

# Managing Manure with Biogas Recovery Systems

## Improved Performance at Competitive Costs



# The AgSTAR Program





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One of the biggest challenges that livestock producers face is managing manure and process water in a way that controls odors and protects environmental quality. Biogas recovery systems can help producers meet this challenge. The environmental benefits provided by these systems far exceed those supplied by “conventional” liquid and slurry manure management systems (e.g., storage tanks, storage ponds, lagoons). These benefits include odor control, improved air and water quality, improved nutrient management flexibility, and the opportunity to reduce greenhouse gas emissions and capture biogas—a useful source of energy.

### About Anaerobic Digestion

Biogas recovery systems are sometimes known as anaerobic digesters, because they use a process called anaerobic digestion. (Conventional lagoons operate on the same biological principle.) During anaerobic digestion, bacteria break down manure in an oxygen-free environment. One of the natural products of anaerobic digestion is biogas, which typically contains between 60 to 70 percent methane, 30 to 40 percent carbon dioxide, and trace amounts of other gases.

**Biogas and energy.** When biogas is captured, it can be used to generate heat, hot water, or electricity—significantly reducing the cost of electricity and other farm fuels such as natural gas, propane, and fuel oil. Biogas can also

be flared to control odor if energy recovery is not feasible. Both the flaring and use of biogas reduce greenhouse gas emissions. Biogas is a renewable source of energy with much lower environmental impacts than conventional fossil fuel. The methane generated from anaerobic digestion provides rural electric cooperatives and utilities with a source of “green power” to sell to customers who wish to purchase power from renewable sources. Biogas recovery also provides rural energy benefits such as distributed generation and voltage support.



**High-quality fertilizer and soil amendment.** Because anaerobic digestion reduces ammonia losses, digested manure can contain more valuable nitrogen for crop production. Also, the fiber in digested dairy manure can be used on the farm as bedding or recovered for sale as a high-quality potting soil ingredient or mulch.

*Floating gas collection cover on a 8,600-hog finishing farm lagoon.*

## Creating Energy on the Farm and for the Community – The Haubenschild Experience

In September 1999, Dennis Haubenschild and sons Tom and Bryan, owners and operators of Haubenschild Farms in Princeton, Minnesota, completed the installation of a heated plug flow digester at their 500-cow freestall dairy. The methane-rich biogas generated by the system fuels an engine attached to a 150 kWh generator set.

The Haubenschilds sell the excess electricity produced to their local electric cooperative, East Central Energy (ECE). Heat, recovered as hot water from the engine and exhaust, is stored in an insulated tank and is used to maintain the digester's temperature and heat the milking parlor floor.

In its first two years of operation, the system produced 1.9 million kWh of power from 46 million cubic feet of biogas. The methane recovery system has produced revenues from the sale of electricity and reduced farm expenditures by virtually eliminating propane purchases, while contributing to the farm's environmentally sound manure management strategy. "Its great!" reports Dennis Haubenschild. "My digester system is working, meeting and exceeding my expectations—particularly my environmental expectations."

Under a power purchase agreement, ECE purchases all excess energy from the Haubenschild farm and resells the energy to other customers who participate in the cooperative's renewable energy program.

"We're very pleased to assist the Haubenschilds in the development of this exciting new renewable energy project, and the results are particularly noteworthy," said Henry Fischer, ECE's Manager of Business and Community Development. "This project exemplifies ECE's mission, which is to enhance the quality of life and provide premier service to our customers," Fischer added.

Fischer said, "The Haubenschild Farm project is an excellent example of how agriculture, utilities, environmental organizations, community groups, and others can effectively pool their resources to develop renewable energy, promote sustainable agriculture, and ensure environmental stewardship."

## Status of Anaerobic Digestion

Biogas recovery systems are a proven technology. Currently, more than 30 digester systems are in operation at commercial U.S. livestock farms, and an additional 30 are expected to be in operation by 2003.

