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Anaerobic Digestion at Twin Birch Farm: Case Study

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Anaerobic digestion overview

Digester type	Plug-Flow
Digester designer	AnAerobics/Twin Birch Farms
Date Commissioned	2003
Influent	Raw manure
Stall bedding material	Post digested separated solids
Number of cows	1,200
Rumensin® usage	Yes
Dimensions (length, width, height)	140’x40’x14’
Cover material	Concrete hard-top
Design temperature	100°F
Estimated total loading rate	29,000 gallons per day
Treatment volume	586,500 gallons
Estimated hydraulic retention time	20 days
Solid-liquid separator	Yes
Biogas utilization	6 Capstone 30-kW microturbines; biogas fired boiler
Carbon credits	Yes; AgCert™
Monitoring results to date	None available

Farm overview

- Twin Birch Farm is a 1,200-cow dairy operation located close to the Village of Owasco in Cayuga county, New York
- The farm is owned and managed by Dirk Young.
- Construction of the digester began in 2001; after overcoming equipment difficulties, the digester was successfully commissioned in September 2006 and the microturbines started producing power in January 2007.
- The digester was funded in part by the NYS Clean Water, Clean Air Act and in part by NYSERDA
- Digester effluent separation, use of separated manure solids for bedding, and pumping separated liquid to a remote storage have all been successful.
- The farm has acted as its own designer and general contractor after the original system designer failed to perform.

<u>Why the digester?</u>

The farm is located across from a golf course and in two sensitive watersheds (Skaneateles and Owasco lakes, both heavily used for recreation and water supply for Syracuse, NY and Auburn, NY respectively). Manure was traditionally managed by weekly spreading from short-term storages under the barns onto crop fields. Watershed recommendations as part of a CAFO plan, as well as the desire to limit spreading on saturated soils for environmental and compaction reasons, led the farm to install a 6-million gallon manure storage pond. It was known that storing the manure long-term and subsequently spreading on a large portion of cropland would create significant odor issues in the community.

Recommendations were made by the Cayuga County Soil and Water Conservation District and the Skaneateles Lake Watershed Agricultural Program for both long-term storage and odor control. Some funding was available from New York State's non-point funding program to implement conservation practices, including an anaerobic digester. The potential for odor control, and anticipated revenue from energy and compost production, motivated the farm to construct a digester. NYSERDA funding that provided cost-share opportunities for innovative agricultural energy recovery practices, led the farm, along with the anticipation of reduced long-term operating costs (compared to internal combustion engines), to choose microturbines for the power generation system.

The project goals were to install a digester system that could demonstrate cost-effectiveness and provide the following benefits:

- Odor reduction
- Energy production (using microturbines)
- Separated manure solids for bedding
- Purchased heat savings

