MEASUREMENT AND VERIFICATION (M&V) PLAN

FOR

ZUBER FARMS DIGESTER GAS (ADG) SYSTEM

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Submitted to:

New York State Energy Research and Development Authority
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Zuber Farms
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Submitted by:

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Introduction

This plan describes the approach to monitor the performance of the anaerobic digester gas (ADG) system that will be installed at Zuber Farms (“The farm” or “the applicant”) to produce biogas and electricity. Biogas will be used to drive an engine-generator to produce power that will be 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. The system has a Total Contracted Capacity of 300 kW.

ADG System Description

The digester system at the farm was designed by RCM Digesters, Inc. The site will operate a synchronous engine-generator system, provided by Martin Machinery, with piping and controls installed in the building near the digester. The generator is installed on the farms main 480V 3-phase service, which supplies the dairy complex and one house. The system does have the capability to run when isolated from the grid, so if power is lost the engine will go down until the farm is manually isolated from the grid and the engine restarted.

Table 1. Biogas Systems at Zuber Farm

Digester	RCM Digester Mixed Tank Reactor, heated
Feedstock	Dairy Manure, 1550 mature cow equivalents; Designed to handle food waste in future
Engine-Generator	Guascor MGG-712 Nameplate: 380 kW
Biogas Conditioning	De-watering system and Sulfur Scrubber - Martin Machinery
Engine Backup/startup Fuel	Propane
Heat Recovery Use	One loop for digester heating
Additional Heat Recovery	Second heat loop installed for house, workshops and milk house in future


Digester and 4x mixers


Biogas flare


Cement storage tanks – 4x


Separator


Biogas cooler and engine flow meter


Genset – Guascor MGG-712 and heat recovery / hot water heat exchanger (left side, blue)

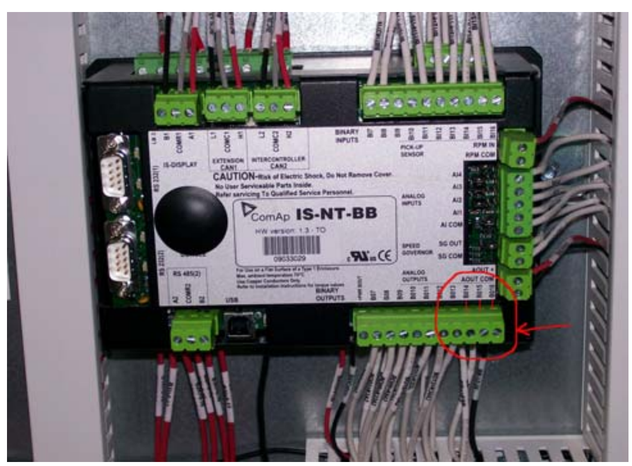
Generator Nameplate

Piping – biogas to engine, hot water to digester, cold water from digester, temporary boiler exhaust (left to right)

H_2S Scrubber

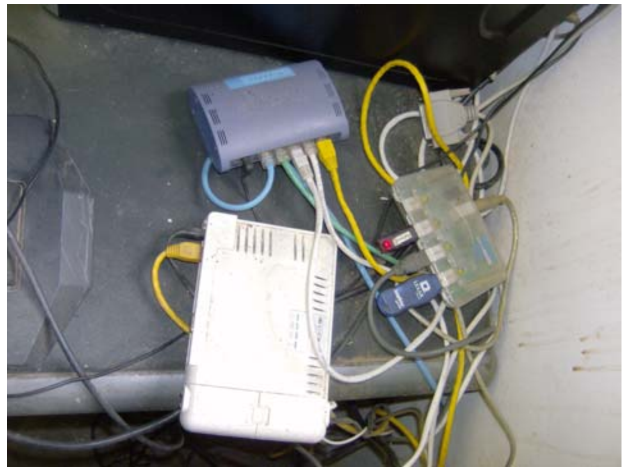
Figure 1. Photos of System Components

Gen-Tec engine control panel



InteliSys NT engine controller – Outputs 14, 15 and 16 can provide pulse outputs. To be programmed by Gen-Tec.