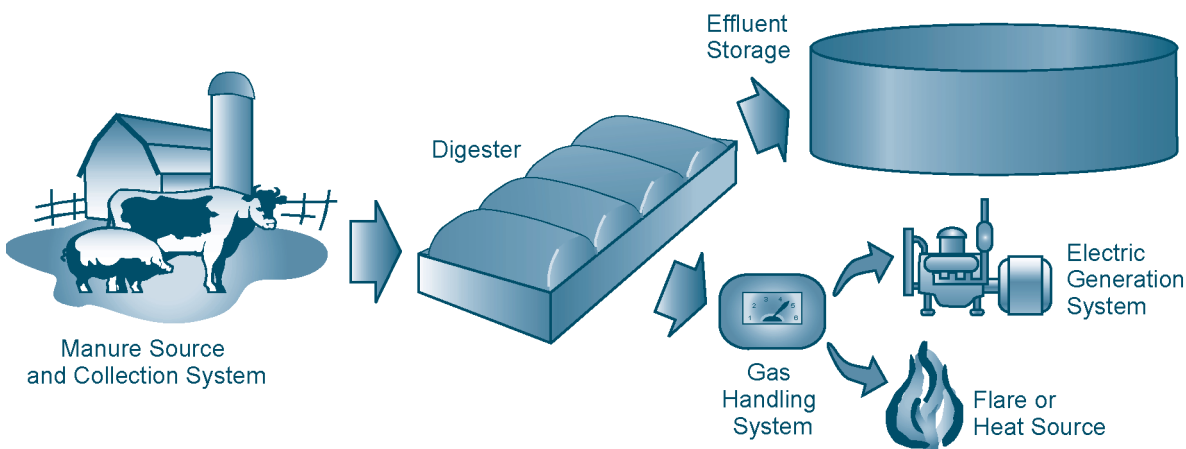
## How Are Biogas Recovery Systems Designed?

Biogas recovery systems have four basic components: a digester, a gas-handling system, a gas-use device, and a manure storage tank or pond to hold the treated effluent prior to land application (see Figure 1). Biogas recovery systems separate the treatment and storage functions. This design provides several financial benefits to producers, including:

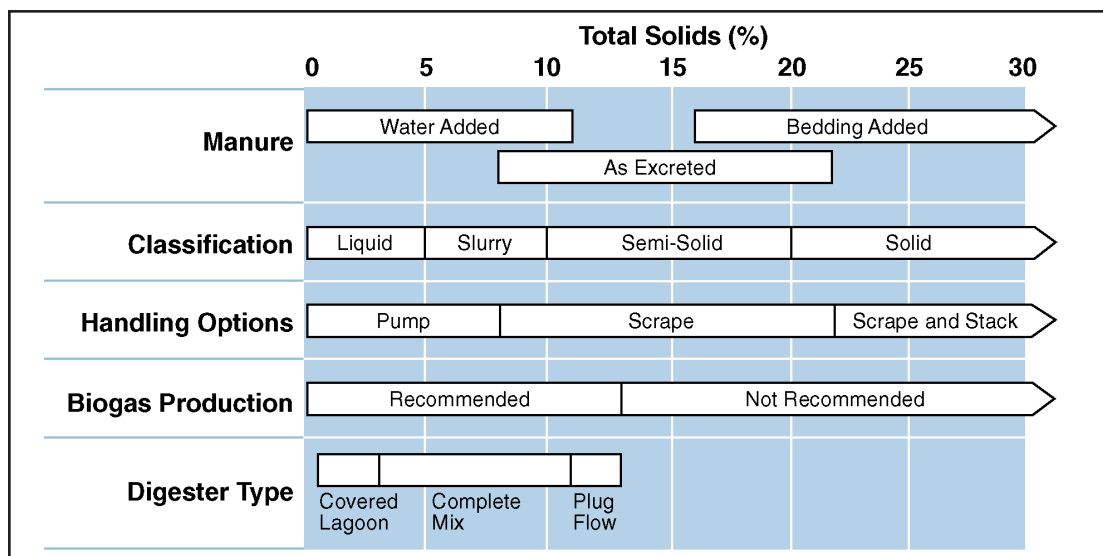
- Lower total volume requirements, which reduce excavation costs and the land area required for the waste management system.
- Lower cover costs because of smaller lagoon surface areas.

