



CAYUGA COUNTY REGIONAL DIGESTER



VISION BECOMES REALITY

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Final Report

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Table of Contents

EXECUTIVE SUMMARY	0
1. INTRODUCTION.....	3
1.1. BACKGROUND.....	3
1.2. DAIRY INDUSTRY CHALLENGES.....	4
ANAEROBIC DIGESTION.....	4
1.3. Benefits of a Centralized Community Digester.....	5
1.4. Project Objective.....	6
2. PROJECT RESULTS	7
2.1 Project Development:	7
2.2. Engineering & Permitting.....	8
2.3. Construction:	9
2.4 Commissioning.....	11
3. PLANT OVERVIEW	12
3.1. PROJECT SITE	12
3.2. OPERATING MODEL	13
3.2.1 FEEDSTOCK.....	13
3.2.2 PRODUCTION ESTIMATES.....	14
3.2.3 UTILIZATION OF PRODUCTS.....	15
3.2.4 QUALITY CONTROL	18
3.2.5 TRANSPORTATION.....	18
4. PLANT DESCRIPTION	20
4.1. MAJOR COMPONENTS	22
4.1.1 LOADING/OFF-LOADING SYSTEM.....	22
4.1.2 PUMP STATION	22
4.1.3 PRE-TREATMENT SYSTEMS.....	23
4.1.4 DIGESTER.....	24
4.1.5 POST FERMENTER/ BIOGAS STORAGE.....	25
4.1.6 SEDIMENT RECOVERY TANK	26
4.1.7 BIOGAS CONDITIONING SYSTEM	26
4.1.8 EFFLUENT STORAGE SYSTEM.....	27
4.1.9 ENERGY STATION	27
4.1.10 Biogas Flare	30
4.1.11 Electric Power Distribution.....	30

4.1.12	Grid Interconnection System	31
4.1.13	PROCESS & PLANT CONTROL & MONITORING SYSTEM	32
4.2.	Commissioning.....	33
4.2.1	ACCEPTANCE TESTS.....	33
4.2.2	Interconnection Tests.....	37
4.2.3	Emergency Management Plan	37
4.2.4	Commissioning of the Plant on Natural Gas.....	37
4.2.5	Commissioning of Biogas Operation.....	38
5.	BUSINESS CASE	39
5.1.	CAPITAL COSTS.....	39
5.2.	Operating Economics	40
5.2.1	Operating Costs	40
5.2.2	Operating Revenues.....	40
5.2.3	Operating Income	41
6.	PROJECT ACCOMPLISHMENTS	42
7.	TECHNOLOGY TRANSFER ACTIVITIES	44
8.	APPENDICES	45
	APPENDIX 1: DESIGN BASIS & P&ID DIAGRAMS.....	46
	APPENDIX 2: CERTIFIED TECHNICAL REVIEW OF INTERCONNECTION	51
	APPENDIX 3: CERTIFICATION OF CHP COMMISSIONING.....	52
	APPENDIX 4: GLOSSARY	53
	APPENDIX 5: CONSTRUCTION PHOTOS	61

List of Figures

Figure 1: Aerial View of Project Site	12
Figure 2: Simplified Operating Model of Cayuga COunty Regional Digester.....	13
Figure 3: Aggregated ElEctric Load of Campus Buildings	16
Figure 4: Simplified Process Diagram of the digester Plant.....	21
Figure 5: Photo of Loading/Unloading Station.....	22
Figure 6: Photo of Pump Station.....	22
Figure 7: Manure Buffer Tank.....	23
Figure 8: Grease Buffer Tank.....	23
Figure 9: Sanitation Heat Exchanger	24
Figure 10: Schematic, Photo and Specifications of Digester	24
Figure 11: Specification and Photo of post fermenter/gas holder	25
Figure 12: Sediment recovery tank	26
Figure 13: Gas conditioning system.....	26
Figure 14: Effluent Buffer	27
Figure 15: Biogas blower	27
Figure 16: Gas analyzer	27
Figure 17: Heat exchange systems.....	29
Figure 18: Flare.....	30
Figure 19: Schematic of new campus distribution system.....	30
Figure 20: Interconnection switchgear	31
Figure 21: PLC	32
Figure 22: Plant control computer	32

List of Tables

Table 1: Estimated Annual Feedstock.....	13
Table 2: Estimated Annual Production.....	14
Table 3: Annual Electricity and Heat Production	15
Table 4: CHP specifications.....	28
Table 5: Process heating specifications	29
Table 6: Sources of funding	39
Table 7: Uses of funds.....	39
Table 8: Estimate of annual operating costs.....	40
Table 9: Estimate of Annual Revenues	40
Table 10: Estimated Operating Income.....	41

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CAYUGA COUNTY REGIONAL DIGESTER

FINAL REPORT

EXECUTIVE SUMMARY

With an average herd size of 113 mature cows, Cayuga County is home to 280 dairy farms and 31,500 dairy milking cows producing approximately 855 million gallons of milk per year. The Cayuga Dairy industry is a major contributor to the county's economy, employing nearly 1200 people, while generating \$140,000,000 of revenue from sale of milk alone.¹ At the same time, the Cayuga County dairy industry also produces 5.7 million gallons of manure daily:

- Nearly 34% of this manure is produced on smaller farms.
- Digesters are expensive pieces of equipment and require attention and care.
- The on-farm digester systems have fairly long payback (>10 years) even for larger CAFO farms (>1000 milking cows).

In 2005, Cayuga County Soil and Water Conservation District (The District), a Public Agency under Cayuga County, decided to undertake a centralized community digester project. The primary goal of the project was to develop an economically sustainable model, under the auspices of The District to address manure management issues facing the smaller dairies, improve the water quality and improve the quality of life for Cayuga County residents.

It is believed that the District has accomplished this goal by completing construction of "Cayuga County Regional Digester on a parcel of land behind the Cayuga County Natural Resource Center located at 7413 County House Road in the Town of Sennett in Cayuga County, New York. The digester facility consists of the following major components.

1. Transfer Station: This an indoor truck bay, where 35,000 gallons of manure from three local farms, 8,500 gallons of liquid organic food-processor waste, and 1,200 gallons of brown grease are unloaded from tanker trucks and the digested slurry is loaded onto the tanker trucks for delivery back to the participating farms.
2. Anaerobic Digester: The project utilizes a hydraulic mix anaerobic digester, a unique design that has no internal moving parts for mixing. The digester, which operates at mesophilic temperatures, is designed to process the daily feedstock

¹ Co.cayuga.ny.us/planning/handout.pdf

and produce 220,000 SCF² of biogas per day. The digester also produces 44,000 gallons of digested slurry per day.

3. Biogas Conditioning System: The plant employs a biological biogas conditioning system to remove the H₂S and moisture contents of the biogas and prepare it to be used by the plant generation system.
4. Combined Heat and Power System (CHP): This is a 633kW high efficiency biogas-fired GE-Jenbacher model JMS-312 GS-NL reciprocating engine cogeneration system. The heat recovery system incorporated into the package is designed to capture the waste heat from the engine exhaust, the jacket cooling water and the engine oil circuit.
5. Electrical Substation and Power Distribution Systems: An electrical distribution system has been constructed on-site that aggregates the electrical service of the different county buildings on the District campus into a county owned electric distribution system that is interconnected with the CHP and the local electric grid. The electrical system is designed, in accordance with the utility guidelines, to allow grid-parallel operation of CHP and provide for import and export of electric power.
6. Thermal Energy Distribution System: The heat recovery system has been integrated into a high temperature water distribution system that distributes the heat to the thermal circuits for the anaerobic digester facility. Additional piping has also been installed to transfer the remaining thermal energy to other county buildings on the campus.

On a daily basis, the plant will co-process 35,000 gallons of manure from local dairy farms, 8,500 gallons of food-processor waste and 1,200 gallons of brown grease to produce 200,000 ft³/d of biogas and 44,000 gallons of pathogen-free nutrient-rich digested slurry for agricultural use by farms and in the local area.

The biogas fueled CHP produces 5,157,000 kWh of electricity and 19,506 dekatherms of thermal energy per year. Electrical power generated by the cogeneration system powers all the buildings on the Cayuga County campus and any surplus power is exported to the grid under a power purchase agreement. Heat recovered from the cogeneration system will be used to maintain the temperature of the process equipment and the excess will be transported to the Cayuga County Public Safety Building to offset purchase of fossil fuel to fuel the boilers.

The majority of plant operations are unmanned and automated. However, the plant will have a small staff of well-trained personnel to coordinate the feedstock deliveries and shipments, supervise the day-to-day operation, monitor the systems and perform maintenance, maintain a safe and reliable operation and to respond to emergencies.

² SCF = standard cubic feet

The financial model for the plant shows a profitable, but a low margin business that has to be closely managed. It is clear that the increasing cost of electricity will improve the financial performance of the plant. However, several important factors have to be addressed to mitigate the risks and substantiate the long term viability and success of the project:

- The plant has to be well-maintained to insure long life, high availability and optimal performance;
- The transportation costs are the largest component of plant operating costs. Therefore this area has to be closely managed to eliminate risks and lower operating costs.
- The sale of biosolids is an important part of the business. It is expected that Cayuga County Regional Digester will install a separation/composting system as soon as possible to produce valuable biosolids for sales.
- An annual risk assessment may prove useful to mitigate, if necessary, any risks associated with plant equipment, transportation, health and safety issues, bio-security, community concerns, and feedstock availability.

The project has been commissioned on natural gas. The commissioning of plant operation on biogas is expected to be completed during the second quarter of 2013 with commercial operation starting in mid-summer.

This project was funded under Award # DE-EE0000618 by the Department of Energy (DOE) Energy Efficiency and Renewable Energy Program.

CAYUGA COUNTY REGIONAL DIGESTER

1. INTRODUCTION

A 633kW “regional digester has been constructed on a parcel of land behind the Cayuga County Natural Resource Center located at 7413 County House Road in the Town of Sennett in Cayuga County, New York. The project was funded through a combination of Federal and State grants and local match from Cayuga County Soil and Water Conservation District.

This Department of Energy (DOE) funding for this project falls under the DOE Energy Efficiency and Renewable Energy Program.

1.1. BACKGROUND

Dairy is the number agricultural industry in New York State. New York has 1.4 million dairy cattle on nearly 5,400 dairy farms with 619,000 milking cows that produce 12.4 billion pounds of milk annually³. According to the national estimates, the majority of these dairy farms--nearly 77% -- have less than 100 cows and produce 2.85 billion pounds of milk per year.

In Cayuga County, there are 280 dairy farms housing 31,500 dairy milking cows. These farms produce approximately 855 million gallons of milk per year.

Dairies are economic engines. According to Cornell University studies, every dollar of expenditure by the dairy industry generates another \$2.50 in local economic activity. Accordingly, a dairy farm with 1,000 milking cows has an economic impact of \$13.7 million on its community each year. Further, the dairy industry in New York directly supports a full-time workforce of 22,000 people.

The dairy industry in Cayuga County employs nearly 1200 people, while generating \$140,000,000 of revenue from sale of milk alone.⁴ Without farmers, local tax bases would look very different and that would affect schools, local businesses and the food supply. It would also affect the natural landscape, the wide open spaces, and the working landscapes that farmers help provide. This makes the dairy a part of the social and economic fabric of the local community. At the same time, these farms produce 5.7 million gallons of manure daily. The use of this manure for fertilizing cropland is an important part of the dairy farm’s operation. However, due to the associated odor and the risks of ground water contamination, this practice is also one of the most contentious issues facing the industry.

³<http://www.farmskeepnygreen.org/toolbox/statistics.html>

⁴ Co.cayuga.ny.us/planning/handout.pdf

1.2. DAIRY INDUSTRY CHALLENGES

A current contemporary dairy farmer faces many policy and operation decisions in his daily business practice:

- Changing of the milk market due to globalization;
- Selling of milk products in a competitive business environment;
- Lowering operating costs to maintain competitiveness and profitability;
- Urban encroachment on agricultural land and intolerance of farm odors by neighbors
- Federal, state and local regulations that affect farm operations and manure management practices and ultimately the cost of production.

Yet, one factor that impacts all of the above is the manure management practices employed at the farm. Municipal, county and state governments along with a multitude of rural residents are raising their expectations that farmers address odor, potential water contamination and fly problems associated with production of manure on the farm and the spread of raw manure on crop land.

Recycling of manure is an important practice, especially for livestock producers. Manure can be used as fertilizer to aid in crop production, aiding livestock producers that grow their own feed crops. While manure does provide a rich nutrient source for crops, it also can contribute to nutrient leaching and runoffs. This can contaminate the surrounding ecosystem and lead to eutrophication of waterways. The application of manure on crop land also leads to offensive odors resulting from decomposition of raw manure.

The desire for farmers to be able to recycle manure in an environmentally safe and socially friendly manner while providing a sufficient supply of nutrients to their crops without reducing profit, is an ongoing struggle. A possible solution to this challenge is by anaerobic digestion of manure.

ANAEROBIC DIGESTION

Anaerobic digestion (AD) is a biochemical process in which particular kinds of bacteria digest biomass in an oxygen-free environment. Several different types of bacteria work together in stages to break down the organic waste and produce renewable “biogas” and low-pathogen digested slurry, “digestate”. AD removes the most offensive and cumbersome attributes – high odor, slime, insect larvae, pathogens and weed seeds – while leaving the most valuable – i.e., humate, water, macro- and micro-nutrients. The substrates that are fed to the digester (feedstock), and the conditions of digestion, determine the quantity and composition of biogas and digestate.

The solid fraction of the digestate resembles compost made from manure and other materials in many ways, but production via AD has greater homogeneity and supply

availability while requiring significantly less space, energy and labor to achieve the final product. Additional processing options may be available to also sequester phosphorus with the solids, or produce vivianite (hydrated iron phosphate), a helpful compound for the prevention of iron chlorosis in plants.

A popular practice among the US dairies is to separate the solids and liquids in the digestate. This creates a solid fraction that can be used as a cattle bedding or blended with other materials to make compost. In larger projects, opportunity may also exist to make fertilizer pellets, fuel pellets, medium density fiberboard, fiber/plastic composite materials (decking), and other value-added products. After the fiber is removed, the remaining liquid organic substance is called filtrate. Some of the organic-N in manure is converted to ammonium-N during anaerobic digestion (deamination), making it more readily available to plants compared to raw manure. The partitioning of nutrients between the particulate matter (fiber) and liquid (filtrate) can be accentuated using chemical or mechanical treatments. It is possible and often cost-effective to reduce BOD/COD in the final liquid to <5% of the original values, or even to reach discharge quality. It is also possible to remove phosphorus from the liquid producing a nitrogen-rich, crop-friendly fertilizer.

