

# Digester technology works for a smaller herd

*A fixed-film anaerobic digester on this 100-cow dairy controlled manure odors and made better use of field-applied nutrients*

By David Ludington and Stan Weeks

**DAIRY FARMERS ARE COMING UNDER INCREASING PRESSURE** to control the release of contaminants from their farms into air and water. Comprehensive Nutrient Management Plans (CNMP) to protect water quality often prescribe long-term manure storage as a Best Management Practices (BMP). Unfortunately, objectionable odors are produced during storage and released to the atmosphere during the mixing of stored manure and at spreading.

This creates a conflict between BMP for water quality and air contamination by the release of odorous gases and methane gas. Dairies need alternative manure treatment and handling systems to resolve this conflict. One system was tested on a 100-cow dairy near East Jewett in Greene County, N.Y. Farber Farm, in the New York City Watershed, originally operated its digester as a fixed-film digester. It treated separated liquid from a screw-press separator in an anaerobic digester while solids were sold or spread on land low in organic matter.

Although the Farber Farm recently converted to a beef operation, this three-year digester demonstration project yielded findings valuable to other dairies considering anaerobic digestion.

## Findings at Farber Farm

Anaerobic digestion will control odors, reduce pathogens and produce methane for heating the digester and for other purposes such as generating electricity. The owner of Farber Farm was only interested in odor control.



The annual cost for odor control on Farber Farm was \$80 per cow. This included the costs of the anaerobic digester, separator, building and solid spreader. The farm received a \$4,500 credit for better hay yields, \$1,000 in reduced fertilizer purchases and \$10,000 from selling solids.

The fixed-film digester accomplished that goal, allowing Jack and John Verhoeven, the farm's managers, to spread manure on land that was previously "off limits." Without the solids, the digested liquid was much easier to handle, emptying the long-term storage with no prior mixing.

Conventional digesters for treating animal wastes generally have a hydraulic retention time (HRT) of 15 to 21 days. A 21-day HRT means that the digester requires a large and expensive tank to hold 21 days of manure production.

In comparison, a fixed-film digester uses increased surface area in the digester to retain bacteria. This cuts the HRT to as little as two days and reduces the cost of a digester. At Farber Farm corrugated black plastic drain pipe served as the fixed film.

Farber Farm's fixed-film digester was an insulated 16-foot

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For more information, see the case studies at this website: <http://www.manuremanagement.cornell.edu/>

Innovations in Manure Management, a special section prepared by the Cornell Manure Management Program, appears in *Northeast DairyBusiness* two times a year. The mission of the Cornell Manure Management Program is to transfer technology from various manure management systems to farmers and their advisers. Many of these projects are supported by the New York State Energy Research and Development Authority (NYSERDA). NYSERDA's Innovation in Agriculture Program is helping New York's agricultural community to improve energy efficiency and profitability, while meeting environmental challenges. For reprints of Innovations in Manure Management, contact Allison Pelletier 324 Riley-Robb Hall, Cornell University, Ithaca, NY 14853. Phone: (607) 255-0150. E-mail: [akp28@cornell.edu](mailto:akp28@cornell.edu)


 PRO-DAIRY

vertical silo with an inside diameter of 10.5 feet. It was made from four sections of pre-cast concrete, which cost substantially less than poured in-place concrete.

The bottom of the silo was flat with a sump in the center with a sludge withdrawal pipe at the bottom. Although this digester did not have one, vertical digesters should have a conical bottom to facilitate sludge and grit withdrawal, as well as periodic clean-out.

The digester was operated in the 100-degree range from April 2002 to June 2003. The data reported here is for 215 days of steady-state operation.

The digester was fed separated liquid via a grinder pump every 30 minutes. The grinder pump kept the particle length to a quarter-inch or less to prevent clogging of the external heat exchanger used to maintain digester temperature.

The average, weighted HRT was 4.8 days, and the average production of biogas was 24 cubic feet per cow-day with an average methane concentration of 63%. When operating under steady state, the system produced an ample amount of biogas to maintain the 100-degree temperature throughout the winter months.

The following situations arose during operation of the fixed-film digester:

- Scale formed on most of the surfaces inside the digester including the fixed-film. Analysis showed that the scale was calcium carbonate, which the farm managers spread – at a rate of about 150 pounds a day – on the tiestall barn litter alley to improve traction. Calcium carbonate settled out in the heated digester but not in reception pits.

Near the end of 15 months of operation, the HRT may have been close to three days.

- There were several major foaming incidents in the digester during the time it operated. Each incident seemed to be related to a feed ration change, perhaps an increase in the fat content of the total mixed ration. The foam was controlled with an antifoam emulsion containing 5% active silicone, used at a concentration of 75 ppm – or 2 gallons per 1,340 gallon of separated liquid. It cost \$13.60 for each day there was a foam incidence. A water spray worked well without the antifoam that contained siloxanes.

- Biogas production averaged 20 cubic feet per pound of volatile solids “consumed.” In one year the digester produced nearly 739,000 cubic feet of biogas with a heating value of 436 million Btu.

