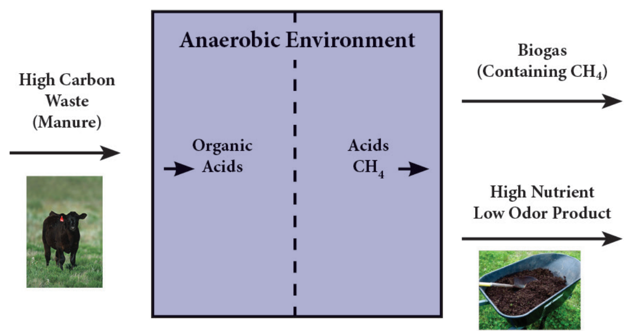
E³A: Anaerobic Digester Applications for the Farm or Ranch

Steps in the Anaerobic Digester Series

- **Understanding Technical Feasibility**
- Estimate Potential
- Economics
- Selection
- Maintenance

Understanding anaerobic digesters

The most widely accepted technology currently available for managing organic wastes in livestock manure is anaerobic digestion, a biological process by which microorganisms convert organic material into biogas. Biogas generated by anaerobic digestion typically contains between 60 and 70 percent methane (CH_4). The other primary constituent is carbon dioxide (CO_2), as well as small amounts of hydrogen sulfide, ammonia, water and trace hydrocarbons. Biogas can be used to generate electricity or refined and supplied to natural gas lines. Collection and use of methane generated from livestock manure has potential to reduce global emissions of methane, replace fossil fuels, reduce carbon dioxide released from fossil fuels, diminish odor from agricultural facilities and improve water quality. In many cases, anaerobic digestion decreases on-farm energy costs or increases revenues from energy sales. Anaerobic digesters may require increased maintenance and are not a good fit for all livestock operations, so make sure this technology is appropriate for your operation.



Depiction of anaerobic digestion process

Anaerobic digestion process

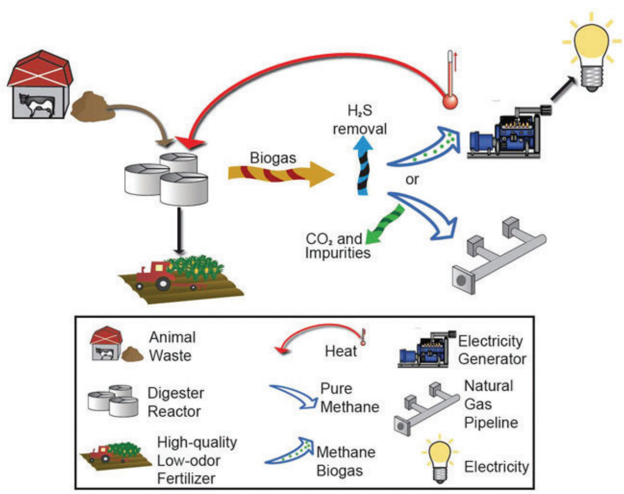
Anaerobic digestion requires that feed material be less than 17 percent solids by weight. The solids content of manure collected on a dry lot is typically much higher than 17 percent. Microorganisms that convert organic materials into methane are sensitive to pH level and temperature. They require a pH level of about 7 and temperatures around 95 degrees F. For every 20-degree drop in temperature, gas production will be cut approximately by half. Nearly half of the biogas generated by anaerobic digestion may be required for maintaining the necessary temperature of the digester. Anaerobic digesters will require more heat input during winter months than summer months, but the rate of methane generation will not change as long as a temperature of 95 degrees F is maintained.

Anaerobic digestion system configuration

Anaerobic digesters are typically large reactors made of concrete or steel. The volume of the reactor depends on the volume of wastes to be processed in the system and the retention processing time required. Most conventional digesters, which are flow-through systems, require a holding time of 20 to 30 days to convert manure solids into methane. Manure is added either continuously or daily to the anaerobic digester. Biogas may be used on- or off-site, serve as fuel for an electricity generator, or be purified and supplied to natural gas lines. Through cogeneration, heat generated as a byproduct of the generator is captured and used to keep the digester at the ideal temperature of 95 degrees F. Cogeneration is the most common use for methane produced by anaerobic digestion.

There has been a growing interest in purifying biogas for supply to natural gas lines or conversion to liquid natural gas. This is due to high maintenance requirements for generators, which are typically not designed to be compatible with biogas generated from manure. This requires that gas components other than methane be removed, including carbon dioxide, hydrogen sulfide, ammonia, water and trace organics. Hydrogen sulfide should be removed from biogas for cogeneration due to its corrosive nature, which can be done by passing biogas through iron particles.

