

# Using food wastes in farm-based anaerobic digesters

*A few U.S. dairy farms with anaerobic digesters have added food wastes to dairy manure for biogas production with generally successful results*

By Norman R. Scott, Jianguo Ma and Brian S. Aldrich

**DAIRY PRODUCERS ARE INCREASINGLY INTERESTED** in mixing food wastes with animal manure as feedstock for anaerobic digesters. Anaerobic digestion (AD) is a biochemical degradation process that converts complex organic materials into biogas in the absence of oxygen. Biogas is composed of methane, carbon dioxide and trace amounts of hydrogen sulfide.

Animal wastes, especially dairy manure, have proven to be ideal feedstocks for anaerobic digesters. Food wastes, mostly generated from food processing and food service, also can be excellent feedstocks for AD. Food wastes typically have high ratios of volatile solids-to-total solids (80–90%), which indicate high energy content. The volatile solids are the fraction of total solids that can potentially be converted into biogas.

As organic matter derived from raw biological materials, food wastes is a category of biomass. They're generated from the following processes:

- Industrial food processing establishments.
- Farm produce that doesn't meet supermarket specifications.
- Discarded and out-of-date foods at supermarkets.
- Foods prepared by restaurants but not served to customers.
- Plate scraps from commercial and residential sources.

## Food wastes add to AD

Animal manure and food wastes have the potential to be converted into useful bioenergy. It's estimated that a methane yield



*Food waste being pumped into the reception pit of an anaerobic digester at Matlink Dairy Farm, Clymer, Chautauqua County, N.Y.*

of about 2.7 to 5.5 ft<sup>3</sup> per pound of total volatile solids of feedstock can be achieved through AD of food wastes. Considering the large amount of food wastes generated, there is a high potential for deriving energy from food wastes using AD.

There are two reasons to add food wastes to farm-based anaerobic digesters:

1. Technical. From a technical perspective, the practice of mixing food wastes with dairy manure in anaerobic digesters has been reported to increase biogas production and, possibly, reduce the hydrogen sulfide concentration in biogas.

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Also see this website: [www.manuremanagement.cornell.edu](http://www.manuremanagement.cornell.edu)

Innovations in Manure Management, a special section prepared by the Cornell Manure Management Program, appears in *Northeast Dairy Business* 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). NYSEDA'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 Kim Gabriel, 324 Riley-Robb Hall, Cornell University, Ithaca, NY 14853. Phone: (607) 255-0150. E-mail: [kmg39@cornell.edu](mailto:kmg39@cornell.edu)


 PRO-DAIRY

Anaerobic digesters treating food waste alone need to be carefully designed and operated to prevent shock loading of the system with such high-energy feedstock. When food waste is mixed with manure in a digester, the manure provides buffering capacity to prevent acidic conditions. The manure also provides a continuing supply of feedstock that keeps the digester microbes healthy when the food waste isn't available. The effluent – both liquid and solid fractions – from the digester can be sold as a byproduct or applied to cropland to recycle the nutrients.

**2. Economic.** The costs of treating and disposing of food wastes can be significant. Dairies that can offer treatment and disposal service at competitive rates can receive significant additional farm revenue from tipping fees.

The average landfill-tipping fee is \$55 per ton in upstate New York, and can be as high as \$125 per ton in New York City. A 500-cow dairy produces approximately 11,000 tons of manure per year. A dairy that size with a suitable digester could treat 3,000 tons of food waste per year, and could receive tipping fee revenues on the order of \$165,000.

### Common questions

Here are three common questions dairies need to have answered when they consider combining food waste with AD.

1. What types of food waste can be added to AD?

For farm-based anaerobic digesters, food wastes that have similar characteristics to dairy manure should be suitable AD feedstock. Some of the key parameters of raw dairy manure and typical percentage concentrations include:

- Moisture content: 88-91%.
- Total solids: 9-12%.
- Volatile solids: 7-9%.
- Chemical oxygen demand: 7.5-15%.

