# QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) PLAN

**FOR**

# CH4 GENERATE CAYUGA, LLC ANAEROBIC DIGESTER GAS (ADG) SYSTEM

Agreement # 106540

May 3, 2019

*Submitted to:*

**New York State Energy Research and Development Authority**
17 Columbia Circle
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*and*

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*Submitted by:*

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# Introduction

This plan describes the approach that will be used to monitor the performance of the expansion of the anaerobic digester gas system (ADG System) that is currently being installed by CH4 Generate Cayuga at an industrial wastewater treatment facility (the WWTF) in Auburn, NY, to produce biogas and electricity. Biogas will be used to fuel an additional engine-generator set to produce more 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 new engine-generator. The data will serve as the basis for payment of ten (10) years of performance incentive payments, which CH4 Generate Cayuga has applied for under a Standard Performance Contract with NYSERDA based on a Total Contracted Capacity of 633 kW.

# ADG System Description

The original ADG System was designed by GBU Germany and constructed in 2008 by the Cayuga County Soil and Water Conservation District. The original system currently processes 40,000 gallons per day (gpd) of dairy manure (85 percent) and liquid food waste (15 percent) to produce heat and 625 kilowatts (kW) of electricity. CH4 Generate Cayuga is planning to increase energy production by integrating digestion of high-energy density solid food wastes and changing the feedstock ratio to be 10 percent dairy manure and 90 percent food waste by weight. Upgrades to the site include the food waste Pre-processing Building, organic biofilter, pre-processing equipment, conversion of the existing manure tank to a hydrolysis tank, installation of a second biogas-fired combined heat and power system, and an expanded biogas treatment system. The additional engine-generator equipment and additional gas conditioning equipment will both be provided by Martin Energy. Gas and power metering are provided by Sage Metering Inc. and Electro Industries, respectively. After the addition of a new 633 kW genset to the original 633 kW genset, the site will operate both gensets simultaneously. Gas conditioning equipment, piping, and controls will be located next to the engine skid in a nearby building. The electrical system includes controls to synchronize the generator to the grid as well as a Schweitzer SEL-300G protective relay and a grid monitoring device to automatically isolate the units from the utility grid in the event of a utility power outage. Most of the available biogas is expected to be used for power generation with waste heat directed to heat recovery.

# Biological System Description

The biological scrubber system was designed by Martin Energy Group. The Martin Energy Group ECS-1200 scrubber system will operate in parallel to the existing Blue Electron conditioning system, which currently serves the existing engine-generator system. The scrubber is a 12-foot diameter by 24-foot high fiberglass structure with a biogas analyzer to measure upstream and downstream methane ($CH_4$), carbon dioxide ($CO_2$), oxygen ($O_2$), and hydrogen sulfide ($H_2S$) quantities. The scrubber is designed for a biogas flow rate of 350 standard cubic feet per minute (scfm) containing up to 4,000 parts per million (ppm) of $H_2S$.

**Figure 1: Ancillary existing ADG buildings**

**Figure 2: Pre-processing Building and pipe bridge**

**Figure 3: Biological scrubber system**

**Table 1 - Biogas Systems at CH4 Generate Cayuga**

| | |
|---|---|
| Digester | Cylindrical, above ground with closed top, carbon steel, heated, 1.06 million gallon capacity, 25-30 day retention time |
| Feedstock | Solid food wastes (90%) and dairy manure (10%) |
| Engine | Jenbacher JGS 312, 1,800 RPM, 633 kW on biogas |
| Generator | Stamford Model CG 634 J – 480 VAC, 3 Phase. |
| Biogas Conditioning | Existing conditioning is handled by Blue Electron biogas conditioning system. A new Martin Energy ECS-1200 scrubber treatment system will operate in parallel to the Blue Electron conditioning system. Total biogas treatment of 350 cfm |
| Engine Backup/startup Fuel | Natural gas to be used as backup fuel |
| Heat Recovery Use | Digester, hydrolysis tank, gasholder effluent tank, Pre-processing Building, and potential future uses (county jail, nursing home) |

Figure 4 and Figure 5 show the site layout and general site plan. Figure 4 shows the existing facilities while Figure 5 shows the planned/proposed facilities with respect to the existing layout. The current operation of the existing digester system utilizes 85 percent manure and 15 percent liquid food waste. The upgraded system will alter the amount of processed waste at the ADG System to be 6,000 gpd of dairy manure and 46,000 gpd of pre-processed/diluted food waste. The gensets will utilize digester gas from 10 percent manure and 90 percent food waste (a combination of pre-packaged food waste and municipal source separated organics [SSO]). SSO will be collected as waste material from restaurants, grocery stores, farmers' markets, and residential sources. The increased biogas production and additional 633 kW of energy production will yield a total power production up to 1.3 megawatts (MW). The existing tankage, pumps, and piping were originally designed in 2008 to be capable of accommodating the increased biogas flow and energy production. The existing biogas treatment system, utility transformer, and flare will be upgraded to accommodate the added production. The main upgrades include the food waste Pre-processing Building, organic biofilter, and pre-processing equipment; conversion of the existing manure tank to a hydrolysis tank; installation of a second biogas-fired combined heat and power system; and an expanded biogas treatment system.