Depending on technology and feedstock, the anaerobic digestion process produces 7 to 12 cubic feet of biogas for every pound of volatile matter destroyed, depending upon the characteristics of the feedstock. Furthermore, the biogas produced from a properly functioning digester is typically composed of 55 to 70 percent methane and 25 to 40 percent carbon dioxide, with the remaining fraction composed primarily of water vapor, hydrogen sulphide, nitrogen, and hydrogen. Typical biogas from a dairy farm has a methane concentration of 60 percent which has a heating value of about 550 Btu of energy per cubic foot of biogas (Lower Heating Value). The most valuable use for biogas is replacement of purchased energy – vehicle fuel, propane, fuel oil, electricity and natural gas.

1.3. Benefits of a Centralized Community Digester

As a part of its mission to improve the quality of watersheds in Cayuga County, the District has always been active in assisting the local dairies with installation of systems that improve the collection and use of manure produced on the farms. This included assisting the local farms with construction of on-site storage systems and, funding the construction of on-farm digesters at local dairies.

Although anaerobic digesters offer a technically viable solution to management and environmental-friendly use of manure, they are not widely used except in larger dairy farms (>1000 cows), where government grants and the economy of scale make the projects affordable. In early 2005, the District expanded its work to find a viable

commercial method to help the smaller farms with manure management. As a part of this work, the District conducted an independent feasibility study that showed:

1. Increasing the digester size beyond a single farm would significantly improve the economics of an anaerobic digester;
2. a centralized digester could provide an economically viable solution for manure management on small to midsize farms;
3. There were a good number of small dairy farms near Auburn that could potentially benefit from such a facility; and
4. The water quality in the Cayuga County watersheds could significantly improve if the project was successful and replicated across the county.

A follow up study was performed to determine the cost of constructing the facility, a suitable location for the project, verify the operating economics and establish a business plan for implementing the project, with the full understanding that such a project would be a large undertaking and subject to availability of grant funding, changing political environment and changing economic conditions.

1.4. Project Objective

Based on these early results, the District embarked on a new initiative to address the uncertainties associated with manure management for the smaller dairy farms. The primary objective of this initiative was:

“To develop and build a publicly funded facility that could pay for its operation using the income it receives from production of electricity and heat, sale of renewable energy credits, tipping fees from foodwaste and sale of biosolids.”

This plant has been constructed and is currently undergoing the commissioning process. The experience has been tremendous and a great deal of knowledge developed in all aspects of implementing such a project. The experience and knowledge have been embedded into the plant personnel and the project staff, and shared with the many visitors who have toured the plant and intend to build similar systems.

This report provides a summary of the project, its accomplishments and its challenges. It has been organized to provide a detailed overview of the project, the plant and its components, the business overview, the milestones achieved and the lessons learned, and the future District plans for improving the plants performance.

2. PROJECT RESULTS

The Soil and Water Conservation District has completed the design and construction of the “Cayuga County Regional Digester” in Auburn, New York. The following shows a short summary of the project milestones that have been completed:

2.1 Project Development:

Task 1.1: Feedstock: The District has signed contracts with two dairy farmers, located within 12 mile radius of the plant, to supply the manure required for the daily operation of the plant. The manure has been delivered to the plant and tested in the systems. Based on these results, some equipment modifications have been implemented to address long straw and other impurities that are delivered with the manure. Furthermore, the participating dairy farmers are being consulted routinely to a) verify that the quantity and quality of manure needed for the project and b) to reduce their loading of undesirable bedding materials in the delivered manure. In addition, the District is in direct negotiation with several hauling companies to secure additional foodwaste for the project.

Task 1.2: Financing Alternatives: The District secured sufficient grant funding to construct the project. The District will continue to evaluate other business options for procuring additional equipment – i.e. separation and composting system – to increase the value of its byproducts.

Task 1.3: Energy Services Agreement: An energy services agreement has been drafted for sale of electricity and heat to the county buildings located on the project campus. The agreement is currently under legal review by the District board and the County. A “Power Purchase Agreement” (PPA) has also been executed for sale of excess power to the local utility, NYSEG.

Task 1.4: Technology Selection: The technologies selected for this project are designed for long life and low maintenance. All steel and manufactured goods used in the project are “made-in-America” and comply with the requirements of American Reinvestment and Recovery Act” (ARRA). The project is also the first demonstration of two European technologies:

- Hydraulic mix digester in a centralized digester setting;
- Biological biogas conditioning system;

Other components of the plant utilize technologies that are commercially available and have a proven track record.

2.2. Engineering & Permitting

Task 2.1.Site Analysis: Prior to the start of the construction, a site survey and geotechnical analysis was performed to establish the baseline for design of the different structures and tanks on this site. The survey did not identify any environmental issues for the construction of the project at this site.

Task 2.2.Engineering Design: The District contracted GBU to perform the general design of the project, and Seeler Engineering to utilize the German design to prepare construction drawings to be used in bidding and construction of the project, in accordance with accepted engineering practice. The deliverables included:

- Design of the plant buildings;
- Design of the above ground storage tanks ;
- Design of the biogas delivery systems;
- Design of the digester vessel;
- Preparation of piping and instrumentation diagrams for the integration of the digester, biogas, and combined heat and power;
- Preparation of equipment specifications; and
- Preparation of engineering construction drawings.

Task 2.3.Engineering Design of Electrical Distribution Systems: The design of the aggregated electrical distribution system and the interconnection of the facility with the electrical grid were completed in accordance with grid requirements and the accepted engineering practice. The delivered products included the design for:

- Plant substation for interconnection with high voltage distribution system;
- High voltage electrical distribution system for interconnection with the grid;
- Low voltage electrical distribution system for station service;
- Electrical systems modifications required for servicing the County Public Safety Building, County, Nursing Home and the Natural Resource Center; and
- Construction drawings and scope for work for construction of the electrical systems.

Task 2.4.Detailed Cost Estimate: This was the most challenging part of the work. The project costs increased significantly due to several funding requirements:

- Compliance with “Made-in-America” requirements per ARRA;
- Compliance with Davis-Bacon Act (Prevailing wages);
- The time allowance for signing the construction contracts was quite short, causing the contractors to include high risk fees in their proposals. The costs also escalated due to “change-orders” after the project construction contracts were awarded.

Task 2.5. Procurement of Long-Lead Equipment: The District procured several long lead items through direct contracts. These included:

- The generator
- The gas conditioning equipment; and
- The plant supervisory and control system.

Other long lead items were procured through the project contractors.

Task 2.6. Permitting: The District, through its consultants, obtained all the required permits for construction and operation of the digester facility, including:

- New York State Environmental Quality Review Assessment;
- Natural Heritage Program-Division of Fish, Wildlife & Marine Resources;
- New York State Office of Parks, Recreation and Historical Preservation;
- State Pollutant Discharge Eliminations System (SPEDS) permits (for construction and operation); and
- Permit for processing of organic waste at site (DEC 360)
- Air Permit;
- Local Permits (building, zoning).

Task 2.7. Interconnection Agreement: An interconnection agreement for grid-parallel operation of the plant generator was executed in January 2012.

2.3. Construction:

The construction of “Cayuga County Regional Digester” was substantially completed in December 2012 with the closure of the contract for “plant electrical and instrumentation”. The plant is still in commissioning and expected to start its commercial operation during the second quarter of 2013. A collection of the construction project photos at various times is provided in Appendix 5 of this report. A summary of the construction project is provided below:

Task 3.1. Site Preparation and Base Infrastructure:

The digester facility was built on five acres of land behind the Cayuga County Natural Resource Center located at 7413 County House Road in Auburn, New York.

Upon the completion of engineering and permitting, the District constructed containment berms, diversion ditches and grassed waterways to restrict excess water from entering the site. The site transportation infrastructure was also constructed. This work consisted of building the roadway from County House Road to the project site, construction of parking areas and building foundations.

A dedicated access road connects the Bioenergy Facility Directly to County House Road, providing access to transport trucks and authorized visitors. The road infrastructure has been designed with the following considerations in mind:

- One-way traffic lanes for delivery of feedstock to the plant and transport of digestate liquids and solids away from the plant.
- Large turning radius for transport trucks.
- Parking area for transport trucks.
- Parking area for automobiles and similar vehicles.
- Pedestrian walkways.

Task 3.2. Buildings: Upon completion of site work, the District constructed a large 50' X 100' pole-barn structure as the main process building. A smaller pole-barn structure was also constructed to serve as the office for the digester facility.

Task 3.3. Buffer Tanks: The District constructed three vented, above ground, epoxy coated steel tanks to store manure, brown grease and the effluents for the process. The buffer tanks for manure and brown grease are equipped with internal heat exchangers made of stainless steel piping to control the temperature of the feed to the digester. The design of the effluent buffer tank does not account for heating heat exchanger due to the large volume of daily exchange. The design for this tank was changed to above ground after wet grounds were discovered at a depth of 6' below surface, where the effluent tank was to be installed. Section 4.1.3 of this report describe the buffer tanks for manure and brown grease. Section 4.1.8 shows the details of the effluent buffer tank.

Task 3.4. Digester Vessel: The project utilizes a 1,057,000 gallons hydraulic mix anaerobic digester that operates at mesophilic temperatures. All piping required to transport the manure from the receiving station to the digester vessel have been installed and tested for structural integrity and leaks. The installed biogas delivery system to transport the gas to the generator includes provisions to store and condition the biogas produced by the digester to the plant generator. This system includes the post-fermenter/wet gas holder, the biogas desulphurization and dehydration system, and the biogas blower. The appropriate controls and safety features to insure reliable and secure operation of the system. The details of this system are shown in Section 4.1.4 of this report.

Task 3.5. Cogeneration System: A 633 kW Jenbacher model JMS 312 GS-B.L cogeneration system has been installed at the facility to convert conditioned biogas into electricity and heat for use on campus. The system is a high

- efficiency (36.8%) reciprocating engine generator with heat recovery to capture the waste heat from the engine exhaust, the lube oil and the jacket cooling water.
- Task 3.6. Electrical Distribution and Interconnections Systems: An electrical distribution system has been constructed on-site that aggregates all the electrical loads from the different buildings on this Cayuga County campus into a single electric point of interconnection with the local utility grid (NYSEG). The electrical system is also designed to provide safe interconnection of the generator with the electrical distribution grid for import and export of power.
- Task 3.7. Balance of the Plant: The District has installed all necessary components to commission the start-up of the Plant. This includes, but is not limited to:
- i. Biogas Conditioning System: The biogas produced by the digester contains contaminants such as H₂S and moisture. The District procured a biological biogas scrubbing system from American Biogas Conditioning, a technology startup in Syracuse, NY, to address the gas conditioning requirements for the project. The system, which was selected in a competitive process with other technologies being considered, uses German design and American-made components to reduce the H₂S concentrations of biogas to below 100 ppm. Once the gas is cleaned of its sulfur content, it is dehydrated using a series of heat exchangers to remove moisture so that it can be used by the cogeneration equipment. The equipment was delivered and installed at the site on April 22, 2011.
 - Heat loop connections for thermal energy utilization: A district heat system has been installed that transfers the heat recovered from the generator to the thermal circuits for the anaerobic digester facility, and the heat exchange stations at the County Public Safety Building. This system will allow the digester to operate at optimal temperatures while minimizing the purchase of natural gas to heat the buildings.

2.4 Commissioning

The commissioning of the “Cayuga County Regional Digester” is still in progress. The commissioning of the plant on Natural gas was completed in January 2012. However, due to repairs that had to be performed on the post fermenter/ wet gas holder system, the operation on biogas has not yet been commissioned. The work on this milestone is expected to begin in April 2013, followed by the start of commercial operation in June 2013. Section 4.2 provides a detailed review of the tests and inspections that have been completed to date, and the remaining scope of work.

3. PLANT OVERVIEW

3.1. PROJECT SITE

The Cayuga County Regional Digester- Facility has been constructed on a parcel of land behind the District campus offices in the Town of Sennett, City of Auburn in Cayuga County, New York.

The site location is home to several county government agencies requiring only minimal permitting and regulatory approval. These agencies include the Army Corp of Engineers, Farm Service Agency and Cayuga County Water and Sewer Authority. Located directly next door to the District offices are the County Public Safety Building and 911 Service Center and the Cayuga County Nursing Home. The property is also home to a Greenhouse which is owned and operated by the District. The facility is currently used to demonstrate the benefits of growing vegetables using hydroponics. The greenhouse offers the bioenergy enterprise a unique opportunity to test and demonstrate the value of its liquid and solid fertilizer by-products. The plant location will be sufficiently distanced from the offices so that it will not disturb the other tenants on the Cayuga County campus.

The site offers future possibilities for new businesses around the digester products including a composting facility, aquaculture, energy-crop farming, and the manufacturing of grass pellets for home heating. Within a 15 mile radius of the site are approximately 68 dairy farms with an approximate total cow population of 11,000 head which ensures availability of manure.



FIGURE 1: AERIAL VIEW OF PROJECT SITE

3.2. OPERATING MODEL

The commercial model for Cayuga County Regional Digester is illustrated in the figure below.

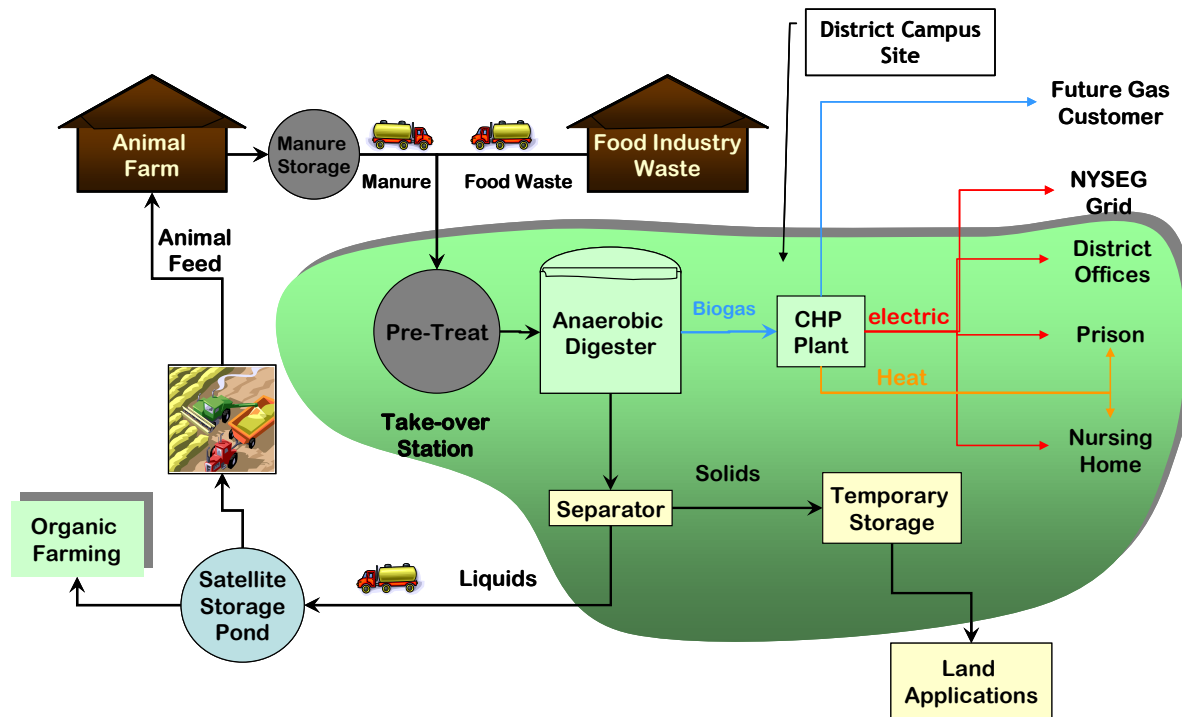


FIGURE 2: SIMPLIFIED OPERATING MODEL OF CAYUGA COUNTY REGIONAL DIGESTER

The following sections describe the elements of this model in more detail.

