



BIOMASS



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LARRY KROM

Solids from manure digestion can be used for a soil amendment or animal bedding.

Anaerobic digestion technology is a powerful tool for managing organic farm waste, particularly cow, swine and chicken manure. In addition to reducing waste volume and odor, however, the process also yields energy in the form of methane, or biogas. Farms making use of this technology have been able to manage their volume of animal waste and produce part or all the energy their farm operation requires as well. While some argue that low fossil fuel prices have kept anaerobic digestion technologies from realizing their full potential as energy producers, the advent of strict new laws regulating odor, groundwater contamination, and greenhouse gases are making the process attractive for waste management compliance.

BENEFITS OF ANAEROBIC DIGESTION

Collected biogas can be used for process heating, electrical and steam generation, and transportation. A rule of thumb for electricity production is one kilowatt (kW) for every seven to ten cows.

Odor and fly control. Bacteria in the digester significantly reduce odor-causing compounds. In addition, fly eggs are killed during anaerobic digestion, reducing this disease-causing pest.

Pathogen control. Pathogens like *E. coli*, *Salmonella* and *Cryptosporidium* can't survive the high temperature of a heated digester.

Disposal. Anaerobic digestion destroys more volatile organic compounds and produces more gas than aerobic digestion does (65 percent to 75 percent of volume), resulting in less solid waste.

Environmental. Where animal manure is stored in pits or lagoons, methane is released into the atmosphere. An anaerobic digester reduces the damaging effects of methane, which is 21 times more potent than carbon dioxide in causing global warming.

Valuable byproducts. In addition to the biogas produced, most of the organic nitrogen present



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Gordondale Farms in Portage County, Wisconsin. Over 600 cows provide manure for the farm's digester.

in the manure is converted to ammonia, a fertilizer readily utilized by plants. Liquid effluent can be spread on fields, and the solids can be sold as a soil amendment.

TYPES OF DIGESTERS

For Wisconsin's climate, three types of digesters are generally suitable. The first type, a **plug flow digester**, is a tank or long, covered trough that is filled daily with manure. Biogas collects under an expandable gas-tight cover and can be drawn off and fed to a generator. It is not advisable to use this type for swine manure, which requires mixing to keep the solids in suspension.

The second type, the **complete-mix digester**, uses a cylindrical tank that heats and mixes the manure for more efficient biogas conversion. Dairy manure also works well in a complete-mix digester.

Farm energy from manure



STEVE DWORAK

The Gordondale Farms manure digester.

A third type, *the temperature-phased digester*, combines two types of digestion technologies (mesophilic and thermophilic) into a two-stage reactor, increasing methane yields. Although it shows great potential, there is currently less field experience with this technology.

System components can be made from a variety of materials including steel, plastic or concrete, and can be built either above or below ground. A typical installation will have a container or area for premixing the organic material, a digesting tank, and systems for storing or using the collected biogas and the liquid and solid effluent that are the products of digestion. If the system is designed to produce electricity, additional components will usually include a combustion engine, generator, control system, power conditioning equipment and waste heat recovery system.

SYSTEM COSTS

The cost will depend on the type of digester selected and specific conditions and requirements on the farm. In general, operations with more than 450 dairy cows are able to benefit

from economies of scale, with installation costs around \$400 to \$500 per cow. A system operated without waste heat recovery uses about 30 percent of the biogas it produces to heat its own digestion process, and it's not unusual for a system to supply a farm's complete electricity or heating needs. The energy payback may be up to ten years or more, but that accounting doesn't include the production of fertilizer or the offsetting of costs for legally disposing of animal waste to meet environmental regulations.

OTHER CONSIDERATIONS

Design. Biogas systems can be very complex and need to be designed for a specific site. Choose a designer with care, and find out if the company provides reliable technical support after installation.

Operation and maintenance. Anaerobic digestion will be most successful where operators commit to receiving training and are able to spend 20 to 30 minutes per day with the digester. Many systems have failed because of poor operation and maintenance procedures.

Temperature. The anaerobic process works best at warmer temperatures. In systems where the waste is not warm, it will need to be heated. Good design and operation will allow for the most optimal control of the operation.

Waste handling. Successful use of anaerobic digestion usually requires a manure handling system in which manure is collected daily.

Corrosion. Sulfur dioxide and water vapor are trace gases sometimes present in biogas. These



The government of China has encouraged the building of household anaerobic digestion systems in rural areas, where 70 percent of its population lives without formal human or agricultural waste management systems. Currently, over 5 million home systems are in operation, providing methane for cooking and heating, and quality fertilizer for crops. The systems also contribute to public health by preventing the transmission of diseases.

Farm energy from manure



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What is anaerobic digestion?

Anaerobic digestion is the bacterial decomposition of organic matter that occurs in the absence of oxygen. Anaerobic bacteria exist naturally at the bottom of ponds, swamps and other moist and airless places, and even in the digestive tracts of termites and large animals. These bacteria are among the oldest life-forms on earth. Thousands of years ago, anaerobic decomposition of organic matter formed the earth's coal and oil deposits and created the natural gas we currently use for cooking and heating.

The same process can be duplicated today with a mechanical digester that re-creates the ideal natural conditions for decomposition. Three primary reasons for use of mechanical digesters in managing organic waste are nutrient recycling, waste treatment, and odor control. The methane (also called biogas) produced in the process is a useful and valuable byproduct.

Anaerobic digestion differs from composting, which is an aerobic, or oxygen-utilizing, process. Composting organisms produce the high temperatures the process requires by consuming oxygen. Their efficiency is maintained by providing the proper mix of air and types of organic matter. Creating a thriving anaerobic climate, however, requires maintaining a consistent temperature and quality of organic matter within a sealed and airless container. The anaerobic digestion process is more chemically complex and technically demanding than the composting process is, but it requires less space. In addition, its products make more efficient use of the organic resource.

can combine to become sulfuric acid, which can corrode equipment. Good design can mitigate this problem, but it could add expense for drying and scrubbing.

Reliability. If you choose to use or sell electricity produced from the biogas, you may find it necessary to provide back-up generation for reliable service.

Scale. The value of biogas collection depends upon economies of scale. Small systems may provide benefits for waste management but may not be economically viable for energy production.

Utility interconnection. If you are planning on generating and selling electricity, consult your utility early in the planning process. Issues to address include sales and interconnection agreements, a service line that is large enough, and control equipment that meets Wisconsin interconnection standards.



LARRY KROM

Heat exchanger tank (upper right) and solids separator. The heat exchanger transfers heat from the generator engine to the heating system for the barn and workshop. The solids separator recovers solids from the manure digestion process.

FOR MORE INFORMATION

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www.makingenergy.com

"Dairy Waste Anaerobic Digestion Handbook"
by Dennis A. Burke, PE

www.epa.gov/agstar/library/index.html

AGSTAR Program and AGSTAR Handbook (joint
program of the EPA and U.S. Department of
Agriculture)

www.discoveryfarms.org/methanepubbw.pdf

"Anaerobic Digesters and Methane
Production...Questions that need to be asked
and answered before investing your money" at
UW-Extension, University of Wisconsin-Madison

www.bae.umn.edu/extens/manure/treatment/

University of Minnesota, Biosystems and
Agricultural Engineering Department

www.cityfarmer.org/biogasPaul.html

City Farmer, Canada's Office of Urban
Agriculture



LARRY KROM

This generator engine uses gas from manure digestion as fuel.
The generator produces about 120 kW of electricity.

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