Feasibility Study of a Central Anaerobic Digester for Ten Dairy Farms in Salem, NY

Introduction

Anaerobic digestion is a microbial process that converts organic carbon to a "biogas" composed primarily of methane and carbon dioxide. Concerns of odor control, nutrient loading, and contaminated storm water runoff continue to mount for dairy farm operators. A growing number of larger-scale dairies are using anaerobic digestion of manure to reduce odors and produce biogas to be used as a fuel for heating and/or electricity generation. The construction of centralized digesters offers a number of advantages for some farms not able to independently construct and operate an anaerobic digestion system. In addition, digested separated manure solids can be used for a compost enterprise or perhaps as stall bedding.

The Salem Dairy Farmer Manure Group contracted with Stearns & Wheler, LLC, and Dr. Stanley A. Weeks to conduct a feasibility study of constructing a centralized anaerobic digester to cost-effectively treat the manure from ten dairy operations. This fact sheet summarizes their report, "Treatment Feasibility Study, Salem Dairy Farmer Manure Group, Salem, NY" (March 2004). The New York State Energy Research and Development Authority provided partial funding for this study through its Innovations in Agriculture program.

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Who Should Consider A System Like This?

1. Farms in need of odor control.
2. Farms where manure can be easily collected and delivered to a central location.
3. Farms with capital available for initial investment.
4. Farms desiring to have a third party operate and manage a digester.
5. Farms with adequate cropland to meet the requirements of a nutrient management plan.
6. Farms desiring more flexibility in the timing and location of field applications of manure with respect to odors and runoff.
7. Farms that understand the risks to herd health involved with pooling manure from multiple sources.

Who Was Involved In This Study?

Ten local dairy farms in the vicinity of the town of Salem, Washington County, ranging in herd size from 125-840 cows, formed the Salem Dairy Farmer Manure Group. The 10 farms have a total of about 3,700 cows, producing approximately 74,000 gallons of liquid manure per day, and are located from one to nine miles from the proposed site for a centralized treatment facility. The Salem Dairy Farmer Manure Group contracted with Stearns and Wheler, LLC and Dr. Stanley A. Weeks to do the feasibility study. Stearns and Wheler is an environmental engineering firm based in Cazenovia, NY. Dr. Weeks is an independent farm waste treatment consultant based in eastern New York. First Pioneer Farm Credit contributed the economic component of the study in a companion report, "Farm Management Report for Salem Digester Group: Feasibility Study on the Economics of Waste Treatment Facility", prepared by William H. Zweigbaum (September 2003).

Why A Central Digester?

Anaerobic digestion requires a large capital expenditure that exceeds the financial means of many farms. Operating and maintaining a digester also adds another job to do on the farm. A central digester allows multiple farms to share the cost of the system. A central digester operated by a private firm would relieve producers of the responsibility of running and maintaining the digester.

The purpose of this study was to specifically determine the feasibility of constructing and operating a centrally located anaerobic digestion facility to treat the dairy manure wastes collected from 10 nearby farms. Although the results from this report are specific to conditions identified by the Salem Dairy Farmer Manure Group, the process used to evaluate waste treatment options, and the information gained, can be applied to similar projects.

The specific goals of the Salem Group and the main issues associated with these goals are identified below:

- **Reduce odors** from current waste management practices, particularly when spreading manure on cropland. This is important to maintain good relations with neighbors.
- **Reduce ground and surface water contamination** from manure spreading. Surface runoff containing high concentrations of nutrients, such as nitrogen and phosphorus, can affect receiving water body quality. In addition, high amounts of fecal coliform entering surface waters and aquifers pose health risks to animals and humans.
- **Meet pending CAFO regulations** for spreading manure on cropland. Concentrated Animal Feeding Operation regulations require that producers must apply nitrogen and phosphorous according to a Comprehensive Nutrient Management Plan (CNMP). The farm's CNMP may limit the amount of manure it can spread on its cropland.
- **Produce electricity** to be sold to an adjacent feed mill with an average daily use of 2,200 kWh.
- **Produce bedding** from composted manure solids. Beddings used on all farms would have to be compatible with the system. Two of the ten farms use sand for bedding, which can not be completely separated from manure and presents problems for anaerobic digesters. These farms would probably have to switch to organic bedding if they chose to send manure to the centralized site.
- **Provide economies of scale** in the construction of treatment facilities, and provide independent, professional operation and management to relieve the producers of these responsibilities.

Which Treatment Systems Were Evaluated?

The three alternative treatment systems evaluated in the study are described below. Raw manure from the milking cows would be trucked to the central facility. (Youngstock manure would stay on the farms.) In all three cases, the solids would be separated at the central location prior to digestion. Alternatives A and B include composting on-site with rotary drums, while in Alternative C, the separated solids would be trucked off site. Alternative B includes centrifuging.

