Sheland Farms

Data Integrator Initial Data Summary

Site Description

This site is a dairy farm located in the Central New York town of Adams. A 75 kW engine generator uses digester gas to produce electricity and recover heat to a common loop that heats the digester, as well as provided heat to two (2) unit heaters. The digester breaks down farm waste (primarily manure) and, produces a fuel resource to power the engine generators. Digester gas that cannot be utilized by the engine is burnt in a flare. Data for this site is collected by Siemens and provided to CDH Energy via an sFTP connection.

Monitored Points and Data File Description

Siemens provides the data for Sheland Farms via Microsoft Excel spreadsheet (XLS) files uploaded once a day. The data set consists of 18 channels, monitored at 15-minute intervals. The data file contains engineering unit descriptors for every column except the temperatures (assumed to be °F), and status (assumed to be 15-minutes of operation per 15-minute data record). Figure 1 displays the system piping and instrumentation diagram. Markups in red indicate points monitored by the Siemens PLC.

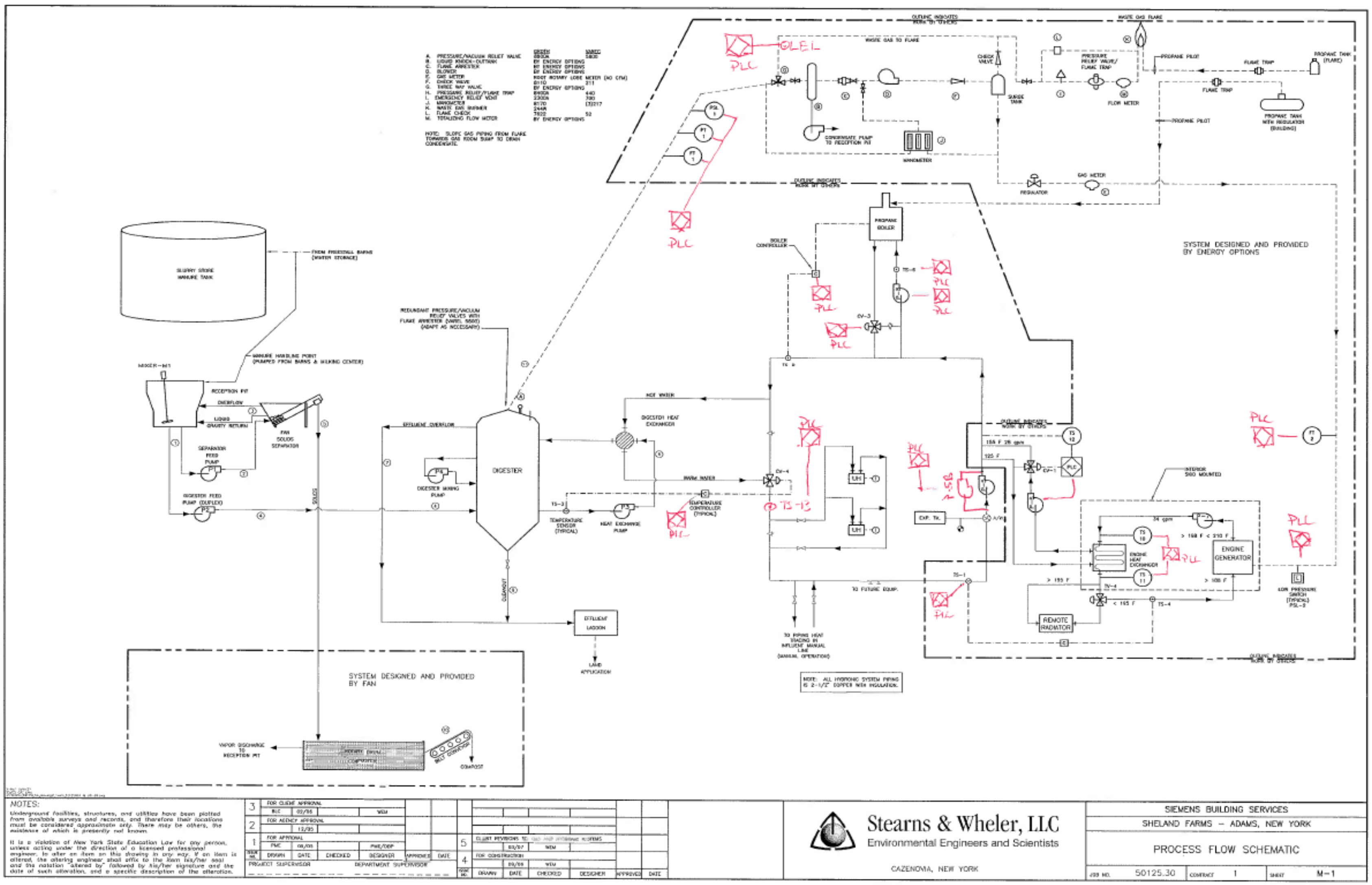

Figure 1. Siemens Schematic for Sheland Farms

DG/CHP Integrated Data System Channels

Table 1 shows the processed data channels from rawdata used in the DG/CHP Integrated Data System for Sheland Farms. The corresponding column letter and descriptions for the entire data file are shown in Table 2.

