Anaerobic Digester at AA Dairy: Case Study

Peter Wright and Kristen Graf
Dept. of Biological and Environmental Engineering, Cornell University
August 2003

Who Should Consider a System Like This?

- Large size dairy farms
- Farms in need of odor control
- Farms where manure can be collected easily
- Farms with capital available for initial start up costs
- Farms with technical interest and skills for the system operation and maintenance

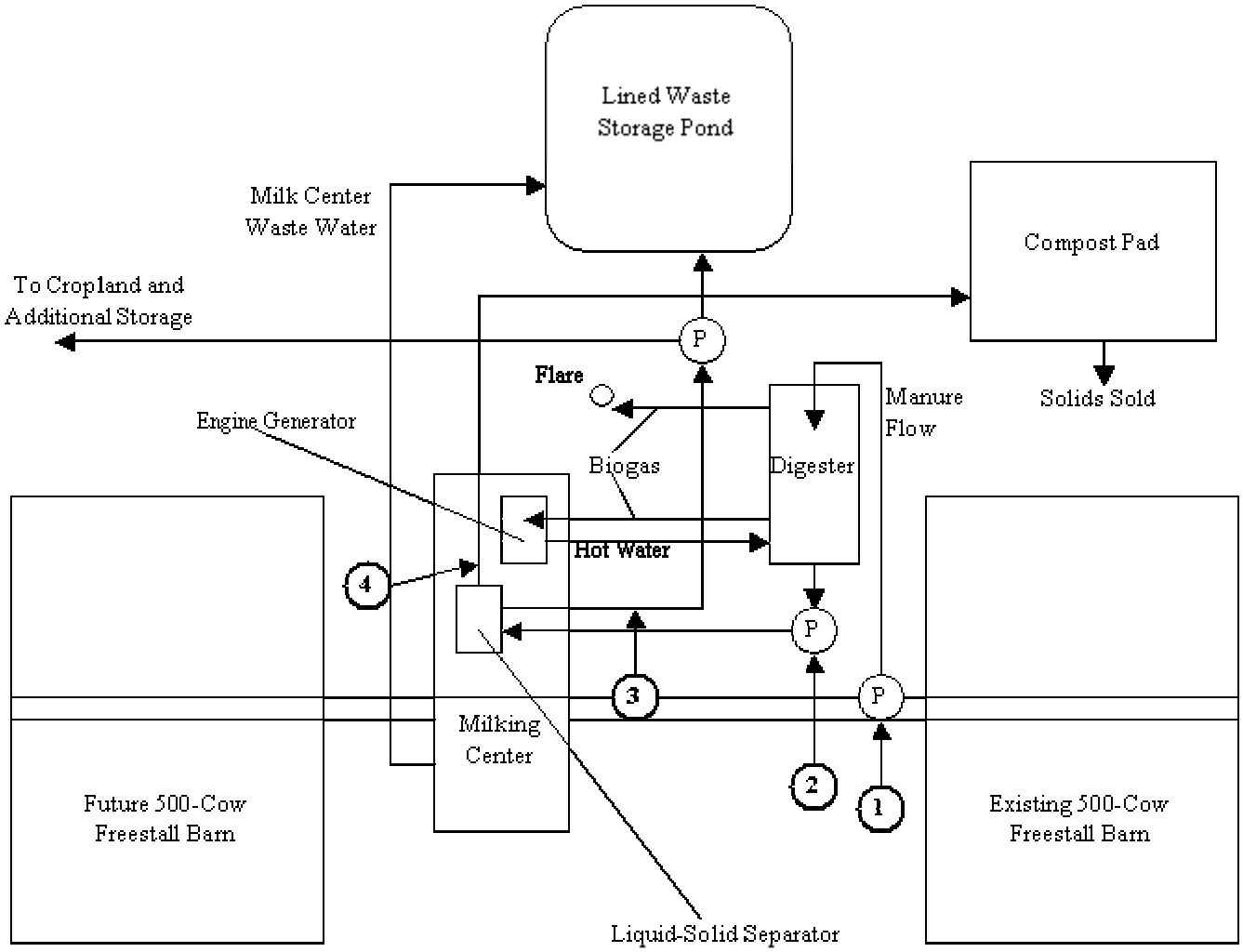
Farm Information

AA Dairy is a 500 cow dairy operation with plans to expand to 1000 cows. It is located on 2,200 acres in the town of Candor in Tioga County. The dairy started operating in the summer of 1993. AA Dairy successfully installed an anaerobic digester in June 1998. The primary reason for this manure management technology was odor reduction for the local community. Right now the digester is also contributing to the overall farm efficiency by generating electricity and heat from the biogas, compost from the remaining solids, and irrigation liquid from the liquid effluent. The electricity is used for on-farm needs and any excess is sold back to the grid. The solids are marketed under the name "Fields of Dreams Compost" to local buyers. The effluent, mixed with milk house waste, flows by gravity to a storage pond. Land application is by tanker truck or by irrigating the manure delivered by underground piping.

Why the Digester?