The dairy burned all the biogas in a boiler to produce hot water used to heat the digester. Heat not needed for the digester was transferred outside via a heat-dump radiator. The amount of heat transferred was controlled by adjusting the speed of the fan motor on the heat-dump radiator with a microprocessor and a

variable frequency drive.

### System change

Due to the build-up of scale on the fixed-film, the farm emptied the digester and removed supporting structures and settled solids. Then the digester was restarted and operated as a vertical plug-flow unit for 368 days in the same manner as with fixed-film. Data reported here are averages for 208 days of good working conditions.

- The average number of cows during the operation of the digester in standard – vertical plug-flow – mode was 80, 11 less than with the fixed-film digester. With fewer cows and no volume reduction due to the fixed-film and supporting structure, the average HRT increased to 8 days.

Production of biogas averaged 21 cubic feet per cow-day, about 10% less than with the fixed-film digester, even though the HRT was nearly twice as long. However, the production of biogas was 28 cubic feet per pound of volatile solids “consumed.” The average concentration of methane was 67%. All other param-

eters were similar for both digesters.

- There was a statistically significant reduction in fecal coliform at the 99% confidence level.

- Some of the solids were sold directly from the separator. Its moisture content ranged from 70 to 80%, too high for direct composting. The farm discontinued its efforts to compost the solids.

Farber Farm’s manure handling/treatment system was designed for 100 cows. The total annual cost of the original liquid system, including the long-term concrete storage, pumps and liquid spreader, was estimated at \$370 per cow. Adding the anaerobic digester, separator, building and solid spreader, the projected total annual cost was estimated at \$450 per cow. This includes an annual earning of \$10,000 from selling part of the solids, and an estimated \$4,500 credit for better hay yield, resulting from more timely manure application, and a potential \$1,000 benefit for reduced fertilizer purchases. The total annual cost for odor control on Farber Farm was \$80 per cow. If more separated solids had been sold, the cost of odor control would be less. ■

*A fixed-film digester uses increased surface area in the digester to retain bacteria. This cuts the HRT to as little as two days compared to the 15- to 21-day HRT for a conventional digester. This reduces digester's cost.*

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# A vision for manure-handling will soon be reality

*A planned community digester solves manure handling concerns for small- and midsize-herd dairies and a New York county's water quality concerns*

By Kamyar Zadeh

**JIM HOTALING**, EXECUTIVE DIRECTOR of Cayuga County (N.Y.) Soil and Water Conservation District, looks over the various permits and plans that are launching his vision of the future. A person of imagination and innovation, Hotaling has successfully guided the District through numerous challenges, including maintaining the county's water quality while encouraging additional investment in dairies and other agribusinesses. Today, Cayuga County is one of the nation's largest dairy production areas.

"My dream has been to develop a program that enhances the value of manure and provides the agribusinessman with the tools needed to improve the water quality in the county," Hotaling says. "During a trip to Europe I recognized that my dream could be achieved through the community digester concept used in Denmark, Germany and Austria.

"Until recently it was not practical to build a community digester facility in the U.S.," he adds. "Fortunately, times changed and the District is now able to construct a community digester to demonstrate a better way of managing manure and generating renewable energy."

## The project

The District is currently in the process of constructing a highly advanced bioenergy facility that incorporates the community digester concepts from Europe. Upon completion in the spring or early summer of 2007, it will be the first in the nation to use a proprietary technology from Germany known as the Hydraulic Mix Anaerobic Digester. This digester has no internal moving parts and self-cleans any debris from inside the digester, eliminating the need to enter the digester for maintenance or service.

The hydraulic-mix digester, operated successfully in Europe for many years, has proven to be highly versatile. European installations process manure, food waste, organic waste from slaughter houses and even crops grown especially for the digester.

The digester's flexibility goes beyond processing different feedstocks. It also allows the operator to switch among the various feedstocks as their availability changes.

The hydraulic-mix digester has a proprietary stirring action created by the regulation of the gas pressure in the vessel. As biogas accumulates in the digester vessel, it creates a mild hydraulic pressure that allows the vessel's contents to be stirred by the controlled release of the gas to the storage tank. The stirring action created by the gas release also cleans the vessel of any debris by pushing it to the outside walls and into a discharge chute.

The hydraulic-mix digester technology being used by the District has been licensed from ECO Technology Solutions (ECOTS), a Virginia-based company that has the exclusive technology rights for the United States. The District digester will be first of its type in the United States, according to ECOTS.

The District project will process waste from approximately 1,500 cows and organic waste byproducts from area food processors. The digester and county buildings on the District campus in Auburn, N.Y., will use the 625 kW of electricity and the hot water from the generator. The District will sell excess electricity to the power grid.

The District's bioenergy facility uses a "community digester" approach to solve manure treatment problems for several small-herd to medium-sized dairies that cannot justify the expense of building their own treatment facilities.