Food wastes from industrial food processors tend to have similar characteristics to dairy manure. They're also available in large quantities and relatively good quality – that is, they have less contamination and a fairly uniform composition.

A few U.S. dairy farms with anaerobic digesters have tried mixing food wastes with dairy manure for biogas production. Successful results have been reported with increased biogas production and better biogas quality. Based on practical experiences and results from comparative studies of co-digestion, the following food wastes seem to be good candidates as feedstocks:

- Cheese whey and dairy processing waste (spoiled yogurt, cheese, butter, ice cream, etc.)
- Vegetable and fruit residues from food processing
- Spoiled grape juice.

2. What is the best percentage of food waste to mix with animal manure?

There are anaerobic digesters in New York State built to process 100% food waste at specific industrial food processing plants. But there is little experience in the state with various manure/food waste ratios. The perception is that it's possible to go as high as 75% food waste. A few New York farms have

experimented with lower percentages. There is a need for better data on the optimum ratios.

The New York State net metering law requires that at least 75% of the feedstock be livestock manure annually to qualify for net metering benefits.

3. Who should consider adding food wastes to AD?

Anaerobic digesters that are designed for processing dairy manure should be able to accept food wastes that are similar to dairy manure in total solids, volatile solids, chemical oxygen demand and moisture. Generally, dairies should consider using food waste if:

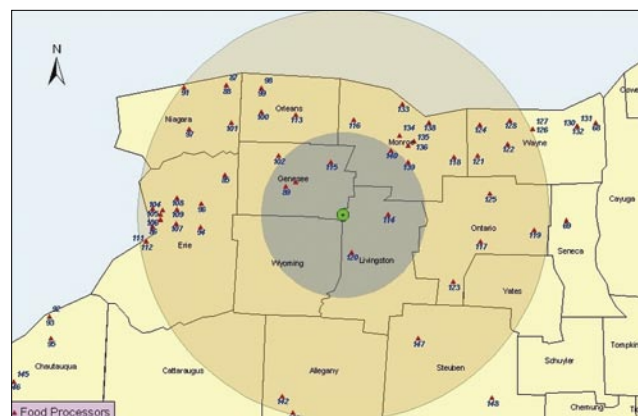
- They have food processing plants or other major food waste generators located within a reasonable distance from them.
- They have adequate technical skills and resources to monitor food waste influent.
- They have necessary resources or contracts to collect and transport food wastes.
- The food waste source is compatible with dairy manure, and the source is stable.

Check with your state's environmental agency for solid waste regulations governing land application of food waste, as these may also apply to food waste co-digested with manure.

### Locating food waste sources

The characteristics of animal manure and food wastes are highly site-specific. It's important to know where potential sources of food waste are located. Research at Cornell is using a geographical information system (GIS) to develop a geo-spatial database to identify and map the locations of major animal manure and food waste generating sources in New York State.

This approach can link dairies with nearby food waste generators. Additionally, we at Cornell are doing research to determine the most appropriate food wastes and the proportion of these wastes to co-digest with manure. x■



Food waste sources within 20 and 50 miles of a farm considering co-digestion of manure and food waste.

The next Innovations in Manure Management appears in the August 2005 issue of Northeast DairyBusiness.

# Financing digesters

*Funding available for dairy manure digesters helps defray a system's high cost*

By David Belcher

**FINANCING CAN BE ONE OF THE HIGHEST HURDLES** dairies face when implementing value-added manure management strategies such as anaerobic digestion. The average digester system cost was \$318,000 in a 2004 study of five systems on New York dairies. The costs of the systems included in the study, conducted by Peter Wright and others, reflected infrastructure, pumps and piping, but not energy generation equipment.

Complete digester-based manure management systems that include infrastructure modifications, mechanical solids separators, digesters, co-generators, composting systems and separated-manure liquid irrigation equipment can easily cost \$1.5 million for dairies with 1,000 cows or more.