This multiple-cell process also improves environmental performance. These environmental benefits are described later in this document.

**Figure 1.** Schematic showing the components and products of a biogas recovery system.







**Figure 2.** Appropriate manure characteristics and handling systems for specific types of biogas digester systems.

## Is a Biogas Recovery System Right for My Farm?

To determine if a biogas recovery system is right for your facility, you will need to consider the following factors: how manure is handled at your facility, the frequency of manure collection, and the options available for using the recovered biogas.

- **Manure handling.** Biogas digester systems can accommodate manure handled as a liquid, slurry, or semi-solid (with little or no bedding added). The total solids content of the manure—a measure of manure thickness—determines these classifications. Figure 2 shows the manure characteristics and handling systems that are appropriate for specific types of biogas digester systems.
- **Frequency of manure collection.** Facilities best suited for biogas digester systems typically have stable year-round manure production, and collect at least 50 percent of the manure daily.
- **Gas use.** Several gas-use options are available, including engines, chillers, and boilers, or gas can simply be flared. When choosing among these options, you will need to take into account how the option affects a system's financial performance, the labor requirements associated with

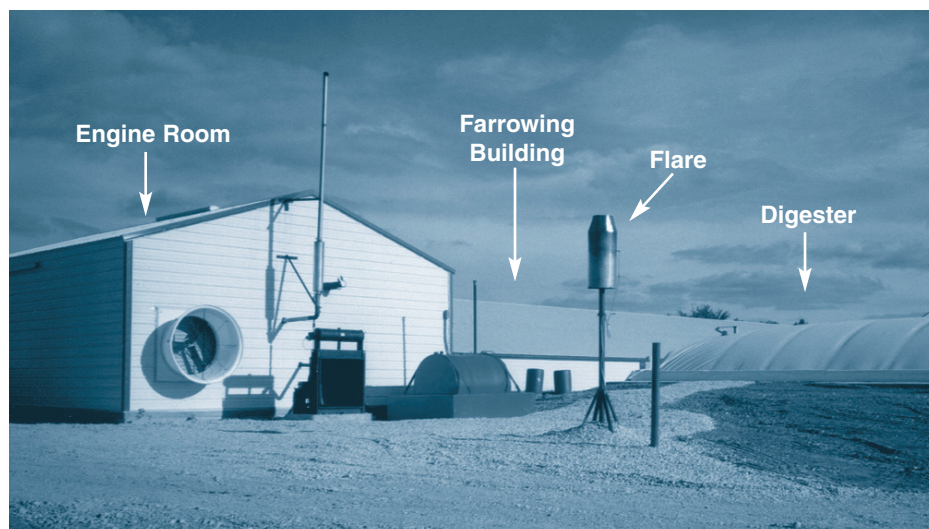
the option, and the skills needed to maintain and repair energy producing equipment.

## What Kind of Digester Will Work on My Farm?

Three different types of biogas recovery systems have been commercialized for managing manures, and several other types of biogas recovery systems are currently being developed. The most suitable type of system for your operation depends on how you collect manure and on the total solids content of the collected manure.

- **A covered lagoon digester** is an earthen lagoon fitted with a cover that collects biogas as it is produced from the manure. These digesters are best

*A compact, clean, low-maintenance waste management system.*



suiting for flush or pit recharge manure collection systems with a total solids content of 0.5 to 3 percent.