Alternative A: Separation, Digestion and Composting. Separation of manure solids prior to digestion, followed by digestion of separated liquids in a complete mix digester. Some of the separated solids would be composted for use as bedding with a rotary drum composter, followed by curing in a covered building.

Alternative B: Separation, Centrifuge, Digestion and Composting. Alternative B is the same as Alternative A with the addition of a centrifuge process to remove additional solids and nutrients prior to digestion.

Alternative C: Separation and Digestion, No Composting. Solids separation and digestion, with no on-site composting. The separated solids would be trucked back to the farms for application to cropland, composting or sale.

Which Options Were Considered for Effluent Utilization?

The quantity and characteristics of the effluents produced from each alternative were also evaluated. The effluents included liquid wastes after digestion, solids collected after separation and after composting, as well as the biogas produced from anaerobic digestion. Five options were considered for utilization of the digested liquid effluent:

Option 1 – Municipal Wastewater Treatment Plant: Liquid effluents would be trucked daily for disposal at a municipal wastewater treatment plant. On-site effluent storage for five days would be provided.

Option 2 – On-Site and On-Farm Short-Term Storage: Liquid effluent would be trucked to the source farms for immediate land application or further storage. Some of the farms would need to construct short-term earthen storage for the treated effluent, so that it could be applied to cropland under optimum field conditions. The treatment facility would have storage capacity for three months of effluent.

Option 3 – On-Site Long-Term Storage: Liquid effluent would be trucked to the source farms for direct land application. On-site storage at the central facility would hold six months of effluent, so that land spreading could occur at optimum times. No temporary storage would need to be constructed at the individual farms.

Option 4 – On-Farm Long-Term Storage: The liquid effluent would either be trucked to remote storage(s), or immediately trucked to the farms for direct application to cropland during the growing season. Only five days storage would be provided at the central facility, since the liquid effluent would be moved off-site at least five days per week.

Option 5 – Piped to On-farm Long-Term Storage: On a daily basis, liquid effluent would be pumped through a main to a remote storage (with six-month capacity) for later application to cropland. There would be on-site storage for just two days capacity, since effluent would be pumped off-site each day.

The five options are summarized in Table 1 below.

Table 1. Five options for storage, transport and utilization of digested liquid effluent.

Option	Effluent Storage Capacity			Fate of Effluent	
	Central Facility	On Farms			
		Single Lined Earthen Storage	One or More Lined Earthen Storages	How Transported	Destination
1	5 days		None	Trucked daily	Municipal wastewater treatment plant
2	3 months		Short-term	Trucked periodically	Return to farms for storage, or direct land application during appropriate seasons
3	6 months		None	Trucked seasonally	Return to farms for direct land application
4	5 days		Long-term	Trucked daily	Return to farms for storage, or direct land application during appropriate seasons
5	2 days	6 months		Pumped daily	Pipe to one farm for storage, then truck to other farms for land application during appropriate seasons

Mass Balance and Energy Results

The recommended treatment system was a mesophilic, mixed digester, with the manure solids separated prior to digestion, since energy production was not a primary goal. Diverting the separated solids from the digester would reduce biogas and energy production by 30%, make more solids available for bedding, and could improve mixing and operation of the digester. A screw-press separator would remove approximately 20% of the manure volume, producing approximately 175 cubic yards per day of separated solids with a moisture content of 70 – 75%. Only half of the separated solids would be needed to compost for bedding for the member farms. The remaining 50% could be:

1. applied to cropland,
2. sold to landscapers,
3. composted and sold as a soil amendment, or
4. composted and sold for bedding to non-member farms.

A rotary drum composter would be used to treat the separated solids, since available information indicates it can reduce pathogens with more quality control compared to aerated static piles or windrow composting. To further reduce the moisture in the composted material below 60%, secondary maturation piles would hold the compost for approximately one week longer under cover. Under Alternative A, this treatment process would produce approximately 100 cubic yards per day of compost ready for use as bedding.

If the separated solids were centrifuged (Alternative B), approximately 50% of the solids could be removed prior to digestion, and compost production would increase to 160 cubic yards per day. Centrifuging would also result in 40% less land required for application of the treated effluent.

The average daily electricity consumption at the feed mill is 2,200 kWh, and the manure processing facility has an estimated parasitic power requirement of 2,200 kWh/day. Alternatives A and C would produce 6,600 kWh/day, while Alternative B would only produce 5,000 kWh/day, due to the additional solids removed by centrifugation. Thus there would be electricity leftover for other uses after meeting the demands of the mill and the manure treatment systems. At peak-demand times, however, the mill would still need power from the utility.

