Anaerobic Digestion at Synergy Biogas, LLC: Case Study

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Anaerobic digestion overview

Digester type	Continuously-Stirred Tank Reactor
Digester designer	Bigadan A/S
Date commissioned	12/30/2011
Influent composition	Raw manure (including bedding, wastewater) and food-grade organic waste
Stall bedding material	Separated manure solids
Number of cows	1,866
Rumensin® usage	Yes
Dimensions (height, diameter)	Upright tank; h = 72 feet, D = 74 feet
Tank material	Steel body and stainless steel top ring and roof
Design temperature	100°F
Design loading rate	100,000 gallons per day
Treatment volume	2,200,000 gallons
Design hydraulic retention time	22 days
Solid-liquid separator	Yes; separated manure solids used for bedding
Biogas utilization	Engine-generator set (1,426-kW)
Carbon credits sold/accumulated	In the process to register and sell carbon credits
Monitoring results to date	Monitoring process starts in April 2012

System overview

- CH4 Biogas, LLC formed Synergy Biogas, LLC to own and operate an anaerobic digester at the Synergy Dairy in Covington, New York. Synergy Dairy leases the site for the facility and supplies manure to the digester. Synergy Dairy is owned by Synergy, LLC, a partnership of large-scale dairy and field crop producers in Western New York organized to develop and manage projects that benefit from their complimentary strengths. John Noble is the President and CEO of Synergy, LLC. He founded Linwood Management Group a company responsible for managing more than 15,000 cows on dairies in New York and Wisconsin. CH4 Biogas, LLC was formed by Paul Toretta, Bob Blythe and Bigadan A/S in 2008 in response to market demand for anaerobic digestion and alternative energy in the United States. Bob Blythe is the president of CH4 Biogas.
- The anaerobic digester co-digests manure from over 1,800 milking cows at the dairy location with imported food-grade organic waste, which is transported to the site. Biogas from the digester is used to fuel a GE Jenbacher model 420 engine generator set with capacity to generate up to 1.4 MW of electrical power. In addition, the system produces pathogen-free bedding from manure solids for the dairy operation and reduces odors.
- The anaerobic digestion system built by the Danish contractor, Bigadan A/S, was commissioned in December 2011.

Why the digester?

The main benefits of having an anaerobic digester, as seen by Synergy Dairy:

- Reduce odor emissions,
- Eliminate/reduce pathogens in the bedding,
- Lower energy bills, purchase electricity at discounted rate,
- No need for composting

The business goal of CH4 Biogas is to own and operate profitable renewable energy facilities based on mixed-waste anaerobic digestion. In the case of Synergy Biogas, Synergy Dairy was chosen because of solid management at the dairy and opportunities for other feedstock in the area, which can potentially increase the profitability of the project.

Anaerobic Digestion (AD) System

The Synergy Biogas AD system was designed and built by Bigadan A/S while CH4 Biogas owns and operates the system. Manure is supplied by approximately 1,666 lactating cows and 200 dry cows from Synergy Dairy. Supply contracts are currently being negotiated for the food waste substrates to be incorporated to the anaerobic digester.

The effective volume of the anaerobic digester is 2.2 million gal. Based on a projected total influent of 100,000 gal per day, composed of 55,000 gal of manure, 40,000 gal of food waste, and 5,000 gal of other dairy wastes, the hydraulic retention time (HRT) will be 22 days.

System and process description

A flow diagram of the Synergy Biogas anaerobic digestion system is shown in Figure 1. The system is located next to Synergy Dairy. A plan view of the project site is shown in Figure 2.