**Figure 4: Site layout**

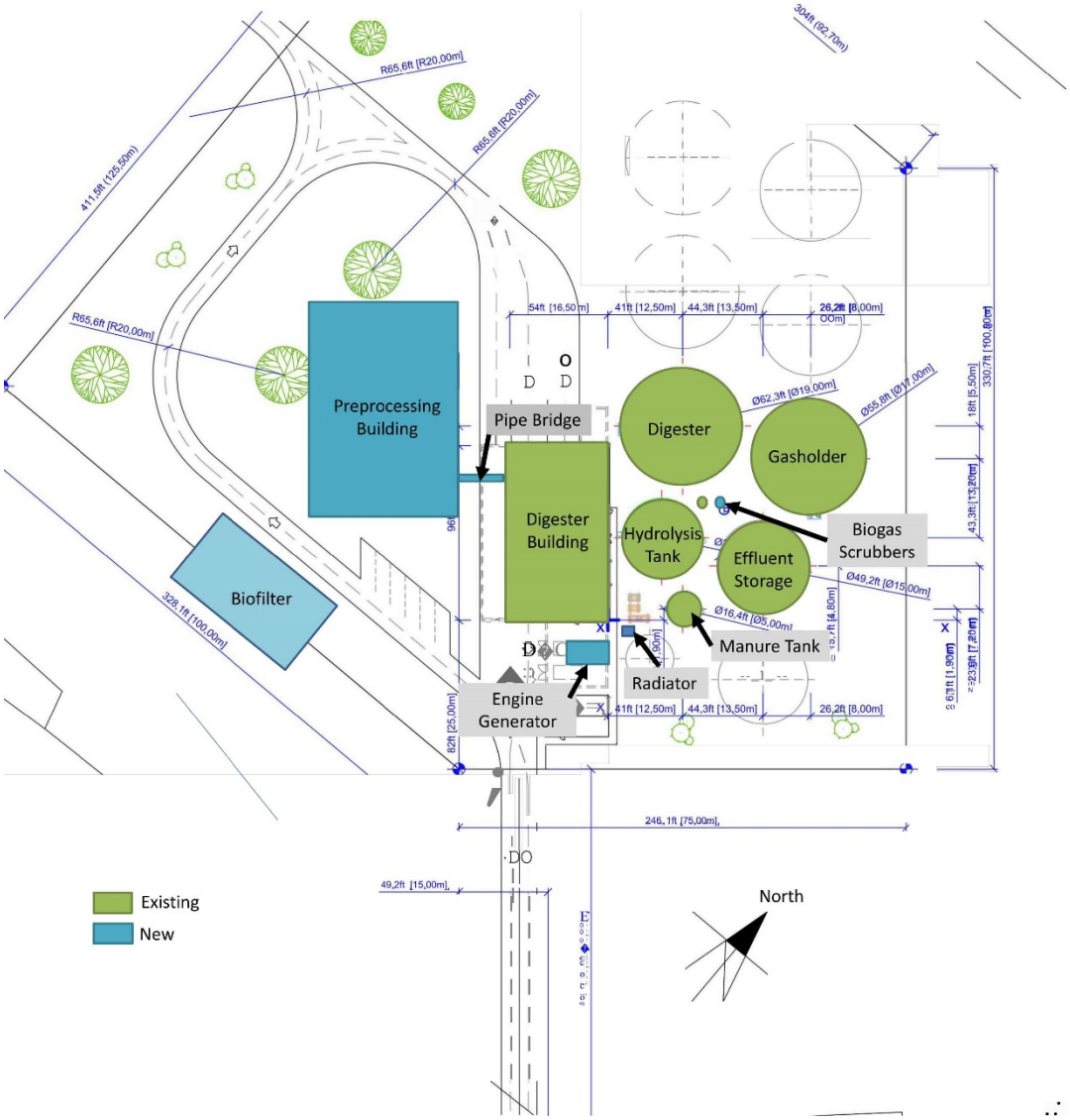


**Figure 5: Site plan**

Figure 6 shows the process diagram for the proposed digester and engine system. There are two process flows for feedstock: food waste and dairy manure. The food waste will be delivered to the Tiger HS640 depackaging unit to remove inorganic materials, including cans, wrappers, bags, plastics bottles, or plastic jars. The organic waste will be pumped to the hydrolysis tank and heated to mesophilic conditions (98°F) using waste heat from the genset and mixed continuously with mechanical mixers. The exiting waste from the hydrolysis tank will be pumped to a 64-foot-high by 62-foot-diameter, 1.06-million-gallon capacity digester where it will be combined with the dairy manure feedstock stream. Effluent from the digester will be pumped to a 13-foot-high by 56-foot-diameter, 211,000-gallon storage capacity gasholder effluent tank. The purpose of the effluent gasholder tank is to store the digested slurry effluent to stabilize the processed effluents, which improves solid effluent quality and increases biogas production. In addition, the gasholder effluent tank will also store biogas produced from the post-fermentation process for use during peak kW periods and digester equipment maintenance. The liquid effluent will be pumped to a 15-foot-high by 49-foot-diameter, 185,000-gallon storage volume effluent storage tank. The digestate will be pumped back to the Tiger depackaging unit, while the solids will be pumped and shipped offsite for eventual land application for farmers.

Biogas from the digester and gasholder effluent tank will flow to one of two biogas treatment systems. One biogas treatment system is currently used as part of the existing combined heat and power system while the second biogas treatment system will be installed in parallel as part of this site upgrade. In the new treatment system, biological removal of hydrogen sulfide from the biogas will occur via a new Martin Energy ECS-1200 biological scrubber treatment system to be operated in parallel with the existing treatment system. Moisture will be removed from the biogas by utilizing a 15-ton Cold Shot ACWC-180-E chiller skid.

New blowers will transport the treated biogas to the two gensets, or during periods of high biogas production, to the flare. The engine-generator set is conservatively expected to operate at a capacity factor of approximately 90% after accounting for biogas production rates and expected maintenance intervals. The planned biogas distribution will be used completely for power generation with potential excess biogas flared as needed for backup, and waste heat recovered for process uses. In addition to electricity production, a heat recovery system will utilize heat in other areas of the process, including the hydrolysis tank, digester, gasholder effluent tank, effluent storage tank, and the newly constructed Pre-processing Building. There is also the potential in the future to utilize heat recovery at the nearby county jail and nursing home.