Table 1. Data Integrator Database Mapping

Integrated Data System Channel	Units of Measure	Raw Data Column Descriptions [col][1]	Raw Data Units	Calculation Formula
DG/CHP Generator Output	kWh/int	Cogen Output Power [E], Parasitic Load Power [F]	kW	=[E-F] (15 minutes/int ÷ 60 minutes/hour)
DG/CHP Generator Output Demand	kW	Cogen Output Power [E], Parasitic Load Power [F]	kW	=[E-F]
DG/CHP Generator Gas Input	cuft/int	FT-2 Gas Flow [C]	cfm	=[C]× (15 minutes/int)
Total Facility Purchased Energy	kWh/int	Farm Load Power [G], Cogen Output Power [E]	kW	=[G-E]× (15 minutes/int ÷ 60 minutes/hour)
Total Facility Purchased Demand	kW	Farm Load Power [G], Cogen Output Power [E]	kW	=[G-E]
Other Facility Gas Use (Flared Biogas)	cuft/int	FT-1 Gas Flow (SCFM) [B] FT-2 Gas Flow (SCFM) [C]	cfm	=[B-C]× (15 minutes/int)
Total Facility Energy	kWh/int	Farm Load Power [G]	kWh	
Total Facility Demand	kW	Farm Load Power [G]	kW	
Useful Heat Recovery [3]	MBtu/int	Engine Heat Exchanger Input Temperature (TS-10) [M] Engine Heat Exchanger Output Temperature (TS-11) [N]	N/A (calculated)	=0.48×42×([M-N])× (15 minutes/int ÷ 60 minutes/hour)
Unused Heat Recovery [2]	MBtu/int	Calculated	N/A	Not Measured[2]
Status/Runtime of DG/CHP Generator	Hours/int	Calculated	N/A	Inferred from generator power
Ambient Temperature	°F	Ambient Temp [P]	°F	
Total CHP Efficiency	% LHV	Calculated	N/A	
Electrical Efficiency	% LHV	Calculated	N/A	

1 – The Raw Data Column Description is from the Siemens XLS files. The corresponding column id (i.e., A, B, C…) is in square brackets and used in the calculation formula.
2 – There is no information for these data channels available from Siemens.
3 – The measured flow across the Heat Exchanger is 42 GPM.

Table 2. Column and Descriptions for Siemens Data File

Column	Description/Header
[A]	Date:Time
[B]	FT-1 Gas Flow (SCFM)
[C]	FT-2 Gas Flow (SCFM)
[D]	Digester Gas Pressure (Inches/H2O)
[E]	Cogen Output Power (DEM-1) KW
[F]	Parasitic Load Power (DEM-2) KW
[G]	Farm Load Power (DEM-3) KW
[H]	EP2 Sub Load (Dairy Barn) (DEM-4) KW
[I]	Return Temperature Heat Loop Before Unit Heaters (TS-1)
[J]	Boiler Supply Temperature (TS-2)
[K]	Digester Sludge Temperature (TS-3)
[L]	Boiler Return Temperature (TS-6)
[M]	Engine Heat Exchanger Input Temperature (TS-10)
[N]	Engine Heat Exchanger Output Temperature (TS-11)
[O]	Return Temperature Heat Loop After Unit Heaters (TS-12)
[P]	(TS-13)
[Q]	Boiler Stage 1 Status
[R]	Boiler Stage 2 Status
[S]	Boiler Stage 3 Status

Data Verification

System Energy Balance

Data for several system energy flows were used to examine the validity of the data being collected. The total output of the system (electrical + recovered thermal energy) must be lower than the energy content of the fuel input.

Generator Fuel Input

Two gas meters are installed at the site. The first gas meter records all of the gas produced by the digester. The second records the gas consumption by the engine generators. Up to February 14, 2008 there was a substantial difference between the engine gas meter (FT-2) and the total gas meter (FT-1). The step change in gas trend on February 14 indicates that the difference between the two meters is a multiplier issue.