3.2.1 FEEDSTOCK

Manure supply contracts have been signed with two different dairy farms near the plant. These farms provide the digester facility with 35,000 gallons manure per day that is needed for its operations. This manure is trucked to the facility by the manure transport trucks. Additionally, 8500 gallons per day of food-processor waste (or material rich in organic matter) and an average of 1,200 gallons of brown grease would also be brought to the facility, under spate contracts with the local haulers. This material is needed to improve the gas production and revenues of the digester. The total annual feedstock for the digester facility is therefore estimated as follows.

TABLE 1: ESTIMATED ANNUAL FEEDSTOCK

substrate	Daily Quantity Gal/day	Annual Quantity Tons/Year	DM-content Tons/Year	VS-content Tons/Year
Cow manure	35,000	52,023	5,599	4,057
Food Processor Waste	8500	12,844	1,027	822
Fat sludge	1200	1,825	273	257
Total	44,700	66,693	7,554	5,257

3.2.2 PRODUCTION ESTIMATES

It is estimated the anaerobic digester would convert nearly 50% of the digestible volatile solids in the manure and 80% to 90% of volatile solids in the foodwaste and brown grease into biogas. The remaining solids and liquids form 44,000 gallons of 6.7% sludge (slurry effluent) per day. This sludge is rich in nutrients (ammonia, phosphorus, potassium, and more than a dozen trace elements) and an excellent soil amendment. It has virtually no smell (processing reduce odor by 90%, smells like dirt), and is low in pathogens. The digester process also mineralizes the organically bound nutrients into a material that is ready for plant consumption. Because of the mix of the feedstock, the resulting digestate could also contain more valuable nitrogen than raw manure, making it more valuable for the farmers. The reduction in the organic nitrogen also means that a higher proportion of nutrients will be absorbed by the plants, which helps to manage the existing nutrient “run-off” concerns.

The estimated annual production by the facility would include:

TABLE 2: ESTIMATED ANNUAL PRODUCTION

Substrat	Annual Quantity	
	Mass Tons/Yr	Volume Unit/yr
Digestate Sludge		
Dry Matter (Fiber)	4,472	
Liquids (water with nutrients)	59,623	14,584,000 gallons/Yr
Biogas		
Methane	1,086	51,170 MCF/Yr
CO ₂	1,494	25,590 MCF/Yr
Other Emissions		
Ammonia	18	
Total Mass	66,693	

3.2.3 UTILIZATION OF PRODUCTS

Renewable Energy

The biogas fuel will be used in a high efficiency combined heat and power system (CHP) to produce electricity and heat. The estimated annual energy production is provided in the table below:

Table 3: Annual Electricity and Heat Production

		Annual Estimate	
Energy Available in Renewable Biogas	Production Rate	1,711kW (5.84 MMBTU/h)	
	Annual Total	14,993 MWh (51,169 MMBTU)	
Renewable Energy Production		Electric	Thermal
Production	CHP Efficiency	36.8%	40.8%
	Production Rate	633kW	2.4MMBTU/h
	Avg. Availability	93%	93%
	Annual Energy Total	5,157 MWh	19,506 MMBTU
Station Service	Annual Total (estimated)	438 MWh	7,632 MMBTU
Losses	~ 5% electric, 10% heat	258 MWh	1,951 MMBTU
Net – Potential Energy Available for Use		4,461 MWh	9,923 MMBTU

The power generation system operates in grid-parallel mode all the time except during a grid outage. It provides all the electrical requirements of the digester facility and the Cayuga County buildings on the Campus. Any excess power is exported to the grid for sale to third parties. The heat recovered by the CHP will be used to heat the process and maintain the process temperatures and offset the natural gas use of the buildings on the Campus.

A new county-owned distribution system has been installed that provides electric service to:

- Cayuga County Natural Resources Conservation Building,
- Cayuga County Public Safety Building
- Cayuga County Sheriff's Training Center
- Cayuga County Nursing Home
- The District Maintenance Shop
- The Digester Plant

Each Building is metered separately, except for the Maintenance Shop and the Digester Plant which are not metered. The meters are manually read and

recorded on monthly basis. These are used to provide monthly billing to County departments located on the campus. On a quarterly basis, the metered data will be used to audit the energy usage and expenses of each building.

Figure 3 shows the recorded NYSEG metered data for the aggregate load of these buildings from March 2011 to October 2011, before the commissioning of the CHP plant on natural gas.

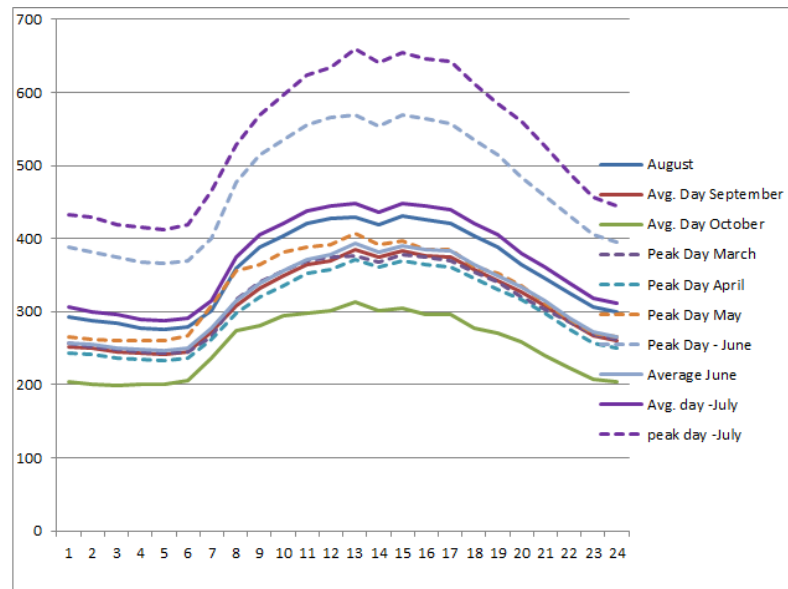


FIGURE 3: AGGREGATED ELECTRIC LOAD OF CAMPUS BUILDINGS

In the event of a grid outage, the plant shuts down and the backup generators installed at the different buildings start to provide the necessary electricity needs of the campus. This aspect of operation is necessary because:

1. It is not possible to run the biogas handling system necessary for operation of the generator – i.e., gas blowers, security systems - without on-site power;
2. Due to the sensitive nature of the public safety building, the standalone operation will require an integrated load control system;
3. Although it is possible to switch to natural gas fuel during a grid outage, it is believed that this option moves the facility into a more expensive tariff class for supplemental power.

The installed hot water distribution system transports hotwater from cogeneration system to

- Digester plant process equipment
- Cayuga County Public Safety Building
- Cayuga County Nursing Home

Digestate

Currently, the Facility's produces approximately 44,000 gallons of digested slurry (digestate) daily. This material, which is trucked back to the farms, will allow the farmers to capture significant cost savings:

- The digestate can be pressed at the farmer site and composted to produce bedding for the animals and fertilizer liquid for their crop field. This provides significant savings in bedding cost and eliminates odor associated with the spreading of raw manure
- Due to the mineralized nature of the nutrients, less volume of liquid may be applied, when the plant needs it. This should lower the labor and cost associated with fertilizing of the crop field.

This practice also lowers the risks of run-offs and leaching of nutrients in the ground water sources. In the near future, The District intends to install a dewatering equipment to separate the digestate slurry into solid and liquid by-products.

- The "Solid" by-product production will be approximately 25 tons per day of high nutrient (30% dry matter), minimum odor (musty smell), low in pathogens, seed-free solids. This solid compost is biologically stable and has a very low C: N ratio. The solids contain organically-bound nutrients and BOD has been substantially reduced, thus mitigating the potential for ground and surface water contamination. The solid nutrients are more concentrated than the raw manure delivered to the Bioenergy Facility, making it a very high quality fertilizer.
- The "Liquid" byproduct is 44,000 gallons per day of minimum odor (musty smell), low in pathogens, reduced organically-bound nutrients and BOD fertilizer. The liquid fertilizer has a lower percentage of N, P, and K than raw manure, and has proven to be a good fertilizer for crops in similar European applications. In Europe, the farmers compete for access to the liquid fertilizer. It is anticipated that the effluent from the Bioenergy Facility will also be sought by local farmers primarily for its application flexibility and lower cost.

The liquid will be shipped back to the farm for crop land application. The solid stream will be sold to cash croppers for organic farming or composting companies for potentially further treatment, bagging and sale to market.

3.2.4 QUALITY CONTROL

All material going in or out of the digester facility will be strictly controlled to avoid operational problems and risk of pathogen transfer. Supply contracts will be in place with the farmers and foodwaste providers that would strictly prohibit delivery of certain materials to the site as a part of the feedstock. The list of such materials could include:

- Toxic materials that inhibit gas production
- Bioagents (antibiotics, etc.)
- Disinfectants (e.g. creosol, phenol, arsenic).
- Long straw and non-biodegradable materials.
- Sand bedding
- Municipal Solid Waste as defined under local and federal regulations

Any feedstock which fails to meet the specification will be rejected. Further farmers are obliged to notify the digester plant if there is an incidence of a disease in its livestock. In this event, all deliveries from the farm will be halted until such time when the risk of disease is eliminated. Any changes to the feedstock will have to be approved by the plant before deliveries are accepted at the plant.

Samples of delivered materials will be collected and stored for a period of 3 months before being discarded. The samples will be randomly selected for testing to make sure materials comply with the specifications. Penalties will apply if deliveries deviate from the contracted specifications.

3.2.5 TRANSPORTATION

An important task for the digester plant is to manage the logistics of feedstock, cost of transportation from and to the farms and the risks of such transport.

Transportation costs, liability and the public's welfare will be closely managed to ensure the success of the digester facility. This includes the following:

- Manure is trucked in several times per day in two 4,500 gallon tanker trucks, owned by the District.
- Food waste is trucked in once a day and brown grease twice a week by professional haulers contracted by the District.
- Hand operated wash spray systems are installed in the in the receiving station of the Digester Facility to keep the trucks clean and to maintain the desired image of the Facility. Drivers will be instructed to rinse the vehicles as necessary before they leave the Facility.
- The trucks used for delivery of manure and effluents have been designed and equipped for the type of deliveries being received.

- The foodwaste and brown grease hauling companies will be required to maintain their vehicles, eliminate any odor or aesthetic concern and comply with all local community ordinances.
- The delivery routes have been carefully selected to minimize congestion and travel, and where possible to avoid travel through residential areas.
- All transportation laws will be fully complied with.
- Feedstock delivery schedules will be eight to ten hours per day, five days per week and scheduled and staged to further reduce congestion and community inconvenience.
- The food waste processing at the Bioenergy Facility is limited to liquid feedstock that must be transported via standard tanker truck. The liquid feedstock significantly reduces potential issues associated with the hauling of solid organic waste, including litter falling from transporting vehicles.

4. PLANT DESCRIPTION

On a daily basis, the plant will co-process 35,000 gallons of manure from local dairy farms, 8,500 gallons of food-processor waste and 1,200 gallons of brown grease to produce 200,000 ft³/d of biogas and 44,000 gallons of pathogen-free nutrient-rich digested slurry for agricultural use by farms and in the local area.

A hydraulic mix anaerobic digester is used to process the organic feedstock. This design optimizes all the biological requirements needed for maximum biogas production and utilizes structural and hydraulic design to capture lower maintenance and operating costs. It has no moving internal parts and operates on the hydraulic pressure of the biogas. It is self-flushing and has an integrated sediment removal system that allows the heavy sediments to be removed from the digester vessel, eliminating the buildup of scales and sediments overtime. The digester choice is ideal for the Auburn area weather conditions. It can process a higher concentration of solids, which provides increased feedstock flexibility, better process stability, higher system reliability and other significant benefits.

The biogas fuels a high efficiency 633kW cogeneration system, that produces 5,157,000 kWh of electricity (estimated 93% availability) and 11.5 of thermal energy per year. Electrical power generated by the cogeneration system powers all the buildings on the Cayuga County campus and any surplus power is exported to the grid under a power purchase agreement. Heat recovered from the cogeneration system will be used to maintain the temperature of the process equipment and the excess will be transported to the Cayuga County Public Safety Building to offset purchase of fossil fuel to fuel the boilers.

The majority of plant operations are unmanned and automated. However, the plant will have a small staff of well-trained personnel to coordinate the feedstock deliveries and shipments, supervise the day-to-day operation, monitor the systems and perform maintenance, maintain a safe and reliable operation and to respond to emergencies. The staff is trained to the highest possible standards in the following:

- Engineering design aspects of the equipment
- Proper operation and maintenance of the equipment,
- Health and safety aspects of operation,
- Diagnostics of process and proper methods of responding to problems.

Multiple hands-on training programs have been implemented for plant personnel, transportation personnel, and outsourced services personnel to ensure they understand and comply with plant operating procedures, regulatory requirements and safety protocols, and advice sought from specialists.

Figure 4 below shows a simplified schematic of the process flow at the digester facility.

