A New Generation of Farm-Based Anaerobic Digesters

Engineers at Michigan State University's Department of Biosystems and Agricultural Engineering are retooling an old technology to become a viable part of odor control, nutrient management, and a sustainable energy system in Michigan.

Steven Safferman and Marianne Triponi

Anaerobic digesters (ADs) have been successfully used to generate energy since 1857.

The first AD was built in a leper colony in India in that year. They first appeared in the United States in the 1970s in response to complaints about odor emanating from a swine farm in Iowa. The energy crisis of the 1970s spurred their growth as an alternative energy source for farms, but the early failure rate for the United States was high — 65 percent and 83 percent for Michigan, as stated in September 1997: "A Report of the Michigan Biomass Energy Program. Farm-Based Anaerobic Digestion in Michigan: History, Current Status and Future Outlook" by Jack L. Rozdilsky, former coordinator of the Michigan Biomass Energy Program.

Despite this initial setback, ADs have steadily increased since AgSTAR's inception in 1994. As of April 2008, there were 114 operational farm-based digesters in the United States, with 10 located in Michigan in various stages of planning and operation (www.epa.gov/agstar/accomplish.html). The reason for their renaissance is their immense potential to provide an environmentally friendly solution to several farm-based problems with one technology. That is why engineers at the Michigan State University's (MSU) Department of Biosystems and Agricultural Engineering (BAE) have made it a priority to ensure that ADs become the cornerstone of a sustainable energy portfolio, an integrated manure management system, are more common in Michigan.

An 800 kW generator at Green Meadows Farms, Inc., ready to produce electricity, runs on biogas produced by the ADs.

ADs are enclosed tanks that decompose manure, food waste, or any organic material in an oxygen-free environment to produce and collect biogas. In the absence of oxygen, decomposing bacteria breaks down fats, proteins, and carbohydrates into biogas, which is 50 to 70 percent methane and 30 to 40 percent carbon dioxide. ADs can help farms produce energy, control odor from livestock, improve air quality, and reduce greenhouse gas emissions. They provide high-value by-products like irrigation water, nitrogen for fertilizer, low-phosphorus manure, and biofibers. Captured biogas can be flared or used to generate heat, hot water, electricity, or natural gas. Both the flaring and use of biogas for energy reduce

Scenic View Dairy Digester, Fennville, Mich.

methane emissions, allowing for the sale of carbon equivalents, which are tradable on the Chicago Climate Exchange. Any facility that processes animal manure, organic chemicals, milk, food, fiber, pharmaceuticals, municipal solid waste, or wastewater has the potential to produce biogas from organic waste matter. Waste streams can also be blended to increase or optimize digester feed stocks and potentially increase methane production.

The first step BAE engineers took to improve the success rate of ADs on Michigan dairy farms was to develop a sand-manure separator. Sand, commonly used for animal bedding in Michigan, mixed with manure and built up in a digester, contributed to Michigan's high, early digester failure rate. The separator also removes and rinses the sand, allowing more flexibility in manure handling and making it available for reuse.

The next step for BAE engineers was to construct a field-scale AD to demonstrate profitable energy production with implications for environmental protection, carbon sequestration, and sustainable agriculture. On June 30, 2005, the Michigan Public Service Commission (MPSC) awarded a $2 million grant to the Michigan State University's Biosystems and Agricutural Engineering Department to construct an anaerobic digester and related innovative manure treatment technologies at Green Meadow Farms, Inc. (Green Meadow Farms is a large dairy operation in Elsie, Mich., that has a unique affiliation with MSU's Department of Veterinary Medicine and is home to the MSU College of Veterinary Medicine Training Center for Dairy Professionals.) This AD system was the first newly constructed digester on a Michigan farm in more than 20 years. The biogas is used to run an 800 kW generator set, which is connected to the grid. A center is currently in development, that will enable researchers to study cutting-edge technologies in a commercial setting as well research projects that rely on AD, such as the production of algae. This center will also facilitate the training of personnel in the operation and maintenance of a digester and associated systems. Consulting engineers, already knowledgeable in the design, construction, and operation of municipal and industrial wastewater treatment systems, will be able to extend their knowledge base to agriculture.

ADs can also help food processors institute protective environmental practices by diverting organic wastes from landfills for the production of green energy. This can protect Michigan's unique, extensive surface water resources and high ground water table. Comprehensive research on many AD-related topics is currently being conducted by BAE engineers to access the feasibility of digesting organic materials in food processing wastewater. The purity and concentration of the organic material could provide economical energy recovery and offset the capital cost of the system and its operation. Ongoing research entails waste blending to optimize feedstocks to maximize the production of commercial-grade methane in ADs. This project is funded by Project GREEEN, an acronym for *Generating Research and Extension to meet Economic and Environmental Needs*. It is Michigan's plant agriculture initiative at Michigan State University and a cooperative effort by plant-based commodities and businesses in cooperation with the Michigan Agricultural Experiment Station, Michigan State University Extension, and the Michigan Department of Agriculture.

As a further measure to ensure the success of ADs, BAE engineers provide biogas potentials assays using anaerobic respirometry. They have developed tools to calculate how much methane can be produced from blending waste organic materials and are developing a GIS mapping tool to locate waste biomass in Michigan to help organizations choose the optimal placement of centralized digesters.

A facility like Scenic View Dairy, a Phase 3 Development in Fennville, Mich., demonstrates what the future of ADs can hold for Michigan. This dairy farm, with approximately 2,200 head of cattle, is the first to combine electricity generation with biogas upgrading to pipeline standards, providing a second option for revenue optimization by selling this energy to local power companies (Michigan Department of Agriculture Anaerobic Digester Case Study, Scenic View Dairy, Fennville, Mich., www.michigan.gov/documents/mda/AD_CaseStudy_221950_7.pdf). Scenic View Dairy has also replaced sand bedding with digested biofibers and utilizes the high-quality methane for on-farm use It is a model of an environmentally safe solution made possible by applying 21st century engineering to an old technology in order to solve complex modern challenges.

ASABE member **Steven Safferman** is associate professor, Department of Biosystems and Agricultural Engineering, Michigan State University, East Lansing, USA; safferma@msu.edu. **Marianne Triponi** is the communications manager in the Department of Biosystems and Agricultural Engineering, Michigan State University.

An anaerobic respirometer is used to provide biogas potential assays.