The costs must be weighed against advantages. Existing digester technology done on a large scale, for more than 800 cows, can be a value-added process that improves overall farm economics. In particular, digester/co-generator systems can reduce such operating costs as electricity, heat and bedding. And they can increase revenue through electricity sales.

Manure digestion can also have positive environmental effects through such things as odor control. Reduced manure odor can be worth a lot to a dairy, even though the exact value can't be quantified.

Despite a digester's positive economic potential, obtaining capital to implement a digester project remains a challenge. From a lender's viewpoint, there are three essential questions about digesters:

1. How does the project affect overall farm cash flow?
2. How much risk does this venture pose to the farm?
3. Will the additional debt limit the business' ability to maintain/update its present machinery, equipment and buildings?

Some of the perceived difficulties that a digester project poses to lenders include:

- Digesters represent little asset value.
- The capital required for a digester is substantial.
- To date, digester performance has been highly variable. And several projects haven't been successful.

## Financial options

To overcome the financing hurdle and better position a dairy to implement a digester project, producers may want to pursue one or all of the following options:

**1. Technical and financial feasibility study and business planning.** This is a must for any dairy considering the scale of investment required by a digester. In particular, a producer must determine the dairy's environmental and economic goals. Then the owner must evaluate in light of these goals the existing

manure management methods and costs, as well as future digester system performance, costs and value-added opportunities.

The feasibility study or business plan should contain pro-forma financials that show the effects on income, cash and the balance sheet of the digester operation.

There are several tools and programs available to assist in the digester feasibility study/business planning process:

- A partial list of digester designers and nutrient planners that offer digester planning services can be found at the Cornell Manure Management website:

**[www.manuremanagement.cornell.edu](http://www.manuremanagement.cornell.edu)**

- The AgStar Handbook is a manual for developing digester systems. The accompanying prefeasibility software package assists in project cost estimating (Farmware v. 2.0). Find the handbook and software at the Environmental Protection Agency (EPA) AgStar website: **[www.epa.gov/agstar](http://www.epa.gov/agstar)**

- An Excel spreadsheet, available for download, assists in pro-forma financial analysis of a proposed digester system as part of business plan preparation. Find it at Cornell University's Ag Innovation Center website: **[www.bee.cornell.edu/extension/manure/financial\\_analysis\\_model.htm](http://www.bee.cornell.edu/extension/manure/financial_analysis_model.htm)**

**2. Grant funding.** There are several state and federal grant funding programs to assist in implementing digesters:

- A general list of the federal and state programs available for this purpose can be found at:

**[www.epa.gov/agstar/pdf/ag\\_fund\\_doc.pdf](http://www.epa.gov/agstar/pdf/ag_fund_doc.pdf)**

- A list of funding opportunities for New York farms, including assistance from the state's Department of Agriculture and Markets and NYSERDA can be found at: **[www.manuremanagement.cornell.edu/HTMLs/Financial.htm#NYS](http://www.manuremanagement.cornell.edu/HTMLs/Financial.htm#NYS)**

**3. Private or third-party ownership.** The arrangements vary from company to company, however, the basic concept is that a third party contracts with a dairy to finance, design, build and possibly operate a digester. The company, which owns the energy and heat produced from the biogas, sells them. Digested solids may also be separated for making marketable bedding or compost.

With third-party ownership, the producer benefits by not having to invest in the digester, when it's financed completely by the third party. Other benefits include possibly getting a fixed price for energy and heat for a predetermined time period and odor reduction. ■

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*Preliminary Comparison of Five Anaerobic Digestion Systems on Dairy Farms in New York State (ASAE Paper No. 044032, 2004), the study conducted by Peter Wright et al., was presented at the ASAE/CSAE Annual International Meeting, Ottawa, Canada, August 2004.*



# Manure management goes online

*Website is one-stop spot for manure management information and resources*

By Brian S. Aldrich and Curt A. Gooch

ARE YOU LOOKING FOR INFORMATION on manure handling and treatment, including anaerobic digestion and aerobic composting? Would you like to know how these systems are working on Northeast farms? Are you looking for consultants to help you achieve your manure management goals? What about trying to find funding sources for capital projects?

