MEASUREMENT AND VERIFICATION (M&V) PLAN

FOR

SUNNYSIDE FARMS

Agreement # ADG-122N

December 15, 2009

Submitted to:

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

and

Sunnyside Farm
2231 Indian Field Rd.
Venice Center, NY 13147

Submitted by:

CDH Energy Corp.
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PROJECT PARTICIPANTS

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Introduction

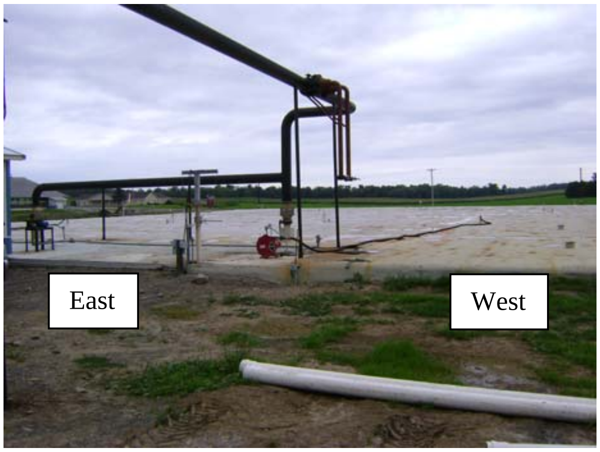
This plan describes the approach to monitor the performance of the anaerobic digester gas (ADG) system that is installed at Sunnyside Farm (the "Farm" or the "Applicant") to produce biogas and electricity. Biogas is used to drive an engine-generator to produce power that is consumed on site and/or exported back to the local utility. A monitoring system will be installed to measure and collect the data necessary to quantify the electric power produced by the engine-generator. The data will serve as the basis for payment of three (3) years of performance incentive payments, which the Farm has applied for under a Standard Performance Contract with NYSERDA.

ADG System Description

The digester system at the farm was designed by GHD. With the installation of the engine-generator the site will operate one 500 kW synchronous engine-generator, with piping and controls installed in the pole barn adjacent to the digester. The electrical loads at the farm have not been consolidated into a single 3-phase electrical service, so the generator has been installed on one of the farm's eight electric services. Currently with this setup the farm will only be eligible for net metering on the one service. The electrical system includes controls to synch the generator to the grid as well as a protective relay and controls to automatically isolate the farm from the utility grid in the event of a utility power outage. The facility does have the capability to run grid isolated and black start with the help of a small, tractor driven generator.

Table 1. Biogas Systems Installed at the Site

Digester	GHD Plug Flow with Mixing, Heated, Hard Cover
Feedstock	Dairy Manure, 2,700 cows
Engine-Generator	Guascor-MGG950 500 kW output on biogas 480 VAC, 3 phase
Biogas Conditioning	H_2S Scrubber, De-watering
Engine Backup/startup Fuel	None
Heat Recovery Use	Digester heating
Additional Heat Recovery	None