*Complete mix digester.*

- A **complete mix digester** is a heated tank, constructed of either reinforced concrete or steel, with a gas-tight cover. The digester contents are mixed periodically, either by a motor-driven impeller or a pump. This digester type works best with slurry manure and with a total solids content of 3 to 10 percent.



*Plug flow digester.*

- A **plug flow digester** is a long, relatively narrow, heated tank, often built below ground level, with a gas-tight cover. Plug flow digesters are used only for dairy manure. This type of digester requires thick manure ranging between 11 and 13 percent total solids. Plug flow digesters can tolerate some bedding, but the amount should be minimized, and sand bedding must be avoided.

Plug flow and complete mix digesters are heated systems that operate at a constant temperature year-round, producing stable gas flows that support gas-to-energy applications in all climates. Covered lagoon digesters are not heated, and this can affect gas flow. In warmer climates, gas flows are relatively stable during all seasons, and the systems produce enough biogas to financially justify energy gas uses. However, in northern climates, gas flows are lower during winter months, so gas use is likely to be limited to flares, with odor control and greenhouse gas reductions as the management objective.

AgSTAR provides several project support products about each of these digester systems. They are available free of charge from the AgSTAR program at 1-800-96AgSTAR (1-800-952-4782) or on the AgSTAR Web site at [www.epa.gov/agstar](http://www.epa.gov/agstar).

## The Environmental Benefits of Anaerobic Digestion Systems

Livestock confinement facilities generate large amounts of animal waste that can create serious environmental concerns. The concentrated waste product from decomposing livestock manure can be environmentally detrimental if it enters rivers, streams, or groundwater supplies. Decomposing manure also causes air quality concerns associated with odor, ammonia emissions, and the contribution of methane emissions to global climate change. Anaerobic digestion offers a number of air and water quality benefits, including:

- **Odor control.** The effluent odor from anaerobic digesters is significantly less than odors from conventional manure management systems. Odor reduction using anaerobic digestion can be very cost-effective when compared to other alternatives such as aeration.

- **Greenhouse gas reduction.** Conventional liquid and slurry manure management practices emit large amounts of methane, a greenhouse gas that contributes to global warming. Biogas recovery systems capture and combust methane, thus reducing greenhouse gas emissions. In addition, by off-setting energy that would otherwise be derived from fossil fuels, biogas recovery and use can help reduce overall quantities of carbon dioxide, another critical greenhouse gas.
- **Ammonia control.** Ammonia emissions from livestock manures—especially emissions from anaerobic lagoons used in the treatment and storage of these manures—are a growing environmental concern. To control ammonia emissions, producers can cover manure storage tanks. Because gas handling is not required, the storage structures of anaerobic digester systems, which separate treatment and storage, are smaller and easier to cover than the larger structures of traditional systems.
- **Water quality protection.** Anaerobic digestion provides several water quality benefits. When an anaerobic digester system, especially a covered lagoon, is properly managed, phosphorous and metals, such as copper and zinc, will settle out in the process cells, thus reducing phosphorous and metals loadings to surface waters when manure is land-applied. Digester systems, especially heated digesters, isolate and destroy disease-causing organisms that might otherwise enter surface waters and pose a risk to human and animal health. Anaerobic digestion also helps protect ground water. Synthetic liners provide a high level of groundwater protection for manure management systems. These protective liners are a more affordable option with anaerobic digester systems than with conventional lagoons, because the multiple-cell design of anaerobic digesters requires

less volume and, therefore, less lining material is needed. The concrete or steel tanks used in plug flow and complete mix digesters also effectively prevent untreated manure from reaching ground water.