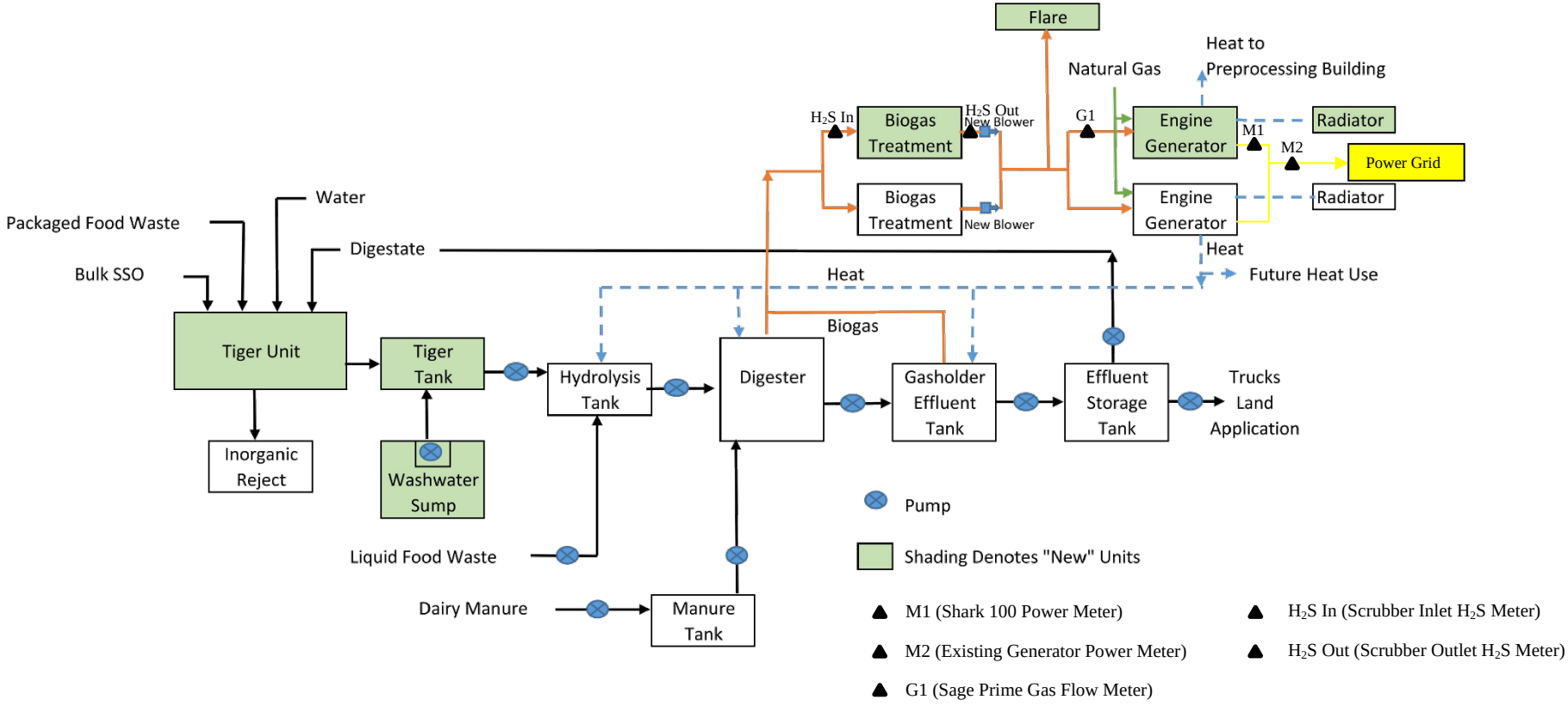


**Figure 6: Proposed Digester Process Diagram**

Sage Metering Inc. devices will measure gas flow to the engine-generator. A Shark 100 revenue grade meter will measure the energy output and power data of the new engine-generator to determine the Annual Performance Incentive. A small amount of air will be injected directly into the digester head space to help reduce $H_2S$ in the biogas prior to the carbon removal system. This limiting of $H_2S$ is to protect the engine from damage or overheating due to concentrations of $H_2S$. Measurement of $H_2S$ is performed by a Sewerin Biocontrol 4/Multitec 545 meter to provide insight to the effectiveness of the gas cleaning techniques and to assist with the calculation of the $H_2S$ Reduction Performance Incentive.

Heat is recovered from the engine exhaust in the form of hot water. This hot water is circulated through the heat exchanger where it provides heat to the digester contents, hydrolysis tank, gasholder effluent tank, and Pre-processing Building. The system is also designed for potential future expansion to provide additional heat recovery for external heating applications at the nearby county jail and nursing home.

