Cornell University

Dairy Environmental Systems Program

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Anaerobic Digestion at Exeter Agri-Energy Case Study

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Anaerobic digestion overview

Digester type	Complete mixed
Digester designer	CH_{Four}
Date Commissioned	2011
Influent	Raw manure, food waste
Stall bedding material	Separated manure solids, saw dust, short paper fibers
Number of cows	870 lactating cows
Rumensin® usage	Stopped when digester was installed
Dimensions (width, length, height)	Two vessels that are 65’ in diameter x 20’ high
Cover material	Rubber flexible top, held on with netting
Design temperature	100°F
Estimated total loading rate	32,000 gallons per day
Treatment volume	800,000 gallons
Estimated hydraulic retention time	27 days
Solid-liquid separator	Yes; separated raw manure solids used for bedding
Biogas utilization	engine-generator set (1 MW)
Carbon credits sold/accumulated	Not at this time
Monitoring results to date	None to date

Farm overview

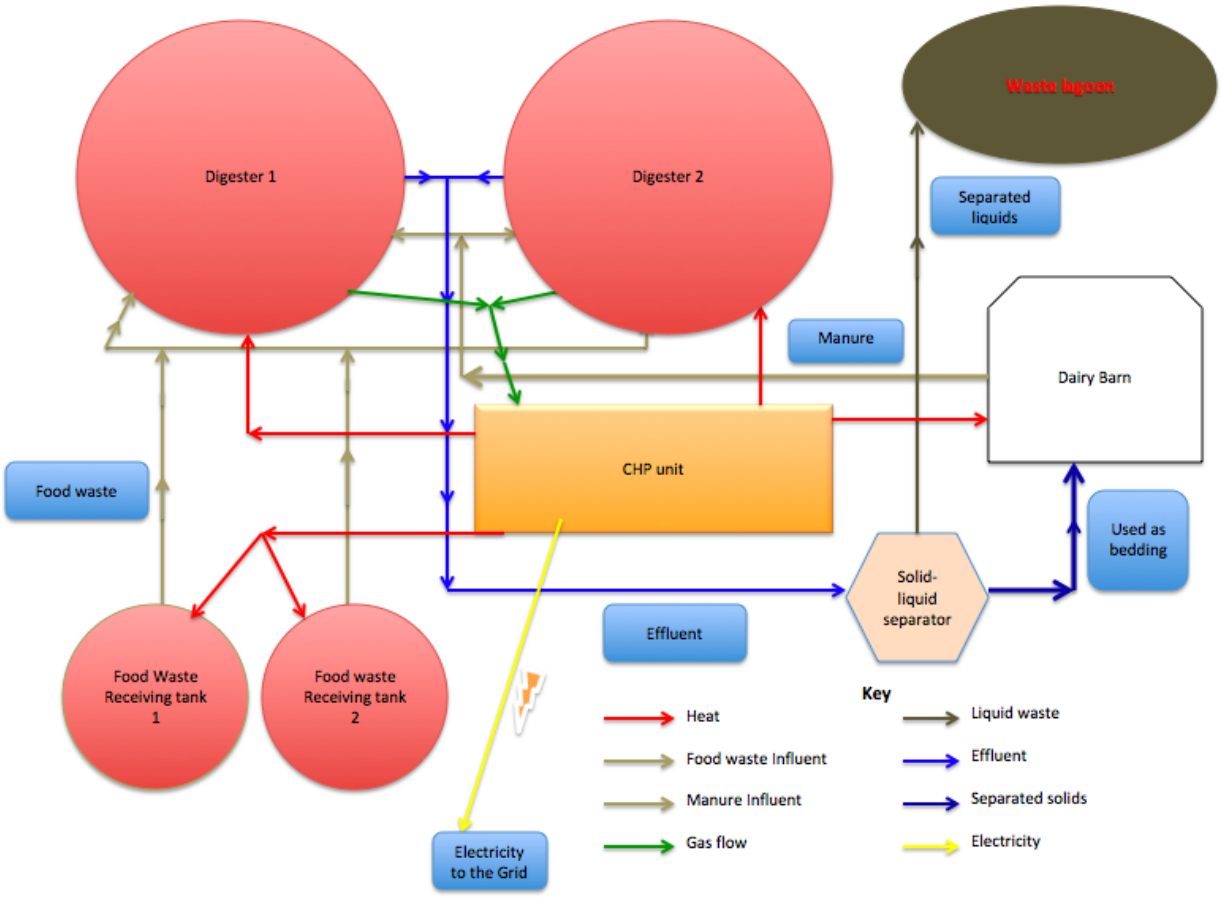
- Stonyvale farm was founded by W.J. Peabody and has been in the family for five generations up to the current manager Travis Fogler.
- The farm milks about 850 Holsteins and has a total of about 1700 head of animals on-site.
- Stonyvale raises forage crops on about 2,000 acres of land that goes to feed the dairy herd.
- W.J. Peabody started the farm with a few dairy cows and other cropping income. When his son in-law, John Fogler came back to the farm in the early 50's, he grew the herd to about 75 cows. John's son Bob returned to the farm in the early 70's to grow the herd to about 450 cows. When Travis returned to the farm from gaining a degree from Cornell University in 1999, the family decided to begin to grow to 1000 cows.
- Travis said that the farm will grow as much as the land base will allow.
- The digester is overseen and operated by John and Adam Wintle.
- The digester is a separate business entity under the company name Exeter Agri-Energy (EAE)
- Construction on the digester began in August of 2011 and was complete by December of 2011