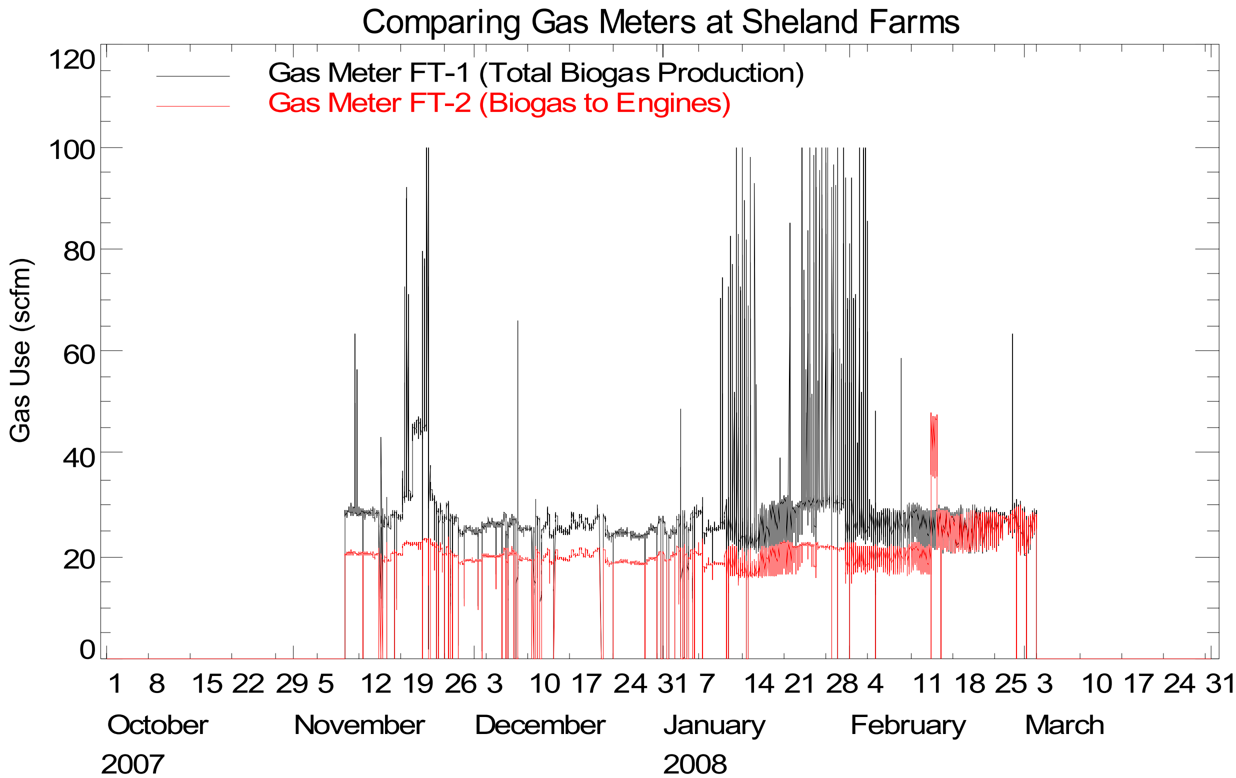

Figure 2. Comparing Gas Meter Readings

Based on a comparison of FT-1 and FT-2 prior to the step change, we have determined that the value for FT-2 should be 1.39-times higher than was being reported. The past data has been updated to reflect this.

Comparing the fuel input from the generator to the electricity produced and the combined output of the CHP system (electricity + heat recovery) indicates that the system has an acceptable energy balance. The combined system output never approaches the total fuel input. An HHV of 600 Btu/cf was used to convert the gas volume flow to Btus.

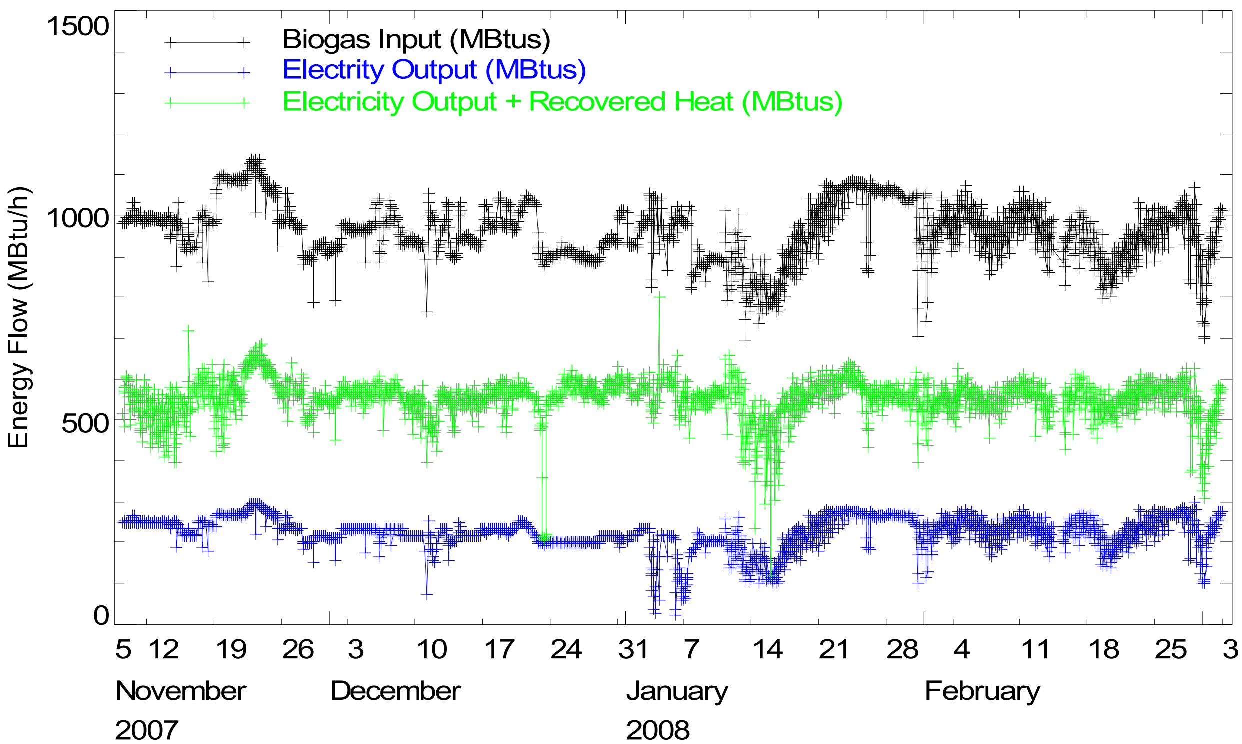

Figure 3. Comparing System Energy Flows

Generator Electrical Output

Figure 4 displays the observed electrical output of the engine generator. The peak output observed is 88 kW, higher than the nameplate data of 75 kW. This may indicate that some further verification is required for the generator power transducer.