Before the anaerobic digester was built, the manure and waste washwater produced on the farm were stored in an underground pit at the back of the holding area. Due to equipment problems and limited land to spread the manure, the contents of the manure pit had to be pumped into slurry trucks every day and taken to crop fields for disposal. Local residents expressed concerns about odor, truck traffic, and a possible threat to water quality. After some exploration into new manure management options, AA Dairy decided to install a plug-flow anaerobic digester. The installation of the digester reduced odor, reduced the risk of runoff and leaching, and reduced manure transport over the roadways. Since the integrated manure management system was put into operation, raw manure is rarely spread on fields from the main dairy. Only a processed liquid, with odor greatly reduced, reaches the fields.

Digester System



AA	Mass Flow (lbs)	Moisture Content (%)
1 - Raw manure	91,740	88.58
2 - Digester Effluent	80,708	91.70
3 - Separated Liquids	67,391	94.96
4 - Separated Solids	13,316	75.97

Figure 1. Schematic of the manure treatment system on AA dairy.

System and Process Description

A plug flow digester with 1,000-cow capacity designed by RCM Digesters, Inc. was installed at AA Dairy. A plug flow digester, is where with no mixing, one days worth of manure is placed in the inlet of the digester, displacing one days worth of effluent out the end. It is a buried concrete manure storage structure, 130 feet long, 30 feet wide and 14 feet deep. The digester is equipped with an airtight, expandable black rubberized dome to trap biogas consisting of methane and carbon dioxide, and other trace gases such as hydrogen sulfide from the digesting manure. The manure is kept at approximately 100^{o}F in the digester for optimal biogas production. A solids-

liquid separator, a 130kW Caterpillar 3306 modified diesel engine connected to a generator, and a lined liquid-waste storage lagoon are features of the current resource recovery system. Thermal and electric energy, digested fiber for compost, and liquid fertilizer are byproducts of the existing digestion system.

Manure is continuously scraped from the 106' X 360' free-stall barn and is gravity-fed into a cross alley with step dams. The barn is insulated below the rafters with 1.5 inches of foil faced urethane insulation to prevent freezing in the free-stall barn, to keep the alley scrapers running during the winter, as well as to limit the heating requirements for the manure. Newspaper, sawdust, and approximately 10 yd^3/week of kiln-dried shavings are used for bedding. A 20-Hp submersible manure pump delivers fresh manure to the digester once a day over a period of 1.5 hours. Approximately 15,000 gallons of manure are fed into the digester each day. The new plug of manure added daily at one end, pushes the material already in the digester slowly through the system. A complete digestion process takes about 20 days, but because the digester has been designed for 1000 cows the retention time is about 40 days for operation with 500 cows. Methanogenic bacteria in the manure, when kept at an optimal 100^oF (mesophillic range), cause the manure to decompose in the warm slurry. This produces biogas consisting of methane (about 50%-55%), carbon dioxide (about 40-50%), a small amount of sulfide compounds (0.1-0.36%), and other trace gases.

Heat and Electricity Generation

Data has been collected daily and the average biogas flow from the digester at AA Dairy (herd size of 500 cows) has been between 35,000-50,000 CF/day, or about 60-100 CF/cow/day. The gas is collected, filtered, measured and slightly pressurized before being used to fuel a 130kW (3306 Caterpillar) engine. The engine is a diesel block with a natural gas head that has been converted to run on methane. The engine produces electrical energy at the current average of about 70 kW (~613,000 kWh/year) with downtime around 5%. The electricity produced most often meets the electricity needs for the dairy farm and provides some excess electrical power for sale to the local utility (New York State Electric & Gas (NYSEG)).

Because the biogas generator is available only 95% of the time, a backup diesel generator is necessary for emergencies, such as when the engine-generator set was taken offline for repairs or when the grid is down. The engine generator is down for weekly maintenance, which usually happens during the daytime (for less than one hour) when the farm is charged peak prices. Initially, when AA Dairy started to use the engine generator, purchasing electricity from the grid was a regular occurrence. Paying the demand charge for connecting to the grid were the primary reasons why AA Dairy incurred electric utility charges in 1999 and 2000. Currently, AA Dairy pays much less (compared to the years of 1999 and 2000) because the farm rarely draws power from the grid.

Heat exchangers transfer heat from engine hot water loops to another loop, which stores hot water in a 4000-gallon tank. Stored hot water is currently available only to warm the digester. Initially it was expected to use the stored hot water for other farm needs to offset propane use. However, it was observed that heat recovered from this hot water loop lost too much heat during the cold months to be used effectively for other farm heating needs.

Liquids and Solids Process Description

After digestion, the treated slurry is pumped to a screw press slurry separator with a 7.5 Hp pump. The separated roughage or fiber (total solids is approximately 24.0%) is transferred to a compost area and the separated liquid (total solids is about 5.2%) is pumped to a plastic-lined liquid storage lagoon.

Recovered solids have the physical characteristics similar to a moist peat moss (a dry matter content of 20 - 30 percent and a pH of ~8) and are essentially devoid of weed seeds. The finished compost is sold in various ways, in large bulk quantities, small bulk quantities, and in 20-pound-bags at local farm and garden suppliers. The composted fiber has been approved for organic food production and is marketed as "Fields of Dreams compost".

