MEASUREMENT AND VERIFICATION (M&V) PLAN

FOR

AURORA RIDGE DAIRY'S ANAEROBIC DIGESTER GAS (ADG) SYSTEM

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Submitted to:

New York State Energy Research and Development Authority
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Introduction

This plan describes the approach to monitor the performance of the anaerobic digester gas (ADG) system installed at Aurora Ridge Dairy LLC (ADG Contractor) 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 Aurora Ridge Dairy has applied for under a Standard Performance Contract with NYSERDA. The system has a Total Contracted Capacity of 400 kW.

ADG System Description

The digester system at the farm was designed by GHD, Inc. The site will operate a reciprocating engine-generator system, provided by Martin Machinery, with piping and controls installed in the existing structure that houses the solids separator/bedding recovery unit. All the electrical loads at the farm are being consolidated into a single 3-phase electrical service in order to accommodate the generator system. The system is tied to the grid, but is not able to run grid isolated in the event of a utility outage.

Table 1. Biogas Systems at Site

Digester	GDH Anaerobic Digesters Plug Flow with Mixing, Hard Cover, heated
Feedstock	Dairy Manure, approximately 1700 cows
Engine-Generator	Guascor SFGLD 480 / 45
Biogas Conditioning	Air-cooled Chiller with Plate Frame Heat Exchanger (HX)
Engine Backup/startup Fuel	None
Heat Recovery Use	Digester heating
Additional Heat Recovery	None

Partially Installed Engine Skid

Biogas blower (25 HP) and
piping for digester mixing

Biogas cooling heat exchanger; 7.5 HP Blower,
Piping to Flare

Figure 1. Photos of System Components

GenCon II Panel w/ Power Meter

Digester Control Panel (from GHD)

Beckwith Protective Relay (from back of door)

Figure 2. Photos of Electrical Panels

Separators and conveyor system

Bedding recovery unit

Figure 3. Manure Separator Units

Figure 4 schematically shows the biogas system, engine and instrumentation. Biogas from the digester is either used in the engine or flared. Biogas is also re-circulated back thru the digester via a 25 HP blower. Biogas supplied to the engine is cooled via an air-cooled chiller and plate frame heat exchanger to de-water the biogas. Unused biogas is sent to a flare. The engine does not use any backup fuel (such as propane).

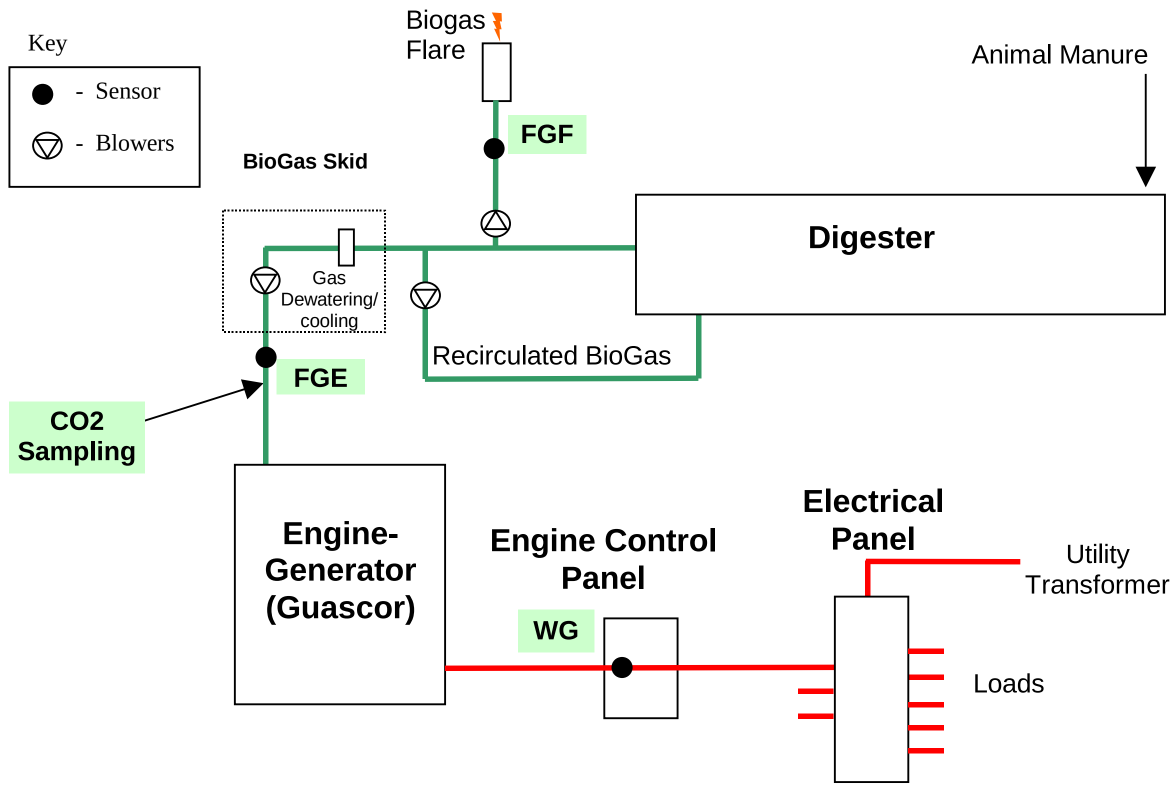

Figure 4: Schematic of ADG System

Manure from the approximately 1,700 dairy cows is to be pumped directly into the digester from the barns. Upon leaving the digester, effluent is pumped into a storage tank before being sent through one of the three separators. The solids are then sent to the bedding recovery unit, seen in Figure 3, while the liquid waste is pumped to the storage lagoon. The digester is a plug flow design that uses biogas recirculation to provide some mixing. The biogas bubbles cause a corkscrew flow pattern as manure travels along the u-shaped digester. The digester is 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 recirculation helps provide some mixing to keep sediment from accumulating at the bottom of the digester while retaining the performance benefits of a plug flow arrangement. Figure 5 schematically shows a basic layout of the digester.

