M&V Plan for DG/CHP System

Morrisania Apartments

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Introduction

All Systems Cogeneration, Inc. (ASC) is installing a combined heat and power (CHP) system at the Morrisania Apartments in the Morrisania neighborhood of the Bronx, a multi-family apartment building. The CHP system will be 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 will contain two (2) separate water loops; 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 cooling radiator to remove excess heat. 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 (**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 measured current (**IPARA**) of all the loads in the parasitic electrical panel. The parasitic loads usually include cogen loop pumps and fans. The total parasitic load is subtracted from the gross power ($\mathbf{WG_{GROSS}}$) 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

Logger Channel	Data Point	Description	Eng Units	Instrument / Transducer	Output
MB-002	WG_GROSS	Gross Power Output	kW	Inverde Modbus Output	Modbus RS-485
	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
Exp IN-1	FG	Cogen gas consumption	Cf	Utility Gas meter w/ pulse	Pulse
Exp IN-2	FL	Flow – Heat recovery loop	Gpm	Onicon F-1111	4-20 mA
Exp IN-3	TLS	Temperature – Supply	ºF	Veris 10k Type II Thermistor	Resistance
Exp IN-4	TLR1	Temperature – After DHW HX	ºF	Veris 10k Type II Thermistor	Resistance
Exp IN-5	TLR2	Temperature – After dump fans	ºF	Veris 10k Type II Thermistor	Resistance
Exp IN-6	IPARA	Current – 208V parasitic panel	A	Veris H921	4 - 20 mA
-	QU	Total Useful Heat Recovery	MBtu/h	-	Calculated
-	QR	Rejected Heat Recovery	MBtu/h	-	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
  - Utility Gas Meter with 10cf/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)