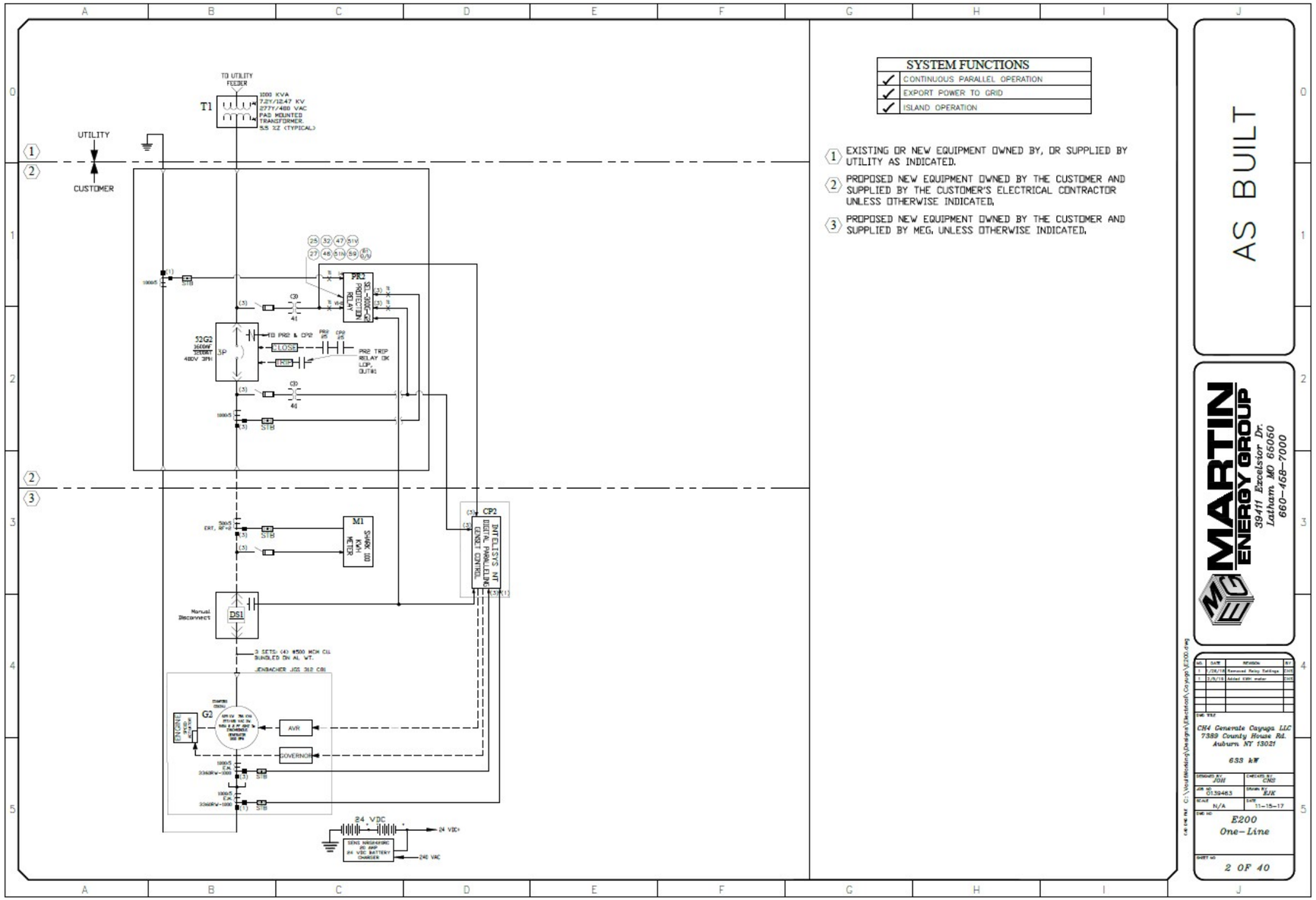


**Figure 7: One Line Electrical Diagram**

# ADG System Capacity Payment Descriptions

This Section describes the Capacity Incentive Payments included in the Agreement, the payment milestones to be achieved in order to receive payment, and the deliverables to be provided in achieving these milestones.

**Capacity Payment #1**: Up to 15% of the Total Capacity Incentive.

Payment Milestones: Initial payments made for major equipment and other work, such as the engine generator system, the anaerobic digester system, the gas scrubbing equipment, and other major components and fees for system design, engineering, CESIR study and other "soft costs".

Deliverables: Documentation that initial payments have been made to suppliers or service providers for major project components.

**Capacity Payment #2:** Up to 45% of the Anaerobic Digester component of Total Capacity Incentive.

Payment Milestones: NYSERDA's designated technical consultant has verified that construction/installation/upgrade of the anaerobic digestion system has been completed.

Deliverables: (a) A QA/QC Plan approved by NYSERDA and (b) Site inspection and verification by the NYSERDA technical consultant that the installation is complete and operational in accordance with the approved QA/QC Plan. The digester can be considered complete and operational if the digester structures, piping, controls and equipment are all installed for the feeding mixing, heating and unloading of digester feedstocks and for gas treatment and flaring. The completed installation may be documented with (1) a listing of the digester structures, piping, controls and equipment for feeding, mixing, heating and unloading and gas treatment and flaring and other major equipment to be installed in the design and (2) provision of as-built drawings, photos, verification by on-site inspection by the NYSERDA technical consultant, and/or other means satisfactory to NYSERDA documenting that these have been installed and are ready to operate to produce and manage the design biogas power generation rate of approximately 20,948 scf/hr identified in the project Application Package to PON 2828 Appendix B Section B as a total of 183,500,000 scf/yr. *(If the installed equipment deviates from that listed in the Application Package, an explanation of the deviation must be provided for determination by NYSERDA whether the installed equipment adequately meets the terms of the Agreement.)*