Digester control and status panel



Internet connection – In computer room in milking parlor

Figure 2. Photos of Meters and Electrical Panels

Figure **3** schematically shows the biogas system and engines. Biogas from the digester is either used in the engines or flared. The biogas flare operates using mechanically actuated valves that vent biogas to maintain the digester at the desired static pressure (approx. ½ inch of water). Biogas for the engines is first treated by the Hydrogen Sulfide (H_2S) scrubber and then the de-watering system. A 3 hp blower pressurizes the biogas to approximately 17 inches before the inlet to the engines. A 1000-gallon propane tank will be kept behind the generator building.

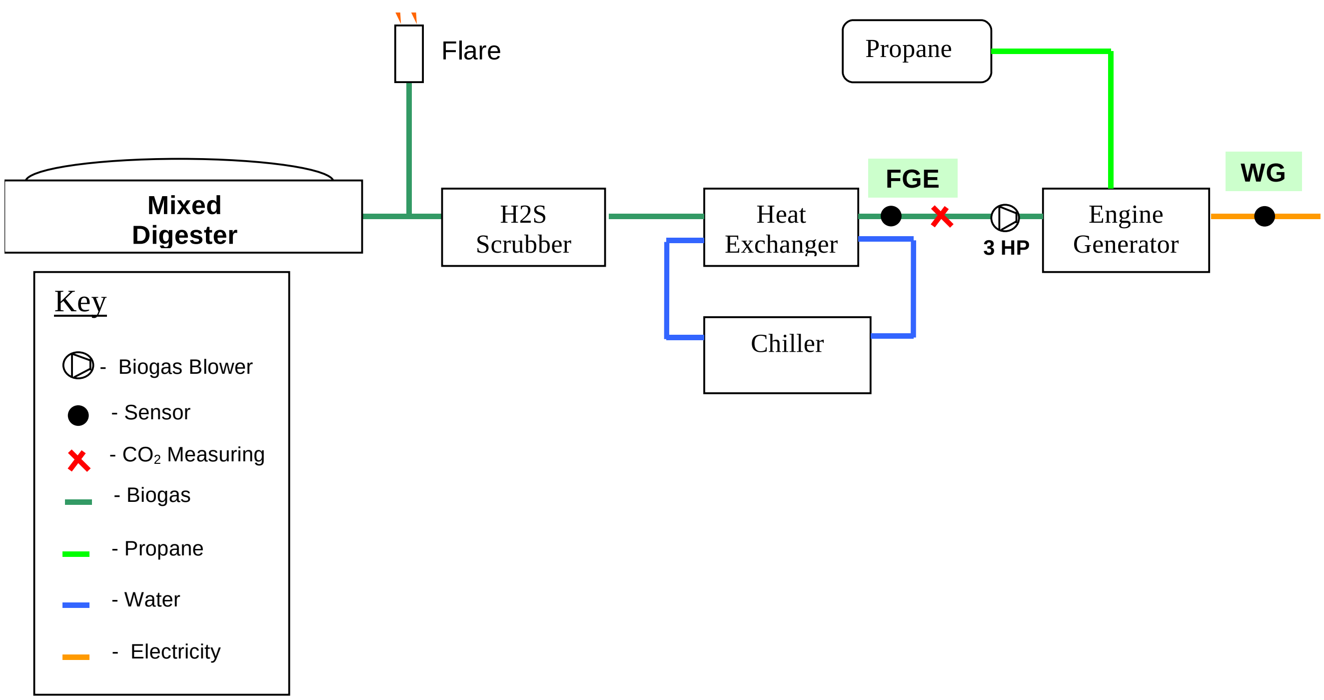


Figure 3. Schematic of Biogas System with Meters and Sensors

Manure from approximately 1,550 milking cows and 100 dry cows, is gravity fed to a short-term storage lagoon, as can be seen in Figure 4. From there it is gravity fed into the first of four cement storage tanks. The influent tank has a mixer in it, and a 10 HP pump sends manure into the digester. Effluent is then gravity fed from the digester into the third storage tank. From there it is pumped to the separator, which removes the solids from the liquids. The liquids then flow via gravity back into the fourth storage tank, temporarily, before being pumped to the lagoon for long-term storage. The separated solids are dried and used for bedding for the cows.

