Single, Paired, and Aggregated Anaerobic Digester Options for Four Dairy Farms in Perry, New York

Introduction

Anaerobic digestion is a microbiological process that converts organic carbon to a "biogas" composed primarily of methane and carbon dioxide. A growing number of larger-scale dairies are anaerobically digesting manure to reduce odors and produce biogas for heating and/or electricity generation.

The Town of Perry is located in Wyoming County, the largest milk-producing county in New York State. Perry recognized the importance of improving manure waste management practices in the region, and organized a study of the feasibility of collaborative anaerobic digestion among four of the larger neighboring dairy operations in the county. This fact sheet summarizes the report, "Feasibility Study of Anaerobic Digestion Options for Perry, NY" (Draft, 2004). The New York State Energy Research and Development Authority provided partial funding for the feasibility study through their Innovations in Agriculture program.

The four dairy farms involved in the study were Emerling, True, Sunny Knoll, and Dueppengiesser. All of these farms are subject to Concentrated Animal Feeding Operation regulations. The primary goal of each farm was to find a solution to odor problems. Other objectives taken into consideration included reducing the potential for negative impacts on the environment from existing practices, increasing the use of by-products from the breakdown of manure, and increasing the number of industries in Perry by providing local sources of energy and by-products.

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Who Should Consider A System Like This?

1. Farms in need of odor control.
2. Farms where manure can be collected and transported easily.
3. Farms with capital available for initial investment.
4. Farms with technical interest and skills for the system operation and maintenance.
5. Farms with adequate cropland for nutrients.
6. Farms looking to maximize the use of by-products.
7. Farms seeking to reduce the potential for negative environmental impacts.

Who Was Involved In This Study?

To accomplish the project objectives, the Perry Waste Management Committee was established to oversee the project. Stephen Childs of Cornell Cooperative Extension of Wyoming County provided technical management support for the project. Other project collaborators included:

- Town of Castile
- Natural Resources Conservation Service
- Soil and Water Conservation District
- Perry Development Corporation
- Wyoming County Bank

The Town of Perry contracted a number of different organizations to perform various aspects of the study, as shown in Figure 1. The economic analysis was done by Agricultural Consulting Services, Inc. (ACS), and the energy audits were done by Diane Chamberlain. Optimum Utility Systems prepared a report on alternative uses of biogas, and AnAerobics prepared a report on the feasibility of piping biogas to a central location.

The relative locations of the four farms are shown in Table 1, along with animal numbers, manure volumes, estimated biogas generation, and potential power generation.

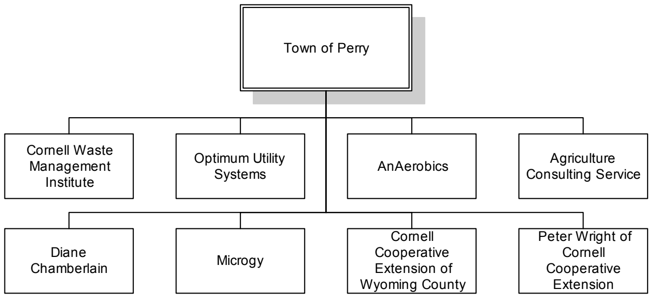

Figure 1. Contract agreements.

Table 1. Farm characteristics.

	Farm			
	Emerling	True	Sunny Knoll	Dueppen-giesser
Distance and direction from Perry	0.5 miles south	0.7 miles south	2 miles north	2 miles north
No. of animals contributing manure*	680	1,050	1,585	1,000
Manure volume (gal./day)	16,700	19,500	28,700	25,500
Estimated biogas production (cu.ft./day)	55,000	77,500	110,000	81,000
Potential power generation (kW)	88	124	177	130

*Animals may include a combination of dairy cows and heifers.

Which Options Were Evaluated?

The initial evaluation included determining the present and projected manure production and current infrastructure for each farm. Surveys were sent to the four farms as well as to other farms in the area to gather opinions on digester ownership, collaboration, and manure transportation (16 surveys were returned). Energy audits of each farm were performed to evaluate natural gas and electricity consumption. Daily biogas production was estimated using the method developed by Lusk (1998). The economic analysis performed by ACS included construction and operating costs, annual benefits, and simple payback in years. The four options considered in this study were:

A. One digester shared by all farms.
B. One digester shared by two nearby farms.
C. One digester on each farm with collaboration in other ways.
D. Collaboration to recruit an independent business to provide digestion services for farms.

The economic analysis of the four options was performed using several basic assumptions. All options assumed $160,000 savings in purchased bedding costs by the four farms using digested separated solids for bedding. It was assumed that energy benefits would only be realized from savings of electric and heating fuel costs at the farms where digesters and their engine generators were located. The basic economic analysis summarized in Table 2 below does not take into account sales of net surplus power to the grid, or the more difficult alternatives of transmitting biogas, power, or heat to other markets.

