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Cow-powered Farm: Exploring the Possibilities of Anaerobic Digesters

M. Charles Gould, Michigan State University Extension

What is anaerobic digestion?

Anaerobic digestion is the biological conversion of organic matter to biogas and digestate in an atmosphere without oxygen. Biogas is typically 60 percent methane and 40 percent carbon dioxide, with some trace amounts of hydrogen sulfide and other gases.

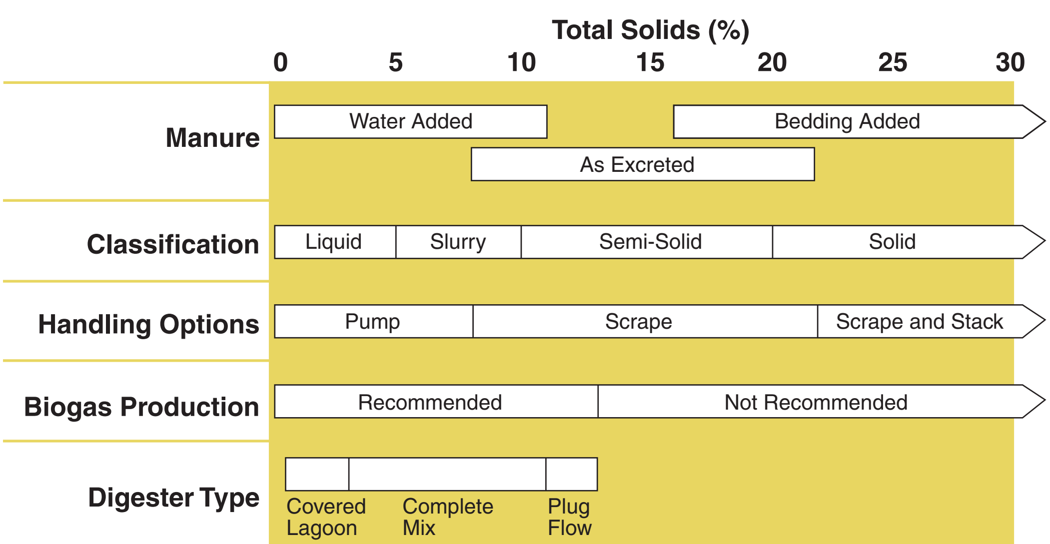
Manure characteristics and handling systems for various types of digesters

Anaerobic digesters are sealed (airtight) tanks operated at either a mesophilic (95 degrees to 105 degrees F) or thermophilic (135 degrees to 145 degrees F) temperature. Common types of anaerobic digesters are covered lagoon, plug flow and complete mix. Less common digester types include fixed film, induced blanket and two-phase. Manure characteristics, handling and the use of bedding dictate which technology is appropriate (see Table 1). Depending on the digester type and technology provider, manure may be mixed. Manure and other feedstocks remain in the digester tank for as few as 5 days or as long as 20+ days. Because of Michigan's cold winters, all digesters constructed in Michigan require insulation and heating to maintain optimum performance throughout the year.

Digester benefits

One of the most important reasons for digesting manure is odor control. Odor is a major issue facing the animal agriculture industry today. Anaerobic digestion leaves digestate with a less offensive odor. In addition, nutrients in feedstocks are mineralized during digestion, making them more plant-available than nutrients in raw manure. Multiple analyses of liquid digestate (filtrate) over a period of 36 months from one complete mix digester on a dairy farm in Michigan indicated that there were, on average, 27 pounds of nitrogen, 9 pounds of phosphate and 27 pounds of potash per 1,000 gallons (McDonald, 2009). It is important to note that nutrient analysis will differ depending on the management of the digester, feedstocks used and other factors.

Table 1. Appropriate manure characteristics and handling systems for anaerobic digester systems.



