NRCS Natural Resources Conservation Service

Fact Sheet

Anaerobic Digester – Controlled Temperature

For anyone thinking or considering the installation of a Anaerobic Digester on your farm, review this fact sheet to ensure that the resource concern(s) is being addressed along with understanding that anaerobic digester systems have a large impact on farm management, human resources to attend to the system on a daily basis, and financial capital to be successful in operating and maintaining the system.

Anaerobic digesters are a significant financial investment and the system requires intensive management during its operation especially the first year. It is important during the planning process is to understand that each farmer's situation is unique and with the financial and labor impacts on the farm it is essential that the landowner understand the purpose of the system and its economics. This fact sheet is intended to provide enough information so you can make an informed decision about your livestock operation and the potential success of operating an anaerobic digester system.

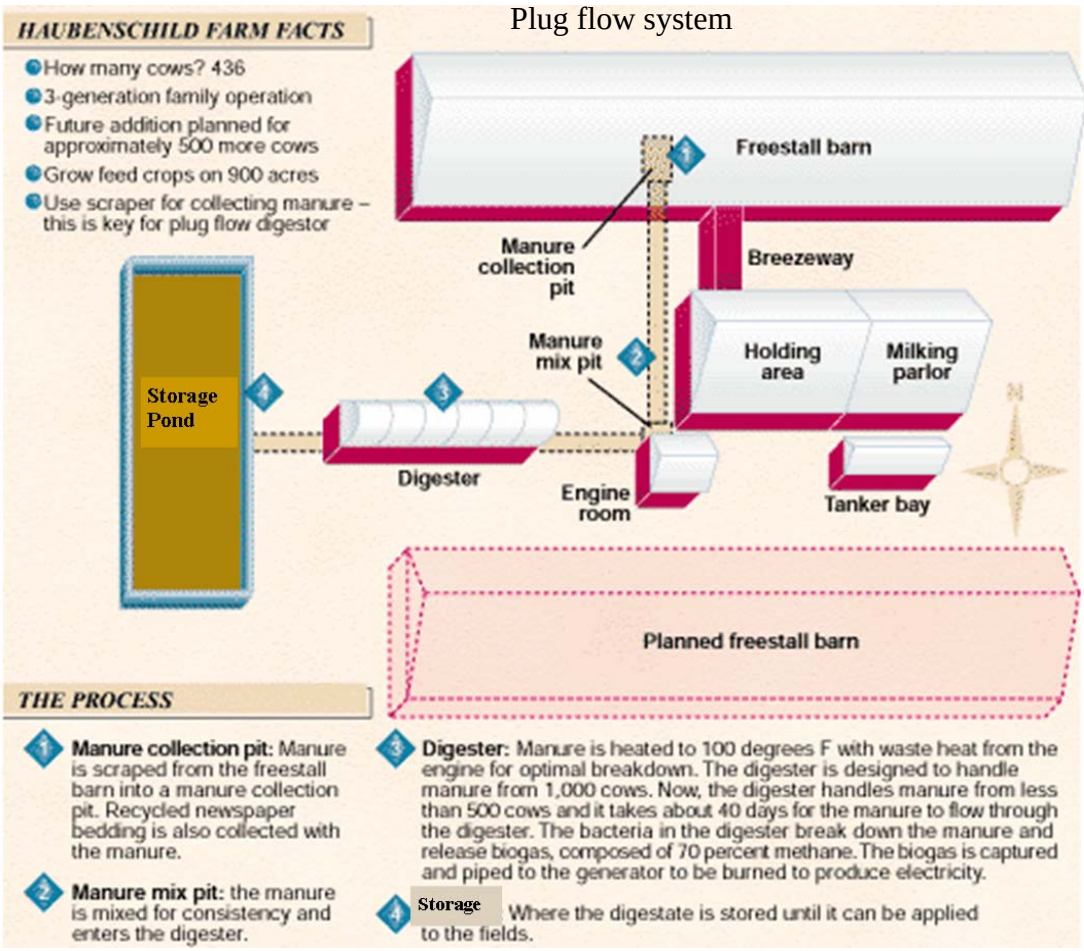


Figure 1. Schematic showing the components of a typical biogas recovery system

How Much Do Anaerobic Digesters 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 cost of these options can vary greatly, in terms of both initial investment and annual operations and maintenance.
For example:

- The cost of typical manure storage facility can range between $60 per Animal Unit (AU) for a typical manure storage pond to $300 per AU for an above-ground prefabricated tank.
- Depending on the type of digester system the average cost can range from $500/cow to $750/cow
  - Plus, annual operation and maintenance costs which can range from $11,000/yr to $20,000/yr for smaller sized operations to as much as $51,000/yr for large operations.
  - It may take 4-8 years to recover the initial investment cost when energy gas uses are employed when considering retail electricity rates. In Michigan where electricity is sold back to the grid at wholesale rates rather than retail rates, the time to recover the initial investment may be 2.5 to 3 times longer.

