MEASUREMENT AND VERIFICATION PLAN

FOR

DG/CHP SYSTEM
AT
DORAL ARROWWOOD
HOTEL CONFERENCE CENTER

As Built

December 18, 2012

Submitted to:

New York State Energy Research and Development Authority
17 Columbia Circle
Albany, NY 12203-6399

Submitted by:

CDH Energy Corp.
PO Box 641
2695 Bingley Rd
Cazenovia, NY 13035
(315) 655-1063
www.cdhenergy.com

Project Team:

NYSERDA Project Manager:

Joanna Moore
Energy Efficiency Services
NYSERDA
1-866-NYSERDA x. 3220
Email: jm1@nyserda.org

Developer/Applicant:

American DG Energy Inc.
45 First Avenue
Waltham, MA 02451
phone: (781) 522-6032
MAddeo@americandg.com

Michael Scorrano, EN-POWER GROUP
Group-S LLC (sub-consultant)
16 Frances Drive
Katonah, NY 10536
mscorrano@en-powergroup.com

NYSERDA QC Contractor:

John Defrees
Modern Energy Technologies (as sub-contractor to CDH Energy)
2830 Tuscaora Road
Erieville, NY 13061
Tel (315) 662-3243
john@modernenergyllc.com

NYSERDA M&V Contractor:

Adam Walburger, CDH Energy
PO Box 641
2695 Bingley Rd
Cazenovia, NY 13035
315-655-1063
walburger@cdhenergy.com

1. Introduction

American DG Energy, Incorporated (AMDG) has installed a combined heat and power (CHP) system at the Doral Arrowwood Hotel Conference Center in Rye Brook, New York. The proposed CHP system is configured around three 100 kW reciprocating engine-generator sets. The system is intended to produce a net output of 285 kW and recover jacket water and exhaust heat for domestic hot water (DHW) service, pool heating, as well as supplementing the facility's seasonal space heating requirements. The CHP system will run in parallel with the existing utility service and operate in an electric load following mode during the summer capability period and thermal load follow over the rest of the year.

2. Instrumentation

In order to quantify the performance of the proposed CHP system, the CHP system fuel input, net electrical output, and useful thermal output must be measured. To capture these energy flows, an instrumentation plan was developed by CDH Energy and presented to the applicant, AMDG. The instrumentation plan covers the location and type of sensors necessary to provide the appropriate measurements of the energy flows of the system.

AMDG has an Obvius Acquisuite 8812 installed to be used for their own data collection purposes. This logger will also satisfy the NYSERDA monitoring requirements as it is equipped with the appropriate sensors installed in locations suitable for characterizing the system energy flows.

In accordance to the instrumentation plan, AMDG has supplied the instrumentation listed Table 1 and shown in the system diagram for use in meeting the NYSERDA CHP program monitoring requirements.

Table 1. Instrumentation Supplied By AMDG

Point	Instrument	Output Type	Sensor Location	Notes
Generator Power Output	Veris H8035-300	Modbus	CHP Container	• WG1, WG2, WG3 • Meter location is gross power output for each generator • Already installed by AMDG
System Parasitic (Combined)	Veris H8035-100	Modbus	Parasitic Load Panel LVTC in boiler room	• WPAR
Generator Gas Input	Utility Gas Pulse	Pulse Output	At gas service entrance to CHP Container	• FG • Meter and rate selection subject to Con Ed discretion • Engine heat rate calculated from utility data and measured generator energy output
Heat recovery Loop Flow Rate	Contrec 212 BTU Meter	Modbus	CHP Container	• FL from BTU meter • Already installed by AMDG
Heat Recovery Loop Temperatures	Contrec 212 BTU Meter	Modbus	CHP Container	• TLS, TLR1 from BTU meter • Already installed by AMDG
Heat Recovery Loop Temperatures	10k Type II Thermistor	Resistance	CHP Container	• TLR2 • Diagnostic measurement

Datalogger and Onsite Installation

The Obvius Acquisuite 8812 data logger installed by AMDG records readings for the installed instrumentation. The data logger samples all sensors approximately once per second and records five-minute totals (of pulse or digital sensors) or averages (of analog sensors). The five minute readings of heat recovery temperatures and flows are used to provide an accurate calculation of heat transfer on the heat recovery loops, which are all continuous flow loops.

Based on the number of monitored data points, the datalogger can record approximately 30 days of data without overwriting data if communications with the datalogger are interrupted. The data logger has been configured to upload the data to the CDH Energy server and to the Obvius Building Manager Online (BMO) system. Data collected are loaded into a database, checked for validity, and posted on the NYSERDA web site.