To help farmers find this information and more, the Cornell Manure Management Program has set up the following website with support from the New York State Energy Research and Development Authority (NYSERDA):

[WWW.MANUREMANAGEMENT.CORNELL.EDU](http://WWW.MANUREMANAGEMENT.CORNELL.EDU)

## SO MUCH INFO

Here's an overview of the information you'll find at [www.manuremanagement.cornell.edu](http://www.manuremanagement.cornell.edu):

**Case Studies.** The growing list of case studies describes different types of anaerobic digesters and other treatment systems. Each study contains farm information, system descriptions and diagrams, economic analysis and lessons learned.

**Lessons Learned.** An interactive list of lessons learned from manure treatment systems in New York State allows the website user to view the lessons by topic or by project location. Topics include site considerations, management, solid-liquid separation, environmental issues and more. Learn from the experience of others what has worked and what has not.

**Directory of Manure Professionals.** Are you looking for a consultant to do a feasibility study of manure handling options for your dairy? You can sort this directory by system designers, consultants, construction managers, equipment suppliers and 13 other categories. Find the right person or company.

**Composting Equipment List.** You can search this list, prepared by the Cornell Waste Management Institute, for compost turners, in-vessel systems, mixers, monitors, screeners, size reduction shredders and vermicomposting equipment.

**Fact Sheets.** Want to find out how the net metering of utility electricity applies to on-farm digesters? Are you curious as to when fuel cells powered by biogas may become affordable on dairies? Want to get a look at a draghose manure application system? Fact sheets available on the website cover these topics and others.

**On-line Tools.** Are you considering composting different types of organic wastes with manure? The "Co-Composter" model is available on-line to help you evaluate different systems. The model provides mass and volume balances, as well as a cost analysis based on inputs provided by the user.

Future tools will include a model that calculates the net energy available from anaerobic digestion and a business analy-

sis model for digester financing options. The website will also feature a user-friendly program for nutrient management planners estimating dairy manure production, and key components excreted, based on milk production and dry matter intake.

## Locating resources

**Financial Resources.** Submitting successful funding applications requires starting early and knowing the requirements and deadlines. The Financial Resources page on the website links you to funding opportunities from USDA, NYSERDA and other agencies.

**Technical Resources.** Ever wonder where to find the practice standards used by the USDA Natural Resources Conservation Service (NRCS)? This section of the website links to these standards in the electronic Field Office Technical Guide.

Link to the NRCS Agricultural Waste Management Field Handbook or access the Agricultural Environmental Management (AEM) Planners Directory to find a certified CNMP planner.

**Manure Management page.** Trying to find a laboratory to analyze your manure samples? Or looking for a way to calibrate your box spreader or slurry tanker? Check this page on the website for this information. You'll also find references for the nutrient content of manure and typical values for the daily amount of manure and nutrients a cow produces.

A couple more important areas of information found on the website:

- Chapters in the Livestock and Poultry Environmental Stewardship Curriculum (Midwest Plan Service, 2001) offer lessons on planning, siting, sizing and operating manure storage systems. It's good information if you're thinking of investing in manure storage.

- Links to other websites take you to the EPA AgSTAR homepage where you can find information about biogas production from manure. There are also links to the University of Minnesota's Manure Management and Air Quality site and the Natural Resource, Agriculture and Engineering Service (NRAES). There are publications on agricultural waste management and information about feasibility studies of "community" digesters shared by multiple farms.

## Another option

Not everyone uses the Internet. If you don't, we can mail copies of information to you. Or if you can't find what you want on the website, contact us at the Department of Biological & Environmental Engineering, Cornell University, Ithaca, NY 14853:

- Curt Gooch at (607) 255-2088. E-mail: [cag26@cornell.edu](mailto:cag26@cornell.edu)
- Brian Aldrich at (607) 255-1819. E-mail: [bsa9@cornell.edu](mailto:bsa9@cornell.edu)