Biogas Digesters

BIOGAS DIGESTERS HAVE CAPTURED MANY IMAGINATIONS because they can turn organic wastes from our farms, factories and cities into a valuable source of renewable energy. In addition, the potential of this technology to reduce odors and other environmental concerns of animal feedlots has resulted in much recent interest from farmers. On-farm uses are not, however, the only digester options. Indeed, other industries have been reaping the benefits of digestion for years, particularly for wastewater treatment. While digesters can be a useful source of energy, they probably will never supply a significant portion of our state's energy needs – it's estimated that farm digesters could at most provide about one and a half percent of Minnesota's energy needs.[1] This chapter will discuss both on-farm and non-farm applications.

Anaerobic digestion is a natural process similar to composting that breaks down organic wastes to produce biogas.

ANAEROBIC DIGESTER BASICS

Biogas digesters work on the principal of anaerobic digestion – a natural, biological process similar to composting that breaks down liquid manure, sewage, or other organic wastes. In the process, biogas is produced. This biogas is about 55-70 percent methane (the primary component of natural gas) and therefore can make an excellent energy source. Anaerobic means "without oxygen," and the bacteria that produce the biogas can only survive if they are not exposed to oxygen in the air. These bacteria generally thrive at two temperature "zones" from 95-105° F, and from 125 to 135° F. Although anaerobic digestion occurs at lower temperatures, it is not as efficient at producing biogas.

ENVIRONMENTAL BENEFITS AND CONCERNS[2]

Anaerobic digestion offers several environmental benefits:

Odor Reduction Odors are significantly reduced in an anaerobic digestion system.

Green Energy Production Biogas is a renewable resource, and when it is converted to electricity it is replacing power than would otherwise be produced from fossil fuel sources.

Pathogen Reduction Harmful pathogens are also reduced – although not eliminated – through digestion.

Greenhouse Gas Reduction Methane produced naturally from animal manure storage is a contributor to global warming – methane is a powerful greenhouse gas 23 times more potent than carbon dioxide, the most common greenhouse gas. Capturing and burning this methane with an anaerobic digestion system reduces this agricultural source of greenhouse gases.

Reduction in Total Oxygen Demand of the Treated Waste Total oxygen demand (TOD) is a measure of potential impact on aquatic systems. In the case of a manure spill into a water body, manure with a high TOD will suck more oxygen from the water and thus kill more fish.

Especially for on-farm digesters, there are also several potential environmental concerns of digesters:

Nitrogen and Ammonia Emissions Although digestion does not remove nutrients from the manure, is does convert organic nitrogen in manure to an ammonia form. This can be both a benefit – it is more easily available as a nutrient to plants – and a potential concern, as

CASE STUDY:

Haubenschild Farms: Making Electricity on the Farm[3]

HAUBENSCHILD DAIRY FARM is a 1000-acre, family owned and operated dairy farm located near Princeton, Minnesota. In 1999 the farm installed a biogas digester at a total cost of $355,000, including the engine and generator. It is a great example of a local waste to energy project, although owner Dennis Haubenschild would dispute the fact that manure from his dairy cows is a waste. "Manure is a valuable resource that we need to use to its fullest extent," says Dennis.

The Haubenschild Dairy Farm collects manure from its approximately 750 cows. Over a period of about 15 days, the manure passes through a covered 350,000-gallon, in-ground concrete tank – the biogas digester. Suspended heating pipes heat the manure inside the digester to create the optimal conditions for creating biogas. A 135-kilowatt engine-generator set is then fueled with the biogas captured from the digester and used to generate electricity. The hot water used to heat the digester is recovered from the engine-generator's cooling jacket and reused to heat the barn floor space. The digested manure is stored in a lined storage lagoon until it can be spread on the fields for fertilizer.

The farm produces enough electricity to meet all on-farm electric needs plus enough excess electricity to power about 75 homes. The excess electricity is sold to East Central Energy, the Haubenshild's local electric cooperative, which markets the "cow power" as green electricity to its customers for a slight mark-up to cover its increased distribution expenses. Haubenschild Farms expect the value of the energy from the digester will pay back total project costs in about 5 years.

For more information, a full report on the Haubenschild digester is available at www.mnproject.org or contact:
Henry Fischer
East Central Energy
763-689-8055
Henry.Fischer@ecemn.com

***The Haubenschilds: Dennis, Bryan, Marsha and Tom** (left to right)*

Digester engine with heat recovery system

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Works well with agriculture

Helps with reliability concerns

Recycles waste materials and waste heat

Offers community economic development

Improves energy independence, local control, and energy security

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Three Primary Types of Digesters for On-Farm Use[4]

While engineers have developed many digester designs for use in treating sewage and industrial waste streams – some of them quite complex – there are three basic designs in commercial use on farms.