Table 2. Summary of basic economic analysis.

	Feasible?	Conclusions
A	No	• Long payback period (13 yrs.) • High capital cost ($1,187,000) • High transport cost ($120,000/yr.) • Low energy benefits ($62,000/yr.) • Liability and biosecurity issues
B	Yes	• Reasonable payback period (6 yrs.) • Higher capital cost ($1,518,000) • Lower transport cost ($20,000/yr.) • Higher energy benefits ($125,000/yr.) • Liability and biosecurity issues
C	Yes	• Reasonable payback period (5 yrs.) • Highest capital cost ($1,976,000) • No transport between farms • Highest energy benefits ($250,000/yr.) • Lower liability and biosecurity risks
D	Yes	• No capital costs incurred by farms • No transport between farms • Business builds and operates system • Business markets energy • Farm receives lease payments • Farm manages digester effluent of treated manure and food waste

Results

A centrally located digester (Option A) shared by all four farms was the least feasible option, due to low energy benefits, logistical concerns and high transportation costs. In addition, the survey revealed a clear consensus that sharing digester ownership was least desirable, especially if digester maintenance and supervision was shared among the farms.

Operating one digester shared by two neighboring farms (Option B) was found to be feasible but not without problems. Collaboration issues raised in the study depend on the distance between farms, and between the farms and other businesses or markets for excess energy. Liabilities and further logistical complications also have a significant impact on the bottom line.

For instance, the distance between the Dueppengiesser and Sunny Knoll farms is about 1.5 miles, whereas the True and Emerling farms are only one-tenth of a mile apart. On the other hand, the True and Emerling farms are separated by a state highway, while the other two only cross a municipal highway, the latter posing less liability risk.

Below are the key collaboration issues examined by the study for Option B, where two farms share a single digester:
(1) **Sale of all electricity and heat generated**. Option B would be more feasible if there was a local market for excess heat energy, and if the electricity could be sold back to the grid at a premium (i.e. as green energy) or to some other special market.
(2) **Off-farm sale of all energy by-products including gas, hot water or chilled water.** Installing the equipment necessary to upgrade and transport the energy by-products may be economically feasible. The greatest obstacle for this option is the distance between the farms (generators) and the off-farm markets. Obtaining right-of-ways and crossing permits may be difficult.
(3) **Electricity distributed to farms** would likely provide the greatest cost savings to each farm, since the farms would save more on electricity costs than they would gain from selling it in the current market. The challenge here would be setting up a system to transfer the electricity between two farms, whether through a utility or installing and maintaining a private power line system. This becomes less feasible with increased distance between farms as well as the presence of municipal roads or state highways between locations.
(4) **Gas piped back to farms.** The cost of cleaning, pressurizing, and piping the gas back to the farms from a centrally located digester was not in itself prohibitive; however, as described under point (2), piping the gas runs into serious logistical challenges.
(5) **All post-digestion solids separated and returned to the farms for bedding.** The economic benefits indicate that sharing separated solids for bedding is highly feasible if the biosecurity concerns can be adequately addressed. The annual savings on bedding would potentially free up funds for paying off annual capital costs and for operation and maintenance of the digester.
(6) **Post-digestion solids separated and marketed.** Once biosecurity and end-product quality issues have been addressed, the sale of excess digested solids in specialized market niches could compliment farm revenues.
(7) **Post-digestion solids separated, composted and marketed.** Taking the previous option one step further, composting the solids before sale can reduce viability of weed seeds and pathogen content, and add market value to the solids.
(8) **Recruit partner or outside business to build a new, nearby company to use excess energy or by-products.** The closer the market for by-products, the more revenue the farm is able to generate. The presence of a business adjacent to the farm could reduce logistical problems while providing a secure market and additional revenue to the farms.

Although biosecurity and logistical problems complicate these issues, collaboration between farms should reduce the capital and operating costs the farms would incur as opposed to building and operating digesters separately.

Option C, to construct and operate one digester on each farm, was the most feasible based on cost-effectiveness and energy efficiency. Six key issues for collaboration were considered:

(1) **Joint marketing of electricity.** There may be advantages for the farms to collectively market their electricity. One possibility, which requires more analysis, is for the participating farms to join an existing electric marketing company or cooperative, possibly one specializing in green power or renewable energy.

(2) **Joint marketing of biogas, hot and/or chilled water.** The four farms could collaborate marketing their excess energy, or all of their energy production in the case of opting to not generate power on-site. This option faces a number of challenges. If all the energy from each digester was sold, another source of heat for the digester would be required, likely being more costly to the farm than the income from energy sales. In addition, the costs of installing and maintaining pipelines, and possible pre-treatment equipment for the biogas, hot water, and/or chilled water would be substantial, given the distances between the farms and any potential markets.