<u>Why the digester?</u>

- Stonyvale was looking for a way to expand without needing a large amount of additional land.
- Two family members were looking to come back to the farm, both had engineering backgrounds, so inviting them back to manage a digester was a perfect match
- New grants that the state of Maine offered became available
- Digesters provide an outlet for dairy waste, yet still leave nutrients in the effluent for soil fertility
- Along with installing the digester, putting in a solid-liquid separator would greatly reduce the cost of previously purchased bedding on the farm.

Digester System

Figure 1. Exeter Agri-Energy AD system flow diagram



System and process description

Manure is collected in the barns by automatic ally scrapers that run 24 hours a day. The scrapers collect the manure into a reception pit where it is sent through a crusher and pumped about 1000 feet to the two 400,000 gallon digester vessels. A portion of the effluent is mixed into the manure reception pit at the farm to liquefy the manure to facilitate pumping.

The digester processes about 20,000 gallons per day of raw manure mixed with 5,000 – 12,000 gallons per day of outside material. Approximately 870 lactating cows, 130 dry cows and 750 heifers supply manure. Food processing waste is delivered to the digester from many different sources in New England. The digester also accepts several other waste streams such as grocery

store waste and rendering waste from pork producers. The food processing waste is received and stored in two 26,000- gallon designated food waste cylindrical concrete pits (Figure 2).

The biogas is contained by a flexible, rubber dome top that is held in place by thick elastic netting. Electric blowers are used to transfer biogas from the digester to the biogas utilization building where it is used to fire an engine-generator set. Each digester is connected to a 2-in. gravity flow flare so excess biogas could be combusted even when there is no electrical power.

Figure 2. EAE Food Waste Reception Tank

Liquids and solids process description

The influent is pumped equally between two vessels, where it is digested for about 27 days then pumped out to a Fan screw press separator, the solids are dropped onto a pile that is used for free stall bedding and the liquid effluent drains to a small tank next to the separator where it is then piped to a 5 million gallon long-term manure storage lagoon, then used as fertilizer on the fields.

Heat and electricity generation

Biogas produced by the digester is utilized in a SFGM 560 Guascor engine that turns a 1 MW generator procured from Martin Machinery. Generated power is sold directly to the grid. Excess biogas is automatically routed to and burned by a flare. Engine oil changes are performed every

370 hours of operation. Specialized oil is required to reduce damage to the engine from the corrosive hydrogen sulfide component of biogas.

H_2S Control

The CH_{four} digester is designed to keep the H_2S levels below 200 ppm by injecting oxygen into the headspace of each vessel. However this only brought the levels down to below 500 ppm but with certain loads of food waste spikes were seen up to 1500 ppm. In order to aid in H_2S control EAE started adding an additive form of Iron Hydroxide powder that brings the level down to below 100 ppm. In addition to the additive EAE may possibly invest in a final stage filter such as an iron sponge or carbon filter that would filter out the remaining traces of H_2S and bring the level down to 0 ppm before utilization in the engine.

Economics

The itemized capital costs for the anaerobic digestion system and equipment are shown in Table 1.

Table 1. Initial capital costs for Exeter Agri-Energy

	Cost ($)
Digester	
-Engineering & Design	451,000
-Hard Construction	2,750,000
Subtotal	***3,201,000***
Electrical Generation	
-Utility Upgrade	875,000
-1 Megawatt CHP unit	802,000
Subtotal	***1,677,000***
Miscellaneous	
-Development, permitting, legal, accounting	494,000
Subtotal	***494,000***
Total	**$5,372,00**

Exeter Agri-energy received about 50% of the total capital cost in the form of grant funding, both from the Federal Government and the state of Maine. The other 50% was achieved through financing with Farm Credit of Maine.

The farm currently sells the power generated back to the utility grid by way of a twenty-year fixed rate energy contract at $0.10 per kWh.

Benefits and Considerations

Benefits	Considerations
• Odor control • Potential revenue from: 1) Value-added products 2) Reduction of purchased energy 3) Sale of 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	• 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 • Increased land base may be required to handle the imported food waste nutrients • Specialized permits may be required to import food waste

Lessons Learned

The farm reported that the following lessons were learned as a result of operating their anaerobic digester.

- When planning the construction of a digester, EAE found the value of communication, between the farm, the engineering firms as well as the construction teams.
- If building the digester again, the farm would recommend trying to work directly with only one engineering firm, who would handle all of the different designs.
- Attempt to identify a single source design team and construction firm to the extent that it is economically feasible
- Digester systems and all that they entail, including the anaerobic vessels, electrical equipment and engine workings, require maintenance and many times a dedicated individual who is skilled in engine mechanics and knowledgeable in the operations of the digester system; they are not self-running systems.
- Analyze the risk, cost, and rewards of all grant funding opportunities before making decisions to participate in any particular program

- When designing a system do not cut corners in engineering designs.

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