QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) PLAN

FOR

WILLET DAIRY ANAEROBIC DIGESTER GAS (ADG) SYSTEM

Agreement # ADG-21265

Third Revision

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Submitted to:

New York State Energy Research and Development Authority
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and

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Introduction

This plan describes the approach that will be used to monitor the performance of the anaerobic digester gas (ADG) system that is currently being installed at Willet Dairy, LLC, ("The Farm") in Locke, NY, to produce biogas and electricity. Biogas will be used to fuel one 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 and amount of biogas used 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 based on a Total Contracted Capacity of 1,000 kW.

ADG System Description

The digester system at the farm was designed by DVO Anaerobic Digesters. The power plant equipment will be provided by Martin Machinery while the gas conditioning equipment will be supplied by DVO Anaerobic Digesters. Gas and power metering are planned to be provided by Gen-Tec and Sage Metering Inc. The site will operate one 1,000 kW synchronous engine-generator with gas conditioning equipment, piping and controls installed in a designated building next to the digester. All the electrical loads at the farm have been consolidated into a single 3-phase, 277/480 volt electrical service in order to accommodate the interconnection of the generator system. The electrical system includes controls to synchronize the generator to the grid as well as a protective relay and controls to automatically isolate the units from the utility grid in the event of a utility power outage. The generator will be connected to the NYSEG distribution network through a two meter system - one outgoing and one incoming. A 1,000 kW, diesel generator will be connected to the farm electrical system through a 2,000 A disconnect/transfer switch for use during power outages.

Engine-Generator Room

Digester Location

Figure 1 - Photos of System Components

Table 1 - Biogas Systems at Willet Dairy

Digester	DVO Anaerobic Digester mixed plug flow, concrete cover, heated
Feedstock	Dairy Manure, 3,500 animal equivalents
Engine	Guascor HGM 560 Engine 1,000 kW on biogas at 100% load
Generator	Marathon Electric MGG-1200 – 480 VAC, 3 Phase
Biogas Conditioning	Martin Machinery, plate & frame heat exchanger cooled by an air conditioner, water trap, a DVO hydrogen sulfide removal system.
Engine Backup/startup Fuel	None
Heat Recovery Use	Digester heating, boiler
Additional Heat Recovery	None

Figure 2 - Engine-Generator Room

Figure 3 schematically shows the biogas system and engine-generator. Figure 4 shows the single line electrical diagram for the system. Biogas from the digester is used in the engine-generator, boiler or flared. The biogas flare operates using a mechanically-actuated relief valve that vents biogas to maintain the digester static pressure requirements. Sage Prime metering devices measure gas flow to the flare (G1), to the engine-generator (G2) or the boiler (G3). Gas flow data from these meters is also shown on the Gen-Tec/Red Lion graphical display. Biogas for the engine is de-watered and pressurized via the gas conditioning equipment provided by DVO Anaerobic Digesters. Prior to the gas being sent to the gen-set, gas is first pressurized then cooled to drop out unnecessary moisture in the biogas. The gas is then re-heated for use in the engine. H2S levels are reduced in the digester by the DVO H2S reduction system.