COVERED LAGOON

- *Least expensive*
- *Large lagoon covered with impermeable cover*
- *Best for liquid manure*
- *Does not work well for energy production in Minnesota because it is not heated, but does help curb odors*

COMPLETE MIX DIGESTER

- *Works for manure with 3 to 10 percent solids (swine or dairy)*
- *Manure processed in heated tank (above or below ground) and solids kept in suspension by mixer*
- *More expensive than plug-flow*

PLUG-FLOW DIGESTER

- *Works well for manure with solids concentration of 11 to 14 percent, such as cow manure*
- *Mixes manure then moves it through the digester in a "plug" (gummy clump of manure). Anaerobic digestion creates biogas that moves through digester; the digester is heated by suspended hot water pipes, and the gas is stored under an impermeable cover*

ammonia nitrogen can be more easily lost to the air, where it is a pollutant. Nitrogen loss can be minimized by using proper management practices such as: injecting the digested manure into the soil instead of spreading it; maintaining a crust on the storage pond; and reducing the surface area of the storage pond.

Digested Manure Storage Concerns Water pollution from potential surface water run-off or groundwater contamination from liner leakage. This is not a concern that is particular to digesters, however, but exists for all confined animal agriculture operations.

Air Emissions from Combusting Biogas The burning of biogas does produce emissions; however, these emissions are significantly cleaner than existing coal-fired power plants.

WILL A DIGESTER WORK FOR MY FARM?

The AgSTAR Handbook includes 5 criteria for preliminary screening of potential anaerobic digester projects at dairy or swine feedlots. For complete information on conducting a pre-feasibility assessment, farmers should see the Ag STAR Handbook.[5]

1. Do you have a "large" confined livestock facility? Ag STAR defines large as at least 300 head of dairy cows/steers or 2000 swine, although digesters have been successful at smaller farms.

2. Can you ensure year-round, stable manure production and collection? A digester needs to be constantly and regularly "fed" manure to maintain methane-producing bacteria.

3. Do you have a manure management strategy that is compatible with digester technology? Digester technology requires the manure to be: managed as a liquid, slurry or semi-solid; collected at one point; collected regularly; and free of large quantities of bedding and other materials (i.e., rocks, sand, straw).

4. Do you have a use for the energy recovered? Can a generator be installed to produce energy and will a local utility purchase it? Are your on-farm electricity costs high? Is there another use for the energy on-farm?

5. Do you have someone to efficiently manage the system? Successful digester operation requires an interested operator who will pay attention to performing the daily routines of digester maintenance and possesses basic "screwdriver friendliness."

CASE STUDY:

Perham Community Digester

WHEN IT'S BUILT, THE LITTLE PINE DAIRY DIGESTER will combine the waste stream of Little Pine Dairy, a 1400-cow dairy farm, with the waste stream of a food processing company a few miles from the farm. Currently the company, located in Perham, Minnesota, is paying fees to dispose of the waste that the digester will treat and produce energy from. This project promises to be an excellent opportunity to test the possibility of combining multiple waste streams, increase the profitability and efficiency of both the dairy and food processing company, increase local energy self sufficiency, produce renewable energy, and provide multiple environmental benefits. This agriculture and industry partnership exemplifies the ways in which communities can come together to address their energy needs.

For more information contact:
Ron Tobkin
Little Pine Dairy
rstobkin@eot.com

CASE STUDY:

Anaerobic Digestion of Food Waste at AnAerobics/Seneca Foods

ANAEROBICS PROVIDES treatment services for organic waste streams. Seneca Foods is a corn and pea processing plant located in Montgomery, MN. The two came together when Seneca Foods realized it would need to expand its land application base in order to renew its wastewater discharge permit, and decided instead to consider a contract with AnAerobics to treat its entire waste stream rather than continue land applying it. AnAerobics, although a wastewater treatment company, always recognizes the potential to generate energy from the tremendous volume of gas that is often produced at the treatment plant. So, while the primary goal of the project was to help Seneca Foods meet its waste stream requirements, AnAerobics realized that Seneca Foods was the perfect location for a complete waste-to-energy system.