The end product of anaerobic digestion is slurry. While liquid volume reduction of waste does not occur during the digestion process, expect a 50 to 60 percent reduction in solids without sacrificing nutrients, making the end product valuable for agriculture. Nearly 95 percent of pathogens are killed through the process of anaerobic digestion. In the digester, organics are converted to methane and nutrients, such as nitrogen and phosphorus, are conserved. The end product is a low-odor, nutrient-rich, stabilized waste suitable for land application. You can learn more about how to handle the end products of anaerobic digestion later in this guide.



Prepared by Sarah G. Lupis, Institute for Livestock and the Environment, Colorado Sate University. Symbols courtesy of the Irrigation and Application Network, University of Maryland Center for Environmental Science.

Technical considerations

Feasibility

Anaerobic digestion is not a good fit for all animal feeding operations. Ensure that anaerobic digestion is feasible at your operation before committing to a system. Anaerobic digestion technologies include covered lagoons, plug flows, complete mixes, upflow sludge blankets and fixed film reactors. See the *Selection* guide for details on these technologies. Consult an expert to determine which technology is appropriate for your operation. After you have determined that anaerobic digestion may be technically and economically feasible, learn about which types of anaerobic digester technologies are the best fit at your site.

Biogas handling

Methane in a concentration of 6 to 15 percent with air is an explosive mixture. Since it is lighter than air, it will collect under rooftops and other enclosed areas. It is relatively odorless, so detection may be difficult. Extreme caution and special safety features are necessary in designing a digester system and storage tank, especially if the gas is compressed.

Corrosive biogas

Biogas generated by anaerobic digesters contains highly corrosive hydrogen sulfide, which must be removed prior to feeding the biogas into a generator. Passing the biogas through iron particles is a simple, low-cost method of removing sulfides. Sulfides attach to the solid iron surfaces, thus removing them from the gas. The iron must be replaced every six to 12 months, depending on the size-to-gas-flow ratio.

Dry wastes

Some collected animal wastes can have a high solids content. Dairies are typically thought to be a good fit for anaerobic digestion technology. However, waste management methods vary by dairy operation. If manure is often scraped from concrete floors or dry lots, solids content can be as high as 90 percent. For wastes containing more than 17 percent solids, substantial quantities of water may be required for anaerobic digestion, which can add to a digester's operating costs. However, clean water will adsorb nutrients and pathogens and become a nuisance if added to an anaerobic digester. Dilution of waste with water is most practical when there is an available source of wastewater, such as from domestic or food processing uses.

High inorganic content

Manure collected from dry lots is often dry with a high inorganic content consisting of rocks and soil particles. Rocks and soil particles cause major operational problems and must be removed before the waste is processed. This has been one of the most prominent causes for failure in on-farm anaerobic digesters. Sand in bedding can also be a problem if it ends up in the supply of waste material. Removal of rocks, soil and sand is possible but typically involves adding water to the waste and allowing particles to settle. Such processes add complexity, capital cost and additional maintenance.

Co-digestion

Combining animal feeding operation wastes with wastewater generated onsite or at nearby facilities can help by increasing water content and methane production capacity. This is typically referred to as co-digestion, and it's growing in popularity. The ability to combine manure with other wastes must be carefully evaluated prior to installation and operation of an anaerobic digester. Waste streams should not vary seasonally or daily, but rather a consistent waste should be supplied to the anaerobic digester at all times. The microorganisms in an anaerobic digester are sensitive, and it can take up to three months for them to adjust and resume producing methane when the waste source is changed. When the waste stream is changed on a daily or seasonal basis, the organisms do not have enough time to recover. If you are considering adding additional waste other than manure into the anaerobic digester, ensure that the waste will be available on a daily basis throughout the year.

Handling end products

Anaerobic digester effluent is a slurry containing 1 to 15 percent solids, depending on the solids content of the waste fed into the system. This effluent is a stabilized product suitable for land application as it is low in pathogens and high in nutrients. The processed material containing solids can be applied by a honey wagon, or solids can be separated for land application separate from liquids. When solids are separated, they can be composted and applied by a manure spreader. Solids separation in combination with composting can result in a lower-weight product, which can be transported at lower costs compared to a slurry for land application. The weight of the processed slurry containing liquid and solids (5 to 15 percent solids) may be too expensive to transport over large distances. Using the nutrient-rich liquid component for irrigation is referred to as fertigation or chemigation and is regulated in most states. When fertigation systems are connected to a freshwater source, appropriate measures must be taken to avoid contamination, such as inclusion of a backflow preventer and shutoff valve. Fertigation systems must adhere to state and local regulations. If land application is not an option, find another method for storage or on-site treatment.

Photo credit: Northern RockyMountain RC&D

Anaerobic digester effluent

Notes

Original work created by Montana State University Extension and the University of Wyoming.
Adapted with permission by University of Missouri Extension.

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New 12/14/POD