The liquid effluent flows by gravity to a 2.4 million gallon plastic-lined storage lagoon. The liner is used to avoid leaching to a shallow groundwater table due to gravel (porous) soils at the farmstead. The stored liquid waste is spread on fields either via 4000-gallon slurry wagons, or distributed through a pipeline system installed on the AA Dairy farm to irrigate cropland (corn, alfalfa, and grass) at the main farm or other farm locations within 4 miles of the main farm.

Economic Information

Component	$
Digester	
- manure pump (20 Hp)	9,000
- engineering design	20,000
- concrete digester (incl. floating insulation, gas containing cover, 2 hot water heating circuits)	160,000
subtotal	***189,000***
Energy conversion	
- engine generator (used) & switching equipment	15,000
- rebuild the engine	2,000
- rebuild the generator	9,000
- plumbing, electric, and mechanical systems	9,000
- run cable to utility hook-up	8,000
- electrical engineer consultant	18,000
subtotal	***61,000***
Solids separation	
- effluent pump (7.5 Hp) & variable speed drive	3,000
- separation equipment	25,000
- building for separator equipment	25,000
subtotal	***53,000***
Liquid waste storage lagoon	
- lagoon (excavation, fence, pipe, outlet structure)	18,000
- plastic liner	42,000
subtotal	***60,000***
TOTAL	**363,000**

Source: Wright and Perschke, 1998

Advantages and Disadvantages

Advantages	Disadvantages
Odor Control	Very high initial capital costs.
Potential for profit from value-added products and energy savings	Biogas can be corrosive and increase maintenance costs for the engine.
Pathogen reduction through digestion process	Contracts with the local utility can be long and tedious and require extra equipment for reliability.
	The digester is a sensitive system, maintaining temperature and appropriate solids content of the influent is important.

Lessons Learned

The noise from the motor in an uninsulated pole barn can be loud. Providing a sound insulated engine room reduces the sound at the farm as well as the sound at a distance. People that had been keeping their window shut from the odors now were complaining about the sound now that they had them open.

The projected savings from hot water use didn't materialize since changing from the existing radiant heat to hot water heat in the parlor would have cost too much. Since the electricity produced by the on farm generation covers the electric needs of the farm there was not a big incentive in making an expensive change.

Digested separated manure solids were used for bedding for a short time. Mastitis incidents rose in the milking herd and the bedding was the first potential cause that was eliminated. The risk of additional mastitis makes the use of the manure solids as bedding a detriment.

Composting marketing has been increasingly successful. This has occurred over time with repeat customers, work of mouth advertising and the use of a website. Prices vary depending on size of the purchase. All the manure solids can be sold.

The engine selected was based more on the price than the most efficient size. A used engine became available and was put into service. An oversized engine will be inefficient in converting fuel to power at lower operating speeds. Building the digester for 1,000 cows while only operating it at half capacity does cause some inefficiencies.

The weir wall consisting of timbers set across the concrete opening at the outlet of the digester failed. Until repairs were made the outlet reception pit needed to be kept full to prevent the loss of gas.

Service support for the engine, generator, electrical inter-tie, and other parts are still not provided by one entity leaving the farm to find the best and quickest solution to a variety of problems. At times the small problem that goes unfixed for a time can lead to more difficult problems. There is an opportunity for a maintenance specialist to assist farms in running the systems that are part of an anaerobic digestion manure treatment process.

Treated separated digested liquid manure from the cow barn when added to the Heifer barn's manure storage pond reduces the odor in that storage. This means that to control the odors on a farm system not all the manure has to be brought to the digester itself.

Who to Contact

- Richard Mattocks, RCM Inc and Environomics, P. O. Box 371, Riverdale, NY 10471. Phone: 718-884-6740, Fax: 718-884-6726, E-mail: environomics@waste2profits.com

- Peter Wright, Manure Treatment Specialist, PRO-DAIRY, Cornell Cooperative Extension. Phone: 607-255-2803, Fax: 607-255-4080, Email: pew2@cornell.edu

Acknowledgements

The authors would like to thank the New York State Energy Research and Development Authority (NYSERDA) for funding in support of this work. Any opinions, findings, conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of NYSERDA or the State of New York, and reflect the best professional judgment of the authors based on information available as of the publication date. Reference to any specific product, service, process, or method does not constitute an implied or expressed recommendation or endorsement of it. Further, Cornell University, NYSERDA and the State of New York make no warranties or representations, expressed or implied, as to the fitness for particular purpose or merchantability of any product, apparatus, or service, or the usefulness, completeness, or accuracy of any processes, methods, or other information contained, described, disclosed, or referred to in this publication. Cornell University, NYSERDA and the State of New York make no representation that the use of any product, apparatus, process, method, or other information will not infringe privately owned rights and will assume no liability for any loss, injury, or damage resulting from, or occurring in connection with, the use of information contained, described, disclosed, or referred to in this publication.