Using a proprietary technology that simultaneously treats both the solid and liquid waste, AnAerobics estimates that 85% of the solids treated could be converted to useable gas. The gas would go through considerable cleanup, and then could either be piped back into the natural gas supply line, or used to power a 1.5 megawatt generator. As of Spring 2003, the project has been shelved, as the company considers alternative means of waste disposal.

For more information contact:
Sarah Ploss
Seneca Foods and Anaerobics
315-364-5062
sjp7@anaerobics.com

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OTHER TYPES OF ANAEROBIC DIGESTERS

Food Waste Wherever a large amount of food waste is generated there is potential for anaerobic digestion. In fact, many food processing industries are required to treat their waste streams, and digestion offers one way to accomplish this.

Often the energy potential of digestion can complement the need to treat organic wastes at a food processing plant. For example, the waste from rendering plants is high in organic wastes that could be treated through digestion.

Landfill Gas Significant quantities of biogas are emitted from municipal solid waste landfills. Landfill biogas has a methane content of approximately 40-55%, with the remaining gas made up of primarily carbon dioxide (CO_2), as well as some nitrogen (N_2) and hydrogen sulfide (H_2S).[6] The gas can be used to generate electricity at the landfill site by collecting the gas and burning it to power a gas turbine and produce electricity.

A large portion of the potential for landfill gas electric generation in Minnesota has already been realized with existing projects, but a study conducted in association with the Lakefield Junction natural gas plant suggested that some landfill gas-based generation potential still exists in Minnesota.

The study suggests that additional landfill gas projects could add roughly two additional megawatts in generating capacity. Existing municipalities and landfill facilities not yet incorporating such a process should explore the option to help lower their electric bills and to reduce the amount of methane they release.

Landfill gas systems are reliable and are expected to be available for combustion over 90 percent of the time. Capital costs for constructing a landfill gas facility are slightly less than $1,000 per kilowatt and annual operating costs are likely less than for a traditional power plant because the landfill would not have to purchase its own gas.

Wastewater Treatment Much like landfill gas, utilizing biogas generated from wastewater treatment can serve to improve the economics of wastewater treatment by producing onsite heat and electricity. Anaerobic digestion is often part of the treatment process at a wastewater treatment plant. These digesters produce biogas with methane contents ranging from 60-70%.[7] Because the treatment process is very energy intensive, most or all of the biogas energy may be used on-site. Often, the biogas is used for process heat or to directly power equipment at the plant, rather than in a generator.

Some examples of existing landfill gas projects in Minnesota include:

- *Browning Ferris Industries in Inver Grove Heights – Pine Bend Landfill*
- *Neo Corp in Eden Prairie – Flying Cloud (Wood Lake Sanitary Services)*
- *Neo Corp in Burnsville – Burnsville Sanitary Services*
- *Power Recyclers Inc. in Anoka – Anoka Landfill*

END NOTES

[1]Assuming all manure in Minnesota was digested. See: Hinds, Paul, *DRAFT: Minnesota's Potential for Electricity Production Using Biogas Resources: Summary Report*, Minnesota Department of Commerce, January 2002. Digestion of additional wastes from food processing facilities, wastewater treatment plants and other sources would increase this amount.

[2]Nelson, Carl, *Final Report: Haubenschild Farms Anaerobic Digester Updated!*, St. Paul, Minnesota: The Minnesota Project, August 2002. Available at www.mnproject.org.

[3]ibid.

[4]ibid.

[5]Roos, K.F. and M.A. Moser, eds., *AgStar Handook, 1st Edition*, Washington D.C.:U.S. Environmental Protection Agency, 1997.

[6]Ross, Charles C., Thomas J. Drake, James L. Walsh, *Handbook of Biogas Utilization, Second Edition*, Atlanta: U.S. Department of Energy, July 1996.

[7]ibid.

[8]Soderberg, Kurt. "WLSSD Announces a New "Beacon" on the Harbor," Press Release, 23 July 2001. Retrieved June 18, 2002 from: http://www.wlssd.duluth.mn.us/PR72301.htm.

PHOTOGRAPHS

page 45 – Natural Resources Conservation Service; page 46 – Carl Nelson/The Minnesota Project; page 48 – Melissa Pawlish/The Minnesota Project; page 50 – Chet Welle/City of Rochester; page 51 – Karen Anderson/Western Lakes community relation's director (upper), Doug Fairchild/Western Lakes Environmental Program Coordinator (lower)

CASE STUDY:

Rochester Water Reclamation Plant

THE ROCHESTER WATER Reclamation Plant has realized the value of making use of its existing resources. The Rochester Water Reclamation Plant generates biogas as a major byproduct of its wastewater treatment process, which includes anaerobic digesters. This biogas has the potential to provide the plant with a renewable source of fuel that saves money on energy costs. During the major plant expansion of 1980, two 400 kW generators were installed which used the biogas gas to produce electricity. In 2000, due to concerns of local energy shortages, plant staff got the Rochester Water Reclamation Plant prepared. Partnering with the local Rochester Public Utility, and utilizing the technical knowledge of its staff, plant management decided to look for ways to use the facility's gas more efficiently.