The NYSERDA database records the “net” power of the DG/CHP systems. Net power is calculated at this site by subtracting the parasitic power from the generator power.

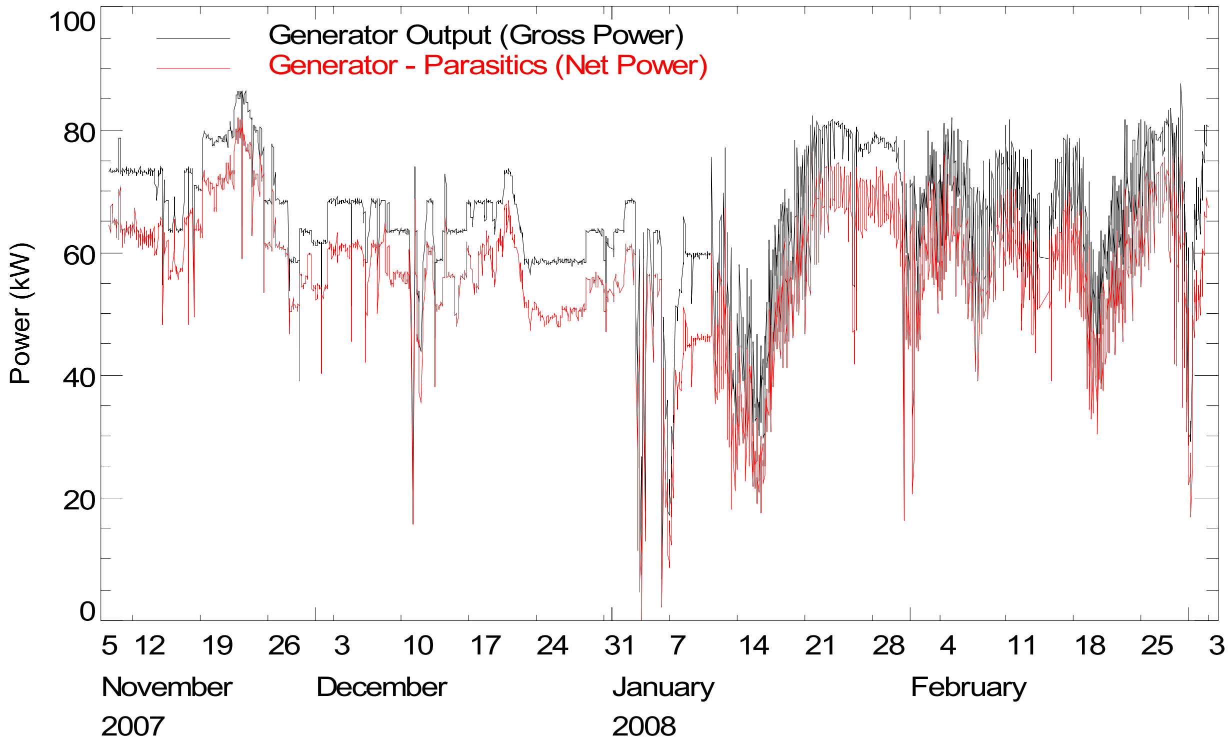

Figure 4. Generator Electrical Output

Heat Recovery

Energy in the engine jacket water is recovered via a heat exchanger to a hot water loop, used for heating the digester and space heating. Two temperature sensors are used to record the temperature drop across the jacket water side of the heat exchanger (TS10, TS11). No flow meter is installed, but the jacket water loop is expected to run at a constant flow rate. The flow rate was measured by Siemens using an ultrasonic flow meter. The jacket water flowrate is 42 GPM, slightly higher than the 34 GPM indicated by the drawing (Figure 5).

Figure 6 displays the observed jacket water temperatures. Both temperatures readings appear reasonable, although slightly lower than the nominal temperatures indicated in the system diagram.

Figure 7 displays the calculated heat recovery rate, using the measured temperature readings, and assuming a flow rate of 42 GPM. A constant of 480 BTU/°F gallon to convert the flow and temperature product to an energy rate, because this loop is assumed to be a glycol/water mixture. The average heat recovery rate for the system has been 375 MBtu/h.

