Anaerobic Digester at Dairy Development International: Case Study

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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
- Farms with adequate land base for nutrients

Farm Information

Dairy Development International (DDI) is an 850 cow dairy operation located in the town of Homer in Cortland County. They broke ground on December 4, 2000 and the first cow went through the milking parlor on August 7, 2001. The anaerobic digester was part of the original designs for manure management and odor control. Odor reduction for the local community was the primary reason for this manure management choice. The digested effluent is pumped directly to the slurry storage tank. The plan is to use the biogas to generate electricity using 4-28 kW Capstone microturbines, which are already in place. The electricity will be used on site, and any excess will be sold back to the grid. The microturbines will also recover heat that can be used to maintain the temperature of the digester as well as warm the floors in the barns. When the microturbines aren't running most of the biogas from the digester can be flared off while some of it runs to the boiler. The digested effluent will be separated into solids and liquids. The screw press separator and housing are next to the digester and DDI is currently investigating potential markets for the solids. The stored digested liquid is applied to 1400 acres of owned and rented cropland.

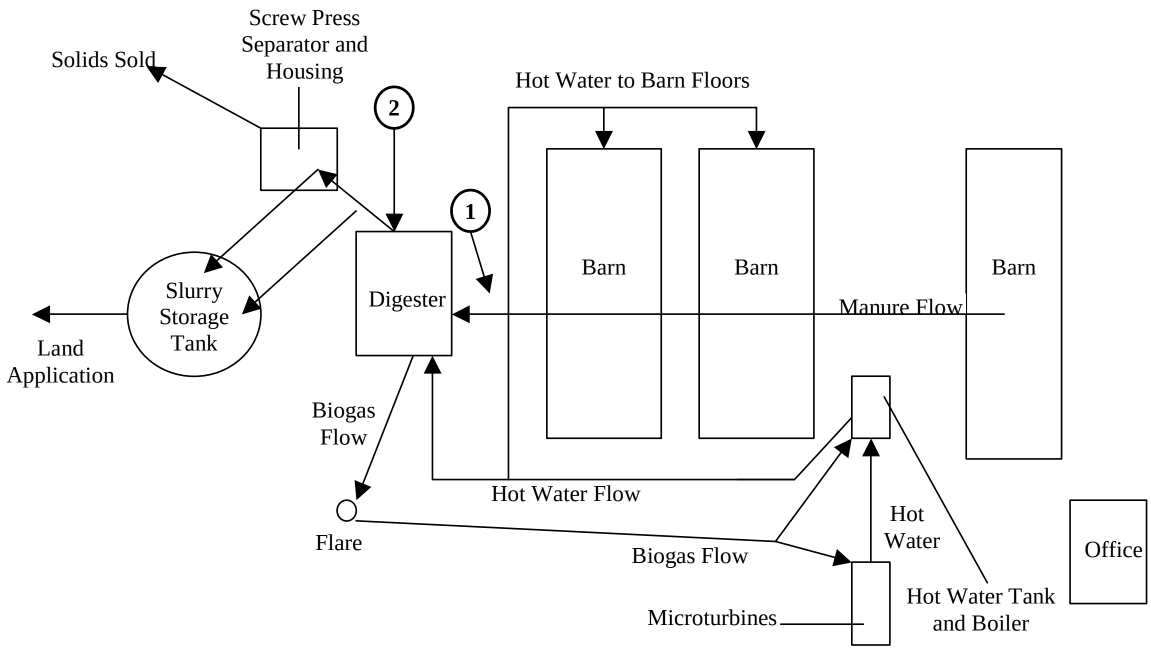
Why the Digester?

