Anaerobic Digester at Matlink Dairy Farm: Case Study

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Who Should Consider a System Like This?

- 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 with access to outside food waste or less than 10% total solids.
- Farm with adequate cropland for the nutrients.

Farm Information

Matlink Dairy Farm, operated by Ted Mathews, is located in the town of Clymer in Chautauqua County, New York. This farm planned for 675 milking cows is the single largest dairy operation in the Clymer Valley employing 16 people, and has considerable impact on the local economy. To address a variety of issues, including odor, nutrient planning, and increasing revenue, Matlink Dairy Farm installed an anaerobic digester with support from New York State Energy Research and Development Authority (NYSERDA) in late December 2001.

Why the Digester?

Matlink Dairy Farm turned to anaerobic digestion for solutions to several problems it has faced. Manure generated at Matlink Dairy Farm was stored in a lagoon and spray-irrigated on the ground in March, April and November. The barns are just a mile upwind of the Village of Clymer. During times of spray irrigation, the public school had to keep its windows closed and neighboring businesses also received comments about the odor. It is well known that anaerobic digestion is an effective technology to reduce odor from animal waste. Thus, to save its standing in the community, Matlink Dairy Farm initiated this project primarily being motivated by the desire of reducing odor from manure management. Another driving force was to reduce the potential for nutrients from manure to leach into the groundwater. This became more of a concern when a test of the Town of Clymer's public water supply exceeded the maximum contaminant level of 10 mg/l for nitrate-nitrogen in 1994. Lastly, the economic benefits of the installation of methane digester were projected to reduce electrical and natural gas purchases at approximately $41,000 per year according to the estimate in EPA AgSTAR program's feasibility study.

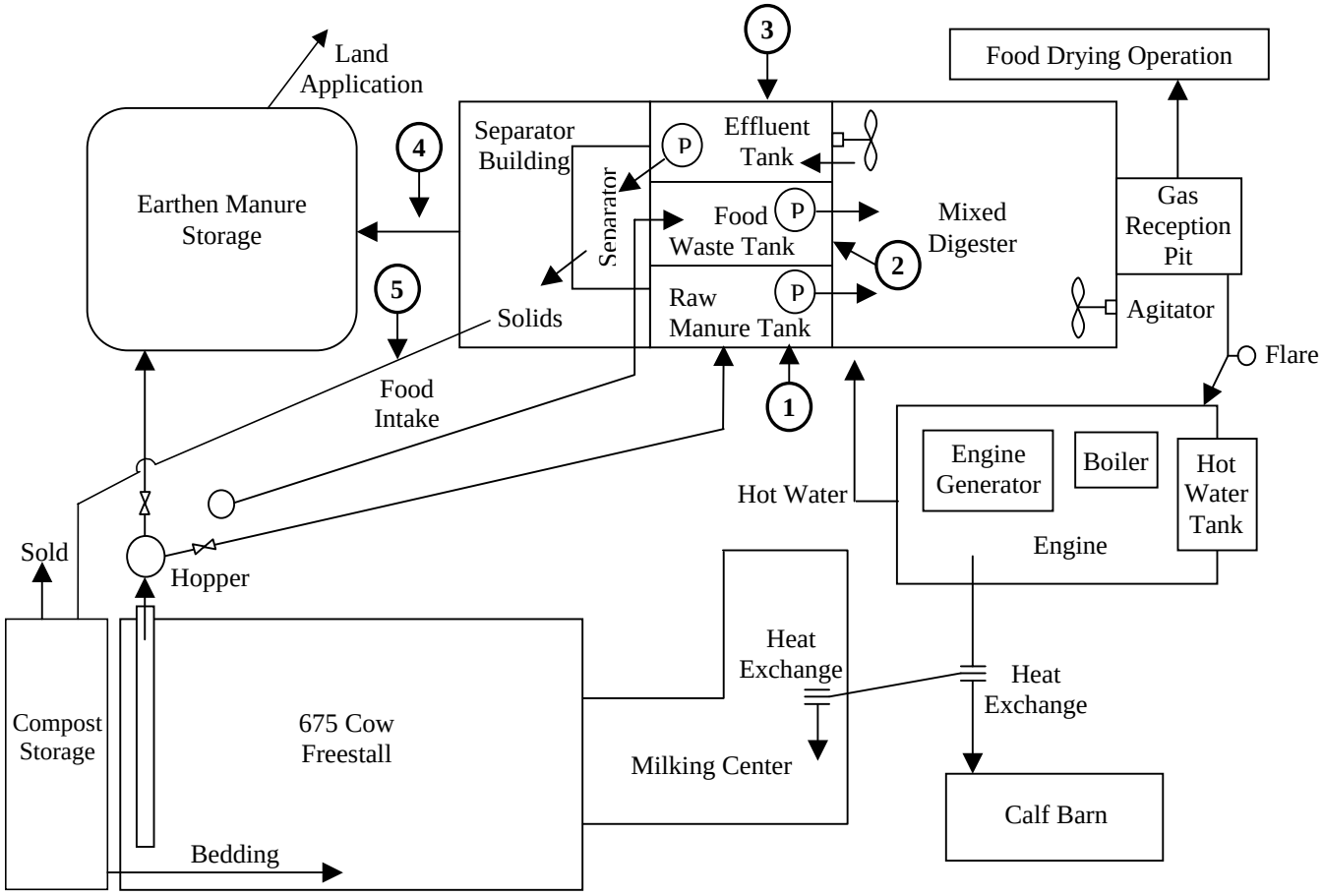
Supported by NYSERDA, designed by RCM Digesters, Inc., Matlink Dairy Farm started the construction of an anaerobic digester system in the summer of 2000 and finished it by the end of 2001.