Intensive management will be needed for at least the first year to effectively run the digester and obtain consistent results. There may also be changes during the first year that could cost money and offset any revenue. Good management is critical to the success of a biogas system. Many systems have failed because operators did not have the technical support, the time, the skills, or the interest required to keep the system operating. Management includes system inspection, mixing and pumping manure into the digester on a regular basis each day, and checking and recording gauges to measure biogas and electricity output. Generator engines also require monthly maintenance including oil changes, valve adjustments and spark plug cleaning. Professional technical support from the digester designer or a designer consultant may be needed occasionally to solve rare or unusual problems.

If solid separation is to be part of the system, operation and maintenance will cost between $0.50 and $1.50/cubic yard of solids recovered. Without solid separation the storage facility (pond) will need to be cleaned out in accordance with the operations Comprehensive Nutrient Management Plan.

Biogas is very corrosive to equipment and requires frequent oil changes in an engine generator in order to prevent mechanical failure.

The heating value of biogas is about 60 percent of natural gas, and about ¼ of propane. That is, one cubic foot of propane is the same as 4 cubic feet of biogas.

About Anaerobic Digestion

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 assist in odor control, improved air and water quality, improved nutrient management flexibility, and the opportunity to reduce greenhouse gas emissions and capture biogas that can be used as a source of energy.

Biogas recover systems are known as anaerobic digesters. During anaerobic digestion, bacteria break down manure in the absence of oxygen, producing methane and other byproducts. One of the natural products of anaerobic digestion is biogas, which typically contains between 60-70 percent methane, 30-40 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.

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. <u>There are no losses of Phosphorus within the digestion process and no meaningful reduction in manure volume. Therefore, there will be no reduction in the amount of manure storage needed and no reduction in the land needed for utilization of manure.</u>

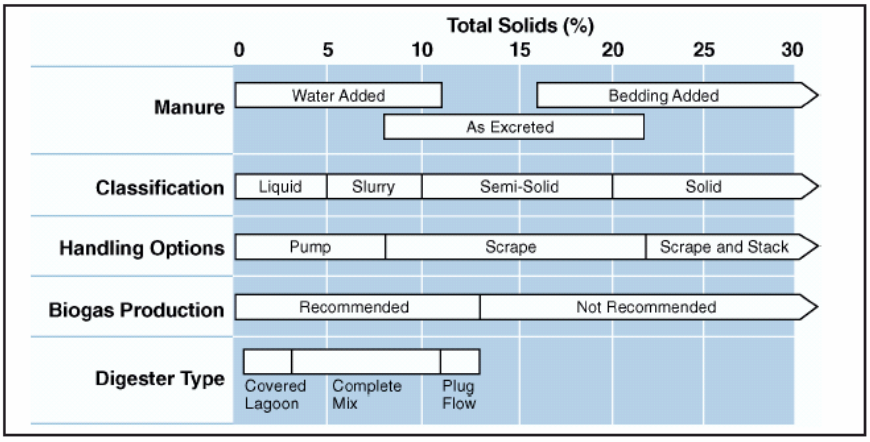


Figure 2. *Appropriate manure characteristics and handling systems for specific types of biogas digester systems.*

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 and 3.) Biogas recover systems separate the treatment and storage functions of manure, but they don't eliminate the storage. This multiple-cell process improves the digestion process. Additional information on designs may be obtained from the reference sources listed at the end of this fact sheet. (**http://www.epa.gov/agstar/resources/handbook.html)**