In its current configuration, the Rochester Water Reclamation Plant produces enough biogas to reduce its power purchasing needs by 25% during summer months, but it plans to increase this percentage with a number of upgrades. The two existing 400 kW generators are currently being upgraded to 1000 kW generators, both with turbocharged engines that will increase generator efficiency by 20%. The plan is to reroute the excess heat given off by the generators back to the anaerobic digesters. This added heat should increase biogas gas available for use in the engine generators by another 25%. Overall, the upgrades should allow the facility to supply 100% of its short-term power needs, and supply 50% of its on-going energy needs – making a significant dent in its fossil fuel energy consumption and making significantly better use of its on-site resources.

For more information contact:
Chet Welle
Rochester Water Reclamation Project
507.281.6190 x 3003
cwelle@ci.rochester.mn.us

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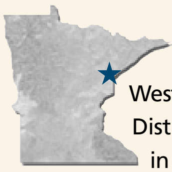
CASE STUDY:

Western Lake Superior Sanitary District[8]



ANOTHER FACILITY that has put its waste to work is the Western Lake Superior Sanitary District wastewater treatment plant in Duluth. In 1999, the Western Lake Superior Sanitary District began a major renovation to install a $32.6 million biosolids anaerobic digestion facility. In July 2001, Western Lake Superior Sanitary District permanently shut down its incinerator and started treating waste in four digesters, each with a million-gallon capacity. The new digesters use a high temperature process (120 to 140° F) to reduce the organic portion of the wastewater to a biosolids product rich in organic matter and nutrients. This biosolids product is used in agricultural and mine land applications. The plant uses a special biogas boiler to provide the heat needed for the digestion process as well as heating for the Biosolids Processing Facility. By using the waste gas without compression or treatment in a dedicated boiler, the District has reduced its costs. Ultimately, the biogas may also provide heat to additional buildings within the treatment plant and power a combustion engine that will generate a portion of electricity used by the Sanitary District.

For more information contact:
Kurt Soderberg, Executive Director
Western Lake Superior Sanitary District
218-722-3336 x. 213

Western Lake Superior Sanitary District wastewater treatment plant in Duluth, MN

Digester controls at a wastewater treatment plant

HELPFUL RESOURCES FOR COMMUNITIES

All web links listed here are available (and updated if necessary) at www.mnproject.org (click on "publications")

Final Report, Updated: Haubenschild Farms Anaerobic Digester. The report, written by Carl Nelson and John Lamb of The Minnesota Project was updated in August 2002 and provides detailed information about the Haubenschild digester project. Contact: Carl Nelson, The Minnesota Project, 651-645-6159 x 5, cnelson@mnproject.org. Along with the report, The Minnesota Project website has a wealth of information on digesters. (www.mnproject.org)

University of Minnesota, Department of Biosystems and Agricultural Engineering have done a lot of work on odor control, as well as having expertise in anaerobic digesters. Contacts: David Schmidt, 612-625-4262, schmi071@umn.edu or Phil Goodrich, 612-625-4215, goodrich@tc.umn.edu. (www.bae.umn.edu)

Handbook of Biogas Utilization, 2nd Edition. Published in July 1996 for the US DOE, Southeastern Regional biomass Energy Program, Tennessee Valley Authority, Muscle Shoals, Alabama.

On-Farm Biogas Production. Written by Robert A. Parsons and published by Northeast Regional Agriculture Engineering Service. Ithaca, New York: 1984.

AgSTAR Handbook. This publication covers several chapters and appendices with pertinent information about how to go about designing and implementing an anaerobic digestion system. (www.epa.gov/agstar/library/handbook.htm)

Industry Directory for On-farm Biogas Recovery Systems. For farmers looking for companies that can build digesters. (www.epa.gov/agstar/library/ind2.pdf)

Agriculture Utilization and Research Institute (AURI) digester website. Contains an analysis of the benefits of using an on-farm digester to treat manure as well as a checklist for farmers to use to decide if it is a viable option. (www.auri.org/research/digester/diglead.htm)