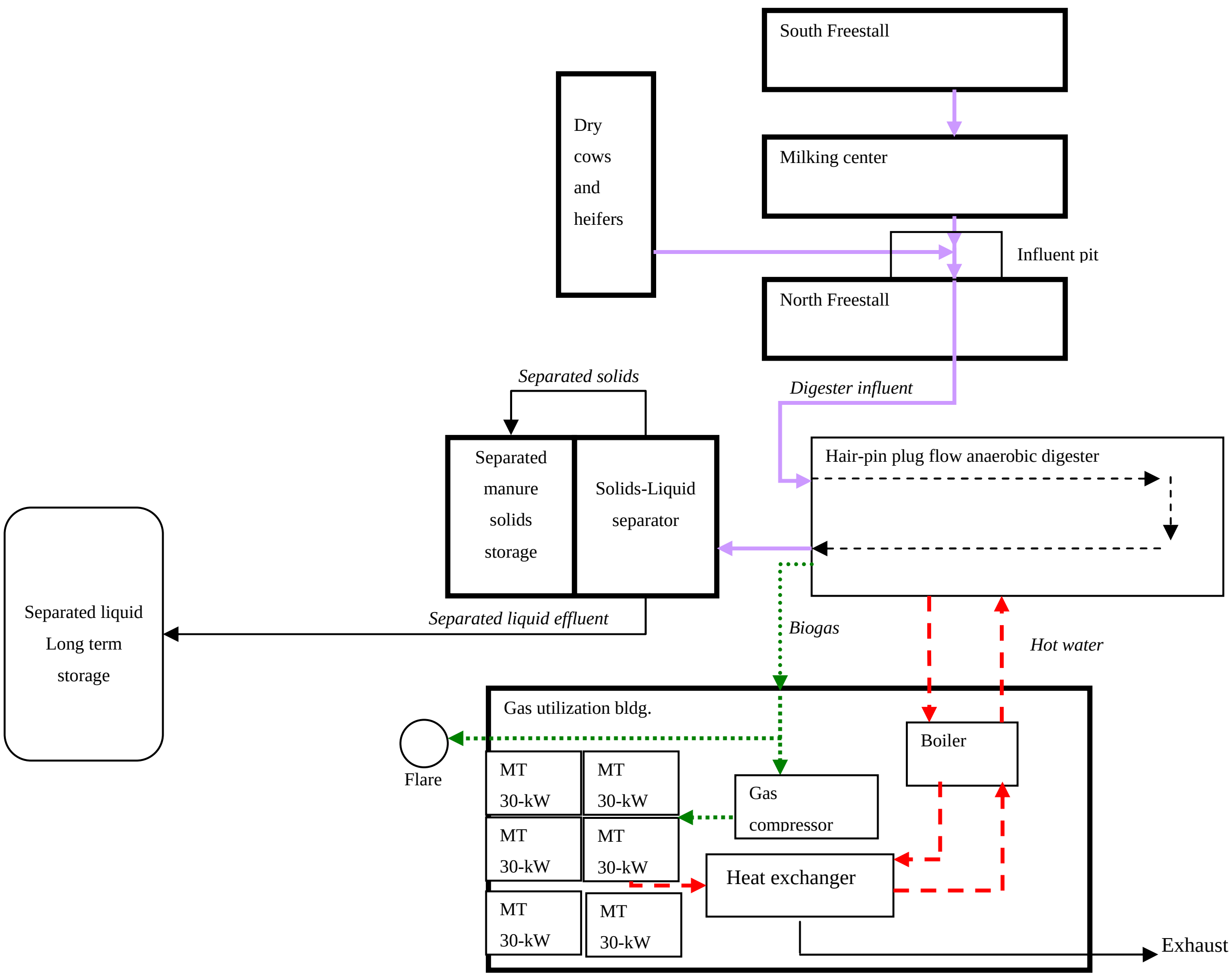
Digester System

<u>System and process description</u>

The Twin Birch digester system is composed of several components:

- Manure collection
- External shell and tube heat exchanger
- Hair-pin plug-flow digestion
- Separation of post-digested effluent
- Separated manure solids used as bedding
- Pump separated liquid effluent to remote long-term storage

The digester, a below-grade rectangular insulated concrete tank, was designed with a hard top to develop a relatively high biogas pressure. Initially, the concrete top formed the base for the equipment room, which was in turn covered with a fabric-cladded metal arch structure. The equipment room formerly housed the gas dewatering and compression equipment along with the microturbines, boiler and heat exchanger. Unstoppable biogas leaks in the concrete top led to the corrosion of several equipment components, and the decision was made to move the equipment to a separate structure, which was later constructed about 100 feet away from, instead of above, the digester.



Liquids and solids process description

Digester influent is comprised of 1,200 dairy animals worth of manure, manure from older heifers and some beef cattle, milking center wastewater, and used bedding. Digester influent is pumped from a centralized collection pit located in the connection barn between the north freestall barn and the milking center to the digester on a 12 minute cycle, every 3 minutes pumping influent.

Influent is warmed to digester operating temperature with a shell and tube heat exchanger. No maintenance heat is added to the digester. Field measurements performed by the farm show the effluent is about 3°F less than the influent. The digester has a longitudinally oriented divider wall resulting in a hair-pin configuration; digester influent and effluent enter and exit the digester on the same end-wall of the digester.
Digested effluent is pumped to a FAN screw-press solid-liquid separator (SLS) with SLS liquid effluent pumped by a 160-Hp centrifugal pump to a remote earthen storage 7,500 feet away with a 220 feet increase in elevation. The separated solids are stacked in a roofed area and either used for freestall bedding, sold or recycled to the land base.

Heat and electricity generation

Biogas is used to fuel:

1) a 900,000-Btu duel-fuel boiler (also runs on No.2 fuel oil)
2) six 30-kW Capstone microturbines

Excess biogas is currently combusted by a flare.

The duel-fuel boiler is used as the secondary means to heat the hot water circulation loop that provides the heat source to the shell and tube heat exchanger. (The primary means is the combustion heat recovered from the microturbine exhaust gas.) Start-up heat was supplied by firing the 900,000 Btu dual-fuel boiler with fuel oil.