**Capacity Payment #3:** Up to 45% of the Power Generation component of Total Capacity Incentive.

Payment Milestones: The Contractor has provided sufficient documentation to NYSERDA verifying that the power generation system has been delivered to the site (e.g., delivery receipt).

Deliverables*:* Delivery receipts, photos or other documentation acceptable to NYSERDA of delivery of the engine and generator equipment as described in the Agreement and adequate explanation of any deviations. *(If the installed equipment deviates from that listed in the*

*Application Package, an explanation of the deviation must be provided for determination by NYSERDA whether the installed equipment adequately meets the terms of the Agreement.)*

**Capacity Payment #4:** Up to 45% of the Project Enhancement component of Total Capacity Incentive.

Payment Milestones: NYSERDA's designated technical consultant has verified that construction/installation of the Project Enhancement component(s) has (have) been completed or the required documentation for the Project Enhancement(s), according to applicable sections of *Using the Incentive Calculation Tool* of Exhibit D has been submitted to NYSERDA. The Contractor may request payment at this time for any Project Enhancements that have been completed and verified. Payment for Project Enhancements completed and verified after the 4th Capacity payment request has been made may be requested with the 6th Capacity payment.

Deliverables: Documentation that the project enhancement for the system designed to accept greater than 20% food waste has been completed, including pretreatment equipment, all meeting the requirement of Enhancements Section 3 of the Using Incentive Calculation portion of Exhibit D.

**Capacity Payment #5:** Up to 20% of the Total Capacity Incentive.

Payment Milestones: Documentation has been provided to NYSERDA that sufficiently verifies successful operation of the newly installed system and completion of interconnection.

Deliverables: The New Power Generation Capacity can be considered complete and operational if it has produced electricity at a minimum average of 75% capacity factor or 474.75 kWh/h for at least one hour. Verification of successful operation may include documentation of operation of the equipment with data from meters or hand-held biogas biogas measurement equipment or other methods of verification acceptable to NYSERDA. Interconnection completion can documented with a copy of interconnection acceptance test documentation from the utility or with other documentation acceptable to NYSERDA.