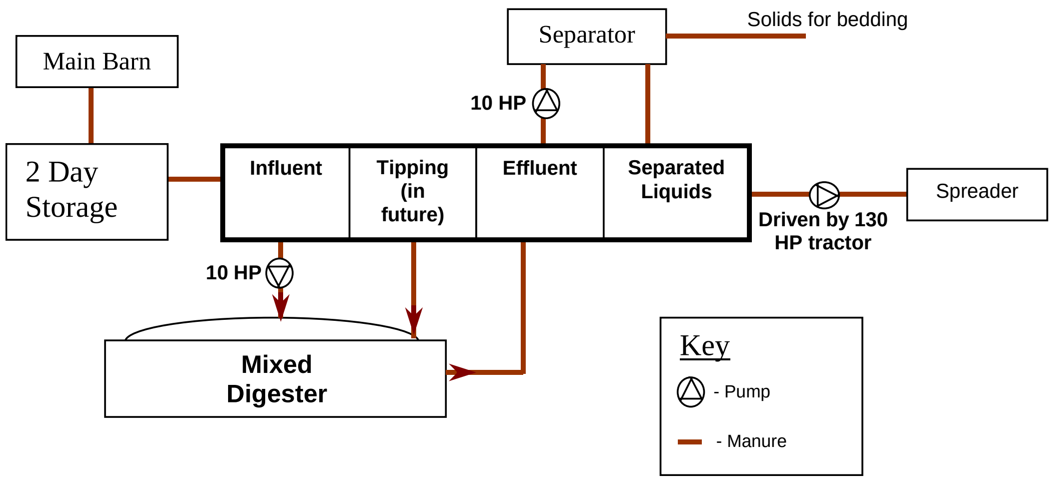


Figure 4. Schematic of Manure Management System

The digester is fully mixed and heated with the heat recovered from the engine. The cylindrical digester measures 108 feet in diameter and is 16 feet deep. There is a single hot water inlet that splits to two pipes that each travel thru the center of the digester and around their respective sides before combining back into a single cold water return. A plan view can be seen below in Figure 5. The digester has four 17.5 hp mixers spaced evenly around it, in order to prevent sediment from settling and a hard crust from forming inside the digester.