Digesters and Biogas Outlets

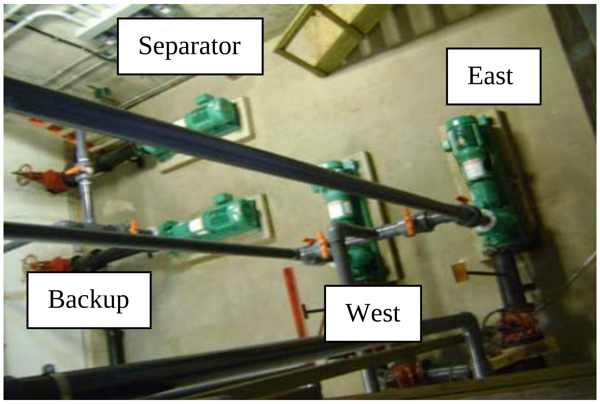
H_2S Scrubber

Engine Skid

Generator Nameplate

Biogas Piping

Hot water storage and digester heat piping



Manure Pumps

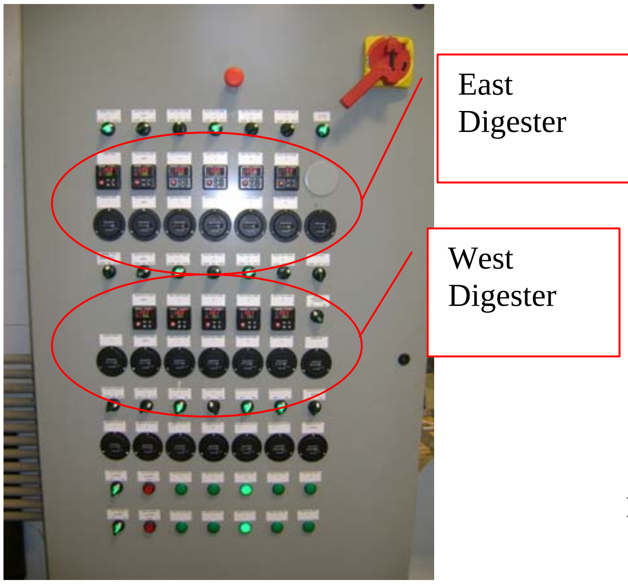
Solids Separator

Biogas Flare

Figure 1. Photos of System Components

Grid Interconnect / Switchover Panel

GenTec Engine Control Panel

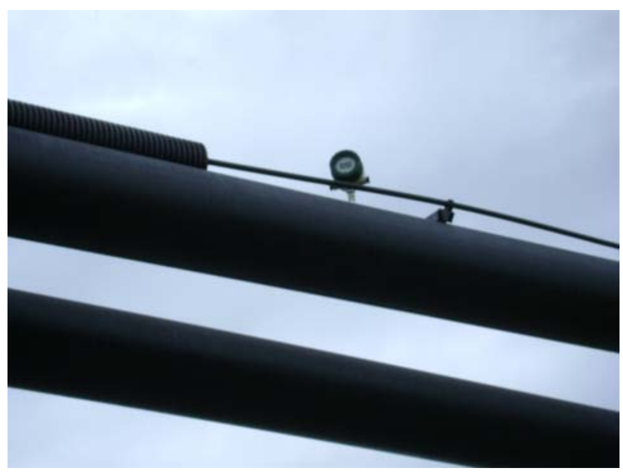


East Digester Temperatures and Setpoints

Digester Temperature Controls

Figure 2. Photos of Electrical Panels

Engine Flow Meter



Flare Flow Meter

Figure 3. Photos of Biogas Meters

Figure 4 schematically shows the biogas system and engines. Biogas directly from the digester is either flared or re-circulated back thru the digester. Biogas passes thru the scrubber before being combusted in the engine or boiler. Typically around 90% of the biogas from the digester passes thru the scrubber, with the remaining 10% bypasses it. Biogas traveling to the engine is de-watered with a chilled water exchanger and pressurized to 30 inches by a VSD controlled blower to maintain the approximate 12-inch pressure set point for the engine inlet. The boiler is only used for startup and during the coldest winter months when the recovered heat from the engine may not be enough to sufficiently heat the digester. The biogas flare keeps the digester around 4-inches of static pressure.

The H_2S scrubber, a Bioscrub-300 provided by Energy Cube LLC, was installed to remove sulfur and other impurities from the biogas in order to reduce engine maintenance and increase operating life. The scrubber operates by first exposing the liquid effluent to air. Then biogas is bubbled up through the aerated effluent so that the sulfur in the biogas bonds to the oxygen molecules, and is captured in the effluent. The scrubbed biogas travels to the engine. The digester effluent with the captured sulfur is then pumped to the lagoon for storage.