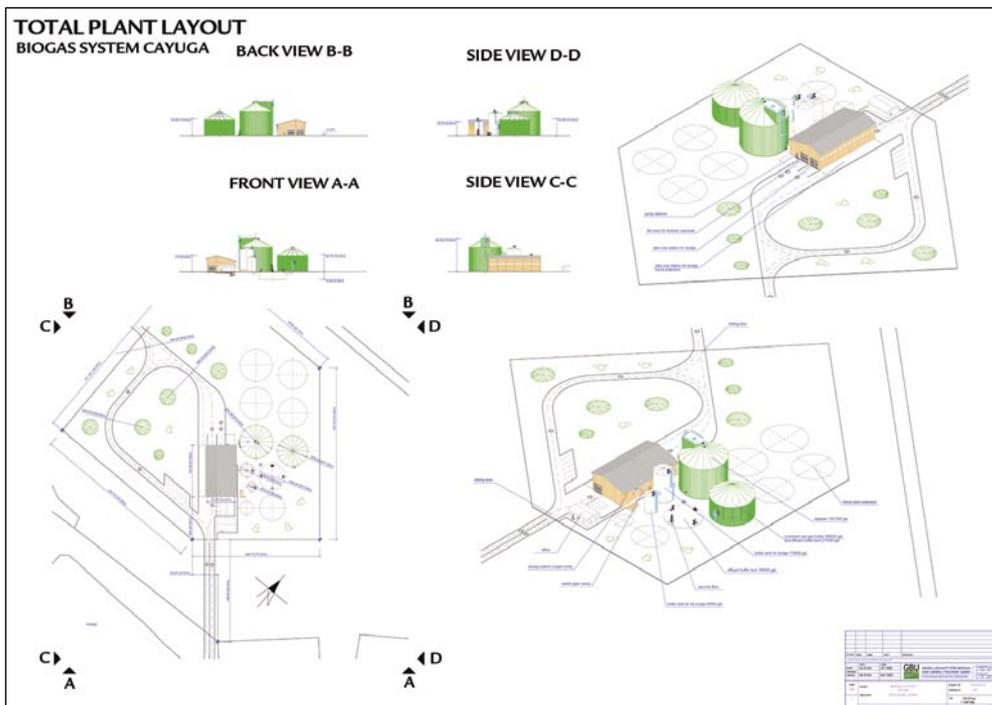
The District will truck manure from the dairies to the bioenergy facility. In return for each truckload of manure, participating dairies will receive a truckload of treated liquid manure from the bioenergy facility. It will replace the nutrients the dairies gave up when they sent their manure to the facility.

The treated liquid manure is a higher quality than raw manure and contains more plant-friendly mineralized nitrogen and a lower phosphorus content. This will help the District to continue to improve the county's water quality.

In addition to the electricity, hot water and treated liquid manure, the bioenergy facility will produce a solid fertilizer. The District will sell it to farmers and others who are currently using chemical fertilizers. Replacing chemical fertilizer with manure-based fertilizer should lessen the overall nutrient loading, further improving the county's water quality.



# INNOVATIONS IN MANURE MANAGEMENT



## More innovations

“The implementation of the community digester concept is only part of the solutions being implemented by the District,” Hotaling says. “We are incorporating additional business solutions that will benefit all the stakeholders involved in the project. These solutions will reduce costs for the farmers and improve the quality of life in the county for everyone.”

Among the District’s plans are these two innovations:

**1.** The construction of satellite storages near cropland that will receive applications of treated manure liquids from the digester. The bioenergy facility will make efficient use of transport trucks by delivering liquids to the storages as the trucks make their rounds to pick up manure for processing.

“The satellite storage facilities will reduce the need for farmers to haul manure liquids from a central point to fields,” Hotaling says. “We anticipate significant transportation savings for the farmer and reduced congestion on the roadways.”

**2.** Mixing compost materials with the solid fertilizer produced by the digester. “This mixture is ideal for the county’s soil stabilization programs, including highway shoulder reseeding and soil erosion control programs,” says Hotaling.

Cost estimates for a project such as Cayuga County’s must be based on many factors, including location, type of business, size, specifications of final products, feedstock and treatment options, and transportation requirements.

The District has completed a six-month study analyzing all of these factors. It shows an estimated cost of \$3.2 million. The facility will produce a net income for the county after it begins commercial operation, according to the analysis. Funding for the project comes from the New York State Energy Research Development Authority (NYSERDA), the U.S. Department of Agriculture (USDA), the Environmental Protection Agency (EPA), and New York State Department of Agriculture and



**Jim Hotaling, executive director of the Cayuga County Soil and Water Conservation District, looks at a diorama of the community digester. It's planned to be operational in 2007.**

Markets. Cayuga County is providing in-kind services.

Cayuga County Soil and Water Conservation District’s pioneering efforts with a community digester and additional business solutions for farms are establishing a new approach to the building and development of manure management and treatment systems. The shared responsibilities, risk and rewards available from community digesters make the concept an ideal solution for many farmers, communities and other stakeholders. ■

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