Digester System

System and Process Description

The digester system on Matlink Dairy Farm is comprised of several subsystems (see Figure 1):

- Manure collection
- Digester for manure digestion and biogas production
- Engine generator set
- Separator to separate liquids and solids after the manure is digested
- Liquid storage
- Compost-making



ML	Mass Flow (lbs)	Moisture Content (%)
1 - Raw manure	111,756	87.54
2 - Food Waste	93,408	82.40
3 - Digester Effluent	172,337	94.45
4 - Separated Liquids	170,265	94.42
5 - Separated Solids	2,072	68.96

Figure 1. Schematic of Anaerobic Digester System on Matlink Dairy Farm (not to scale).

The digester installed on this farm is a complete mix digester, which is a rectangular concrete tank buried in the ground (78’ long x 68’ wide x 16’ deep). The digester was built on a slope to utilize gravity to aid the flow of manure from the barn collection system to the end production. A flexible, impermeable cover on the digester traps the gas.

Manure is scraped daily and gravity flows to a collection pit. Two 20-Hp manure pumps fixed at two opposite corners of the digester running 2 hours per day turn and mix the manure. The retention time is about 20 days. In addition to manure from 675 milk cows, other feedstock to the digester includes food waste, which actually increase the biogas production with higher methane content.

Heat and Electricity Generation

Biogas flow from the digester at Matlink Dairy (herd size of 675 cows) has been used by the engine generator at a rate of approximately 76,440 ft^3/day, or about 113 ft^3/cow/day. This biogas consists of methane (about 65%), carbon dioxide (about 35%), a small amount of sulfide compounds, and other trace gases. The biogas is collected and fed into a Waukesha engine attached to a Marathon generator (130 kW) that uses 22-25 ft^3/kWh. The engine will operate 90-95% of the available hours per year. Because of the corrosive hydrogen sulfide in the biogas, engine oil has been changed every 500 hours.

This engine-generator set produces about 884,000 kWh/year, which meets the electricity needs for the dairy farm and also provides some excess electrical power for sale to the local utility, Niagara Mohawk. Moreover, the heat generated provides hot water to heat the digester and for other on farm uses, which saves about $500/month.