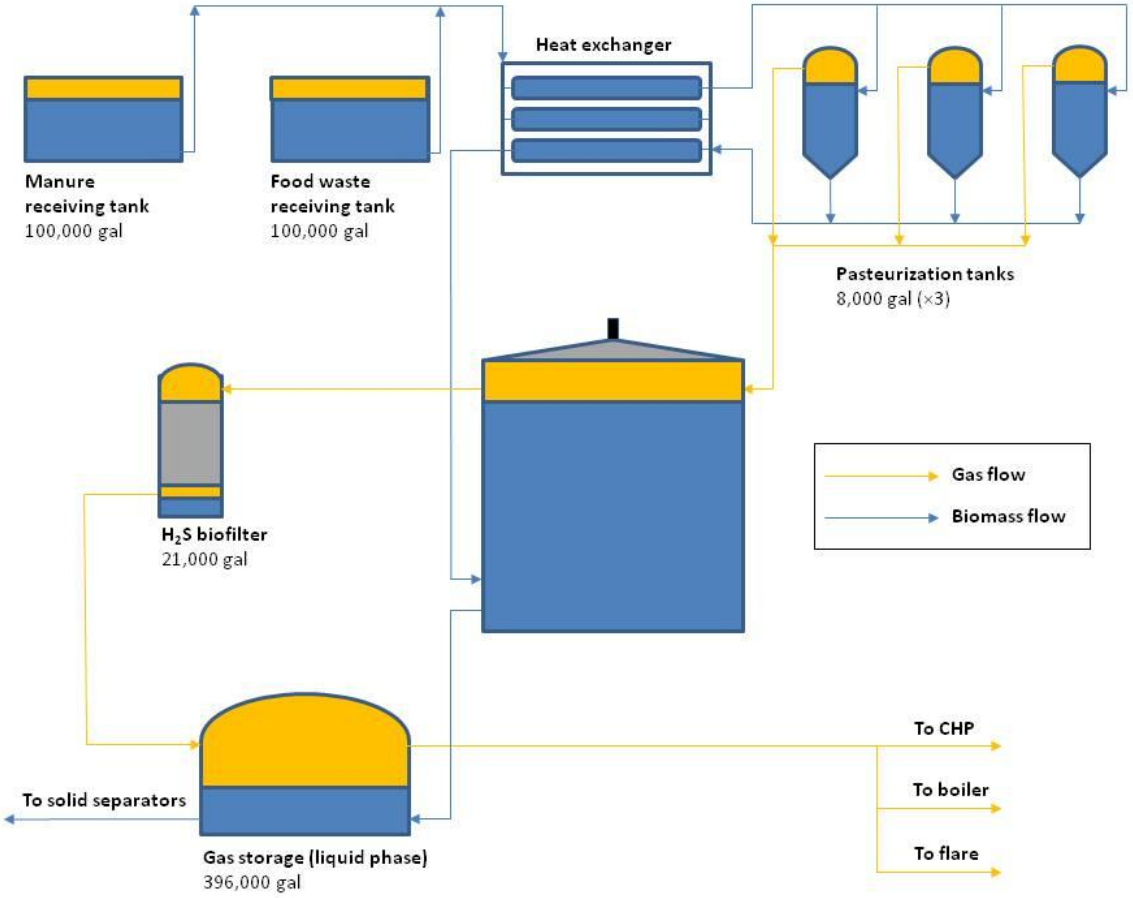

Figure 1. Synergy Biogas AD system flow diagram

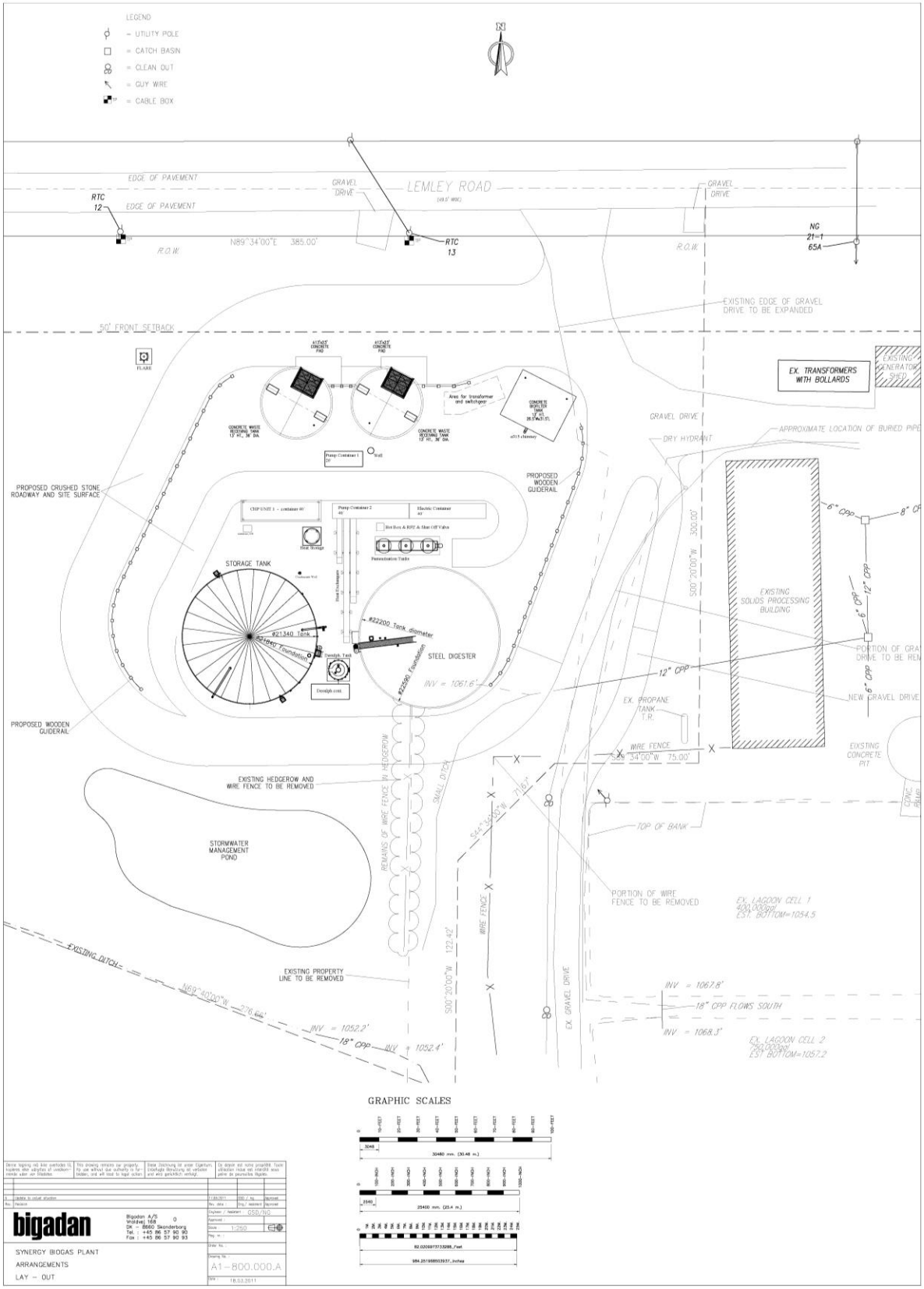

Figure 2. Plan view of the Synergy Biogas project site

There are two receiving tanks, each 100,000 gal in total volume; one to store the food waste substrates and one to store the manure supplied by the farm (see Figure 1 and Figure 2). Manure is collected via skid steer three times per day during milking shifts and scraped to a trench in the center of the barns. Manure flows by gravity to a collection pit and is pumped to one of the 100,000-gal storage tanks. Manure and contents of the food waste receiving tank are pumped via macerator pump through the heat exchange system and combined in one of three pasteurization tanks (8,000 gal each). The influent blend is heated to 158ºF and maintained for one hour for pasteurization. Pasteurized biomass is pumped to the digester vessel through the heat exchange system to bring the temperature of the biomass down to 100ºF. The anaerobic digestion process operates in the mesophilic range.