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

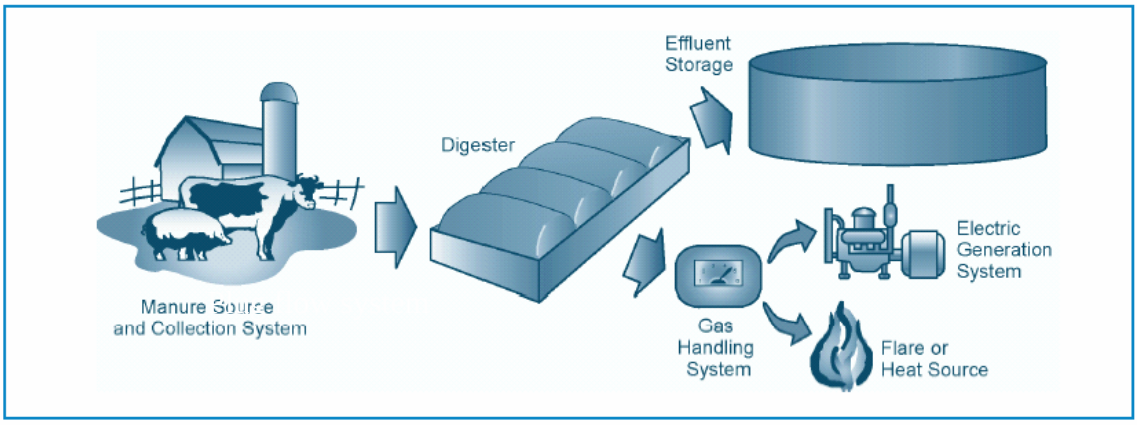
What Kind of Digester Will Work on My Farm?

Plug flow, complete mix, and fixed film digester systems that are heated will operate at a constant temperature year-round, producing stable gas flows that support gas-to-energy applications in Michigan's climates. Keep in mind that in northern climates, gas flows are lower during the winter months.

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. Three types of digesters are best suited for Michigan's climate.

- ***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; sand bedding must be avoided.
- ***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.
- ***A fixed film digester*** is a tank filled with plastic media on which a consortia of bacteria attach and grow as a slime layer or biofilm. The media is fully submerged. As the wastewater passes through the media-filled reactor, the attached and suspended anaerobic biomass covert both soluble and particulate organic matter in the wastewater to biogas. This digester type works best with slurry manure.

Figure 3.



What are the risks?

- There is a high initial capital cost that may cause a financial burden for the operation.
- Complications in operating and maintaining another biomechanical process on the farm.
- Safety issues with working with flammable gas. Digester gas is heavier than air as it displaces oxygen near the ground, and if hydrogen sulfide is present, the gas can act as a deadly poison. It is critical that a digester system be designed with adequate venting to avoid these dangerous situations.
- Availability of a utility that will buy back energy from the facility at a reasonable rate.
- Availability of a contractor locally that can build and provide guidance for maintain the manure digester.
- The amount of system monitoring and management time required to run a successful system.

Summary

Digesters have some benefits, but are not for everyone. Below is a list of questions to assist in determining if an anaerobic digester system is the right choice for your farm.

Below are some of the key factors which you should consider when making a decision about an anaerobic digester and the significance of that factor.

Factor to Consider	Significance of the Factor
Would the digester be constructed because it would be a "good idea"?	A resource concern must be addressed and the owner/operator must be committed to the raised level of management, maintenance and financial investment for a successful system.
The Comprehensive Nutrient Management Plan for the farm does not identify the need for biogas recovery on the farm nor does it include an anaerobic digester.	An anaerobic digester is a major component with implications for the entire manure management system on the farm. If the CNMP does not identify the need for biogas recovery or does not include an anaerobic digester, then you cannot be sure that adding an anaerobic digester will be compatible with your overall operation.
Typically animal numbers by species: • Less than 300 mature milk cows • Less than 500 sow farrow to finish • Less than 1000 farrow to wean • Less than 3000 finished swine	Typically animal numbers need to be larger then the numbers listed in order for the system to be economically feasibly:
Cows are bedded with sand	Sand causes handling and maintenance problems and sand must be separated from the waste before it is fed into the digester. The presence of sand increases the frequency that the digester must be shut down for clean out.
Hogs are "all in-all out"	This creates a "down time" for the digester. Daily manure input, a steady supply of manure to the digester, is needed year round for effective operation.

Factor to Consider	Significance of the Factor
The Projected farm life is less than 10 years	It takes at least that long to recover the initial investment; a digester system is not economically feasible if the anticipated life is less than 10 years.
Water management is less than optimum; use varies significantly	Water inputs and dilution factors play a key role in the design of the digester system. Digesters require much less management when the inputs are relatively consistent.
Manure is "flushed"	Too much water inputs reduce the solid content of the manure. The reduction of total solid content has a significant impact on the digestion process.
I have limited financial resources	The initial capital cost for construction and initial start-up are estimated at $500-750 per cow for a dairy operation. USDA financial assistance is capped at $100,000 for the digester. The producer must show receipts from the contract before USDA will pay the financial assistance. The annual operating cost can range from $10,000 to $50,000; these costs are not eligible for financial assistance.
I have limited human resources to effectively manage the digester system and controls	An anaerobic digester requires regular maintenance and management in order to operate effectively. A digester that is not managed properly is a safety concern as well as an inefficient use of the financial resources invested.

References

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