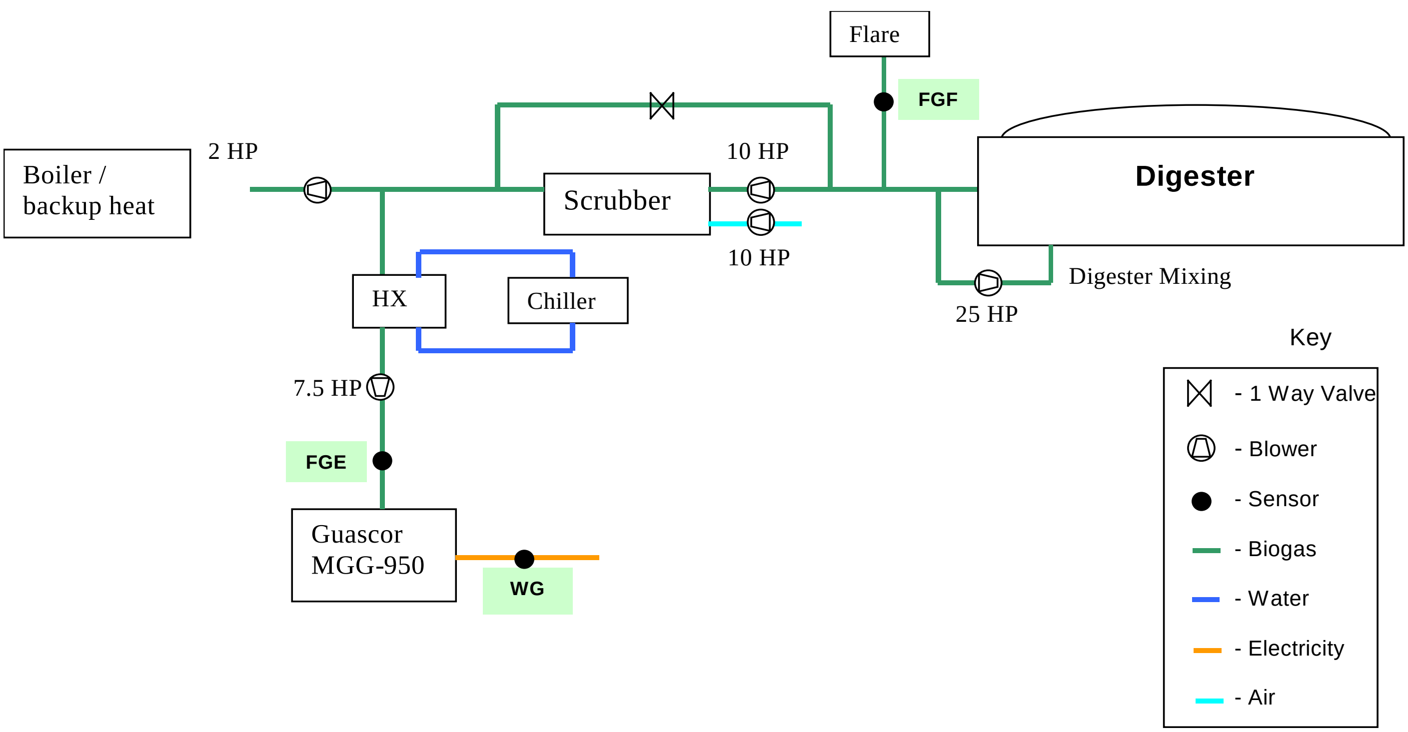


Figure 4. Schematic of Biogas System

Manure from approximately 2,700 dairy cows is pumped directly into the digesters from the barns. The farm has installed two hard top digesters, East and West, which share an effluent pit (see the plan view in Figure 6.) Three pumps are responsible for bringing the manure to and from the digester. A 7.5 HP and 10 HP pump influent into the East and West digester, and the 15 HP pump removes effluent from the shared effluent pit and sends it to the separator. There is also a 15 HP backup pump, which can be piped to replace any of the other three pumps. As seen in figure 5, the effluent travels from the digesters to the separator where the solids are removed from the liquid waste. Solids typically account for 33% to 35% of the effluent; approximately half of which is used for bedding and the other half is spread on the fields as fertilizer. The separated liquid is sent to the scrubber where it acts as a sulfur filter for the biogas.