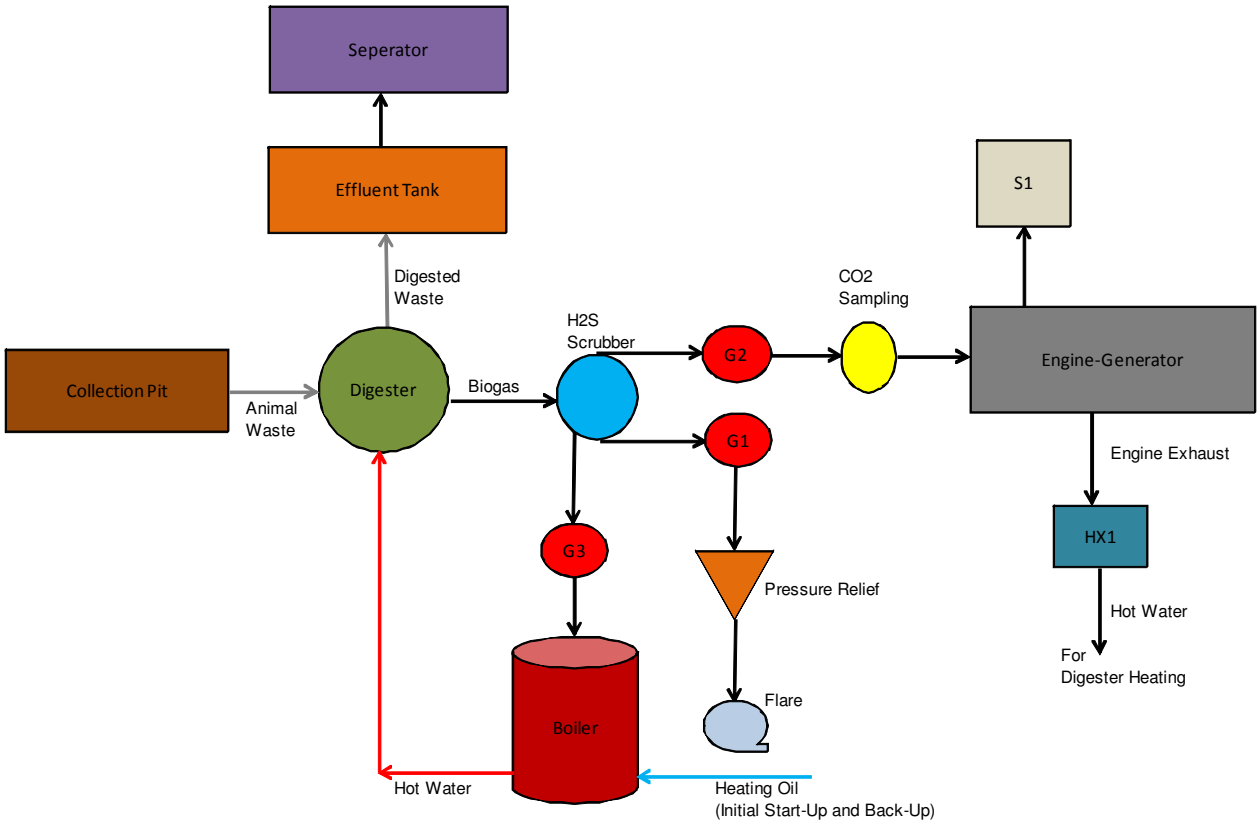

Figure 3 - Biogas System Schematic

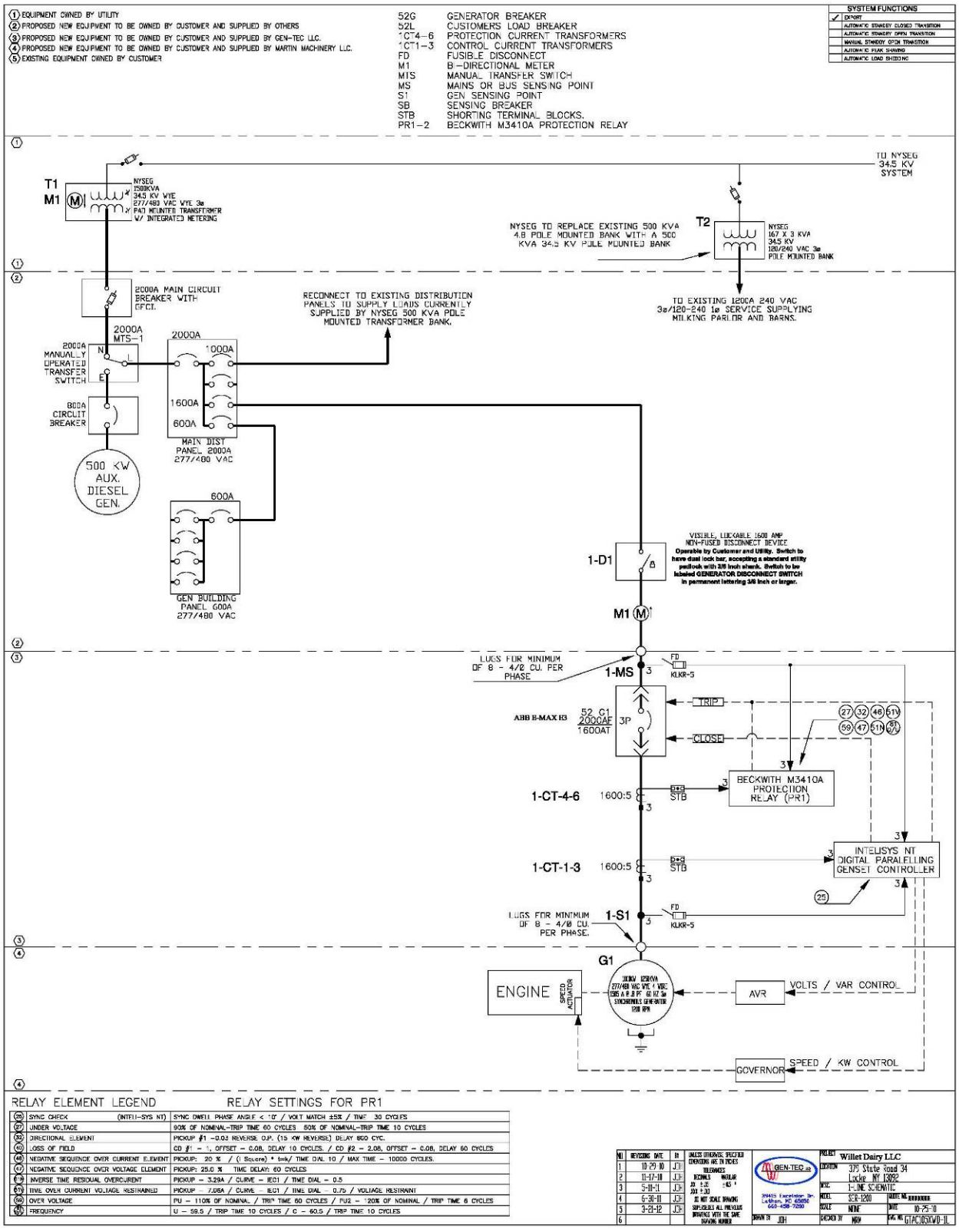

Figure 4 - Single Line Electrical Diagram

Monitoring System Equipment, Installation, Operation, and Maintenance

Figure 3 shows the location of the meters used to measure fuel gas input to the engine-generator (G2), the flare (G1) or the boiler (G3). Figure 4 shows meter S1 used to measure the kilowatts generated. 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	S1	Engine-Generator Power	Intelisys Base Box IS-NT-BB with LCD display	kW	0-1,200 kW
Pulse	G1	Engine Flare Flow	Sage Metering Inc. Model SIP-05-10-DC24-DIG-GAS	SCFM	0 – 500 SCFM
Pulse	G2	Engine Biogas Flow	Sage Metering Inc. Model SIP-05-06-DC24-DIG-GAS	SCFM	0 – 500 SCFM
Pulse	G3	Boiler Biogas Flow	Sage Metering Inc. Model SIP-05-06-DC24-DIG-GAS	SCFM	0 – 500 SCFM

The electrical output of the engine-generator will be measured with the Intelisys NT engine controller 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 appropriate operator guide. The controller will be protected by a dedicated circuit breaker.

The biogas input to the engine will be measured by a Sage Prime mass flow meter (G2) that provides pulse output proportional to the volume flow that is compensated for temperature. A second Sage Prime mass flow meter (G1) will be installed to measure biogas flow to the flare. Finally, a third Sage Prime mass flow meter (G3) will be installed to measure the biogas flow to the new boiler. The meters will be installed and maintained according to the "Sage Thermal Gas Mass Flow Meter Operations and Instruction Manual for Models SIP/SRP," 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 580 Btu/$ft^{3,}$ based on past measurements of the CO_2 content of the biogas. This value will be verified weekly based on measurements of carbon dioxide using a Shawcity GFM400 Series Gas "Analyser" for CO_2 range 0-100%. The Farm staff will perform the CO_2 tests and log the results in the project log. This test is performed by taking a gas sample from the low pressure gas supply before it enters the gas conditioning equipment. The sampling point is marked in Figure 3 as "CO2 Sampling"

The boiler backup/startup fuel flow (#2 Heating Oil) will not be continuously metered or logged at this site. The fuel oil will be used to run the new boiler during the startup process for the digester when the biogas that is produced does not have enough methane concentration to combust. Once the composition changes and will combust, then the boiler will be converted over

to bio-gas so that in the event the gen-set is down for any length of time, The Farm still have a heat source for the digester.

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. 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. The Farm will provide a static IP address that will be used by CDH Energy, the NYSERDA CHP Website Contractor, to communicate with the data logger. We have confirmed that CDH Energy 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.