**Capacity Payment # 6:** Up to 100% of the Total Capacity Incentive.

Payment Milestones: The newly installed system is successfully commissioned. Commissioning includes operating both of the two biogas-fueled energy generation systems at a minimum of 75% average capacity factor over seven (7) consecutive days, and demonstrating the ability to upload data generated by the system to NYSERDA's CHP website, if applicable. Any Project Enhancements payments that were not made with the 4th Capacity payment may be requested with this payment.

Deliverables: A Project Commissioning Report documenting the completion of all elements of the Commissioning process required by the QA/QC Plan and successful uploading of data to the website that is adequately consistent to NYSERDA's satisfaction with the data recorded on site. The Project Commissioning Report shall consist of the compilation of the following deliverables is provided to NYSERDA's satisfaction as meeting the requirements for the 6$^{th}$ Capacity Incentive Payment.

1. Documentation that construction of the new ADG System components are complete;

2. Documentation that the System's New Equipment has satisfactorily operated for at least seven consecutive days, which is defined as operation with a minimum average 75% Capacity Factor of the Total Contracted Capacity or 474.75 kWh/h during which time sufficient biogas is produced for the original genset to also be producing an average of at least 474.75 kWh/h;

3. Documentation that the new biogas scrubber produces biogas with less than 400 ppm of $H_2S$ during 75% of the hours in that 7-day period in accordance with the requirements described in the Monitoring section below.

4. Documentation that the System has demonstrated the ability to upload information to NYSERDA's CHP Data Integration Website in conformance with the following section of the QA/QC Plan: Monitoring System Equipment, Installation, Operation, and Maintenance;

5. As-Built Diagrams of the installed system, including an explanation of any deviation of the equipment from that listed in the Application Package. Diagrams may consist of electronic copies of as-built drawings.

# Monitoring System Equipment, Installation, Operation, and Maintenance

Figure 6 shows the general location of the meters used to measure biogas input to the engine-generator (**G1**), the generator electrical output of the new system (**M1**), the generator electrical output of the old system (**M2**), $H_2S$ levels on the biological scrubber inlet (**$H_2S$ In**), and $H_2S$ levels on the biological scrubber outlet (**$H_2S$ Out**). 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 | M1 | New Engine-Generator Power | Electro Industries Shark 100 | kW | 0 - 650 kW |
| Pulse | M2 | Existing Engine-Generator Power | Eaton IQA6400 | kW | 0 – 650 kW |
| N/A | $H_2S$ In | Biological Scrubber Inlet $H_2S$ | Sewerin BioControl 4/Multitec 545 | ppm | 0 – 5,000 ppm |
| N/A | $H_2S$ Out | Biological Scrubber Outlet $H_2S$ | Sewerin BioControl 4/Multitec 545 | ppm | 0 – 5,000 ppm |
| Pulse | G1 | Engine Biogas Flow | Sage Metering Inc. Model SIP-05-06-DC24 | SCFH | 0 – 15,000 SCFH |

The energy output and power data of the engine-generator will be measured with an Electro Industries Shark 100 to determine the Annual Performance Incentive. The electrical output of the engine-generator system will be measured with the Intelisys BaseBox engine controller. The controller provides an external graphical display of instantaneous kWh and total kWh. The controller will be installed according to the requirements in the appropriate operator guide and will be protected by a dedicated circuit breaker. The measurements available on the controller are for backup purposes only. Additionally, an existing energy production meter on the old engine-generator system will measure the energy output of the original engine-generator system to confirm that biogas production is sufficient to operate both engine-generator systems. The ADG System staff will manually record monthly energy production of the existing engine-generator system alongside the energy production of the new system.

The biogas input to the engine will be measured by a Sage Prime mass flow meter that provides pulse output proportional to the volume flow that is compensated for temperature. The meter will be installed and maintained according to the "Sage Thermal Gas Mass Flow Meter Operations and Instruction Manual for Models SIP/SRP," by the facility. A log of maintenance activities for the meters will be maintained at the site. The gas flow into the biogas treatment system will be calculated as the sum of biogas flow into the flare, to the new engine generator, and to the old engine generator to determine total biogas produced and treated.

The lower heating value for the biogas is estimated to be 550 Btu/$ft^3$ based on past measurements of the $CH_4$ content of biogas. This value will be analyzed weekly based on measurements of methane using a Sewerin BioControl 4/Multitec 545 gas analyzer for $CH_4$ range of 0-100%. The

ADG System staff will perform the $CH_4$ 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 engine generator equipment.