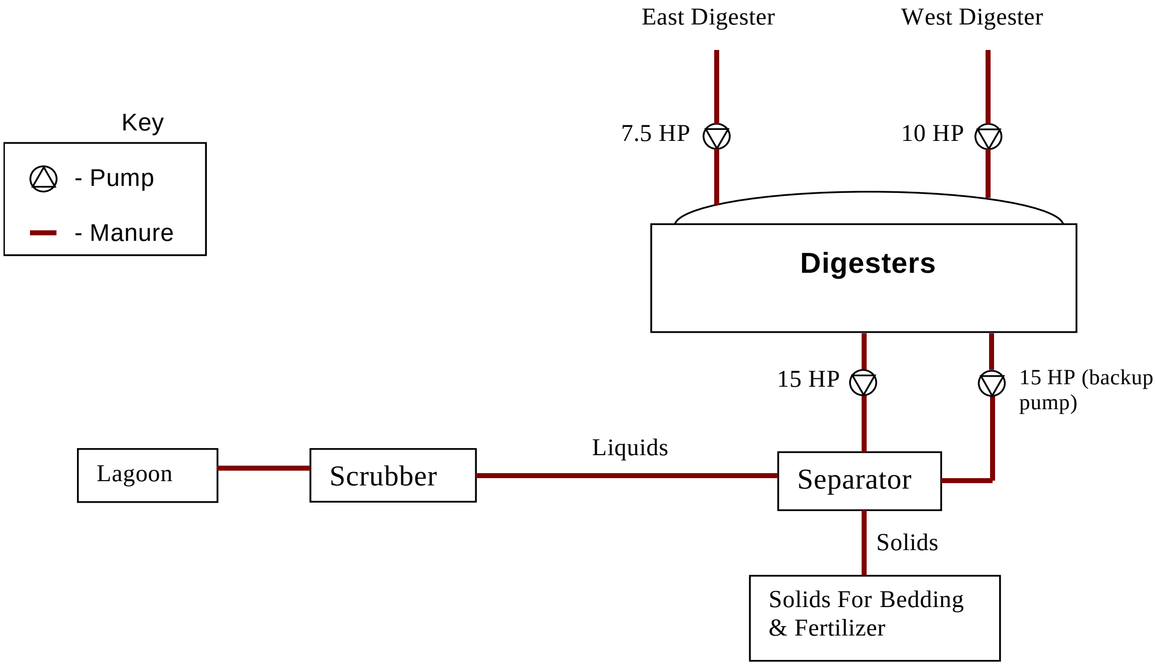


Figure 5. Schematic of Heat Loop and Manure Treatment

Both digesters are a plug flow design, which uses biogas re-circulation to provide manure mixing. A portion of the biogas produced is pressurized and piped thru nozzles lining the inside bottom walls of the digesters as shown in Figure 6. The bubbles created cause a corkscrew flow pattern as manure travels along the u-shaped of both digesters. The digesters are heated with recovered heat from the engine. Heat transfer is enhanced by biogas bubbles driving manure flow across the hot water pipes which are mounted on the inside wall of the digester. The biogas re-circulation helps provide some mixing to keep sediment from accumulating at the bottom and a crust from forming on top while retaining the performance benefits of a plug flow arrangement. Figure 6 schematically shows a basic layout of the digester.