Odor reduction is paramount. The site that was selected for DDI's farm is right beside a major interstate and there are residential areas very close. From the very beginning the management at DDI has been concerned with choosing the best practices for manure management to reduce odor as much as possible. Before construction even began DDI was under pressure because there was some local opposition to the farm that primarily focused on worries about the potential nuisance of foul odors from manure storage and land application. In authorizing their building permit, the Town of Homer requested that they follow the proven technology already in use at AA Dairy in the town of Candor in Tioga County. AA Dairy installed an RCM plug flow digester in June of 1998 and had significantly reduced odors from manure. AA Dairy was also reaping the benefits of the other byproducts of anaerobic digestion by converting the biogas to electricity and selling the separated solids as compost. So, as requested, DDI included a digester designed by RCM in their building plans as well as 4 microturbines for electricity generation.

Digester System

System and Process Description

A plug flow digester designed by RCM Digesters, Inc. was installed at DDI. It is a buried concrete manure storage structure with about 20 days retention time. The digester is equipped with an airtight flexible fabric 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°F in the digester for optimal biogas production.



DDI	Mass Flow (lbs)	Moisture Content (%)
1 - Raw manure	141,780	90.99
2 - Digester Effluent	124,730	93.25

Figure 1. Schematic of the manure treatment system on Dairy Development International.

Primary manure flow is through a gravity step-dam system under the barns. Parlor and milk house wastewater is collected in a 21,000 gallon holding tank. This water is used to flush the holding pen. Solids from this holding tank are pumped regularly to the top of the flow gutter from the bottom of the tank. This design allows for complete monitoring and control of water entering the flow gutter. One of the main reasons for this requirement is to maintain manure with 12% solids going to the digester to optimize plug flow.

Each barn is scraped to the center to the flow gutter using mechanical alley scrapers. In the first barn (i.e., hospital barn), the elevation of the floor of the flow gutter is 1157 feet. In the second barn, the elevation is 1156, and 1155 in the third barn. Using a series of one-foot step-dams, the manure flows easily to the final collection pit. Agitation is available here to homogenize the manure as needed.

Approximately 20,000 gallons of manure and milking center waste washwater are fed into the digester each day. Most of the digestion occurs in approximately 20 days. Methanogenic bacteria in the manure, when kept at an optimal 100^{o}F (mesophillic range), cause the manure to decompose in the warm slurry. This produces biogas consisting of methane (about 65%), carbon dioxide (about 34-35%), a small amount of sulfide compounds (0.1-0.36%), and other trace gases.

Heat and Electricity Generation

The biogas recovered from the digester has a high water content and comes out at low pressure (< 1" water column) with an energy content around 600 BTU/ft^3. From the digester the gas is sent to three different places. There are two microturbines at DDI that are retrofitted for low BTU fuels. They convert the biogas to electricity for use on the farm or for sale back onto the grid. The system includes a heat exchanger to recover heat from the microturbine exhaust. The microturbines were located onsite close to the connection for the electrical power lines instead of close to the digester because it is much cheaper to lay pipe and pump the gas across the farm than it is to pay for additional electrical lines. DDI also has a 1.5 million BTU boiler that runs on the biogas and is used for the heating needs on the farm. Gas not used by the microturbines and the boiler is flared off.

Liquids and Solids Process Description

Digested separated liquids are stored in a 2.9 million gallon structure since the farm site is on permeable soil. Extra monitoring and secondary containment were added due to the sole source aquifer beneath the site. The effluent from the digester can be pumped directly to the tank and hauled off site in tanker trucks for land application. Or the effluent can be sent through a screw press separator to remove the solids and here only the liquids will go in to the slurry storage. The solids that are removed can then be collected and sold.

Economic Information

	Items	Costs/Benefits
Capital Costs	Digester	$350,000
	Electrical and Heating Systems - Microturbines - Boiler and Piping Subtotal	 $136,000 $50,000 $186,600
	Solids and Liquids Separation - Separator - Separator Building Subtotal	 $46,613 $42,387 $89,000
	Liquid Storage	$315,000
	Others	$43,800
	Total Capital Cost	**$984,400**
	Total Annual Capital Cost*	**$73,705**
Annual Operating Costs	Maintenance, Repairs, Insurance	$29,619

	Spreading	$58,000
	Management	$6,370
	Total Annual Operating Cost	**$93,989**
Potential Annual Benefits Including:	Electric Savings	$42,400
	Heat Savings	$6,000
	Odor Control	$15,000
	Solids	$12,000
	Nutrients	$45,000
	Total Annual Benefits	**$120,400**
Annual Cost Per Cow ($/cow/year)		**$55.64**

*Total Annual Capital Cost = Annual interest charge of 5% plus depreciation.