(3) **Gas piped to a common cogeneration site.** It was estimated that it would cost a minimum of $230,000 for the five miles of gas pipe required to connect the four farms. Adding this cost to the difficulties of locating a route (negotiating highways, right-of-ways and other obstacles) led to the conclusion that gas piping was not viable for these farms.

(4) **Joint composting and marketing of separated solids.** Each farm could bring their digested solids to a central location for composting, processing and packaging. The farms would then work together to market their final product for bedding or other uses.

(5) **Joint digester design, construction, management and maintenance.** If all four farms could agree on a similar digester design, construction costs were estimated to be lowered by $70,000 per farm. A common design would facilitate the hiring of a single technician to maintain the digesters.

(6) **Recruit partner or outside business to build a new, nearby company to use excess energy or by-products.** The main challenge would be to find a business with compatible energy needs and site acceptance. Zoning laws may also need to be addressed for the collocation of agricultural and commercial businesses. This line of thought could lead to a new model for business development in Perry.

The final option (D), to collaborate or recruit an independent business to provide digestion services for each of the farms, was evaluated in detail by Microgy Cogeneration Systems, Inc.. Microgy proposed to significantly increase gas production by mixing food processing waste with dairy in the digesters, and to market electricity as green power through an energy service corporation. Based on its plans and assumptions, Microgy determined that privately financing, constructing and operating a digester on each farm would be economically, technically and environmentally feasible. Similar to the other options, the private company would generate by-products from the digested manure and food waste for return back to the farms.

Summary

The initial idea of having a single, collaborative digester (Option A) turned out to have limited reliable energy benefits, the highest transportation costs, the most complicated logistical issues, and was not found to be feasible. Option B, having two farms share one digester, was found to be possible, but not without hurdles related to moving materials between the farms. Option C, having one digester on each of the four farms with collaboration in other ways, was found to be the most economically and logistically feasible option at this time. Option D, an outside company owning and managing separate digesters on each farm, was also reported to be feasible according to the study done by Microgy.

Lessons Learned

The findings of this feasibility study will be useful for groups of dairy farms looking for ways to work together to solve their manure management problems. The following factors need to be considered:

1. While there are certain cost savings and economies of scale to be gained by sharing a centrally located digester, there also can be serious logistical issues if the system involves running powerlines and gas pipelines between farms.
2. There are limits to how far manure can be cost-effectively hauled from farms to a central digester, and there are biosecurity issues related to bringing centrally digested manure back to the farms, or selling it to other farms for bedding.
3. The potential markets for energy and separated solids need to be carefully researched.
4. Equipment options also need to be thoroughly investigated.
5. Applicable state and local laws and ordinances need to be considered, such as those covering state roads and zoning.

6. Working together and sharing resources requires a high level of management and high degrees of cooperation, communication and coordination between farms.
7. Consultants can help with all of these questions and decisions.
8. Alternatively, farms can elect to negotiate with companies that specialize in waste management to operate a digester on their premises.

References

The results of this feasibility study were based on a number of assumptions described more fully in the complete document, which may be found on the website of Cornell Cooperative Extension of Wyoming County at: www.cce.cornell.edu/wyoming/Anaerobic%20Digestion/anaerobic_digestion.htm . This webpage also has several other reports related to the feasibility study, including:

1. Chapman, Dana C. Undated. Anaerobic Digestion Options for Perry, NY. Agricultural Consulting Services, Inc., Rochester, NY.

2. Lusk, Philip D. 1998. Methane recovery from animal manures: The current opportunities casebook. U.S. Dept. of Energy, Washington, DC.

3. Smears, Darrell T. 2001. Biogas Applications for Large Dairy Operations: Alternatives to Conventional Engine-Generators. Optimum Utility Systems, Langhorne, PA.

Further Information

For further information about centralized anaerobic digestion, see the other fact sheets in this series:

Bothi, K.L., and B.S. Aldrich. 2005. Centralized anaerobic digestion options for groups of dairy farms. Fact Sheet FS-1. Dept. of Biological and Environmental Engineering, Cornell University, Ithaca, NY. http://www.manuremanagement.cornell.edu/HTMLs/FactSheets.htm

Bothi, K.L., and B.S. Aldrich. 2005. Feasibility study of a central anaerobic digester for ten dairy farms in Salem, NY. Fact Sheet FS-3. Dept. of Biological and Environmental Engineering, Cornell University, Ithaca, NY. http://www.manuremanagement.cornell.edu/HTMLs/FactSheets.htm

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