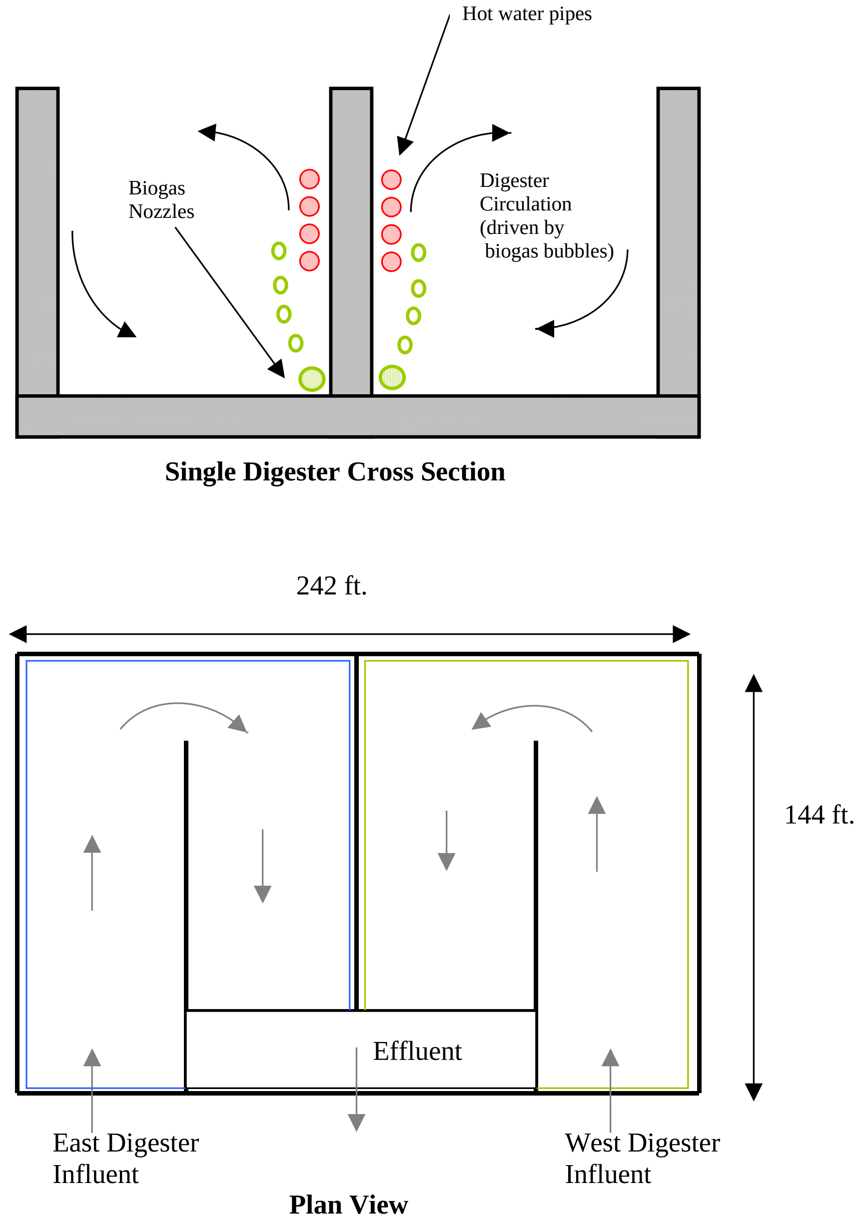


Figure. 6 Digester Schematic

Monitoring System Equipment, Installation, Operation, and Maintenance

Figure 4 also shows the locations of the three data monitoring points, which are used to measure system performance. Two gas meters measure fuel gas input to the engine generator (**FGE**) and fuel gas being flared (**FGF)** respectively, and a power meter measures the kilowatts generated (**WG**) by the engine. Information on these data points is shown in Table 2.

Table 2. Monitored Points for ADG System

Point Type	Point Name	Description	Instrument	Expected Range
Pulse	WG	Engine-Generator Power	Intelisys NT Engine Controller (Wh per pulse to be determined)	0-550 kWh/h
Pulse	FGE	Engine Biogas Flow	Sage inline flow meter SRP-05-18 (0-33,000 cfm)	0 – 13,700 ft3/h
Pulse	FGF	Flare Biogas Flow	Sage inline flow meter SRP-05-15 (0-3150 cfm)	0 – 13,700 ft3/h

The electrical output of the engine-generator **(WG)** will be measured with the Intelisys NT engine controller. The controller will be installed in a stand alone cabinet on the side of the engine by the electrical contractor. It has an external graphical display which shows real time and total kWh. The controller will be installed according to the requirements in the "IntliGen^{NT}, Intelisys^{NT} Modular Gen-set Controller Operator Guide for SPI, SPtM, MINT, Cox" Software version IGS-NT-2.3. The sensor will be protected by a dedicated circuit breaker.