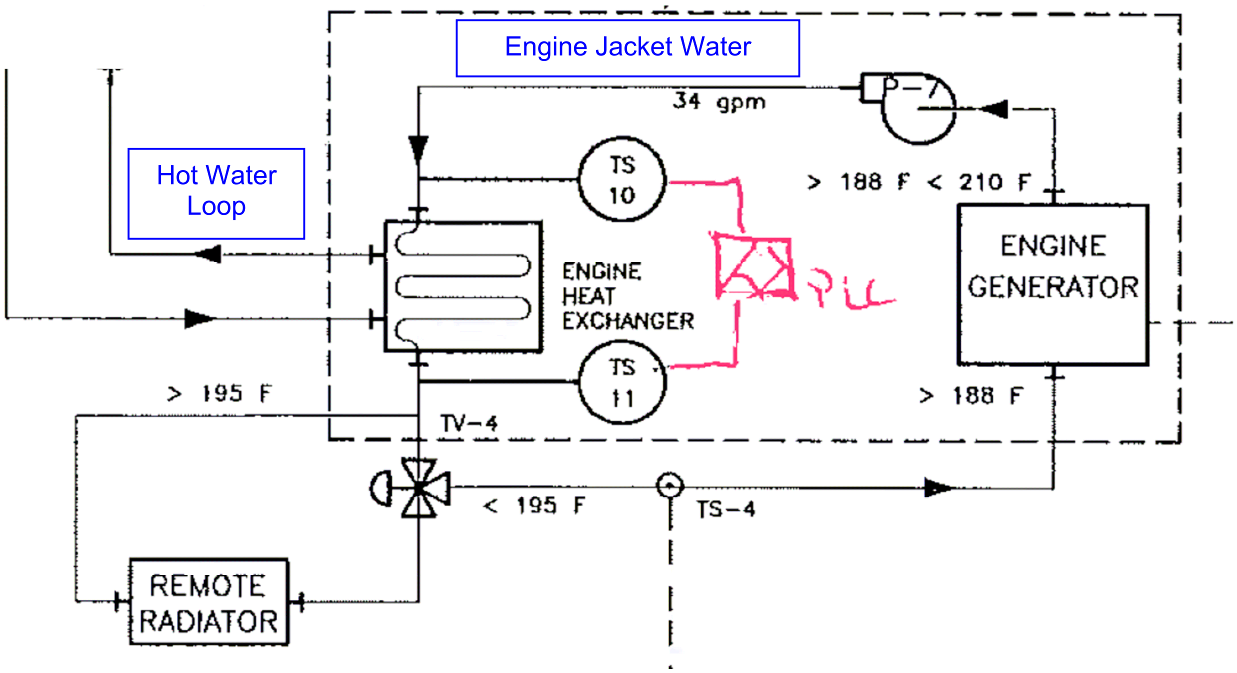

Figure 5. Partial System Diagram - Heat Recovery HX

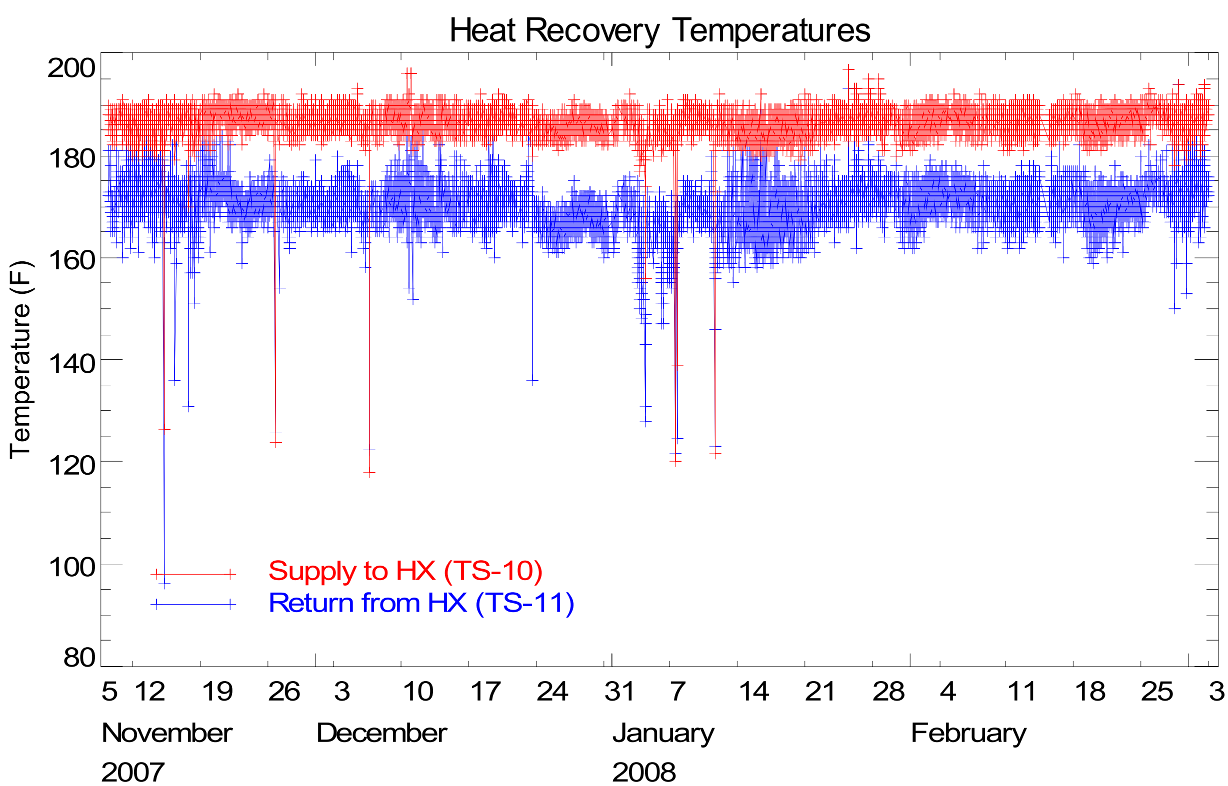

Figure 6. Engine Jacket Water Heat Recovery Temperatures

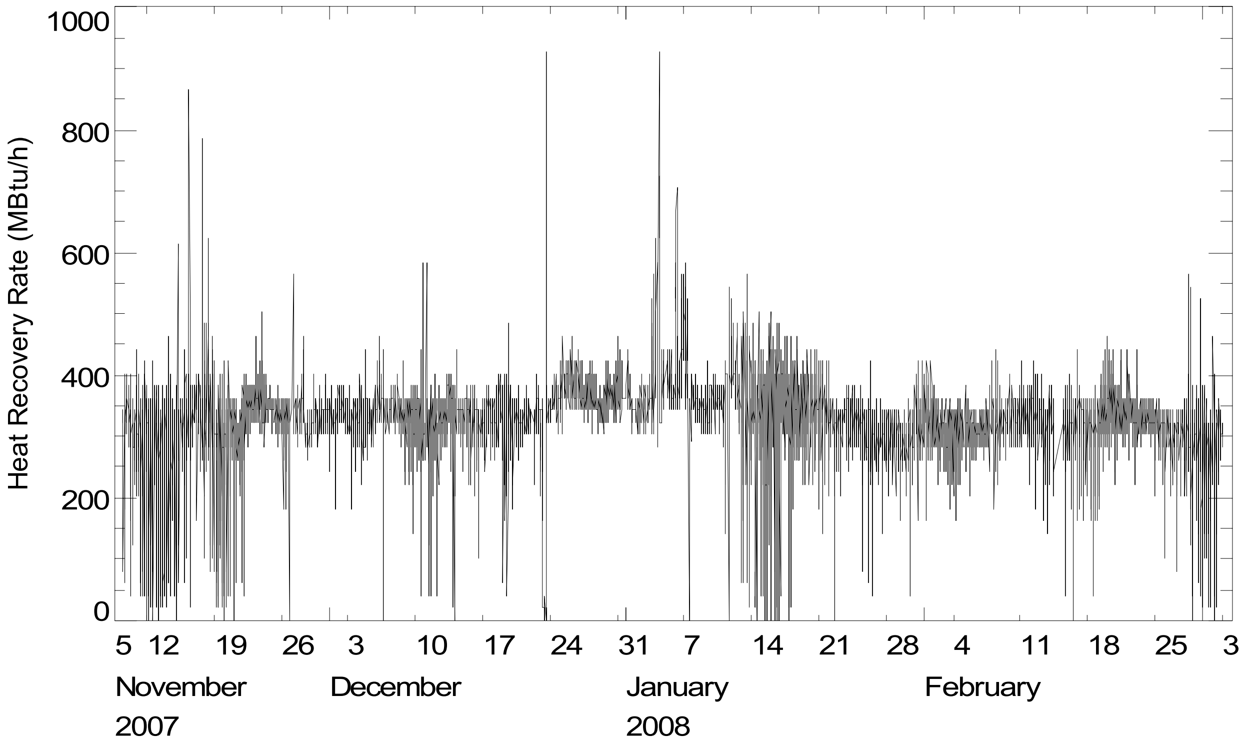

Figure 7. Calculated Heat Recovery Rate

Electrical Efficiency

The electrical efficiency shown below is calculated by the following formula:

$$Eff_{elec} = \frac{[E - F] * 3.413}{[C] * 60 * 0.6}$$

The letters in [brackets] indicates the column of the spreadsheet used to calculate efficiency. The follow subset of data channels were used in this calculation:

[C]	FT-2 Gas Flow (SCFM)
[E]	Cogen Output Power (DEM-1) KW
[F]	Parasitic Load Power (DEM-2) KW

Again, 600 Btu/cf was assumed to be the HHV fuel content of the biogas at this site.

The plot shown in Figure 8 shows the electrical efficiency for the site. From the plot we see that the electrical efficiency is peaking around 23-24%, typical for an engine generator.