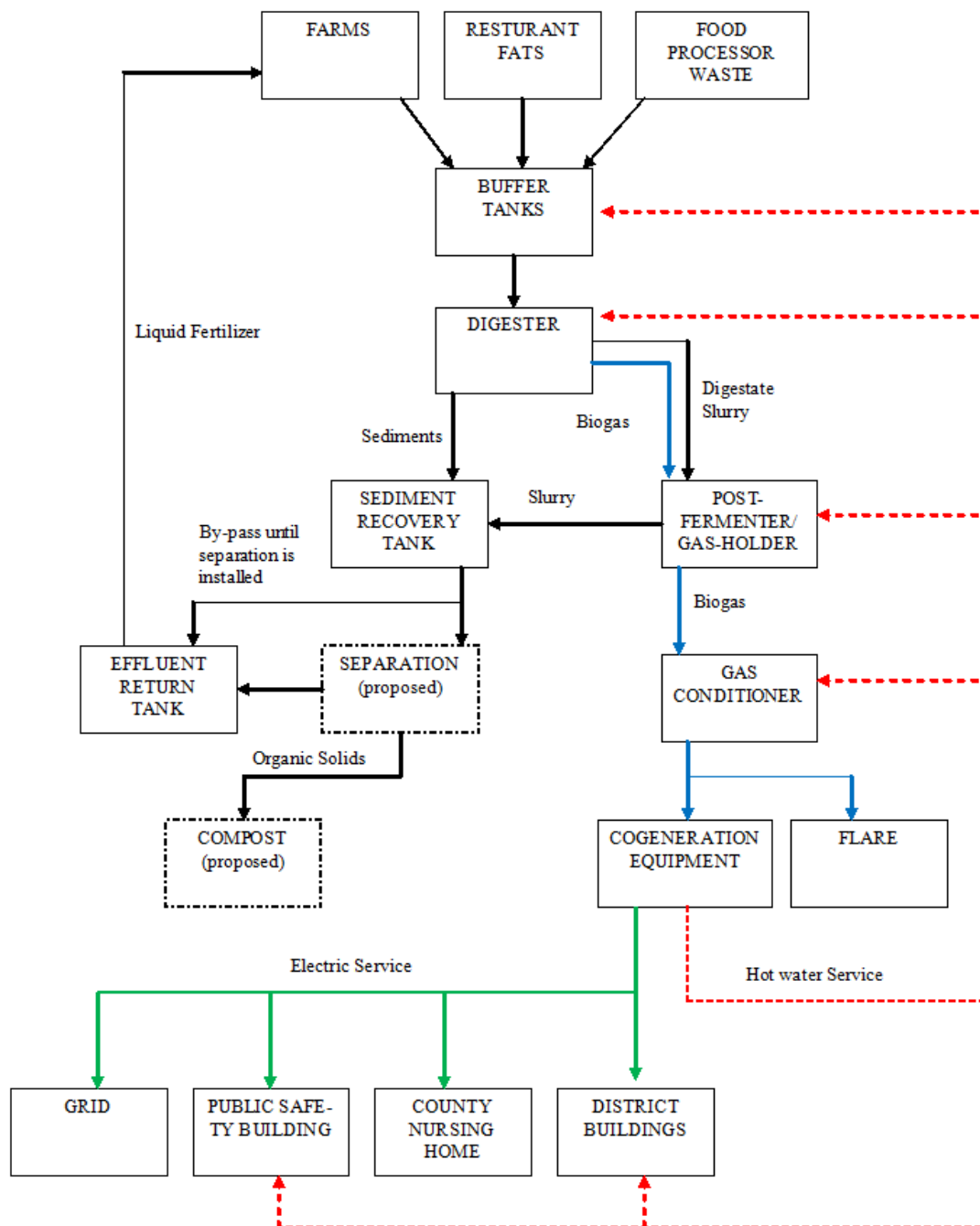


FIGURE 4: SIMPLIFIED PROCESS DIAGRAM OF THE DIGESTER PLANT

4.1. MAJOR COMPONENTS

4.1.1 LOADING/OFF-LOADING SYSTEM

The plant's loading/unloading station is located inside the process building. The service location is on top of a small concrete collection bin covered with a grated floor. This design provides the means to collect possible spills and drippings during the deliveries. These collections are pumped to the sludge buffer by a separate submerged pump installed inside the bin. The indoor design also protects the loading stations



FIGURE 5: PHOTO OF LOADING/UNLOADING STATION

against the elements and controls the release of odor to atmosphere. The truck offloading is done using a flexible hose connection and a rotating piston pump. The manure and food-waste are pumped from the truck to the manure input buffer where it can be stored for a maximum period of 5 days. The brown grease is pumped into the brown grease tank, where it can be stored for 15 days.

4.1.2 PUMP STATION

The Pump Station incorporates all the pumps and control valves that unload/load the trucks and transfer process slurry between the process tanks and the digester.

The unloading line is equipped with a rotary lobe pump that provides the necessary pressure to empty the tankers at a rate of 500 gpm (113 m³/h). These are also used to load the trucks with digested slurry or the process liquids. On



FIGURE 6: PHOTO OF PUMP STATION

the suction side of the pump the material passes an inline- macerator in order to decrease the particle size of straw and other organic material. The macerator also acts as a stone and solids filter. Stones and other inorganic material are gathered in an integrated containment of the macerator and will be removed manually whenever necessary. Other equipment includes another rotary lobe pump that facilitates the transfer of manure and sanitized brown grease to the digester.

4.1.3 PRE-TREATMENT SYSTEMS

Pre-treatment systems include the manure buffer tank, fat sludge buffer tank, and sanitation system.

- **Manure Buffer** is an above ground storage tank with two mixers. The tank specifications are as follows:

Tank Construction		
1.	Material	Epoxy Coated Steel
2.	Structure	Vented Cylindrical, Above Ground
3.	Volume	170,000 gallons Capacity: 5 days
4.	Diameter	28 ft
5.	Height	40 ft
6.	Temperature	68°F
7.	Controls	<ul style="list-style-type: none"> • Overflow Level Sensor • Ultrasonic Level Sensor • Temperature sensor



FIGURE 7: MANURE BUFFER TANK

The tank is heated and agitated to prevent settlement of the material inside the buffer. The feedstock from this tank is fed to the digester 10-16 times per day. The feed volumes are controlled by the supervisory control and a magnetic inductive flow meter.

- **Grease fat buffer tank** is a 16' diameter by 26' high (40,000 gallon) above ground steel tank storage tank with the following specifications.

Tank Construction		
1.	Material	Epoxy Coated Steel
2.	Structure	Vented Cylindrical, Above Ground
3.	Volume	40,000 gallons
4.	Diameter	16 ft
5.	Height	26 ft)
6.	Temperature	68°F
7.	Controls	<ul style="list-style-type: none"> • Overflow safety sensor • Ultrasonic level sensor • Temperature Sensor



FIGURE 8: GREASE BUFFER TANK

The tank is heated and agitated to prevent sticking of the fatty material inside the buffer. Material from the grease/fat buffer tank is pumped to the sanitation tank, where it is heated to 158°F and held for one hour to meet the sanitation requirements.

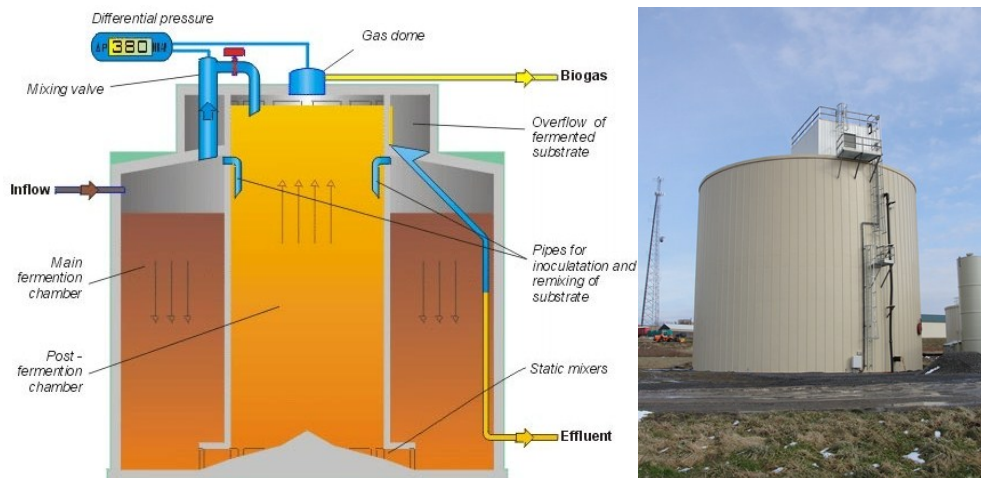
- Sanitation System:** From the grease fat buffer the material is pumped, in equal charges of 500 gallons, into the sanitation tank. The Sanitation Tank is a small 500 gallon, above ground, insulated stainless steel tank. An insulated stainless steel spiral heat exchanger is used to raise the temperature of grease sludge to 158°F (70° C). The material is then held at this temperature for 60 minutes so that all bacteria are killed and the material is safe for mixing with manure. Once the sanitation process is complete, the fat sludge is dosed into the feeding line of the digester, where it is mixed with the manure during the feeding process of the digester.



FIGURE 9: SANITATION HEAT EXCHANGER

4.1.4 DIGESTER

The digester is the above ground mesophilic hydraulic-mix system, which consists of two above ground, concentric, circular cylindrical vessels constructed of mild carbon steel, with welded seams to ensure gas-tight integrity, as shown in Figure 10.



Tank Construction			
1.	Material	Carbon steel	
2.	Structure	Cylindrical, Above Ground	
3.	Volume	1,057,000 gallons	
4.	Diameter	62.3 ft	
5.	Height	64.3 ft	
6.	Operating Temperature	95°F-105°F	
7.	Instrumentation	a. Sludge flow b. Overflow security c. pressure	d. Temperature e. Filling level

FIGURE 10: SCHEMATIC, PHOTO AND SPECIFICATIONS OF DIGESTER

The digester processes 45,000 gallons of feedstock per day. Feedstock is automatically fed, 10 to 16 times per day, from the top of the digester. The feed will include manure at 68°F and fats at 158°F. Once inside the digester, the mixed feedstock will be heated to 100°F and processed over the course of 24 days. The digestion process and biogas production begins as soon as fresh feed reaches 80°F. The biogas production is greatest in the outer chamber where fresh feedstock in larger quantity is available to the bacteria. As the biogas production in the outer chamber continues, the pressure in the main fermenting chamber (outer chamber) rises, forcing the fluid level in the outer chamber to drop and fluid level in the inner chamber to rise. Once the difference in the fluid levels between the two chambers has reached a predetermined level, the digester is fed again. This forces fully-digested materials to exit the digester vessel to the post fermentation tank. Once the feed cycle is complete, the gas-mixing valve opens causing instantaneous pressure equalization, the flushing of the entry ports to the second chamber and mixing of the substrate. At the same time, the biogas in the outer chamber is transferred to the inner chamber and eventually released into the storage vessel when the next mixing action occurs.

4.1.5 POST FERMENTER/ BIOGAS STORAGE

Following digestion, the digestate slurry moves to the post-fermenter by gravity. Here, the digestate slurry is allowed to stabilize while it continues to off-gas. The biogas from the digester is also vented to the post-fermenter, where it is stored in the gas-holder membrane and steadily supplied to the cogeneration system, or as it is needed. The following table shows the specifications of the system:

Post-fermentation Tank Construction		
1.	Material	Reinforced Concrete
2.	Structure	Cylindrical, closed top with double lined membrane
3.	Volume	240,000 gallons
4.	Diameter	55.8 ft
5.	Height	13.1 ft
6.	Temperature	100°F
7.	Controls	Liquid Level, Pressure, Pressure Relief Valve
Wet Gas Holder		
1.	Material	Diffusion-tight, impermeable PE
2.	Volume	264,000 gallons
3.	Controls	Storage Level, Membrane Air Pressure, Purge Valve, Membrane air chamber CH ₄ analyzer



FIGURE 11: SPECIFICATION AND PHOTO OF POST FERMENTER/GAS HOLDER

4.1.6 SEDIMENT RECOVERY TANK

The sediments in the digester are piped directly to the sediment recovery tank. These are then remixed with the digestate slurry from the post fermenter and pumped to the effluent tank for delivery away from the site.

Future plans include the construction of a separation and composting facility, where the digestate slurry and sediments would be separated into solids and liquids and the solids processed further to produce high-value biosolids for sale to third parties. The liquid is then returned to the effluent tank where it is stored for shipping back to the farms.



FIGURE 12: SEDIMENT RECOVERY TANK

4.1.7 BIOGAS CONDITIONING SYSTEM

The biogas produced by the digester will contain small amounts of H_2S (4000 ppm) (hydrogen sulfide), NH_3 (trace levels), Nitrogen, Oxygen, and traces of Hydrogen. Before combustion in the engine generator, the biogas is scrubbed, in a biological desulfurization system, to reduce the H_2S concentration from 4000 ppm down to 100 ppm.

Inside the scrubber, the H_2S pollutant is first dissolved in the washing liquid and then oxidized by the microbial degradation of the dissolved H_2S ions. The process byproducts resulting are elemental sulfur and sulfates that are environmentally safe and suitable for other beneficial applications. This solution is piped to the effluent buffer tank, where it is mixed with the nitrogen rich effluents. The cleaned biogas is further processed in the dehydration system to remove its moisture and prepare it for use in the cogeneration system.



FIGURE 13: GAS CONDITIONING SYSTEM

Safety systems are incorporated in the biogas conditioning system to prevent high concentrations of oxygen in the fuel, provide continuous monitoring of equipment operation and safety as well as respond to emergencies from other parts of the plant.

4.1.8 EFFLUENT STORAGE SYSTEM

This buffer is an above ground storage tank with the following specifications:

Tank Construction		
1.	Material	Epoxy Coated Steel
2.	Structure	Vented, cylindrical
3.	Volume	170,000 gal, 5 days buffer
4.	Diameter	28 ft
5.	Height	40 ft
6.	Temperature	68°F
7.	Controls	overflow, level, temperature



FIGURE 14: EFFLUENT BUFFER

The effluent buffer can hold 5 days of digestate slurry or separated liquids. The storage allows for disruption in deliveries due to weekends, holidays or inclement weather. The material in the effluent buffer is typically returned to the participating farms on the same trucks that are used to pick up the manure from the farm.