Management of Monitoring System Data

The Farm will perform the following quality assurance and quality control measures to ensure the data produced from our 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 QA/QC 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) from meter S1 and gas flow (cf or ft^3) recorded by the Sage meters 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 stored in the NYSERDA CHP Website (chp.nyserda.org) to ensure it is consistent with our 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 track the system performance, including:

- a periodic email report summarizing system performance and the estimated incentive,

- an email report sent out if data is not received at the web site or does not pass the quality checks.

The website will automatically take the data collected from the data-logger and evaluate the quality of the data for each 15-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 passes the range and relational quality checks will be used in the incentive reports listed above. However, all hourly data is 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 Energy to resolve the issue in a few days.

If unanticipated loss of data occurs when the engine-generator continues to produce electricity, The Farm intends to follow the procedures outlined in Exhibit D, of their contract, i.e. use 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 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 being produced from biogas during the period in question.

Annual Performance Reports

Willet Dairy will prepare Annual Performance Reports summarizing the monthly data over the 12-month performance period. The reports will include a table (example provided below) showing the monthly kWh production, biogas use by the engine, and other data listed in Table 3, and if used, any heating oil or other fuel used for the engine/boiler. 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 Performance Reports

Start Date of Reporting Period	Number 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)
TOTALS					

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 follows.

Monthly Biogas Lower Heating Value

The readings of CO_2 concentration in the biogas gathered weekly will be used 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 (cubic feet or ft^3) of biogas in month

Reasonable Electrical Efficiency

The Annual Performance 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% over any interval for the engine-generator at Willet Dairy.

Appendices

Cut sheets and Manuals for:

Sage Metering Inc., Model SIP-05-06-DC24-DIG-GAS Mass Flow Meter
http://www.sagemetering.com/pdf/datasheets/100-0107_SIP-INSERTION-InstrumentDataSheet2.pdf

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

Shawcity GFM400 Series Gas "Analyser"
http://www.shawcity.co.uk/sites/www.shawcity.co.uk/files/Shawcity%20GFM400%20Brochure%20.pdf