RENEWABLE ENERGY

Farm anaerobic digesters: producing energy from waste

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Anaerobic digestion technology is a powerful tool for managing organic farm waste, particularly cow, swine and chicken manure. In addition to providing water quality benefits, odor control and greenhouse gas reductions, the process also yields energy in the form of biogas (of which methane is the major component). Farms making use of this technology have been able to manage their animal wastes and produce energy for sale, beyond what their farm operation uses. While some argue that low fossil fuel prices have kept anaerobic digestion technologies from realizing their full potential as energy producers, the advent of better electricity buy-back rates (tariffs), as well as strict new laws regulating farm nutrients, is making anaerobic digesters attractive for waste management compliance.

BENEFITS OF ANAEROBIC DIGESTION

Collected biogas can be used for process heating (water or space heat), electrical generation, production of pipeline-quality methane and transportation fuel. A rule of thumb for electricity generation is approximately one kilowatt (kW) is produced for every 5 Holstein milking cows contributing manure to the digester.

Reduction of waste strength. Anaerobic digesters perform well at degrading the strength of organic wastes by reducing chemical oxygen demand (COD). COD is one measure of the degree to which organic wastes reduce dissolved oxygen in waters. Reducing the COD of wastes helps to protect the health of aquatic ecosystems since fish and other aquatic life require a minimum level of dissolved oxygen for survival.

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

Quantum Dairy near Weyauwega, Wisconsin, employs a modified plug-flow digester system to produce enough energy to power 325 average Wisconsin homes.

Pathogen control. Pathogens like E. coli, Salmonella and Cryptosporidium can't thrive in an anaerobic digester.

Disposal. Anaerobic digestion destroys more volatile organic compounds and produces more gas than aerobic digestion does.

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 as a greenhouse gas is 21 times more potent than carbon dioxide.

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

A complete-mix digester at the Crave Brothers Farm near Waterloo, Wisconsin also incorporates waste from their farmstead cheese facility which is located across the street from the digester.

TYPES OF DIGESTERS

Two types of digesters are generally suitable for Wisconsin's climate. The first type, a **plug-flow digester,** is a tank or long, covered trough that is filled daily with manure. Biogas collects under a gas-tight cover and can be drawn off and used as fuel. Some variants of plug-flow digesters provide a means of mixing as the waste moves through the digester as a plug.

The second type, the **complete-mix digester,** typically uses a cylindrical tank with continuous aggressive mixing of the manure for more efficient biogas conversion.

System tanks and components can be made from a variety of materials, including steel, plastic, or concrete, and can be built either above or below ground. Components made with copper or other non-corrosion resistant metals are subject to the hydrogen-sulfide corrosive effects of biogas and should not be used.

A typical installation will have a tank (or area) for pre-heating and mixing the wastes with bacteria-rich effluent, a digesting tank (with some biogas storage capacity), a mixer or pump and areas for storing the liquid and solid effluent that the digestion produces. If the system is designed to produce electricity, additional components usually include gas clean-up equipment, an engine generator, system controls, electrical switchgear and a 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 approximately $1,000 to $1,400 per cow (not including effluent lagoons). A system operated without waste-heat recovery uses about 30 percent of the biogas it produces to heat the digester, and it's typical for a system to produce more than three times a farm's complete electricity or heating needs. The system payback may be six to eight years, depending on the type of system used (not including lagoon construction).

OTHER CONSIDERATIONS

Design. Biogas systems can be implemented in many configurations and need to be designed specifically for the site. Choose a design/builder contractor with care, and find out if the company provides reliable technical support after installation.

Operation and maintenance. Anaerobic digestion is most successful where operators commit to receiving training and are able to spend 30 to 45 minutes per day with the digester. Early systems have failed because of poor operation and maintenance procedures.

Temperature. The anaerobic process works best at specific warmer temperatures (typically about 100°F or 130°F). In systems where the waste is not warm, it must be pre-heated. Good design and operation allow for the most optimal control of the digester system.

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

Reliability. If the digester is primarily heated with the waste heat from an engine generator, you may find it useful to provide backup digester heating with a boiler. A backup heating source allows for continuous biogas production when the engine generator is offline due to maintenance.

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 to generate and sell 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.

Financial accounting. To assess the financial performance of the farm digester system, you should use separate accounting that enables the income and expenses of the digester to be tracked and analyzed separately from the other operations of the farm.

Heat exchangers like this one transfer heat from the engine generator to the digester in addition to the heating system for a barn and office.

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 digester system that recreates the ideal natural conditions for decomposition. Three primary reasons for use of a digester system in managing organic waste are nutrient recycling, waste treatment, and odor control. Methane (the major gas component of biogas) produced in the process is a useful and valuable byproduct.

Anaerobic digestion differs from composting, which involves some aerobic, or oxygen-utilizing, processes. 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.

This engine generator uses biogas from manure digestion as fuel. The generator produces about 225 kW of electricity.

FOR MORE INFORMATION

Focus on Energy Financial Incentives
focusonenergy.com/reincentives

"Wisconsin Agricultural Biogas Casebook"
focusonenergy.com/biogascasebook

Biogas Toolbox
renewwisconsin.org/biogas/biogastoolbox.htm

Wisconsin Department of Agriculture, Trade and Consumer Protection "Got Moola?"—an overview of business incentives available in Wisconsin
datcp.state.wi.us/mktg/business/business_resources/pdf/Wisconsin_Business_Resources.pdf

"Dairy Waste Anaerobic Digestion Handbook"
by Dennis A. Burke, PE
makingenergy.com
(click on the "publications" page)

AGSTAR Program Documents, Tools and Resources
This is a joint program of the EPA and U.S. Department of Agriculture.
epa.gov/agstar/

University of Minnesota Farm Methane Digester Economic Analysis Spreadsheet Tool
http://www.apec.umn.edu/faculty/wlazarus/tools.html

Wisconsin Utility Buy-Back Rates for Renewable Electricity
psc.wi.gov/apps/tariffs/content/elelist.aspx

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