4.1.9 ENERGY STATION

Biogas Blower

A Hartzell biogas blower model 07T-Turbo Pressure Blower has been installed in the generator station. The blower, which is powered by a variable frequency drive, is designed to move up to 250 scfm of biogas from the gas-holder through the gas conditioning system to the power generation equipment and/or the flare. The plant PLC system regulates the operation of the blower, based on the fuel produced, gas pressure in the gas holder membrane, and security parameters for the operation of the biogas conditioning system

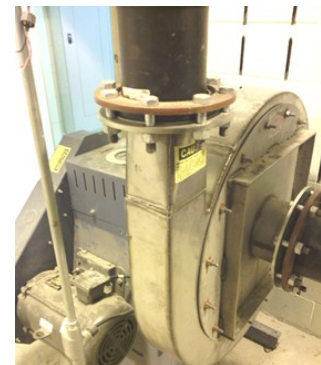


FIGURE 15: BIOGAS BLOWER

Biogas Analyzer:

An ADOS three channel biogas analyzer has been installed in the energy station to monitor the quality of biogas to the engine generator. This is done by discrete measurements of three constituents in the biogas

Element	Range
H ₂ S	0 - 5,000 ppm
O ₂	0 - 21 Vol-%
CH ₄	0- 100 Vol-%

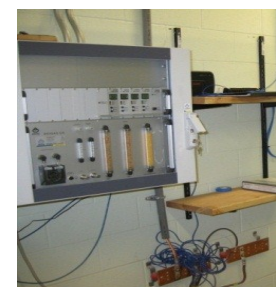


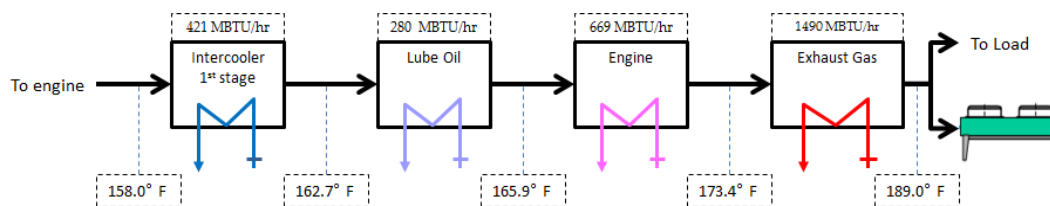
FIGURE 16: GAS ANALYZER

Combined Heat & Power System

The conditioned biogas is used to fuel a 633 kW Jenbacher model JMS 312 GS-B.L reciprocating engine CHP system, specifically designed to run on biogas. The Jenbacher CHP system was selected due to its high efficiency and low maintenance costs. The following shows the specifications of the CHP systems

TABLE 4: CHP SPECIFICATIONS

Model	JMS 312 GS-B.L	
Voltage	3Φ 277/480	
Frequency	60Hz	
Generator Type	Synchronous	
Fuel Source (BTU/scf – LHV)	Biogas (457)	Natural gas (868)
Energy Input (mmBTU/h)	5.879	5.353
Biogas Volume (scf/hr)	12,865	6,167
Electric Production		
Electric Efficiency	36.8%	36.3%
Name Plate Rating (kWe)	633	570
Recovered Heat		
Intercooler Stage 1 (MMBTU/h)	0.421 (not used)	0.310
Lube Oil (MMBTU/h)	0.280	0.255
Jacket Water (MMBTU/h)	0.669	0.798
Exhaust (MMBTU/h)	1.490593	
Total Heat Recovery (MMBTU/h)	2.41	
Thermal Energy Losses		
Surface Heat (MMBTU/h)	0.204	0.194
Balance heat	0.058	0.054
Thermal efficiency	40.8%	
Total Efficiency	77.4%	



Heat Exchangers

Heat recovered from the cogeneration system is used to maintain the temperature of the process equipment and provide heat for the public safety building. This is done through a system of heat exchangers and piping. Any unused thermal energy is dumped via remote radiators.



FIGURE 17: HEAT EXCHANGE SYSTEMS

The process heating requirement will depend on the season (ambient and soil temperatures). However, it is estimated that the 50% of the recovered heat from cogeneration plant (~1.4 BTU/h) will be used to service the plant thermal loads during the winter months. The following shows a list of process equipment that require heat to maintain temperature:

TABLE 5: PROCESS HEATING SPECIFICATIONS

Process Equipment	Media	Volume	Process Temp.
Manure Buffer	Manure & Foodwaste	184,000 gal	65 °F
Grease Buffer	Brown Grease	44,000 gal	65 °F
Sanitation tank	Brown Grease	500 gal	158 °F
Digester	Slurry	1,048,000 gal	105 °F
Post Fermentation tank	Digested Slurry	240,000 gal	105°F
Desulphurization System	Biogas & Water	10,000 gal	85°F
Dehydration System	Biogas	258 cfm	80°F

The campus buildings use natural gas for hot water and space heating. The total gas consumption in 2011 was 13,120 decatherms (DT). The largest user of natural gas is the public safety building accounting for 80% of the overall use. The peak NG consumption of approximately 2,100 DT occurred in January 2011. Based on these results and results of prior years, the District has constructed a hot water service pipeline to the public safety building to service its natural gas needs throughout the year.

It is estimated that the Digester Plant will fully utilize all of its recovered heat during winter months. However, during summer months, May through October, nearly half of the recovered heat will have to be dumped.

4.1.10 Biogas Flare

In the event that the generator is not available and the gas holder is completely filled, an emergency 1.5MW biogas flare is installed to flare off 235 cfm of biogas and to avoid methane emissions into the atmosphere. The flare is equipped with automatic ignition systems, UV sensor, flame arrestor for security, and PLC controls to network into overall plant controls.



FIGURE 18: FLARE

4.1.11 Electric Power Distribution

The District has constructed a campus-wide power distribution system (Figure 19) that integrates the electrical output of the Digester Plant, provides electrical service to each of the Cayuga County buildings on the campus and interconnects with the NYSEG distribution grid on the County House Road through a single point of interconnection.

A 1000kVA pad-mounted transformer steps up the output from the generator to the 12.47kV distribution system that consists of both overhead and underground primary cable serving pad-mounted transformers situated at each of the campus buildings. The primary cables and transformers are protected by pad mounted 15 kV vacuum interrupter switchgear.

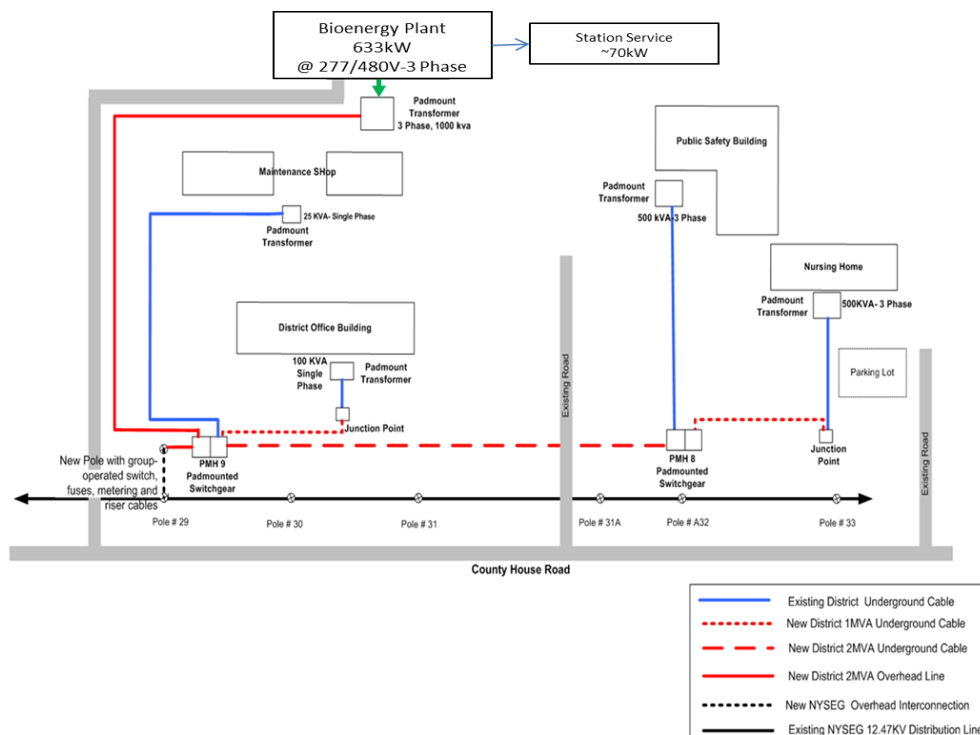


FIGURE 19: SCHEMATIC OF NEW CAMPUS DISTRIBUTION SYSTEM

4.1.12 Grid Interconnection System

The CHP system is interconnected with the District's aggregated distribution service, which provides electric service to all of the County buildings on the campus. The District's distribution service is also interconnected with the NYSEG grid at the County House Road. The onsite interconnection equipment consists of several components:

Customer-Owned Interconnection Systems

- Cutler Hammer Magnum DS Low Voltage Switchgear rated at 3200 Main Buss Amps, 600/346 wye, 4 wire, 60 Hertz with associated breakers.
- Schweitzer SEL 300G and SEL 351S relays
- Howard Industries Pad Mount GSU Transformer 7000/12,470 volts grounded wye primary; 480/277 grounded wye secondary

NYSEG's Interconnection System

- One (1)- TransData Mark V Solid State Revenue Meter
- One (1)- Set of CT/VT 12.5kV Meter Class Instrument Transformers
- One (1) – New pole and meter mounting equipment

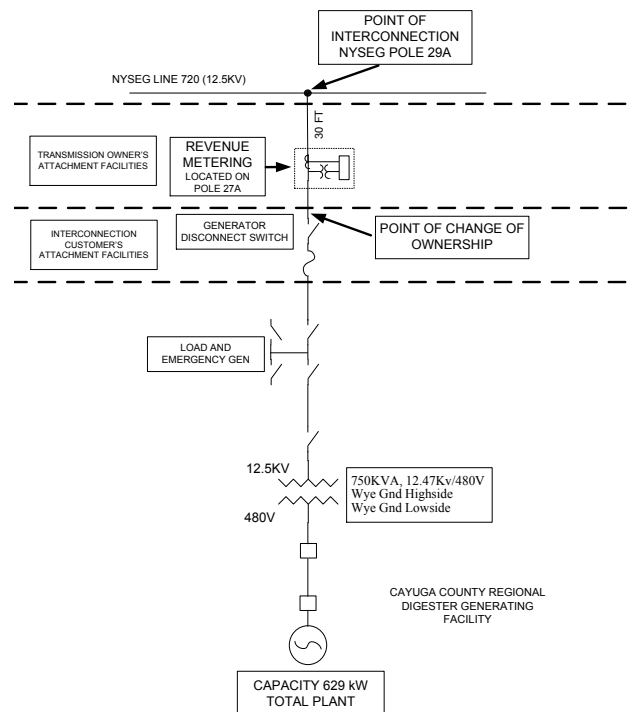


FIGURE 20: INTERCONNECTION SWITCHGEAR

The import/export data is metered by a TransData Mark V Solid State Revenue Meter owned and operated by NYSEG. The metered data is read monthly via phone and posted on NYSEG's ftp site. NYSEG uses this information for billing purposes. The District also has the ability to download the data for determining energy balance and calculation of true-up costs for the different County departments.

4.1.13 PROCESS & PLANT CONTROL & MONITORING SYSTEM

Programmable Logic Controller (PLC)

The plant is fully automated, with the exception of the loading/unloading station, and operates 24 hours a day, 365 days per year. The computerized supervisory control and data acquisition system (SCADA) provides:

- Continuous process visualization and access to operating parameters.
- Overall plant supervision and controls
- Overall supervision of security systems with manual over-rides for emergencies
- Setting of alarms and alarm horn.
- Recording of all process parameters such as temperature, pressure, flow quantities, as well as alarms including their graphical evaluation.
- Data memory for 12 months.
- Remote monitoring and diagnostics capability, with proper authorization and access codes.



FIGURE 21: PLC

Metering, Monitoring & Documentation Systems

The plant will include a computerized performance monitoring and documentation system to perform the following functions:

- Assess and document the quality of feedstock and digester byproducts regularly;
- Monitor the plant operating parameters and assess process conditions;
- Monitor equipment health conditions, trend maintenance parameters and schedule maintenance;
- Optimize economic and environmental performance ;
- Ensure planned actions are carried out in a timely and effective manner.

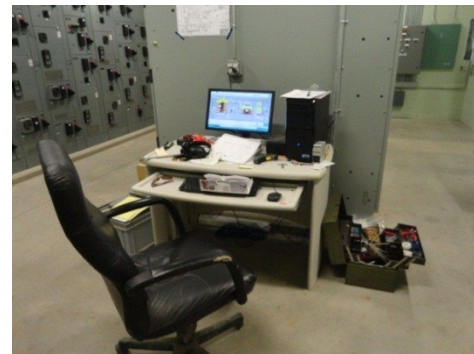


FIGURE 22: PLANT CONTROL COMPUTER

4.2. Commissioning

The construction of Cayuga County Regional Digester was completed in October 2011. Once the interconnection systems were reviewed and approved, the plant began its commissioning process in January 2012. The commissioning process included several steps that are outlined below:

4.2.1 ACCEPTANCE TESTS

As a part of the construction process, all major equipment was subjected to visual inspection and functional testing. The following describes these tests:

Structural/ Architectural Inspections

All building structures were inspected after completion and appropriate tests were performed to make sure that all load bearing and pressure bearing structures met the specified construction requirements specified under the contract.

When problems were discovered, appropriate corrective measures were implemented. A small number of modifications were performed to make the plant buildings compliant:

- Digester Office Building: Modifications were implemented to make the office accessible to disabled and handicapped;
- Additional reinforcement and door awnings were installed in the process building to make the building and the work environment safer for employees and visitors;
- Freeze protection were installed in the process building to protect the concrete base during cold weather;
- The generator room walls were retrofitted with acoustic tiles to reduce the noise levels in the room and the noise emanated from the plant to the surrounding areas.

Component Tests

All process equipment was visually inspected upon arrival on-site. The arriving equipment had to carry a report indicating compliance with contracting regulations and factory acceptance screening. The equipment were then inspected to identify any visible shipping damage before they were cleared for installation. After completion of the installation, each piece of equipment was inspected by the manufacturer and the Project Engineer and cleared for operation.

Manure Buffer Tests

The manure buffer epoxy coated vessel, insulation, heat exchanger, vertical mixer and safety systems were visually inspected. After all the visible defects were corrected, the buffer was hydro-tested to ensure structural integrity. The following problems and solutions were recorded:

- Minor leaks around the foundation were sealed;
- There was significant discoloration in the interior coating after the tank was drained. The manufacturer was brought in and additional coats of epoxy paint were applied to rectify the problem.
- The tank was hydrotested again and the problem appears to have been resolved.
- The District will need to conduct annual quality control test (thickness measurement) on the tank to ensure structural safety.

Fat Buffer Tests

The grease buffer epoxy coated vessel, insulation, heat exchanger, vertical mixer and safety systems were visually inspected. No problems were detected. The buffer was then hydro-tested to ensure structural integrity. The following problems and solutions were recorded:

- There was significant discoloration in the interior coating after the tank was drained. The manufacturer was brought in and additional coats of epoxy paint were applied to rectify the problem.
- The tank was hydro-tested again and the problem appears to have been resolved.
- The District will conduct annual quality control test (thickness measurement) on the tank to ensure structural safety.

Sanitation System Tests

The sanitation system, which incorporates an insulated 500 gallon stainless steel tank, a spiral stainless steel heat exchanger, and associated piping and pumps were visually inspected. No problems were detected.

Digester Tests

The digester construction took approximately six months to complete. During the construction process,

- The concrete foundation was routinely tested for quality and strength.
- The structural steel, seam welds were routinely tested. Any problem was reported and quickly rectified as construction continued.

- The insulation, heat exchanger, the equalization piping and valves, control and safety systems, and all associated piping were inspected and found to be acceptable.
- The only exception was the control air piping, which was increased in size to provide faster open/close cycle of the equalization valve.
- The digester vessel was hydrotested after its construction was completed to ensure structural integrity, and verify gas seal. No problems were detected.

Post Fermentation Buffer Tests

The post Fermentation buffer concrete vessel, insulation; heat exchanger, mixers and safety systems were visually inspected. Once the visible defects were corrected, the buffer was hydro-tested to ensure structural integrity. No problems were detected.