The biogas input to the engine-generator **(FGE)** will be measured by a Sage Prime mass flow meter installed in-line just above the engine-generator. A second Sage Prime mass flow meter, installed outside on the flare piping, measures biogas flow to the flare **(FGF)**. The meters will be installed and maintained according to the "Sage Thermal Gas Mass Flow Meter Operations and Instruction Manual for Models SIP/SRP, Document 100-0001 Revision 05-SIP/SRG" as part of the engine generation equipment provided by Gen-Tec. A log of maintenance activities for the meters will be maintained at the site.

A separate cabinet supplied by Gen-Tec mounted on the wall across from the controller houses the Red Lion HMI data logger. This unit collects, and assembles mass flow and power output data from the three monitoring points described in Table 2 into .csv format reports. The following data will be logged and compiled by the data logger:

1. Flare 1 SCFM
2. Total CF to the flare
3. Engine SCFM
4. total CF to the engine

5. Accumulated kWh
6. Flare 1 temperature
7. Flare 2 temperature

A graphical display on the outside of the cabinet shows kWh production and mass flow information. The data logger will be programmed to record the totalized data for each monitoring point for each 15-minute interval. A record of all multipliers and data logger settings will be maintained. The data logger will be connected to an uninterruptible power supply (UPS) to ensure the data logger retains its settings and data in the event of a power outage. We will provide a static IP address that will be used by the NYSERDA CHP Website Contractor to communicate with the data logger. We have confirmed that the NYSERDA CHP Website Contractor will call the data logger nightly, via high speed modem link, to extract monitoring data from our ADG system and transfer the data to the NYSERDA CHP Website. If communications are lost, the Red Lion data logger is capable of holding up to 2 years of 15 minute interval data.

The lower heating value for the biogas is estimated to be 550 Btu/$ft^{3,}$ based on past measurements of the CO_2 content of the biogas from other sites. This value will be verified weekly based on measurements of carbon dioxide using a Fyrite Gas Analyzer Model No. 10-5032 for CO_2 range 0-60%. The Farm staff will perform the CO_2 tests and record the results in the project log.

Sunnyside Farms will be responsible for the cost to purchase and install the power meter and engine biogas meter. CDH Energy will pay for the cost to install the flare gas flow meter as part of the Digester Protocol test effort.

Management of Monitoring System Data (Farm/Applicant Responsibilities)

The Farm will perform the following quality assurance and quality control measures to ensure the data produced from the monitoring system accurately describes system performance.

On a daily basis, the farm equipment manager (or other specified employee) will perform inspections of the digester and engine-generator equipment and record findings into the project log.

On a weekly basis, the farm equipment manager will perform inspections of the M&V meter installations and complete the routine maintenance on the meters, noting any abnormalities or unexpected readings. The farm will also maintain a weekly log of the cumulative power generation (kWh) and gas flow (cf or ft^3) from the new engine in the event that data transfer to the NYSERDA CHP Website fails or other anomalies occur.

On a weekly basis, the farm staff will review the data available on the NYSERDA CHP Website (chp.nyserda.org) to ensure it is consistent with their observed performance of the ADG system and logged readings. The farm will review the data using the reporting features at the website, including:

- Monitored Data – Plots and Graphs and
- RPS: Customer-Sited Tier Anaerobic Digester Gas-to-Electricity Program NYSERDA Incentive Program Reports

In addition, the farm staff will also setup and use the email reports that are available at the CHP Website to help the track system performance, including:

- a periodic email report summarizing system performance and the estimated incentive,
- an email report sent out if data are not received at web site or do not pass the quality checks

The website will automatically take the data collected from the datalogger and evaluate the quality of the data for each interval using range and relational checks. The expected ranges for the sensors (see Table 2) will be used for the range checks. The relational check will compare the kWh production data and gas production data for each interval to ensure both meters always provide non-zero readings at the same time (e.g., to detect if a meter has failed). Only data that pass the range and relational quality checks are used in the incentive reports listed above. However, all hourly data are available from the NYSERDA CHP Website using the “Download (CSV file)” reporting option.

In the event of a communications or meter failure, the farm will work with CDH to resolve the issue in a few days.