Communications

The data logger uses a local WIFI connection for access to the internet. The connection is intermittent, resulting in data transfer being delayed occasionally, but no data has been lost due to this issue. The WIFI connection uses a DCHP, preventing CDH from the ability to access logger for remote configuration/diagnostics.

Output from the Obvius data logger is directly compatible with the requirements for the NYSERDA CHP integrated data system. The logger was configured to upload data by adding the following URL as an additional upload channel:

http://207.126.122.87/obvius/doral/receive_obvius.py

The logger does not have a functioning DNS to resolve non-numeric domains, so the IP address of the CDH Energy server was entered on the logger.

On Site Support.

The site and the applicant will be responsible for providing access to all areas necessary to complete the monitoring installation, as well as any return trips for verification of sensors or service to the monitoring system.

3. Data Analysis

The collected data will be used to determine the net power output of the system as well as the fuel conversion efficiency (FCE).

Table 2. Summary of Monitored Data Points

No.	Data Point	Description	Engineering Unit
1	WG1	Generator #1 Electrical Output	kW/kWh
2	WG2	Generator #2 Electrical Output	kW/kWh
3	WG3	Generator #3 Electrical Output	kW/kWh
4	WPAR	Parasitic Power - Dump Radiator Fans, Glycol Pump, Building Water Pump	kW/kWh
5	FG	Combined Generator Fuel Input	CF
6	FL	Glycol Flow Rate (Cogen Loop)	GPM
7	TLS	Glycol Loop Supply Temperature	deg F
8	TLR1	Glycol Loop Return Temperature (From HX1)	deg F
9	TLR2	Glycol Loop Return Temperature (To CHP Container)	deg F

Peak Demand or Peak kW

The peak electric output or demand for each power reading will be taken as the average kW in a fixed 15-minute interval (0:00, 0:15, 0:30, etc.), or

$$\text{kW} = \sum_{15\text{min}} \frac{\text{kWh}}{\Delta t} = \sum_{15\text{min}} = \frac{\text{kWh per interval}}{0.25\ \text{h}}$$

The location of the generator power meter measures the gross output of each engine generator separately. The net power delivered is determined by adding the power from each generator and then subtracting out the parasitic power measured for the combined parasitic power loads in the parasitic loads panel. The following loads were identified in the parasitic load panel; dump radiator fans; CHP glycol loop pump, building water loop pump, and boiler circulating pump.

Heat Recovery Rates

The heat recovery rates will be calculated offline based on the 5-minute data collected. The piping arrangement at this site allows for multiple heat rates to be determined with three temperature sensors and one flow reading on the heat recovery loop:

Useful heat recovery (**QU**) = $K \cdot \Sigma\ [FL \cdot (TLS-TLR1)]\ /\ n$

Rejected (unused) heat recovery (**QD**) = $K \cdot \Sigma\ [FL \cdot (TLR1-TLR2)]\ /\ n$

The loop fluid is expected to be a glycol-water mixture. The factor K will be determined based on a periodic reading of the fluid properties with a refractometer to determine the glycol concentration. (K ~ 500 Btu/h-gpm-°F for pure water; ~480 for 20% glycol). 'n' is the number of scan intervals included in each recording interval (e.g., with 5-minute data, n=12).

Calculated Quantities

The net power output from the CHP system, WG_{net}, will be defined as the combined gross power from the engines WG1, WG2, and WG3, minus the parasitic power, WPAR.

The fuel conversion efficiency of the CHP system, based on the lower heating value of the fuel, will be defined as:

$$FCE = \frac{QU + 3{,}413 \cdot (WG_{net})}{0.9 \cdot HHV_{gas} \cdot FG}$$

where: QU - Useful heat recovery (Btu/h) (QU)
WG_{net} - Engine generator net output (kWh) (WG1 + WG2 + WG3) - (WPAR)
FG - Generator gas consumption (Std CF)
HHV_{gas} - Higher heating value for natural gas (~1030 Btu per CF). Where 0.9 is the conversion factor between HHV and LHV

The FCE can be calculated for any time interval. When converting to daily, monthly, or annual values, the each value is summed and then the formula is applied:

$$FCE = \frac{\sum^{N} QU + 3{,}413 \cdot \sum^{N} (WG_{net})}{0.9 \cdot HHV_{gas} \cdot \sum^{N} FG}$$

Where N is equal to the number of intervals in the period of interest.

Appendix A

Cut Sheets for Key Sensors and Instruments