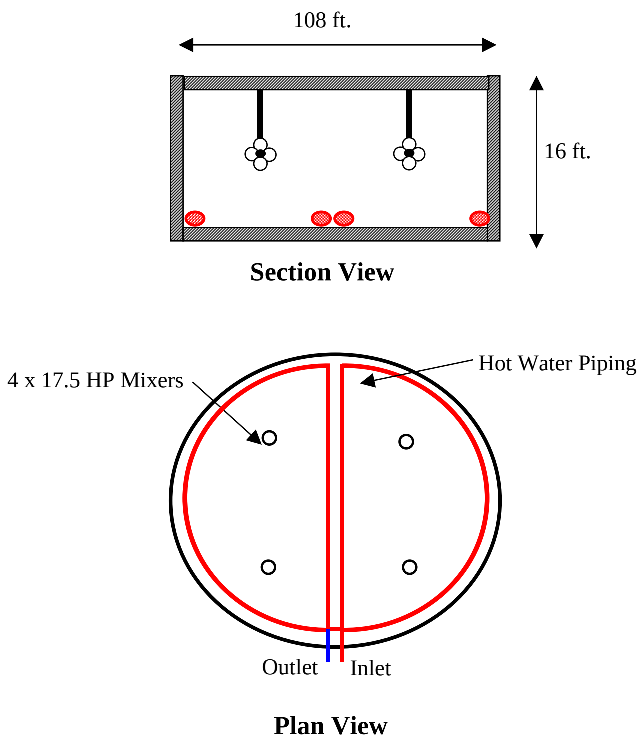


Figure 5. Digester Schematic

Monitoring System Equipment, Installation, Operation, and Maintenance

Figure **3** also schematically shows the locations of the monitoring points that will be used to measure system performance. One gas meter will measure biogas input to the existing engine generator (FGE) and one will measure biogas being flared, and one power transducer will measure the kilowatts generated by the engine (WG). Information on these data points is shown in Table 2.

Table 2. Monitored Points for ADG System

Point Type	Point Name	Description	Instrument	Engineering Units	Expected Range
Pulse	WG1	Engine Generator Power	Intelisys NT Engine Controller (Wh per pulse to be determined) Pulse Output	kWh	0 – 500
Pulse	FGE	Engine Biogas Flow	Sage inline flow meter SRP-05-15 (0-3150 cfm) Pulse Output	SCF / hr	0 – 12,000
Pulse	FGF	Biogas Flare	Sage inline flow meter SRP-05-15 (0-3150 cfm) Pulse Output	SCF / hr	0 – 12,000

The electrical output of the engine-generator will be measured with a Gen-Tec power transducer, connected to the Intelisys NT engine controller. The controller provides a pulse output, and will be installed in a stand-alone cabinet next to the engine. It has an external graphical display, which shows real time and total kWh. The power transducer will be installed according to Gen-Tec requirements.

The biogas input to the engine-generator 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 is installed on the flare piping to measure biogas flow to the flare. 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.

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. This value will be confirmed or adjusted based on weekly measurements of carbon dioxide using a Fyrite Gas Analyzer Model No. 10-5032 for CO_2 range 0-60%. Farm staff will perform the CO_2 tests and log the results on the biogas log sheet.

The engine uses propane as a backup/startup fuel. Propane use will not be continuously metered at this site. However, the farm will provide the propane delivery logs and summarize them in a spreadsheet for the Annual M&V Report (Table 3) in order to account for periods when the backup/startup fuel is used. If there is a meter on the tank, monthly meter readings could take the place of propane delivery logs for the Annual M&V Report.

Data Logger Installation

CDH Energy will install an Obvius AcquiLite datalogger to log the monitoring points listed in Table 2. The datalogger will be programmed to record the totalized data for each monitoring point at 15-minute intervals. A record of all multipliers and datalogger settings will be maintained. The datalogger will be located in the engine room next to the control panel, and will be connected to an uninterruptible power supply (UPS) to ensure the datalogger retains its settings and data in the event of a power outage. The farm will provide internet connection with a fixed IP address, run in underground conduit from the computer room in the milking parlor. The Obvius datalogger will be setup to upload data nightly to CDH Energy so it can be transferred to the NYSERDA CHP Website. If communications are lost, the Obvius datalogger is capable of holding at least 15 days of 15-minute interval data.

Management of Monitoring System Data (Farm 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 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) in the event that data transfer to the NYSERDA CHP Website fails or other anomalies occur.

On a weekly basis, the farm staff agrees to 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 web site, 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 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, 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 Annual M&V Report will include a table showing the monthly kWh production, biogas production, and propane use. The farm may use the standardized incentive report (see above). 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 table will also include monthly values for the calculated lower heating value of the biogas, total energy content of the biogas, total energy content of the propane, and adjusted kWh production. The methods for calculating these values are provided below.