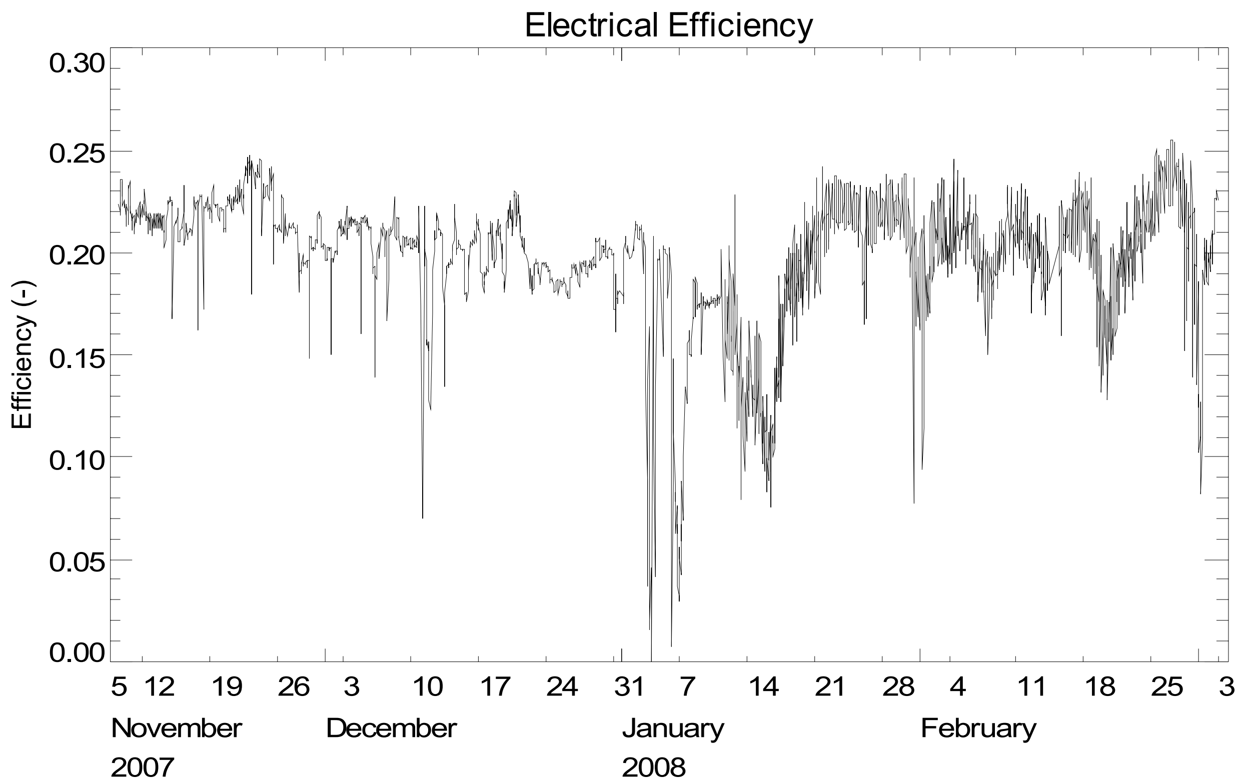

Figure 8. Electrical Efficiency

CHP Efficiency

The CHP efficiency shown below is calculated using the following formula:

$$Eff_{CHP} = \frac{(([M - N]) * 42 * 0.480) + ([E - F] * 3.413))}{[C] * 60 * 0.6}$$

The letters in [brackets] indicates the column of the spreadsheet used to calculate efficiency. The follow subset of data channels were used in this calculation:

[C]	FT-2 Gas Flow (SCFM)
[E]	Cogen Output Power (DEM-1) KW
[F]	Parasitic Load Power (DEM-2) KW
[M]	Engine Heat Exchanger Input Temperature (TS-10)
[N]	Engine Heat Exchanger Output Temperature (TS-11)

Again, 600 Btu/cf was assumed to be the HHV fuel content of the biogas at this site.

The plot shown in Figure 9 shows the CHP efficiency for the site. The typical CHP efficiency observed so far has been 55%. Excursions in the data toward higher or lower values indicate startup and shutdown periods, and do not represent the performance over a full 15-minute interval.