Biogas destined for use by the bank of microturbines first goes thru a multi-step dewatering process and is subsequently compressed to about 90 psi.

For the month of January 2008 the average daily metered biogas production was 115,086 ft^3 per day with a calculated methane (CH_4) content of 58%. For this same time period, the farm averaged 1,995 total animals feeding the digester; the corresponding gas production per animal was 57.7 ft^3/cow/day.

Benefits and Considerations

Benefits	Considerations
• Odor control • Potential revenue from: 1) Value-added products 2) Reduction of purchased energy 3) Sales of excess energy 4) Efficient use of biogas production 5) Carbon credit sales • Nutrient conversion, allowing use by plants as a natural fertilizer, if effluent is spread at an appropriate time • Pathogen reduction	• 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 system is required • Careful attention to equipment maintenance and safety issues due to the characteristics of raw biogas

Lessons Learned

The farm has overcome many difficulties and obstacles in order to order to meet success. The following are some of the major problems they encountered, and lessons that were learned as a result of operating their anaerobic digester system.

<u>Digester designer</u>

Choosing an engineering company to design and construct the digester can be confusing. Each company has different ideas on the type of digester, gas collection, gas cleaning, power system, electric hookup, and heating system. Each company has to have the capacity, tenacity and range of expertise to put a complex system together on a farm. Comparing companies with different pricing schemes, sales pitches, and promises can be difficult. Many seemingly little issues become big issues when they cause the whole system to fail. It is important to review the experiences and references of the engineers carefully, paying particular attention to their work on similar projects.

Engineering companies have to put together various disciplines to design a digestion system. Drains to control the water table around the digester to prevent buoyancy of the empty digester and to control heat loss were not included in the initial design. Uplifting and excessive cooling were prevented by adding well positioned drainage pipes after construction. The water and gas pressure was compromised. All in-ground structures should have drainage systems in the backfill to reduce heat loss and prevent floatation.

<u>Hard top to contain biogas</u>

The digester was designed with a hard top with the goal of developing 12 inches of water column biogas pressure to force biogas into the compressor. The compressor is needed to increase biogas pressure to microturbine target inlet to pressure to 90 psi. Difficulties in sealing the concrete top led to biogas leaks and partially digested by-products. Biogas leaks caused odor problems, and since the equipment building was initially located on top of the digester, leaking biogas created both a safety problem and corrosion of electronic equipment.

A blower and control system was installed in an attempt to keep the biogas pressure in the digester gas head space neutral to minimize biogas leakage; however, when equipment fails, gas still leaks causing odor emissions. The greater the pressure the more difficulties there are in sealing a digester. Digesters operated at high pressures should be pressure-tested as part of the start up procedure. Use proven technologies to seal digesters. Separate any equipment as much as possible from biogas sources.

Heating system

Operational experience revealed that the digester heating system had several initial flaws. The heat exchanger was sized too small to heat incoming manure to 100°F. Groundwater saturating the insulation outside the digester increased heat loss.

These issues were partially overcome with the addition of a larger heat exchanger and drainage around the digester. Possibly heat pipes added inside digester walls during construction would have been able to maintain temperatures in the digester. The heat balance of the digester system is vital. Designs need to address heat recovery from the biogas, methods to heat the incoming manure, and correct estimates of the maintenance heat are needed to maintain a constant temperature in all weather conditions.

Biogas to electrical energy conversion

Microturbines are sensitive to biogas pressure and the fuel ratio (methane concentration) can range widely. Microturbines have complex, sensitive electronics controlling their operation. Microturbines may have significant advantages over some internal combustion engines (including energy conversion efficiency, lower maintenance, higher exhaust temperatures, and lower noise), depending on the goals of the farm. The farm's microturbines ran successfully in a test mode before the biogas compressor failed; however, until the recent past, they have not provided the ease of operation that perhaps an engine generator would have.

The majority of the problems experienced in the past with microturbines at this site were due to the corrosive environment created by the leaking concrete top. The electronics had to be replaced after being in a corrosive gas environment prior to start-up. Also, the initial biogas compressors failed despite specifications for biogas use. Bottom line for this topic: select a reliable power system and learn as much as you need to ensure its successful operation. Dirk Young attended a weeklong training session to be certified to operate the microturbines.

Project cost estimate

The cost estimate for this project was under $500,000. The actual cost to date has been over $1,300,000. Get realistic cost estimates and include plans for contingencies.

Who to Contact

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