Gas Holder Tests

The gas holder was inspected and tested upon arrival and then installed on the post fermenter tank. The following problems and solutions were recorded:

- The purge valve was not operating correctly. This was removed by the manufacturer and corrected. The purge valve was subsequently reinstalled and re-wired.
- The deflection gage to measure the volume of the membrane was not working. This instrument was removed and repaired by the manufacturer.

Gas Conditioning System Tests

The gas conditioning system tank was hydrotested and found to work satisfactorily. The control valves and the instrumentation in the unit's technical room were also found to be in proper working condition. The tests for communication between the Plant PLC and the I/O unit of the gas conditioner have also shown these systems to be in proper working condition.

PLC System Tests

The PLC was wired according to the approved point-to-point diagrams and found to be work satisfactorily.

Instrumentation and Controls Tests

The plant incorporates a large number of sensors and controls for its proper operation. The majority of the instrumentation and control systems (>99%) were tested prior to plant commissioning in January 2012. The few systems that have not been tested include:

- pH Sensor in Biogas Conditioning System
- Biogas Analyzer in process building
- Level Sensor in Sediment Recovery Tank
- Replacement CT's in the Switchgear.

HMI System

The man-Machine interface is a computer installed in the plant control room. This computer operates the plant control software that monitors and controls all plant processes. The system has been tested and is in proper working condition. However, the plant control software will continue to evolve as the system switches from natural gas to biogas operation.

Generator Tests

After the generator equipment was installed and the interconnection equipment was successfully connected, the generator installation was thoroughly inspected by the manufacturer. The inspections included the following equipment:

- Natural gas fueling systems,
- Biogas fueling system
- Generator wiring
- Cooling circuits
- Instrumentation and controls
- Electrical interconnection switchgear,
- Ventilation and supply air circuits
- Safety equipment
- Point-to-point wirings between the Digester Plant PLC and generator controls,
- Test operation under idle (no-load) conditions using natural gas.
- Pre-commissioning checklist,

These tests were completed in October 2011

Plant Safety and Security Systems

All safety and security systems were inspected by the Project Engineer. The equipment was accepted after proof of performance. The Safety and Security Systems were also audited and approved by the Local Code Reinforcement Inspector, Local Fire Marshal and the Director of Local Emergency Management Response.

4.2.2 Interconnection Tests

The district completed the following work to finalize the interconnection with NYSEG grid:

- An independent technical review of the impacts of new generation on NYSEG system. This included a NYSEG commissioned study to perform a coordination study on Line 720, a coordination study of at least two busses back into the NYSEG system, and throughout the project;
- NYSEG review of all electrical drawings related to the interconnect protection;
- Review of all settings and equipment specifications related to the critical interconnection protection;
- A steady state study on the impacts of new generation on the NYSEG feeder serving the County campus;
- Trip and close schematics for interconnection critical relays;
- A dedicated half duplex POTS line for connection to the new revenue meter;
- An interval meter at Grant Avenue to assess the risk to NYSEG substation;
- New pole and meter mounting equipment, solid state revenue meter,
- One set of CT/VT 12.5kV meter class instrument transformers
- NYSEG witnessing of the CHP commissioning;
- Updating of NYSEG databases.

Once these steps were completed, inspected and approved by NYSEG, the Interconnection Agreement was executed and the District was granted permission to interconnect the CHP and test it in grid parallel mode.

A copy of the Stamped Technical Review is attached in Appendix 2 of this report.

4.2.3 Emergency Management Plan

An Emergency management Plan was developed and presented to the appropriate personnel in Cayuga County. The plan was reviewed and approved in March 2012.

4.2.4 Commissioning of the Plant on Natural Gas

On January 21, 2012, after the Interconnection Agreement between the District and NYSEG was signed, the generator was commissioned in grid-parallel mode using natural gas for fuel. The following issues and solutions were recorded:

- The current transformer's (CT) were installed incorrectly. The polarity issue was corrected by reversing the three CT connections to the relays.
- The wiring of one of the CT's was done incorrectly by the manufacturer. The problem was corrected by the manufacturer.

4.2.5 Commissioning of Biogas Operation

The start of biogas operation was filled with challenges. This process required patience and careful consideration of several important factors: smell, digester health, loading rate and testing of the testing of slurry pumps during the startup.

The digester achieved full capacity by mid-March 2012. Several issues were discovered that were addressed. The most notable issue is the generator cooling system. The plant operation and control software had to be adjusted several times to optimize the hot water temperature for process heat.

It was important that this gas be mixed with natural gas and flared to prevent the release of odorous emissions. One issue that was discovered was a bad wiring on the flare igniter. This problem was corrected by the plant personnel, in consultation with the manufacturer.

The most serious problem during the plant commissioning occurred during May 16 to May 18 time period. A series of very high currents occurred on one phase of the 3-phase service, as recorded by the interconnection Schweitzer relay. On the afternoon of May 16, another unexplained electrical ground fault knocked out the communication between the Plant control system and the digester feed pump. This caused the manure in the buffer to flow to the digester, into the post fermentation system causing it to overflow. With the post fermenter in an overfilled condition, the biogas flow during the mixing of the digester caused an overstress situation in the post fermenter, causing the concrete deck on the post fermenter to crack.

The digester process was then shut down and investigation into the cause and solutions to the problem began immediately. While the exact cause of the accident has not been determined, the concrete deck has been repaired and many additional safety features have been incorporated to address any potential future problems.

It is expected that the commissioning of the biogas operations will commence again in April 2013.

5. BUSINESS CASE

The business framework needed to address the key success criteria for the project and protect the participants against technical and financial risks commonly associated with digester operations needed to assist CCSWCD fund the construction of the plant, its start-up, as well as its future expansions, while at the same time aiding its effort to create jobs and improve the environment.

5.1. CAPITAL COSTS

The cost of plant escalated beyond the original budgets due to several factors:

- Length of construction period
- Bidding schedules & requirements
- Funding requirements
 1. Compliance with the use goods produced in the United States
 2. Compliance with the provisions of the Davis-Bacon Act

However, THE DISTRICT was able to secure sufficient funding to complete the construction of the project by October 2012. The following shows a summary of the plant costs. The sources of funding for the project are listed below:

TABLE 6: SOURCES OF FUNDING

Source	Amount	Nature
DOE	\$475,750	
GIGP Award	\$6,277,801	Competitive
USDA Rural Development	\$500,000	Competitive
NYSERDA	\$1,000,000	Competitive
NYS Ag & Mkts	\$60,000	
EPA - EM992528-11-0	\$700,000	
Local Match	\$1,500,000	
Total	\$10,513,551	

These funds were used as follows

TABLE 7: USES OF FUNDS

Project Elements	Cost	
Construction	\$8,849,200	84%
Project Development & Engineering:	\$1,500,475	14%
Legal	\$100,000	1%
Electric Interconnection	\$63,876	1%
Project Total	\$10,513,551	100%

5.2. Operating Economics

5.2.1 Operating Costs

This section describes the operating costs of the Cayuga County Regional Digester. The annual operating expense budget for the plant is estimated to be \$669,000 (2012 dollars). This includes administration and management costs, plant operation and maintenance costs. The following table shows a breakdown of annual operating expenses:

TABLE 8: ESTIMATE OF ANNUAL OPERATING COSTS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Fulltime Employees	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	58.8
Part Time Employees	0.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	121.1
Truck O&M	0.0	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	93.1
Truck Lease	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	24.0
Composter Lease	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	70.0
Generator Maintenance	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	87.6
Other Maint. & Services	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	50.7
Professional Services	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	13.0
Utilities (Natural gas)	17.2	17.8	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	41.0
Utilities (Electricity)	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	86.0
Other Expenses	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	23.7
TOTAL OP. EXPENSE	51.7	71.8	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	669.0

5.2.2 Operating Revenues

This section describes the operating Revenues of Cayuga County Regional Digester. The annual operating budget for the digester facility is estimated to be \$842,300 dollars (2012 dollars). The revenue data below was based on current or quoted prices of products and services. This analysis does not include any revenue escalation factor. These data show the revenues that are used in developing the “Base Case” financial performance of the plant

TABLE 9: ESTIMATE OF ANNUAL REVENUES

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Energy Sales:													
Campus @ 8.98¢/kwh	17.8	19.7	16.2	13.5	17.5	23.1	21.7	22.5	21.1	15.1	15.1	15.1	218.5
Grid @ 5 cents/kWh			54.3			54.3			54.3			35.5	198.4
Heat (@ 10\$/DT)	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	87.5
Credits (@ 4\$/ton)				8.8			8.8			8.8			26.3
Tipping Sales	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	218.0
By-Product Sales:													
Liquids													0.0
Solids (@ \$10/yd.)	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	93.6
TOTAL OP. REVENUE	51.1	53.0	103.8	55.5	50.8	110.6	63.7	55.8	108.7	57.1	48.4	83.9	842.3

5.2.3 Operating Income

The following table shows the annual income statement for Cayuga County Regional Digester. According to the data, the project nets approximately \$55,100 annually after the repayment of capital and interest. It is also assumed that the project starts with a small operating capital of \$50,000.

TABLE 10: ESTIMATED OPERATING INCOME

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Op. Revenues	51.1	53.0	103.8	55.5	50.8	110.6	63.7	55.8	108.7	57.1	48.4	83.9	842.3
Op. Expenses	51.7	71.8	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	669.0
Net Op. Income	-0.6	-18.8	49.2	1.0	-3.7	56.1	9.1	1.2	54.1	2.6	-6.2	29.3	173.3
Financing Expenses													
Principal Loan	3.6	4.6	5.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	73.2
Interest	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	45.0
Net Monthly Cash Flow	-8.0	-27.1	39.9	-9.4	-14.1	45.7	-1.2	-9.1	43.8	-7.8	-16.5	19.0	55.1
Cash on Hand	50.0	42.0	14.9	54.8	45.4	31.3	77.0	75.8	66.7	110.5	102.7	86.1	105.1

As evident, the financial model of the Cayuga County Regional Digester shows a low margin business that has to be closely managed. Therefore, several important steps have to be taken to address the risks and substantiate the long term viability of the project:

- It is clear that the increasing cost of electricity will improve the financial performance of the plant. However, the plant has to be operated efficiently and be well-maintained to insure its availability and performance.
- The transportation costs are the largest component of plant operating costs. The trucks have to be well maintained and operated by reliable personnel to eliminate risks and lower operating costs.
- Cayuga County Regional Digester will need to install a separation/composting system as soon as possible to produce valuable biosolids for sales. This will improve the financial performance and provide the plant with a much needed source of revenue.
- In addition to the above, The District may conduct an annual risk assessment to mitigate, if necessary, the risks associated with labor cost risks, transportation cost risks, health and safety issues, bio-security, community concerns, low gas production, and feedstock quality or quantity.

6. PROJECT ACCOMPLISHMENTS

By constructing and operating this centralized digester, the District is addressing several environmental and operational issues affecting Cayuga County:

1. *The quality of water resources in Cayuga County will improve.* The nearby farms can use the fertilizer liquids on their land, offsetting the use raw manure. This would require smaller applications of liquids thus reducing nutrient overloading of land and eliminating the risk of nutrient laden run-off.
2. *The air quality in Cayuga County will improve.* The digester captures the gaseous emissions resulting from decomposing manure applied on agricultural land. This reduces odor, harmful emissions of ammonia and sulfur compounds and emissions of organic aerosols to the atmosphere.
3. *Emissions of greenhouse gases in Cayuga County will be reduced:* Since anaerobic digestion operates in a closed system, substantial reductions in greenhouse gas emissions are achieved by preventing the uncontrolled release of CH₄ from decomposing manure.
4. *The facility lowers the cost of energy for Cayuga County.* The Cayuga County Campus is the first government facility in the United States to replace 82% of its energy needs (electricity and fossil) needs with renewable energy produced on-site with animal manure and food waste. This should help lower the tax basis for Cayuga County residents and improve the business development environment.
5. *Sustainable Renewable Energy Business:* Based on the current projections, the facility will produce nearly \$800,000 in revenues, enough to offset its operating costs, lower Cayuga County's energy costs and produce a small profit to fund future improvements.
6. *The project created an economic development opportunity during tough economic times.* The project produced over 200 construction jobs during the 2010-2012 period. The local businesses benefit significantly from the infusion of the \$9.5 million of construction budget into the local economy. It is expected that another 10 new operation and service jobs will be created when the plant operation begins. Further, economic models indicate that another 196 new jobs would be created due to the multiplier effect and the infusion of \$842,000 of operating revenue into the local economy.

Furthermore, the project has become a venue for demonstration of unique new technologies and business concepts:

1. **Hydraulic Mix Digester:** This digester technology uses proprietary GBU technology that uses the pressure of biogas in the digester for its internal mixing. This design optimizes all biological functions required for biogas production taking structural and hydraulic requirements into account. The structural principles guarantee

reliable function, a long service life and practically maintenance-free operation. The design provides full control over vital process functions including thermal stability, continuous blending, homogenization, processing and mixing of high solids feedstock and co-substrates as well as excellent operating reliability and low operating costs. Blue Electron holds the exclusive license for the GBU hydraulic mix technology for North America and the Caribbean Islands.

2. **Community Digester:** The project is one of the first municipal projects in the U.S. that employs the principles of a community digester to address manure management problems for smaller farms. It is expected that by solving the dairy farmers' environmental problems, Cayuga County Regional Digester Facility is also developing a business model that benefits the majority of dairy farmers in Cayuga County. This strengthens the competitive position of the milk production in the county, while addressing two pressing needs for Cayuga County: lowering the cost of farmer's compliance with the growing manure management regulations and managing the increased energy costs in Central New York.
3. **Self-Sustaining Renewable Energy Enterprise:** The Cayuga County Campus located near this facility is the first government facility in the United States to replace 82% of its energy needs (electricity and fossil) needs with renewable energy produced from animal manure. Based on the current projections, the facility is expected to produce nearly \$800,000 in revenues, enough to offset its cost of operation, lower Cayuga County's cost of energy by 25% and produces a profit that could offset capital costs for future expansion.
4. **Biological Biogas Conditioning:** The project employs a biological desulphurization system manufactured by American Biogas Conditioning with all made-in-America components. This is a **flexible and enabling technology** that would allow more reliable and economic operation of CHP systems by removing H₂S and siloxane from *renewable biogas* generated by anaerobic digester. The system produces a clean gas that is suitable for all commercial CHP systems including internal combustion engines, microturbines and fuel cells. The byproduct from the process can also be used to enhance the nutrient value of digester byproducts.
5. **Fertilizer Bank:** The excess nitrogen-rich liquid fertilizer that is not used by the participating farms can be stored by the District and provided to the other nearby crop farms who require fertilizer, but have no existing animal stock of their own.