The anaerobic digester is a cylindrical upright continuously-stirred tank reactor (74 feet diameter, 72 feet high) made of bolted carbon steel construction (Figure 3). The top ring and roof are stainless steel, to resist corrosion. Mixing is provided by a single roof-mounted mixer with two large impellers driven by a central shaft. The tank is insulated with 3-½ inch fiberglass batt between the siding and carbon steel wall. After approximately 22 days in the anaerobic digester, the treated effluent is transferred to the biomass/gas storage tank where it is maintained for up to 4 days before it is pumped to screw-press separators to produce solids for bedding.

Biogas produced by the digester is treated by a biological filter to reduce hydrogen sulfide (H_2S). The unit is a 21,000-gal packed-media column. Biogas entering the scrubber contains over 2,000 ppm H_2S, which will be reduced to approximately 100 ppm when the microbiological community is operating at full capacity. Scrubbed biogas is contained in a 396,000-gal biomass/gas storage tank with a flexible membrane cover. Biogas flows by pressure through a condensate well and blowers are used to pressurize biogas for use in the generator, boiler or flare. The facility includes a biogas-fired boiler (Columbia, MPH-70) with a 2.9-MBtu/hr capacity, which provides heat for biomass pasteurization and anaerobic digestion when the generator is idle. Excess biogas is combusted by a flare (C-DEG, GmbH) with a 3.5 MW capacity.

Figure 3. Continuously-stirred tank reactor and pasteurization units

Liquid and solid effluent utilization

Digested effluent is transferred to two screw-press units (Integrity Ag Systems) for liquid-solid separation. The liquid portion is diverted to the storage lagoon, which is then applied on the dairy farm cropland. The separated solid portion is used for cow bedding at the dairy farm. Enough bedding is produced for the 10 pens used at the farm.

Heat and electricity generation

After treated via the biological scrubber to reduce H_2S, the biogas produced by the anaerobic digester flows through a condensate well to reduce moisture and via a blower to a GE Jenbacher model 420 combined heat and power (CHP) unit. The containerized CHP unit which was installed by North East Energy Systems, has a design capacity of 1,426-kW of electric power and 5,411 MBtu/hr of thermal output. All the generated electricity is sold through NYISO grid to

counterparties in the Northeast. The project received a NYSERDA grant under the anaerobic digester gas to electricity program and a portion of the renewable energy credits generated are sold to NYSERDA. Engine oil changes are to be performed every 2,000 hours, and a complete rebuild of the engine is required by the manufacturer at 60,000 hr.

Economics

The total cost of the anaerobic digestion system project as built was $7,750,000. The itemized capital costs for the systems and equipment are shown in Table 1.

Table 1. Initial capital costs for Synergy Biogas AD system

Component	Cost ($)
Interconnection and switchgear	1,250,000
Site work	1,200,000
Mechanical systems	350,000
Heat exchange and pasteurization	400,000
Digester vessel	1,250,000
Biomass and gas storage	350,000
Hydrogen sulfide scrubber	150,000
CHP unit	1,250,000
Motor control systems	300,000
Engineering installation	1,250,000
Total	**7,750,000**

Overall Benefits and Considerations

Benefits

- Odor control
- Potential revenue from:
  1) Value-added products
  2) Reduction of purchased energy
  3) Sale of excess energy
  4) Food waste tipping fees
  5) Efficient use of biogas production
  6) Carbon credit sales
- Nutrient conversion, allowing use by plants as a natural fertilizer, if effluent is spread at an appropriate time
- Pathogen reduction

Considerations

- Possible high initial capital and/or high operating costs
- Long and tedious contracts with the local utility; may require special equipment for interconnection
- Dedicated management of the digestion and power generation system is required
- Careful attention to equipment maintenance and safety issues due to the characteristics of raw biogas
- Increased land base may be required to handle the imported food waste nutrients
- Specialized permits may be required to import food waste

Who to Contact

- Bob Blythe, President of CH4 Biogas, LLC.

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- Curt Gooch, Dairy Housing and Waste Treatment Engineer, PRO-DAIRY Program, Cornell University. Phone: 607-255-2088, E-mail: cag26@cornell.edu

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