Data logging is going to be done in one of two ways:

1) The installed system has the capabilities to perform the necessary data logging. This includes receiving signals from the power meter and gas meter (Modbus 485, Modbus TCP, pulse, 4-20mA, BACnet, etc.) and logging time stamped data at 15-minute intervals. Data will need to be transferred to Frontier Energy (the NYSERDA DER Website Contractor) nightly and on an automated basis. This can be done in a number of ways:
    - A nightly automated email to datacollection@cdhenergy.
    - A nightly automated upload to Frontier's FTP server (Frontier Energy will setup and provide server credentials).
    - If a static IP address can be provided, and the data made available online, Frontier could set up automated processes to pull data on a nightly basis.

2) If the installed system does not have the capabilities required, Frontier will provide an Obvius AcquiSuite data logger and panel. Frontier will then terminate sensor wiring to the logger, and verify that accurate measurements are being received. The facility will be responsible to provide Frontier with 110 V power, and an internet connection, preferably with a static IP address.

The worksheet in Appendix B will be used as a template for documenting the capabilities of the biological scrubber system. Biogas flow and $H_2S$ input to and output from the new scrubber will be documented for each hour of the year that samples are taken with the Sewerin BioControl 4/Multitec 545. The ADG System staff shall provide the hourly data on biogas flow and $H_2S$ concentrations to Frontier Energy in the manner described above. The percentage of cumulative outlet $H_2S$ samples (up to a maximum of 90% of the hours in a year) with 399 ppm $H_2S$ and below will be submitted as part of the Annual Performance Reports to provide the basis for calculation of the scrubber portion of the annual performance payments as described below. The summary of samples will show the percentage of cumulative samples with 399 ppm $H_2S$ and below as well as the percentage of cumulative samples with 400 ppm $H_2S$ and above.

Incentive calculation methods for the 6th Capacity Incentive Payment and the annual Performance Payments, which are based on $H_2S$ data, are as follows:

- To satisfy requirements for the 6th Capacity Incentive payment, a minimum of 75% of the hourly samples taken in a 7-day period, while the biogas flow through the new scrubber averages 75% of 350 cfm, must be below 400 ppm.
- The annual Performance Incentive payment for $H_2S$ reduction is determined by multiplying the Contract Capacity (633 kW), times the factor of 75% divided by 90%, times the verified hourly samples below the minimum $H_2S$ threshold (during which hours the biogas flow through the new scrubber is at least 50% of the design capacity of 350

cfm), times the $H_2S$ Performance Incentive variable for a biological scrubber ($0.0023/kWh). NYSERDA will consider other formulations for calculating the $H_2S$ Performance Incentive, for example in the event that the biological scrubber is unable to operate due to reasons outside of the operation of the scrubber itself. NYSERDA may direct its technical contractors to sample the biogas, determine $H_2S$ removal efficiency, and compare the results to the data originally provided by the operator.

**Management of Monitoring System Data**

The ADG System staff 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 ADG System equipment manager will perform inspections of the digester and engine-generator equipment and record findings into the project log.

On a weekly basis, the ADG System 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 ADG System staff will also maintain a weekly log of the cumulative power generation (kWh) from the power meter and gas flow (cf or $ft^3$) recorded by the Sage meter in the event that data transfer to the NYSERDA DER Website fails or other anomalies occur.

On a weekly basis, the ADG System staff will review the data stored in the NYSERDA DER Website (https://der.nyserda.ny.gov/) to ensure it is consistent with our observed performance of the ADG system and logged readings. The ADG System staff will review the data on the website, including:

- Monitored Data – Download (CSV file)

In addition, the ADG System staff will also use the Monitored Data – Download (CSV file) that is available at the DER Website to help track the system performance, including:

- an email report sent out if data is not received at the website 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 base time interval using range and relational checks. The range checks will be setup based on the expected ranges for the sensors (see Table 2).

The relational check will compare the kWh production data and gas production data for each base time interval to ensure that both meters are reading properly. This check is to ensure that both meters are operating properly; power cannot be produced without gas, and gas cannot be combusted by the engine without producing power.

Data that passes the range and relational quality checks will be used to compile the production amounts used for the incentive calculations. However, all hourly data is available from the NYSERDA CHP Website if the data quality flag of “Data Exists” is selected. In the event of a communications or meter failure, the ADG System staff will work with Frontier Energy to resolve the issue in a few days.