## How Much Do These Benefits Cost?

Livestock producers can choose from a wide range of waste management options provided by a variety of agricultural engineers, vendors, and equipment suppliers. The costs of these options can vary greatly, in terms of both initial investment and annual operation and maintenance. For example, the cost of a typical manure storage facility can range between \$60 per Animal Unit (AU) for a typical pond to \$300 per AU for an above-ground prefabricated tank. (An AU equals 1,000 pounds live animal weight, or approximately the weight of one beef

## What AgSTAR Provides

To find out more about the opportunities that digester technology can offer the livestock industry, AgSTAR provides information and tools to help swine and dairy producers make informed decisions about these technologies:

- The AgSTAR Handbook, a comprehensive manual developed to provide guidance on developing biogas technology at commercial farms.
- FarmWare, an expert decision-support software package that you can use to conduct biogas recovery system prefeasibility assessments.
- The AgSTAR Industry Directory, which you can use to identify consultants, project developers, energy services, equipment manufacturers and distributors, and commodity organizations.
- The AgSTAR Web site ([www.epa.gov/agstar](http://www.epa.gov/agstar)), which contains a library where you can download the resources listed above. In addition, the Web site includes information on farm-scale digesters currently operating at commercial livestock farms in the U.S., as well as articles and case studies.

*Contact an AgSTAR representative at 1-800-952-4782 or visit the AgSTAR Web site at [www.epa.gov/agstar](http://www.epa.gov/agstar).*



## Environmental Effectiveness of Manure Management Options

Options	Odor Control	Greenhouse Gas Reduction	Water Quality Protection	Cost Range <sup>††</sup> (per 1,000 lbs/ live weight)
Covered lagoon digesters with open storage ponds	E	H	G	\$150-400
Heated digesters (i.e., complete mix and plug flow) with open storage tanks	E	H	G	\$200-400
Aerated lagoons with open storage ponds <sup>†</sup>	G-E	H	F-G	\$200-450
Separate treatment lagoons and storage ponds (2-cell systems)	F-G	L	G	\$200-400
Combined treatment lagoons and storage ponds	P-G	L	F-G	\$200-400
Storage ponds and tanks	P-F	M-H	P-F	\$50-500

Key: P=poor, F=fair, G=good, E=excellent, L=low, M=medium, H=high

<sup>†</sup>Aerated lagoon energy requirements add an additional \$35-50 per 1,000 lbs/year.

<sup>††</sup>Cost ranges do not include annual operation and maintenance (O&M) costs.

Here's what some digester owners have to say about their biogas recovery systems:

*"Community and consumer-owned electric systems can realize benefits from distributed generation, while supporting biogas projects that conserve energy and provide economic and environmental solutions for farmers and rural communities."*

Greg Booth, Power Manager,  
Tillamook People's Utility District,  
Oregon

*"I want my operation to produce and exist without my neighbors even knowing I'm there. And I want to leave the environment in better shape than I found it."*

Julian Barham, speaking about the environmental benefits of the covered lagoon digester at his 4,000-sow farrow-to-wean operation in North Carolina

cow.) Similarly, an open-air conventional lined lagoon that combines both treatment and storage functions can range between \$200 to \$400 or more per AU, depending on annual rainfall and process water use at the facility.

Anaerobic digestion is cost-competitive when compared to conventional waste management practices. For example, the installed cost of both a covered lagoon and heated digester (including an attached storage pond) ranges between \$200 and \$450 per AU. These systems can also have financially attractive payback periods of 3 to 7 years when energy gas uses are employed.

Conventional waste systems, in contrast, do not provide this payback opportunity and become sunk costs to the farm enterprise.

The *Environmental Effectiveness Table* above compares conventional waste management options to their environmental benefits. The table is intended to provide livestock producers with an easy-to-use tool to understand the environmental performance that they can achieve with their investment dollar. This type of comparison can help producers make informed business decisions related to the environment and the neighboring community.



ENERGY AND POLLUTION PREVENTION

For more information about methane recovery technologies, contact an AgSTAR representative at:

1-800-95AgSTAR (1-800-952-4782)  
(Hours of Operation: 9:00am to 5:00pm EST)

[www.epa.gov/agstar](http://www.epa.gov/agstar)