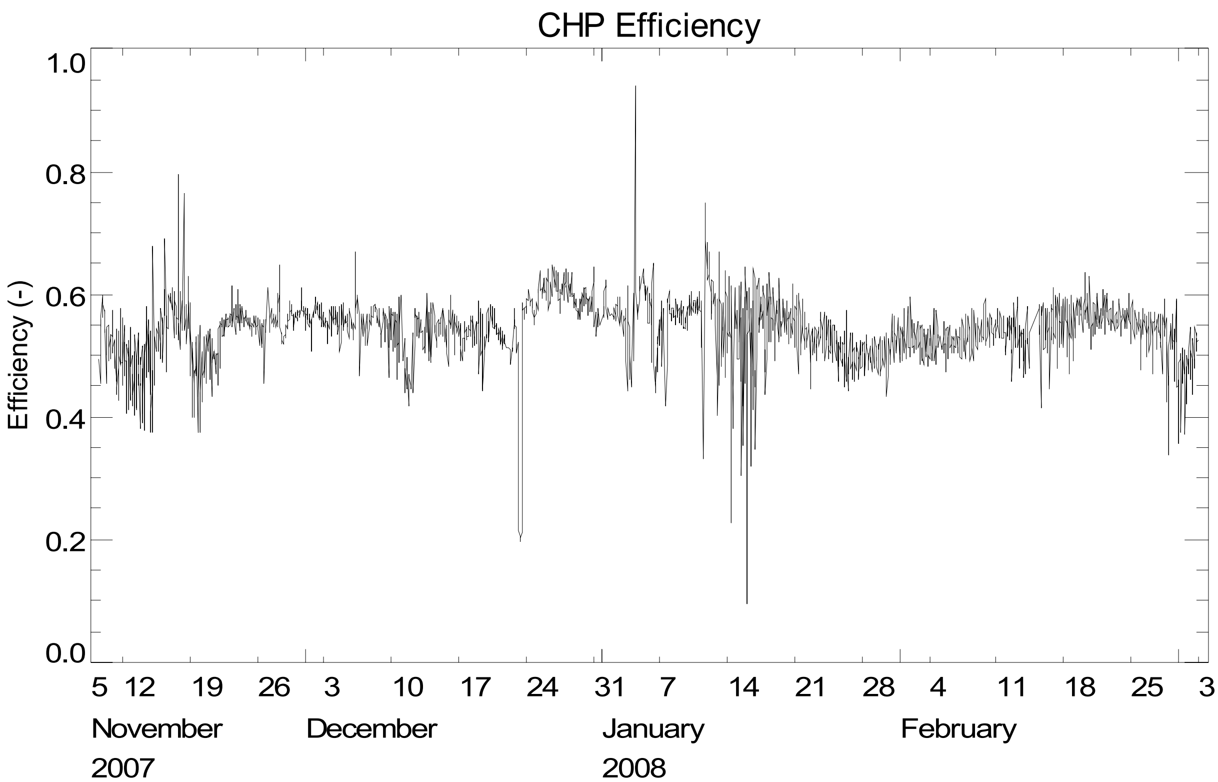

Figure 9. CHP Efficiency

Dumped Heat Recovery

The schematic shows a temperature point TS-4. CDH Energy does not receive data for this point and hence dumped heat recovery cannot be calculated. Dumped heat recovery would be calculated using the difference between TS-11 and TS-4 and the nominal jacket water loop flow rate.

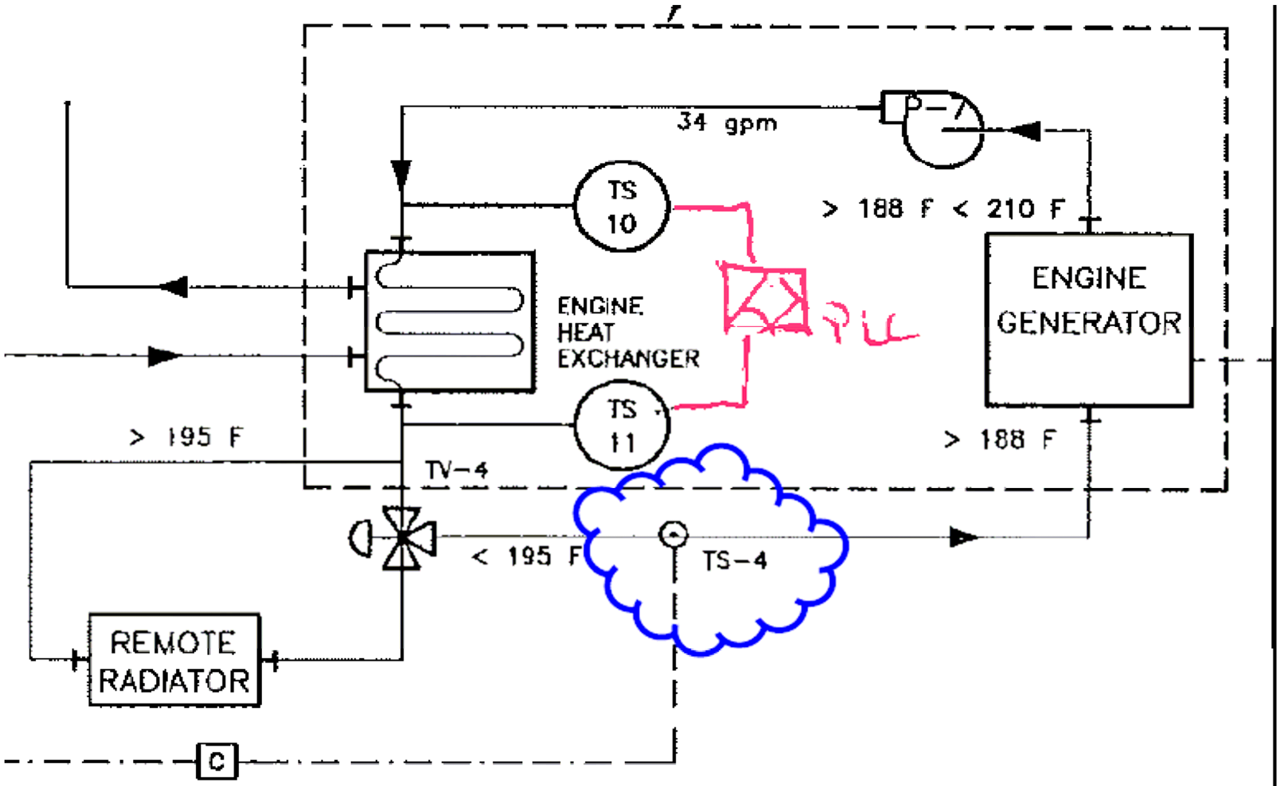

Figure 10. Partial System Diagram Showing Un-recorded Temperature Used for Calculating Dumped Heat

Assumptions

The following assumptions are use in analyzing this data and for inclusion in the NYSERDA database:

1. The HHV of the biogas is 600 Btu/cf
2. The measured generator electrical output is the gross output. The measured parasitic load must be removed from the generator output to report the net electrical output.
3. The jacket water flow rate will remain constant at 42 GPM across all operation.
4. The total facility power reported includes the CHP system electrical output.

Summary Questions

Here is a summary of the questions from a review of the data set:

1. Is data available for TS-4 and can it be connected to the PLC?
2. Is FT-2 Gas Flow compensated for Pressure or Temperature?

Recommendations

1. Connect TS-4 to PLC for reporting of dumped heat.