If unanticipated loss of data occurs when the engine-generator continues to produce electricity, the ADG System 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

ADG System 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 ADG System 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**

CH4 Generate Cayuga will prepare Annual Performance Reports summarizing the monthly data over the 12-month performance period. The reports will include a table (such as the example provided below) showing the monthly kWh production of both the old generator and new generator, biogas use by the new engine, and other data listed in Table 3, and if used, any natural gas, propane, or other fuel used for the engine/boiler. CH4 Generate Cayuga may use the data found on the DER Website or alternatively, ADG System staff may provide their own summary of the data using on-site sources 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 | Total Electricity Production of Existing Generator, kWhgenerator | Total Electricity Production of New Generator, kWhgenerator | Electricity Production of New Generator from Natural Gas | Net Electricity Production of New Generator from Biogas | Total Biogas Generated (cubic feet) | Biogas Used by Original Engine (cubic feet) | Biogas Used by Flare, (cubic feet) | Biogas Used by New Engine, (cubic feet) | Total Biogas Used (cubic feet) | Average Biogas Heating Value $LHV_{biogas}$ (Btu/cf) | Natural Gas Used by New Engine (cubic feet) |
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CH4 Generate Cayuga 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:

$$LHV_{biogas} = LHV_{methane} \cdot (F_{CH4})$$

where:

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

$F_{CH4}$ - fraction of biogas that is $CH_4$ (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 31% to 38% range over any interval for the engine-generator at CH4 Generate Cayuga.

**Appendices**

**Appendix A - Martin Engineering Shark 100 Power Meter Quote**

**Appendix B – $H_2S$ Reduction Spreadsheet**

**Cut sheets and Manuals for:**

**Jenbacher JGS 312, 1,800 RPM Engine**

**ComAP Intelisys BaseBox Controller IS-NTC-BB**

**Electro Industries Shark 100 Meter**

**Sage Metering Inc., Model SIP-05-06-DC24 Mass Flow Meter**

**Sewerin Multitec Biocontrol 4/Multitec 545**

## Appendix B

$H_2S$ Reduction Spreadsheet

| Worksheet to Determine the Number of Hours Qualifying for Use in Payments Based on Hours Scrubber Produces Biogas with H2S <400 ppm | | | | | | | |
|---|---|---|---|---|---|---|---|
| Data to be supplied by operator | | | | | Analysis can be done by Technical Contractor | | |
| A | B | C | D | E | F | G | H |
| Sample Date | Sample Hour | H2S in Biogas Entering Scrubber* (ppm) | H2S in Biogas Exiting Scrubber* (ppm) | Biogas Flow through New Scrubber (cfm) | Worksheet Enters 1 for Hours When Biogas After Scrubber is less than 400 ppm | Worksheet Enters 1 for Hours When Biogas Flow is above Minimum** | Worksheet Enters 1 for Hours When Values in Columns F & G are Both 1 |
| 3/15/19 | 12:00 AM | ND | ND | ND | 0 | 0 | |
| | 1:00 AM | 1,400 | 320 | 300 | 1 | 1 | 1 |
| | 2:00 AM | 1,500 | 340 | 200 | 1 | 0 | |
| | 3:00 AM | 1,600 | 399 | 350 | 1 | 1 | 1 |
| | 4:00 AM | 1,700 | 400 | 300 | 0 | 1 | |
| | 5:00 AM | 1,800 | 401 | 325 | 0 | 1 | |
| | 6:00 AM | 1,900 | 360 | 200 | 1 | 0 | |
| | 7:00 AM | 2,000 | 350 | 350 | 1 | 1 | 1 |
| | 8:00 AM | 2,100 | 340 | 300 | 1 | 1 | 1 |
| | 9:00 AM | 1,600 | 330 | 10 | 1 | 0 | |
| | 10:00 AM | 1,700 | 320 | 0 | 1 | 0 | |
| | 11:00 AM | 1,800 | 310 | 200 | 1 | 0 | |
| | 12:00 PM | 1,900 | 390 | 300 | 1 | 1 | 1 |
| | 1:00 PM | 2,000 | 380 | 300 | 1 | 1 | 1 |
| | 2:00 PM | 1,300 | 370 | 300 | 1 | 1 | 1 |
| | 3:00 PM | 1,400 | 360 | 333 | 1 | 1 | 1 |
| | 4:00 PM | 1,500 | 350 | 300 | 1 | 1 | 1 |
| | 5:00 PM | 1,600 | 200 | 300 | 1 | 1 | 1 |
| | 6:00 PM | 1,000 | 100 | 200 | 1 | 0 | |
| | 7:00 PM | 900 | 50 | 333 | 1 | 1 | 1 |
| | 8:00 PM | 800 | 0 | 300 | 1 | 1 | 1 |
| | 9:00 PM | ND | ND | ND | 0 | 0 | |
| | 10:00 PM | ND | ND | ND | 0 | 0 | |
| | 11:00 PM | ND | ND | ND | 0 | 0 | |
| Totals | | 31,500 | 6,070 | 5,201 | 18 | 14 | 12 |
| Average for hours reported | | 1,313 | 253 | 217 | | | Qualifying Hours |
| * Analyst enter ND for "No Data" in all three data columns C, D, and E when starting the month. | | | | | | | |
| **Worksheet enters 1 if flow greater than minimum. Minimum for 7-day evaluation is 263 cfm. Minimum for annual calculations is 175 cfm. | | | | | | | |