gpm)	Onicon (gpm)
	27.18	26.58
	26.71	24.40
	27.60	24.07
	27.55	26.33
	27.84	25.52
	27.53	24.89
	27.29	24.73
	27.52	24.66
	26.64	25.70
	27.38	26.24
	27.05	23.47
Avg.	27.30	25.14

Site Photos

CDH M&V enclosure with Cradlepoint cellular modem mounted on right side of enclosure

Tecogen InVerde INV100e+ Modbus Door Panel

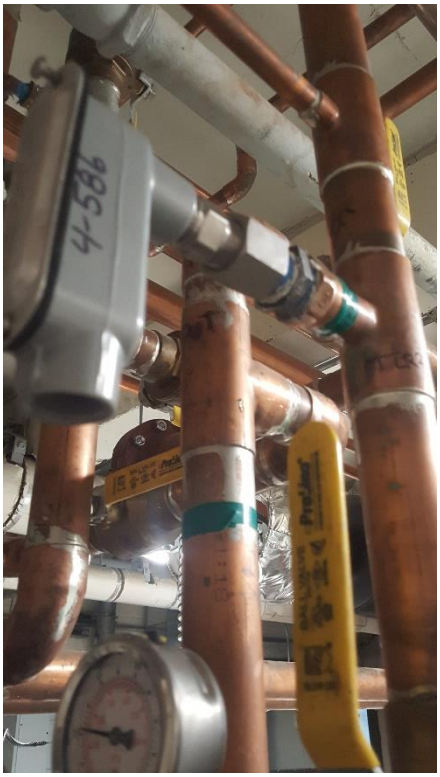
Veris H921 Analog CTs measuring dump radiator fans (**IFC1, IFC2**)



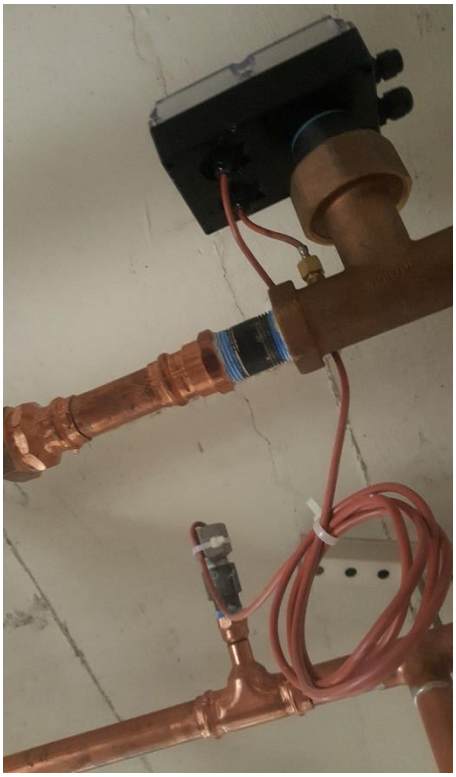
GE Roots Meter with 100CF/pulse pulse output (**FG**)

TJWS Thermistor

TJWR1 Thermistor



TJWR2 Thermistor



Badger BTU Meter for Exhaust Gas HW Loop

Onicon Flow Meter for Jacket Water Loop