7. TECHNOLOGY TRANSFER ACTIVITIES

The project has offered many opportunities to share knowledge and experience. The site has been visited by almost three hundred (300) people of different backgrounds – i.e., engineers, farmers, regulators, business owners and academia – who are interested in getting a close-up view of a municipal regional digester project. A list of these attendees can be provided upon request. The following comments were provided by the visitors' as positive observations and lessons learned:

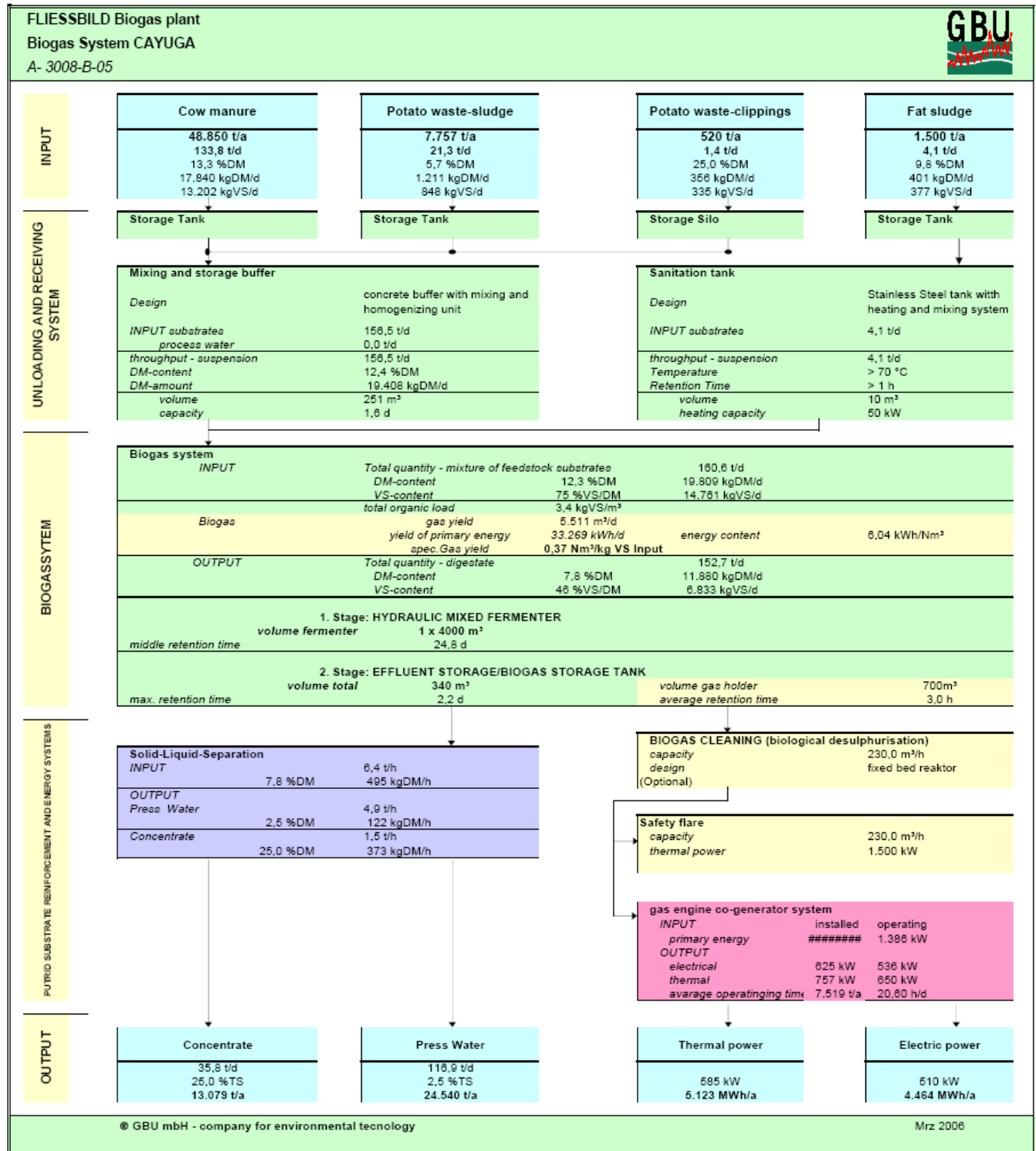
1. The project provides a showcase for other communities seeking to fill the need for regional manure and food waste processing.
2. The site can become a test and demonstration site for new technologies and new businesses that can be tied to the back end of the plant.
3. The project utilizes the GBU Hydraulic Mix Digester technology that is gaining more popularity in Europe and elsewhere in the world. This installation will provide data on this digester's performance as well as establish a show-case demonstration plant and a training location, based on the District's intent, for New York farmers and other farmers in the U.S.
4. This plant will provide a new option to dairy operations or communities considering digester applications. The project has a unique business farmer cooperative model for the operation of the digester and gas production.
5. The business model and the technologies utilized in this project can serve as a template for other regions with abundant dairy and food wastes.

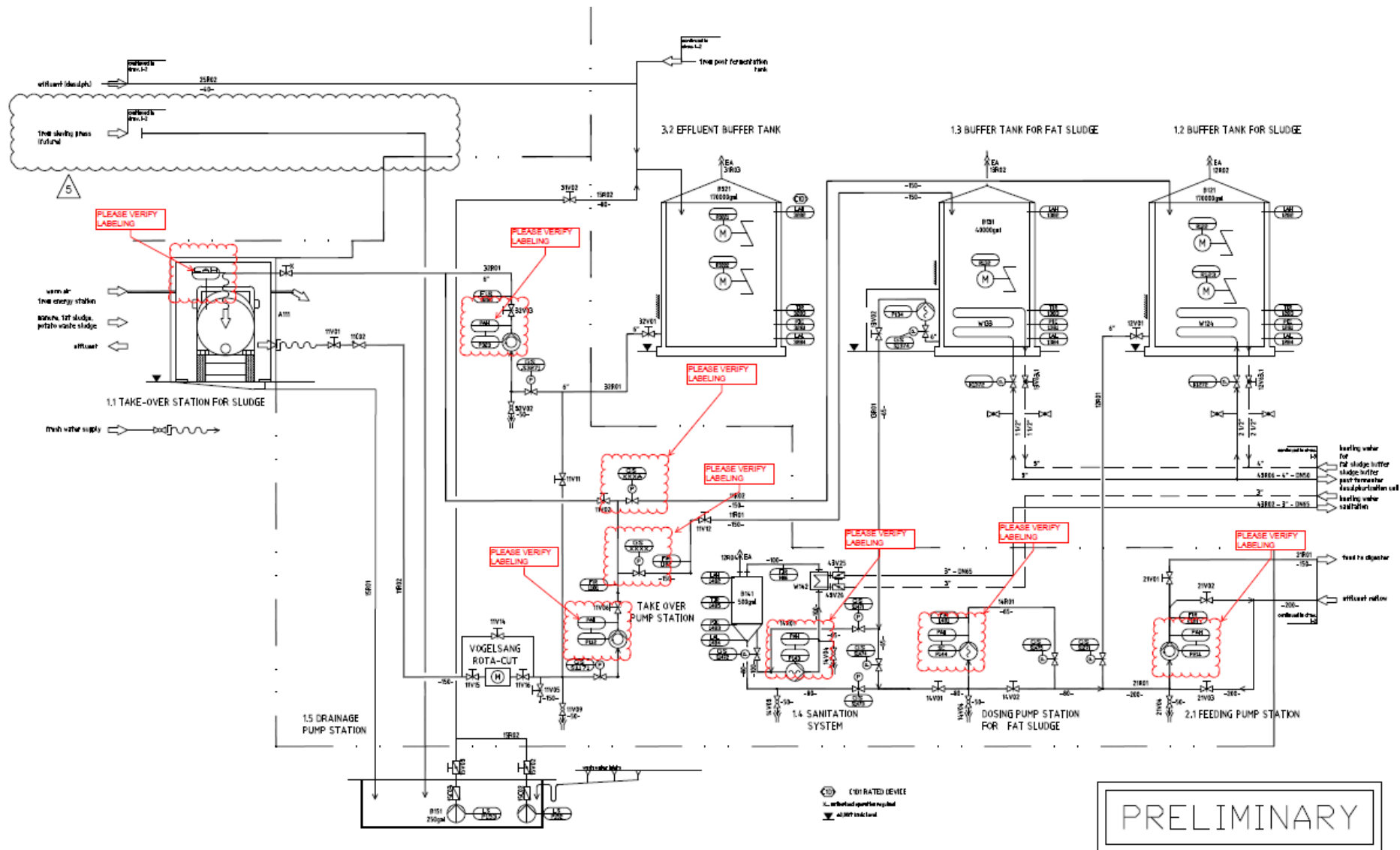
The future plans at the facility are to use the biogas and electricity produced from the digester to manufacture grass biofuel pellets for home heating from switchgrass or other biomass. Located north of the Thruway in Cayuga County are small to medium size farms struggling to stay in business. The soils in this part of the county are marginal unlike those in the southern part that are very productive for crops such as alfalfa, soybeans and corn. Switchgrass, a native species is well adapted to marginal land. Switchgrass requires minimal fertility and management, is low cost to produce, has moderate to high yields and produces 40% more net energy gain per acre than corn. Utilizing marginal land for energy production instead of prime farmland allows agriculture to maintain its role in supplying food.

8. APPENDICES

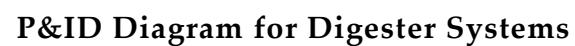
APPENDIX 1: DESIGN BASIS & P&ID DIAGRAMS

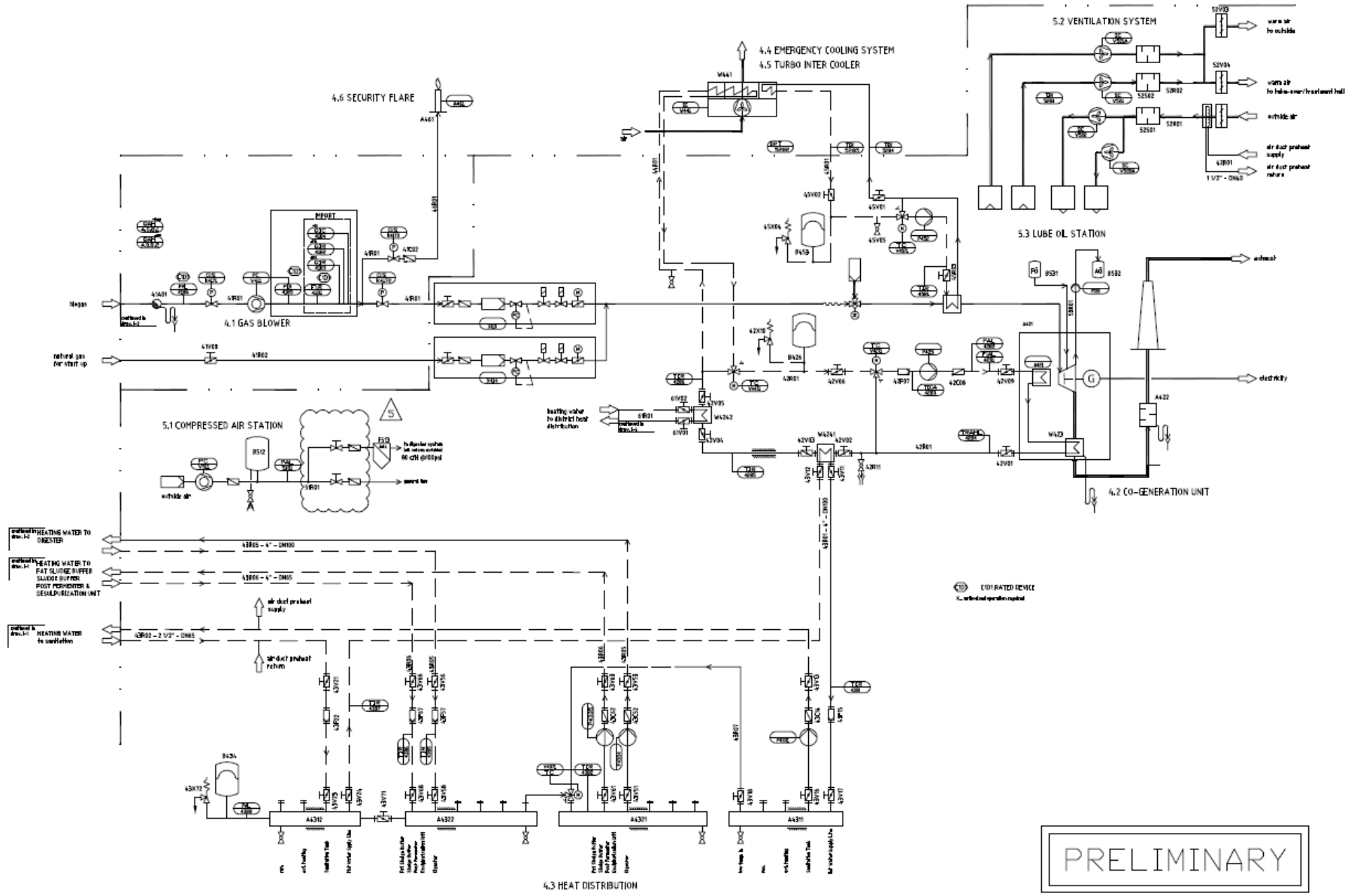
DESIGN BASIS



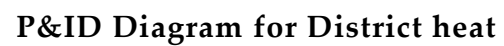


P&ID Diagram of the Transfer Station





P&ID Diagram for Energy Station



APPENDIX 2: CERTIFIED TECHNICAL REVIEW OF INTERCONNECTION



Adobe Acrobat
Document

APPENDIX 3: CERTIFICATION OF CHP COMMISSIONING



GE Certification of
Commissioning

APPENDIX4: GLOSSARY**Acronyms**

ARRA	American Reinvestment and Recovery Act
BACT	Best available control technology
BDT	Bone dry tons
BOD	Biological oxygen demand
Btu	British thermal units, unit of energy
CAFO	Confined animal feeding operation
CARB	California Air Resources Board
CFM	Cubic feet per minute
CFR	Code of Federal Regulations
CH ₄	Methane
CHP	Combined heat and power
CO	Carbon monoxide
CO ₂	Carbon dioxide
DGE	Diesel gallon equivalent
District	Cayuga County Soil & Water Conservation District (CCSWD)
DOE	U.S. Department of Energy
DT	Dekatherm (1 MMBTU)
EPA	US Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
ERC	Emission Reduction Credits
ft ³ /d	Cubic feet per day
ft ³ /h	Cubic feet per hour
ft ³ /y	Cubic feet per year
GHG	Greenhouse gas
gpd	Gallons per day
gpm	Gallons per minute
GWe	Gigawatts of electricity (10 ⁹ watts)
H ₂	Hydrogen
H ₂ O	Water