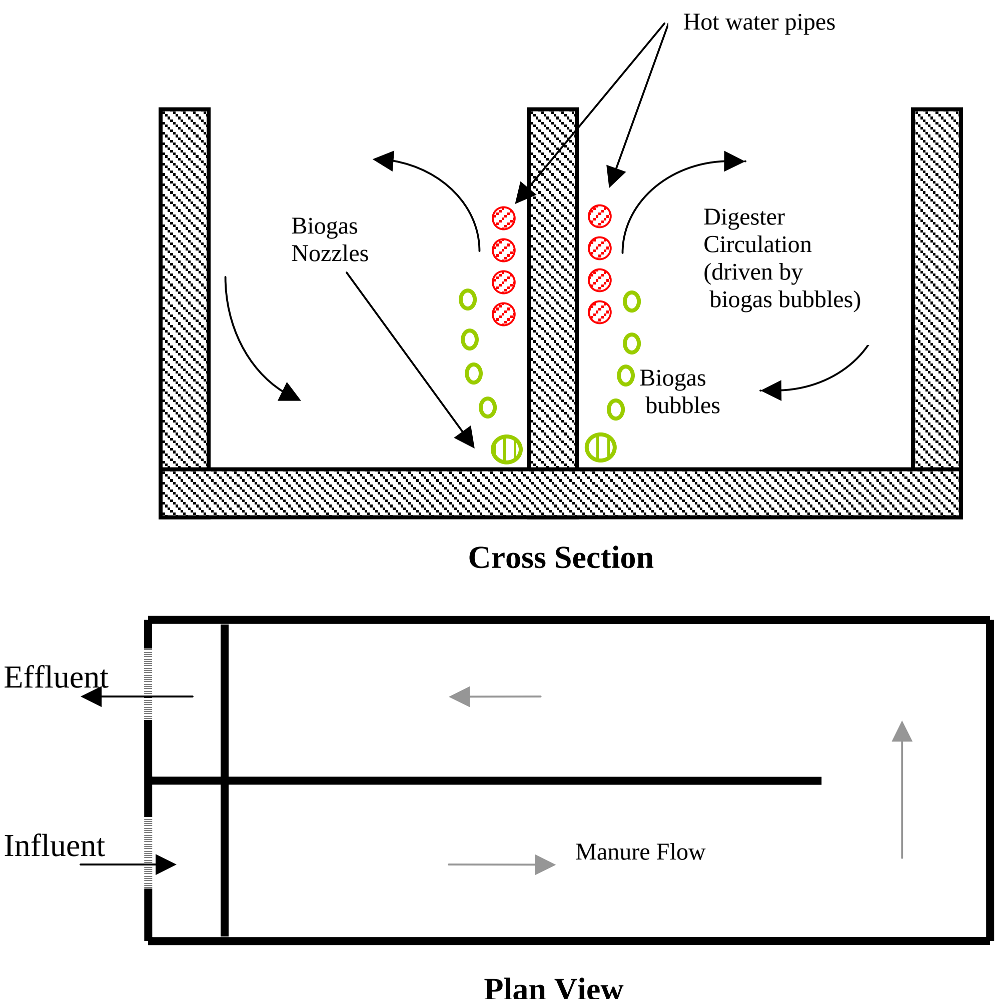

Figure 5. Digester Schematic

Monitoring System Equipment, Installation, Operation, and Maintenance

Figure 4 also shows the locations of the three data monitoring points where system performance will be measured: 1) a meter to measure fuel gas input to the engine generator (**FGE**), 2) a meter to measure fuel gas being flared (**FGF**), and 3) a meter to 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	WG	Engine-Generator Power	Intelisys NT Engine Controller (Wh per pulse to be determined)	KWh	0-520 kW
Pulse	FGE	Engine Biogas Flow	Sage SIP Industrial Mass Flow Meter	SCF / hour	0 – 13,000
Pulse	FGF	Flare Biogas Flow	Sage SIP Industrial Mass Flow Meter	SCF / hour	0 – 13,000

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 near the ceiling in the on the back wall of the building 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 SCFM
2. Total CF to the flare
3. Engine SCFM
4. total CF to the engine
5. Accumulated kWh
6. Flare 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.

Aurora Ridge Farms will be responsible for the cost to purchase and install the power meter (**WG**) and engine biogas meter (**FGE**). CDH Energy will pay for the cost to install the flare gas flow meter (**FGF**) as part of the Digester Protocol test effort.

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) from both the engine and flare 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 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, which will include a table showing the monthly kWh production biogas sent to 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 Data for Annual M&V Report (provided for each engine)

Monthly Periods	No. of Days in Each Period	Biogas Used by Engine (cubic feet)	LHV_{biogas} (BTU/cf)	Biogas Energy Content Q_{biogas}	Electricity Production $kWh_{generation}$

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.

<u>Monthly Biogas Lower Heating Value</u>
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

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 Metering Inc. Model SIP-05-06-STCF05-DC24-DIG-GAS Mass Flow Meter
http://www.sagemetering.com/specs/2ndgen/SIP-insertion-spec.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