NOTE: This economic analysis takes into account the annual cost of spreading. This is a cost that would be required with or without the digester system. If you subtract that from the analysis, the system actually has an annual income around $15 per cow.

Advantages and Disadvantages

Advantages	**Disadvantages**
Odor Control	High initial capital costs
Potential for profit from value-added products and energy savings	Contracts with the local utility can be long and tedious and require extra equipment for reliability
Pathogen reduction through digestion process	The digester is a very sensitive system. Monitoring and reacting to changes in influent and gas production is important.

Lessons Learned

Temperature control of the digester is critical. Air locks in the heat pipes can prevent the proper circulation of the heated water inside the digester to heat the incoming manure to 100 degrees F and to keep it at that temperature throughout the 20-day retention time. Temperature gauges if they worked properly would show the lack of heat, however if the temperature gauges are not calibrated then the lack of heat in the digester may go undetected. Groundwater impingement on the bottom of the digester can take a significant amount of heat away from the digester making it hard to heat. When flows to the digester are curtailed the amount of heat to the digester needs to be adjusted since heat will not be needed for incoming manure. With out adjustment higher temperatures than desired may result.

The plug flow digester relies on the proper moisture content of the influent. Dairy manure as produced will not separate into floatable solids and settleable solids very easily. When extra moisture is added the floatable and settleable solids sort out inside the digester leaving a Floating crust and a deposit. As these two portions of the digester get larger they will decrease the usable volume and decrease the Hydraulic retention time. Lower retention times will decrease biogas production and fail to reduce the odors in the effluent.

Gas conditioning for the compressors and microturbines is critical. Hydrogen Sulfide and water vapor in the gas present the potential for corrosion. Methods to remove a significant portion of these contaminants are crucial. The compressor may have sensitive components that will corrode. The output from the compressor must be reduced in moisture content and have no excess oil in it or the microturbines may fail.

As foaming occurs it often flows into the pipe chase where the gas collection pipes leave the digester. They have water basins set to provide the pressure needed to keep the cover inflated. Foam flowing out creates a mess. Providing a drain for the pipe chases and a solid bottom and water supply makes clean up easier. Removing the top of the pipe chase allows easy access and good ventilation for those working in the area.

The 3” pipe leading to the flare was designed to take excess gas to the flare. When none of the gas is being used the pipe is too small and a blow out in the pipe chase occurs. Keeping the flare lit during windy conditions and when both high and low biogas flows are present is difficult. Two automatic spark producers are needed to provide a spark where a flammable mixture of biogas and oxygen is present.

Solid sales marketing needs to be done to sell manure solids. The digested separated solids are homogeneous, dark in color, and have good tilth. They should be preferred over other forms of organic soil amendment. However with out a marketing effort it can’t be assumed that they can be sold at any price. Transportation costs make the market area relatively near to the farm.

Odor control can be achieved by a digester system. The odors are negligible when the Volatile acid levels leaving the digester are below 500 ppm. As the digester experiences difficulties with temperature or retention time the volatile acids leaving the digester may be higher and odors may occur.

Heavy snow load can collapse the flexible cover on the digester if it falls faster than it can melt. Shoveling the snow off will allow the cover to reinflate.

Foaming can occur when changes occur such as: the diet of the cows the temperature of the digester, and additions of other organic loading. Spraying water over the foam can control foaming. A water source and spray device near the effluent tank is useful.

Heat pipes in the barn floor may not keep manure from freezing during weather colder than 5 degrees F. Although heat can be supplied continuously from the heat recovered off the electrical generation system, during sharp cold snaps the in floor heat cannot prevent freezing.

Who to Contact

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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.