Economic Information

	Items	Costs/Benefits
Capital Costs	Digester	
	- Digester Construction and Materials	$260,000
	- Mixture Pumps	$77,000
	Subtotal	330,000
	Engine-Generator Set	
	- Engine Generator	$96,317
	- Switching Equipment	$10,000
	- Engine Building	$22,614
	Subtotal	$128,931
	Solids and Liquids Separation	
	- Separator	$46,613
	- Separator Building	$15,076
	Subtotal	$61,689
	Liquid Storage	$45,000
	Others	$56,900
	Total Capital Cost	$622,520
	Total Annual Capital Cost	$61,232
Annual Operating Costs	Maintenance, Repairs, Labor, Fuel, Insurance, Reporting, Water treatment, Spreading Costs, etc,	$115,910
Annual Benefits Including	Electricity savings, Tipping fee for handling food wastes, Bedding material replacement, Compost sales, Hot Water (heat), and Odor Control	
	Total Annual Benefits	$292,785
Annual Income Per Cow ($/cow/year)		$171

Liquids and Solids Process Description

After digestion, the treated slurry is pumped to a screw press slurry separator. The separated solid is transferred to a compost area and the liquid flows to a 4.5 million gallon earthen manure storage pond. The screened fiber has the physical characteristics of moist peat moss, with a dry matter content of 25-28%, a pH of 8+, essentially devoid of weed seeds, rich in mineralized nutrients, and

the odor of moist earth. Fiber compost is held a couple of days in the lower part of the separator building, achieving temperature exceeding 150 degrees. Up to 65% of the solids have been used on the farm for bedding. Remaining solids are sold at $5/yard and can generate revenue of $500/month. The stored liquid waste is spread on fields either via 4000-gallon slurry wagons, or distributed through a pipeline system installed on the Matlink Dairy farm to irrigate cropland.

Environment Benefits

Since the installation of the anaerobic digester system on Matlink Dairy Farm, the odor from manure handling and spreading has been greatly reduced. The nutrients in manure can now be spread to optimize their uptake by crops without concern for odor when applied during warm weather. The pathogens are also reduced.

Advantages and Disadvantages

Advantages	Disadvantages
- Odor Control - Energy Production - Fuel Saving - Energy Saving - Nutrient Management Ease - Pathogen Reduction - Food Waste Utilization	- High Capital Cost - Dedication to Digester System Management - Contracts with the local utility can be long and tedious and require extra equipment for reliability

Lessons Learned

Accepting food waste is highly profitable. The tipping fees make the manure treatment system a profit center for the farm. This is a win-win-win situation. The farm gets a payment to accept the food waste and the extra energy as the volatile solids are converted to methane, the food company has an environmentally responsible and relatively cheap way to get rid of their waste product and the nutrients from the food waste are recycled back to the land while green energy is produced.

The food waste is high in energy having three times the gas production per unit of mass than manure, yet the nutrient content is comparable to manure so imported nutrients are keep low. Not all farms can take advantage of this. Only farms that have a land base that can accept the extra nutrients should consider this option.

The sizing of gas handling pipes, flares and enterprises for the energy use need to be sized for the additional production that a food waste system will require. Pre planning and analysis of potential food waste should be done to estimate the gas production and the size of the utilization equipment.

The mixed digester performs well and offers flexibility in operation accepting various consistencies of manure and food waste mixtures. By mixing the influent into the total volume of the digester the biomass that has been built up in the digester can attack all the new feed. Even though some of the influent goes out of the digester the first day the total volatile solids reduction is significant and the volatile acids (indicators for odor production) are low.
Shock loading of a digester with high energy food waste will create substantial amounts of foam. Loading the digester incrementally throughout the day reduces the potential for foam.

The design of the anaerobic digestion system including manure handling, gas collection, gas utilization, and digester heating should not just be designed by each individual component but designed as a system. This site experienced a beam failure due to lateral loads that were not anticipated by the concrete designer. If the concrete design had been better integrated with the rest of the project they may have realized that lateral loads could develop.

Although the food waste brings in additional solids to the digestion system less solids are in the effluent than when just manure is digested. The extra energy of the food waste apparently makes it possible for additional solids destruction. Solids were broken down in the effluent storage as well. The existing manure storage was about one half full of manure solids when digested effluent was introduced. After two years of operation the solids in the storage are almost all gone with out excessive agitation.

The waste heat given off by the engine generator is significant. Utilizing the coolant to heat the influent and maintain the digester temperature and using it for heat exchangers for hot water in the calf barn and milking parlor still requires a radiator to dissipate extra heat. Even in the winter the uninsulated engine building is very warm. This makes a very good heated shop so it should be sized for that function.

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