If unanticipated loss of data occurs when the engine-generator continues to produce electricity, the farm will follow the procedures outlined in Exhibit D of their contract, i.e. using data from similar periods – either just before or after the outage – to replace the lost data. The farm understands that they can use this approach for up to two 36-hour periods within each 12-month performance reporting period. If more than two such data outages occur, the farm will provide information from other acceptable data sources (e.g., weekly recorded logs) to definitively determine the amount of power that was produced from biogas during the period in question.

Annual M&V Reports

The Farm will prepare the Annual M&V Report summarizing the monthly data over the 12-month performance period. The report will include a table showing the monthly kWh production, biogas used by the engine, and other data listed in Table 3. The farm may use the NYSERDA Incentive Program Reports found on the CHP website. Alternatively, they may provide their own summary of the data (using hourly CSV data downloaded from the Website) along with a narrative justifying why their data and calculations are more appropriate. The methods for calculating these values are provided below.

Table 3. Summary of Monthly Data for Annual M&V Report

Start Date of Reporting Period	No of Days in Each Period	Electricity Production, $kWh_{generator}$	Biogas Used by Engine (cubic feet)	LHV_{biogas} (Btu/cf)	Biogas Energy Content, Q_{biogas} (Btu)

TOTAL					

The farm will calculate monthly values for lower heating value of the biogas (LHV_{biogas}) and total energy content of the biogas (Q_{biogas}) as defined below.

Monthly Biogas Lower Heating Value

The readings of CO_2 concentration in the biogas will be gathered weekly to estimate the average monthly Biogas Lower Heating Value using the following equation:

$$LHV_{biogas} = LHV_{methane} \cdot (1 - F_{CO2})$$

where:

$LHV_{methane}$ - lower heating value of methane (911 Btu/ft^3 at standard conditions, 60 °F and 1 atm)

F_{CO2} - fraction of biogas that is CO_2 (average of readings for each month)

Monthly Biogas Energy Content

Calculate the average monthly Biogas Energy Content using the following equation:

$$Q_{biogas} = CF \cdot LHV_{biogas}$$

where:

CF - volume (ft^3) of biogas in month

Reasonable Electrical Efficiency

The M&V Report will also provide a comparison of power output and fuel input for the engine to confirm their reasonableness. For instance the electrical efficiency – measured as power output ($kWh_{generator}$) divided by the energy content of the fuel input (Q_{biogas}) in similar units and based on lower heating value – should be in the 25%-35% range over any interval for the engine generator on Sunnyside Farm.

Appendices

Cut sheets and Manuals for:

Red Lion Controls G306A000 Data Logger with Graphic Interface
http://www.redlion.net/products/groups/operatorinterface/g306/docs/07037.pdf

ComAP Intelisys NT Controller IS-NT-BB
http://www.comap.cz/products/detail/intelisys-nt

Sage Insertion Flow Meter: SRP-05-18 (Flare – 12" piping)
http://www.yizhu.com.sg/products/sage/industrial/SRP_specs_insertion.pdf

Sage Insertion Flow Meter: SRP-05-15 (Engine – 3" piping)
http://www.yizhu.com.sg/products/sage/industrial/SRP_specs_insertion.pdf

Fyrite Gas Analyzer
http://www.bacharach-inc.com/PDF/Brochures/fyrite_gas_analyzers.pdf
http://www.bacharach-inc.com/PDF/Instructions/11-9026.pdf

Sunnyside Farms Addendum

Site Events

Date	Event
9/25/2009	Carbon Catcher begins recording WG
10/27/2009	Carbon Catcher begins recording FGF & FGE
12/8/2009	Data put up on CHP site

Hardware

Device	Serial #	Output	Carbon Catcher Data Point	Notes
Sage SRP-05-18	39943	CF & CFM	SCFM_Engine1	Mod-bus connection
Sage SRP-05-15	41274	CF & CFM	SCFM_Flare	Mod-bus connection
Intelisys NT Controller		KWh (acc)	G1_KWH_Output	Mod-bus connection