Source: EPA AgSTAR, 2002

Value-added products from the digestion process

A digester presents many opportunities for value-added products. Biogas can be used to generate electricity or fuel a boiler, or it can be upgraded (impurities removed) to natural gas standards. Upgraded biogas can be sold into the natural gas pipeline or used on the farm as vehicle fuel. Digestate can be land applied as a source of nutrients. Digestate can also be separated into a liquid fraction (filtrate) and a solid fraction (fiber) via a solid-liquid separator. Filtrate can be used as a fertilizer or further treated to meet discharge quality standards. Fiber can be used as a soil amendment, cattle bedding or compost feedstock, or to make medium-density fiberboard. These represent only a small fraction of the value-added options available with a digester.

A sample of medium-density fiberboard made from digester fiber.

Predicting anaerobic digester size and energy potential

Table 2 summarizes the manure production and biogas yield for various animal species commonly associated with anaerobic digestion systems. Converting energy potential into electrical energy, assuming 40 percent mechanical conversion efficiency and 90 percent runtime efficiency, results in yields for dairy, beef and swine of 4.2, 0.86 and 0.35 kWh/animal/day, respectively.

Capital cost estimates of anaerobic digestion systems

The capital requirements to install a digester vary widely and depend on the digester design type, size, biogas utilization system and postdigester manure management system. Several case studies have also been completed that provide insight into the feasibility of anaerobic digesters (Lazarus, 2009). A summary of the results follows:

1. A 2006 analysis of the cost-size relationship for dairy farm plug flow digesters found that a digester for a 500-cow operation would have cost $805/cow; at 2,000 cows, the cost would decline to $371/cow.
2. A plug flow digester installed on a Washington state dairy farm in 2005 with the addition of food processing wastes and fiber separation cost $1,136,364. That digester was on a 500-cow farm but was also receiving manure trucked in from an additional 250 cows, resulting in an installation cost of $1,515/cow. However, that particular digester was sized to allow for expansion to 1,500 cows, which would reduce the investment to $757/cow.

Table 2. Manure Production and Biogas Potential

Animal Type	Average Weight	Manure Production[1]		20 Day HRT Volume	Biogas Yield[2]	Energy Potential[3]
	(lb)	(lb/animal/d)	(gal/animal/d)	(gal)	(ft^3/animal/d)	(Btu/animal/d)
Dairy cow	**1400**	**120.4**	**14.5**	**290.5**	**65.9**	**39,540**
Beef cattle	**600**	**34.8**	**4.1**	**82.6**	**13.6**	**8,160**
Hogs	**150**	**12.6**	**1.5**	**30.4**	**5.6**	**3,360**

[1]ASABE. 2003. Manure Production and Characteristics. ASAE D384.1.

[2]USDA NRCS. 2007. An Analysis of Energy Production Costs from Anaerobic Digestion Systems on U.S. Livestock Production Facilities.

[3]Assumes bio gas is 60% methane and 1 ft^3 of methane contains 1,000 Btu.

3. A complete mix digester with a separator installed on a 160-cow Minnesota dairy farm in 2008 cost $460,000, or $2,875/cow.
4. Another recent study found that the electrical generation equipment made up, on average, 36 percent of the total investment of a group of 36 digesters, so substantial cost savings may be possible in situations where the biogas can be used for heating rather than to produce electricity.

Digester decision-making tools

The AgSTAR Handbook and software found on the EPA's AgSTAR Web site provide sound advice for evaluating digester opportunities. The handbook and software are available free at **www.epa.gov/agstar/resources.html**.

The MSU Anaerobic Digester Research and Education Center

The purpose of the center is to comprehensively research, develop, evaluate and educate on integrated anaerobic digestion systems, with an emphasis on cost-effective and cost-efficient technologies for small and medium-sized dairy farms. Dana Kirk is the manager and can be reached at kirkdana@msu.edu or 517-432-6530.

Michigan On-farm Anaerobic Digester Certification Program

This course is designed to ensure that on-farm digester operators possess the skills necessary to start, maintain the operation of and troubleshoot problems with an anaerobic digester. For more information, contact Charles Gould at gouldm@msu.edu or 616-994-4580 or Michelle Crook at crookm@michigan.gov or 517-242-3773.

References

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