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

Monthly Periods	No of Days in Each Period	Electricity Production $kWh_{generator}$	Biogas to Engine (cubic feet)	Propane Use (gal)	LHV_{biogas} (BTU/cf)	Biogas Energy Content Q_{biogas} (Btu)	Propane Energy Content $Q_{propane}$ (Btu)	Adjusted Electricity Production from biogas $kWh_{adjusted}$

The farm will calculate monthly values for lower heating value of the biogas (LHV_{biogas}), total energy content of the biogas (Q_{biogas}), total energy content of the propane (Q_{biogas}), and adjusted kWh production ($kWh_{adjusted}$) 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 delivered to engine in month

Monthly Propane Energy Content

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

$$Q_{propane} = Gallons \cdot \left[83{,}500 \frac{Btu_{LHV}}{gal} \right]$$

where:

Gallons - propane consumption in the period (gallons)

Monthly Adjusted Electricity Production

Calculate the monthly adjusted electricity production using the following equation:

$$kWh_{adjusted} = kWh_{generator} \left[\frac{Q_{biogas}}{Q_{biogas} + Q_{propane}} \right]$$

where:

$kWh_{generator}$ - actual electricity production

Reasonable Electrical Efficiency

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

Appendices

Cut sheets and Manuals for:

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

AquiLite Data Acquisition Server – A7801-1
http://www.obvius.com/documentation/Obvius/A7801Cutsheet.pdf
http://www.obvius.com/documentation/Obvius/A7801Manual.pdf

Sage Metering Inc. Model SIG-05-15 Mass Flow
http://sagemetering.com/description_files/SRG_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

Zuber Farms Addendum

Site Events

Date	Event
12/31/2009	Generation begins: 100 –110 kW
11/19/2010	Generator output increased to 260 kW
2/12/2010	Installed datalogger: began logging FGE & FGF, WG1 still needs to be hooked up.
2/23/2010	Verified pulse output, need relay to wire to obvius.
3/11/2010	Relay installed, WG1 began logging

Hardware

Device	Serial #	Output	Multiplier	Notes
Sage SRP-05-15 (engine)	47236	CF & CFM	10	
Sage SRP-05-15 (flare)	47229	CF & CFM	10	
Intelisys NT Controller		KWh (acc)	1	Checked on 2/23/10

Database Setup

Chan Name	Device	column
WG1,	mb-250,	
FGE,	mb-250,	
FGF,	mb-250,	

Sensor Verification

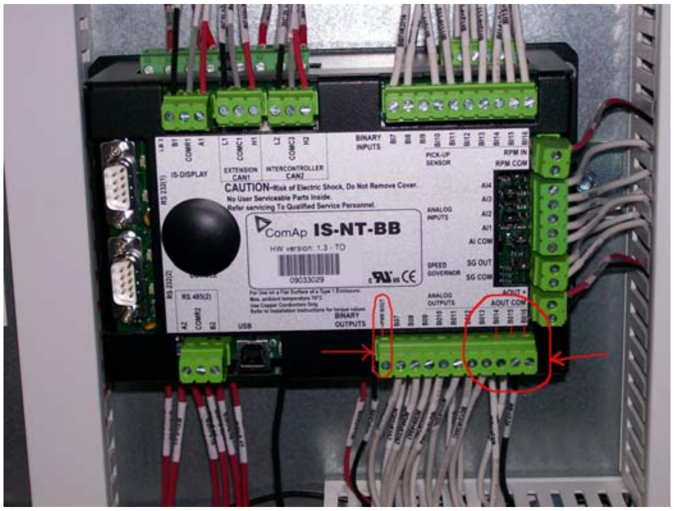
Power Meters

Pulse Counts	Measurment
1 kWh / Pulse	113 kw + 170 kW = 283 kW
1 pulse / 11 seconds	
327.27 kWh	% Diff. = 13.5

Biogas Flow Meters

	Obvius (scf/h)	Sage (scf/h)	% Difference
Sage #2	8571	8580	0.10%

Manual Check:	1 pulse / 4.5 seconds
	800 pulses / day
	8,000 cf / day



Intelisys NT Engine Controller

GenTec Panel with power output display

CDH panel will be on right wall between two existing panels.

Sage Flowmeter – Biogas to engine