Database Setup

Chan Name	Device	column
SCFM_Flare,	FlowRate,	2
SCFM_Engine1,	FlowRate,	3
SCF_Total_Flare,	GasUsage,	2
Flare1_Temp,	GasUsage,	3
Flare2_Temp,	GasUsage	4
SCF_Total_Engine1,	GasUsage,	5
G1_KWH_Output,	GasUsage,	6

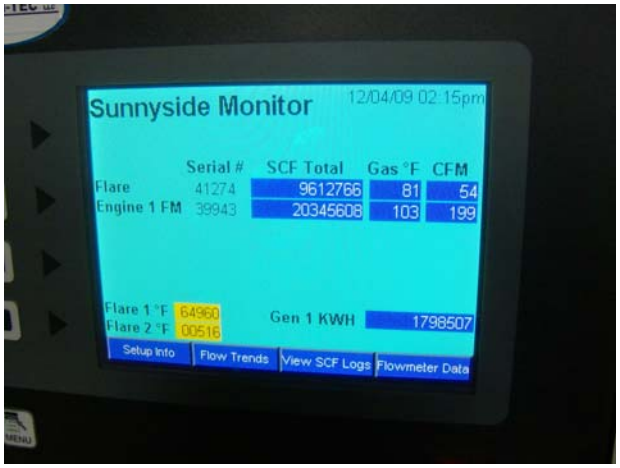
Sensor Verification

Power Meters

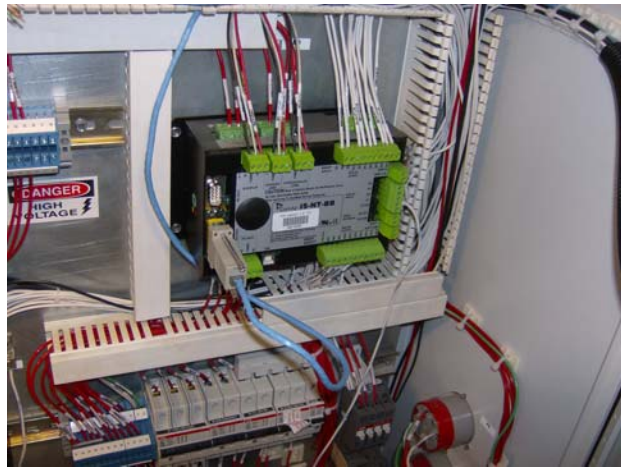
Carbon Catcher
10 kWh in 72 seconds = 500 kW
Fluke
(66 kW + 62 kW) * 4 conductors = 512 kW
% Difference
2.3%

Biogas Flow Meters

		Carbon Catcher		*Sage*		*% Difference*	
Meter	**Serial #**	**cfm**	**cf**	**cfm**	**cf**	**cfm**	**cf**
Engine	39943	198	20344362	196	20344437	1.0%	0.0%
Flare	41274	70	9612431	-	-	-	-

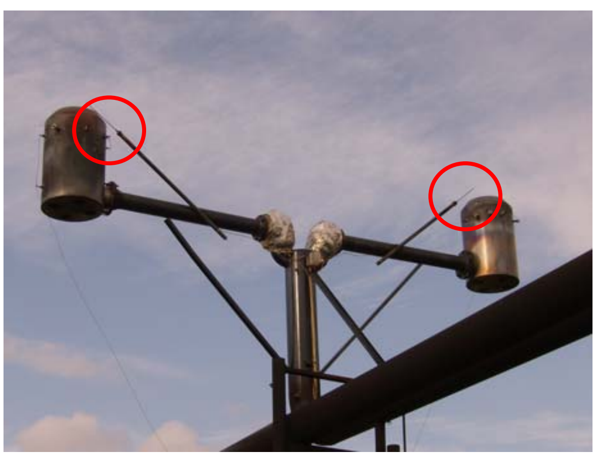


Carbon Catcher display


Intelisys NT Engine Controller


Carbon Catcher panel

Sage Flowmeter – Biogas to engine


Thermocouples measuring Flare 1 and Flare 2 temperatures