H ₂ S	Hydrogen sulfide
H ₂ SO ₄	Sulfuric acid
hp	Horsepower
HRT	Hydraulic retention time
IOU	Investor owned utility
kW	Kilowatt (10 ³ watts), unit of power
kWh	Kilowatt-hour, unit of energy
lb	Pound(s)
LHV	Lower Heating Value
MCF	1000 cubic feet
MMBTU	1000,000 BTU
MW	Megawatt (10 ⁶ watts), unit of power
MWh	Megawatt-hours, unit of energy
MW _e	Megawatts of electricity
N ₂	Nitrogen gas
NO _x	Nitrogen oxides and dioxides, typically NO and NO ₂
N ₂ O	Nitrous oxide
NPDES	National Pollution Discharge Elimination System
NY EFC	New York State Environmental Facilities Corporation
NYDEC	New York State Department of Environmental Conservation
NY-PSC	New York State Public Service Commission
NYSEG	New York State Electric and Gas
NYSERDA	New York State Energy Research and Development Authority
O ₂	Oxygen Gas
OM	Organic Matter
PM	Particulate matter
ppm	Parts per million
ppmv	Parts per million volumetric
psi	Pounds per square inch, unit of pressure
psig	Pounds per square inch, gauge, unit of pressure
PURPA	Public Utility Regulatory Policy Act
RPS	Renewable Portfolio Standard

scf	Standard cubic feet
scfm	Standard cubic feet per minute
SEQR	NY State Environmental Quality Review
Therm	Unit of heat equal to 100,000 BTU
TS	Total solids
USDA	US Department of Agriculture
US DOE	US Department of Energy
US EPA	US Environmental Protection Agency
VOC	Volatile organic compounds
VS	Volatile solids

Definitions

<i>Acetic acid</i>	A carboxylic acid, acetic acid is a relatively weak acid mainly used as a pH buffer (chemical formula CH_3COOH).
<i>Acidogenic</i>	Acid-forming; used to describe microorganisms that break down organic matter to acids during the anaerobic digestion process
<i>Air Permit</i>	
<i>Anaerobic digestion</i>	A naturally occurring biological process in which organic material is broken down by bacteria in a low-oxygen environment resulting in the generation of methane gas and carbon dioxide as its two primary products.
<i>Anaerobic digester</i>	A device for optimizing the anaerobic digestion of biomass and/or animal manure, often used to recover biogas for energy production. Commercial digester types include complete mix, continuous flow (horizontal or vertical plug-flow, multiple-tank, and single tank) and covered lagoon.
<i>Biofuel</i>	Technically, any biomass derived substance used for energy (heat, power, or motive). The term 'biofuel' usually is used to describe liquid transportation fuels derived from biomass.
<i>Biogas</i>	A naturally occurring gas formed as a by-product of the breakdown of organic waste materials in a low-oxygen (e.g., anaerobic) environment. Biogas is composed primarily of methane (typically 55% – 70% by volume) and carbon dioxide (typically 30% – 45%). Biogas may also include smaller amounts of hydrogen sulfide (typically 50 – 2000 parts per

	million [ppm]), water vapor (saturated), oxygen, and various trace hydrocarbons.
<i>Biogas Conditioning</i>	A process whereby a significant portion of hydrogen sulfide, moisture and other impurities are removed from raw biogas (digester gas) leaving primarily methane and carbon dioxide.
<i>Biogas upgrading</i>	A process whereby a significant portion of the carbon dioxide, water, hydrogen sulfide and other impurities are removed from raw biogas (digester gas) leaving primarily methane. Also referred to as “sweetening.”
<i>Biological oxygen demand</i>	A measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. Biological oxygen demand (BOD) is used as an indirect measure of the concentration of biologically degradable material present in liquid organic wastes. It usually reflects the amount of oxygen consumed in five days by biological processes breaking down organic waste. BOD can be used as an indicator of water quality, where the greater the BOD, the greater the degree of pollution.
<i>Biomass</i>	Biomass is any organic matter that is available on a renewable or recurring basis, including agricultural crops and trees, wood and wood wastes and residues, plants (including aquatic plants), grasses, residues, fibers, and animal wastes, municipal wastes, and other waste materials.
<i>Biomethane</i>	Biogas which has been upgraded or “sweetened” via a process to remove the bulk of the carbon dioxide, water, hydrogen sulfide and other impurities from raw biogas.
<i>Building Permit</i>	A construction permit or building permit is a permit required in most jurisdictions for new construction, or adding on to pre-existing structures, and in some cases for major renovations. Generally, the new construction must be inspected during construction and after completion to ensure compliance with national, regional, and local building codes.
<i>Certificate of Occupancy</i>	A certificate of occupancy is a document issued by a local government agency or building department certifying a building's compliance with applicable building codes and other laws, and indicating it to be in a condition suitable for occupancy.
<i>Chemical Oxygen Demand</i>	Chemical oxygen demand (COD) is used to indirectly measure the amount of all organic compounds in a water sample (whereas BOD indicates the amount of biodegradable compounds in solution). COD is widely used in municipal and industrial laboratories to measure the overall level of organic

	contamination in wastewater. COD is determined by measuring the amount of oxygen required to fully oxidize organic matter in the sample.
<i>Co-digestion</i>	Co-digestion is the simultaneous digestion of a mixture of two or more feedstocks. The most common situation is when a major amount of a main basic feedstock (e.g., manure or sewage sludge) is mixed and digested together with minor amounts of a single or a variety of additional feedstocks. The expression co-digestion is applied independently to the ratio of the respective substrates used simultaneously.
<i>Desulfurization</i>	Any process or process step that results in removal of sulfur from organic molecules.
<i>Dew point</i>	The temperature at which vapor in a gas-vapor mixture starts to condense when the mixture is cooled at constant pressure (most commonly used for water vapor in gas mixtures).
<i>Digester gas</i>	Biogas that originates from an anaerobic digester. The term is often used, and used in this report, to represent only biogas from a wastewater treatment plant.
<i>Economy of scale</i>	The principle that higher volume production operations have lower unit costs than smaller volume operations.
<i>Endothermic</i>	A process or reaction that absorbs heat. For example, ice melting is an example of an endothermic process because it absorbs heat from its surroundings.
<i>Emergency Management Plan</i>	Emergency management an interdisciplinary field dealing with the strategic organizational management processes used to protect critical assets of an organization from hazard risks that can cause events like disasters or catastrophes and to ensure the continuance of the organization within their planned lifetime.
<i>Enteric fermentation</i>	A digestive process by which carbohydrates are broken down by microorganisms in the rumen to simple molecules for absorption into the bloodstream of a ruminant animal, such as a cow.
<i>Exothermic</i>	A process or reaction that releases heat.
<i>Global warming</i>	An increase in the near surface temperature of the Earth. Global warming has occurred in the distant past as the result of natural influences, but the term is most often used to refer to the warming that occurs as a result of increased emissions from human activity of greenhouse gases, such as carbon dioxide, methane, and nitrous oxide, which trap the sun's heat.

<i>Hydraulic retention time</i>	HRT is the average time a 'volume element' of fluid resides in a reactor. It is computed from liquid-filled volume of an anaerobic digester divided by the volumetric flow rate of liquid medium.
<i>Heating Value</i>	The heating value of a substance is the amount of heat released during the combustion of a unit mass/volume of that substance.
<i>Interconnection Agreement</i>	An interconnect agreement is a business contract between an on-site electric power generator and the local utility for the purpose of interconnecting the generator with the electric utility network, ensuring the safety of the interconnected system and regulating the exchange of electron between the customer and the utility.
<i>Lower Heating Value</i>	The lower heating value (LHV) is the amount of useful energy released during the combustion of the substance. LHV assume that the water component of a combustion process is in vapor state at the end of combustion.
<i>Mesophilic</i>	Conditions in a biological reactor where temperatures are around 95° F (35° C).
<i>Methanogenic</i>	Methane-forming; In the anaerobic digestion process, methanogenic bacteria consume the hydrogen and acetate (from the hydrolysis and the acid forming stages) to produce methane and carbon dioxide
<i>Methane</i>	Methane is the main component of natural gas and biogas. It is a natural hydrocarbon consisting of one carbon atom and four hydrogen atoms (CH ₄). The heat content of methane is approximately 1,000 Btu/scf (standard cubic feet). Methane is a greenhouse gas with 21 times the global warming potential of carbon dioxide on a weight basis.
<i>Nameplate rating</i>	The initial capacity of a piece of electrical equipment as stated on the attached nameplate in watts, kilowatts or megawatts. Actual capability can vary from the nameplate rating due to age, wear, maintenance, fuel type or ambient conditions.
<i>Net metering</i>	A method of crediting customers for electricity that they generate on-site in excess of their own electricity consumption. Customers with their own generation offset the electricity they would have purchased from their utility. If such customers generate more than they use in a billing period, their electric meter turns backwards to indicate their net excess generation. Depending on individual state or utility rules, the net excess generation may be credited to their account (in some cases at

	the retail price), carried over to a future billing period, or ignored.
<i>Nitrogen or nitric oxides</i>	NO _x is a regulated criteria air pollutant, primarily NO (nitric oxide) and NO ₂ (nitrogen dioxide). Nitrogen oxides are precursors to photochemical smog and contribute to the formation of acid rain, haze and particulate matter.
<i>Nitrous oxide</i>	N ₂ O, a greenhouse gas with 310 times the global warming potential of carbon dioxide.
<i>Nonpoint source</i>	Pollution source that is diffuse, without a single identifiable point of origin, including runoff from agriculture, forestry, and construction sites.
<i>Power Purchase Agreement</i>	PPA is a contract between the local electric utility and an on-site generator for sale of excess electricity, when the on-site generation equipment produces more power than the site needs, and for purchase of supplemental power during periods when the on-site generator is short in meeting the on-site demand..
<i>Point source</i>	Contamination or impairment from a known specific point of origination, such as sewer outfalls or pipes.
<i>Rumen</i>	The large first compartment of a ruminant's stomach in which cellulose is broken down by the action of symbiotic microorganisms.
<i>SEQR</i>	The basic purpose of SEQR is to incorporate the consideration of environmental factors into the existing planning, review and decision-making processes of state, regional and local government agencies at the earliest possible time. To accomplish this goal, SEQR requires that all agencies determine whether the actions they directly undertake, fund or approve may have a significant impact on the environment, and, if it is determined that the action may have a significant adverse impact, prepare or request an environmental impact statement.
<i>Scrubbing</i>	Cleaning emission gases from a chemical reactor, generally with sprays of solutions that will absorb gases.
<i>Thermophilic</i>	Conditions in a biological reactor where temperatures are around 130° F (55° C) or higher.
<i>Total Solids</i>	Used to characterize digester systems input feedstock. Total solids (TS) means the dry matter content, usually expressed as % of total weight, of the feedstock.

Volatile organic compounds VOCs are non-methane, non-ethane, photoreactive hydrocarbon gases that vaporize at room temperature (methane and ethane are not photoreactive). The quantity of VOC is sometimes determined by measuring non-methane non-ethane organic compounds. When combined with NO_x and sunlight, VOCs produce ozone, a criteria air pollutant.

Volatile Solids Used to characterize digester systems input feedstock Volatile Solids (VS) are the organic (carbon containing) portion of the prepared reactor feedstock. Usually expressed as a fraction of total solids, but sometimes expressed as a fraction of total sample (wet) weight. The amount of VS in a sample is determined by an analytical method called "loss on ignition." It is the amount of matter that is volatilized and burned from a sample exposed to air at 550 °C for 2 hours. The inorganic (ash) component of total solids remains after the loss on ignition procedure. $\text{VS} + \text{ash} = \text{TS}$.

Wheeling The process whereby owners of electricity or natural gas pay to transport and distribute their commodity through another entity's, distribution system (wire or pipeline grid)

APPENDIX 5: CONSTRUCTION PHOTOS



Grassed waterway



Containment berm



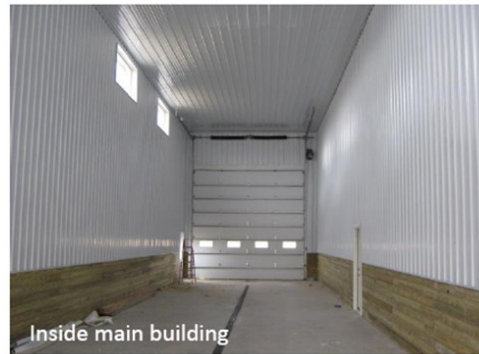
General site preparation



Road construction



General view



Inside main building



Outside of office building



Inside construction



Before construction



During construction



Tank foundation



First tank being constructed



Second tank being constructed



Three tanks completed



Completed manure storage facility
(Shown prior to fence installation)



Heat exchangers inside tank



Nearly complete manure storage facility
(Shown prior to fence installation)



Future manure storage location on a
participating farm



GENERATOR ROOM



ACOUSTIC WALL INSIDE THE
GENRATOR ROOM



PIPE SUPPORTS INSIDE THE
GENRATOR ROOM



HEAT EXCHANGER
PIPING



GENERATOR COOLING
PIPES



PROCESS HEAT PIPING



GENERATOR UNLOADING



GENERATOR IN PLACE

ELECTRICAL ROOM



ELECTRICAL UTILITY ROOM



MCC



ELECTRICAL UTILITY ROOM



INTERCONNECTION SWITCHGEAR



PLC

PUMP STATION



LOADING/UNLOADING STATION



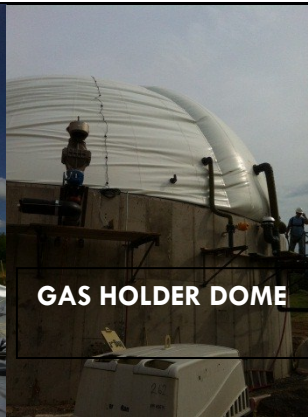
DIGESTER





POST FERMENTER/GAS HOLDER





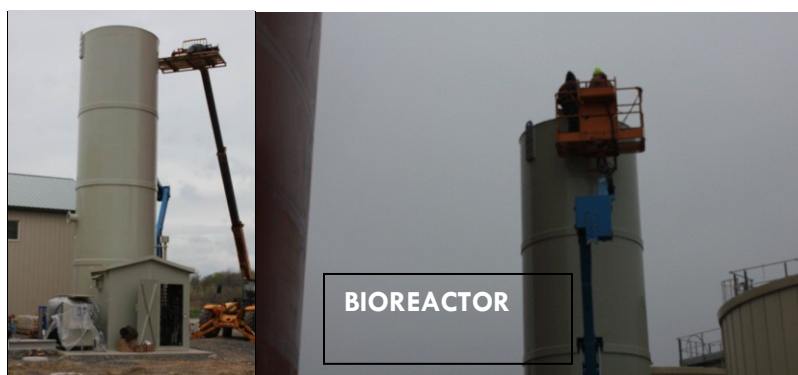
PROCESS PIPING



ELECTRICAL



GAS CONDITIONING UNIT



BIOREACTOR



CHILLER

COOLING HEX

HEATING
HEX





CAYUGA COUNTY REGIONAL DIGESTER