Economic Analysis Results

At the time of the study, it was not economically feasible to implement any of the options evaluated, due in part to the relatively low price the utility would pay for the electricity generated. (The study assumed that the facility would not qualify for net metering, because it would be located at the feed mill, not on a farm.) Some of the capital and annual costs for each combination of the three treatment alternatives and the five effluent disposal options are shown in Table 2. The treatment plant capital cost estimates do not include the land cost and utility/interconnection cost which may be associated with construction. The degree of plant automation and instrumentation, which would affect electrical cost, was also not included in the analysis.

Alternative B had the highest treatment plant capital costs ($3,380,910), due to the centrifuge equipment. Alternative A capital costs, without centrifuging, were somewhat lower, at $3,170,310. Alternative C, without centrifuging or on-site composting, had the lowest capital costs of $2,105,610. These results suggest it might actually be less expensive to dispose of the separated solids off-site rather than compost them with the system evaluated in this study (rotary drums with maturation in a building).

For all options, trucking costs were a significant component of the total annual cost. The overall one-way trucking costs averaged out to 1.4 cents per gallon, which included loading, travel and unloading. The cost of two-way hauling, which includes back-hauling treated effluent to the remote earthen storages, was estimated at 1.8 cents per gallon. Spreading the treated effluent on cropland was estimated to cost an additional 1.4 cents per gallon.

The lowest net annual cost per cow was $282 for Alternative C/Option 5 (no centrifuge, no composting, liquids pumped to an off-site six-month storage). Centrifuging, composting, and trucking the liquids to a municipal wastewater treatment plant resulted in the highest cost per cow of $560 (Alternative B/Option 1). For all three treatment systems, trucking the liquids to the municipal plant (Option 1) had the highest net annual cost per cow ($511 - $560), due mainly to an annual tipping fee of $1,100,000 (based on 5 cents per gallon). The remaining Options 2- 5 did not differ greatly in cost per cow, ranging from $282 to $343 (total net annual costs $1,039,836 to $1,264,768).

Table 2. Selected capital and selected annual costs for three manure treatment alternatives and five liquid effluent storage and transport options. (Net annual cost/cow is the sum of the annual capital costs and the annual operating and maintenance costs.) (Adapted from poster prepared by Aaron Gabriel for NYSERDA's 5th Annual Innovations in Agriculture Conference, January 2004, Syracuse, New York.)

Effluent Option	**Alternative A** Separation, Digestion & Composting	**Alternative B** Separation, Centrifuge, Digestion & Composting	**Alternative C** Separation & Digestion, No Composting
1 Storage on-site 5 days; municipal treatment	Treatment Plant Capital Cost $3,170,310 Effluent Lagoon Capital Cost $75,000 Raw Manure Trucking $384,345 Effluent Trucking $220,000 Tipping Fee $1,100,000 **Net Annual Cost/Cow $511**	Treatment Plant Capital Cost $3,380,910 Effluent Lagoon Capital Cost $75,000 Raw Manure Trucking $384,345 Effluent Trucking $220,000 Tipping Fee $1,100,000 **Net Annual Cost/Cow $560**	Treatment Plant Capital Cost $2,105,610 Effluent Lagoon Capital Cost $75,000 Raw Manure Trucking $384,345 Effluent Trucking $220,000 Tipping Fee $1,100,000 **Net Annual Cost/Cow $518**
2 Storage on-site 3 months, and on-farm	Treatment Plant Capital Cost $3,170,310 Effluent Lagoons Capital Cost $1,320,000 Two way Manure Hauling $490,560 Spreading Cost $384,345 **Net Annual Cost/Cow $332**	Treatment Plant Capital Cost $3,380,910 Effluent Lagoons Capital Cost $1,320,000 Two way Manure Hauling $490,560 Spreading Cost $384,345 **Net Annual Cost/Cow $343**	Treatment Plant Capital Cost $2,105,610 Effluent Lagoons Capital Cost $1,320,000 Two way Manure Hauling $490,560 Spreading Cost $384,345 **Net Annual Cost/Cow $326**
3 Storage on-site 6 months	Treatment Plant Capital Cost $3,170,310 Effluent Lagoon Capital Cost $200,000 Two way Manure Hauling $490,560 Spreading Cost $384,345 **Net Annual Cost/Cow $303**	Treatment Plant Capital Cost $3,380,910 Effluent Lagoon Capital Cost $200,000 Two way Manure Hauling $490,560 Spreading Cost $384,345 **Net Annual Cost/Cow $314**	Treatment Plant Capital Cost $2,105,610 Effluent Lagoon Capital Cost $200,000 Two way Manure Hauling $490,560 Spreading Cost $384,345 **Net Annual Cost/Cow $297**
4 Storage on-site 5 days, off-site 6 months	Treatment Plant Capital Cost $3,170,310 Effluent Lagoons Capital Cost $275,000 Two way Manure Hauling $490,560 Spreading Cost $384,345 **Net Annual Cost/Cow $305**	Treatment Plant Capital Cost $3,380,910 Effluent Lagoons Capital Cost $275,000 Two way Manure Hauling $490,560 Spreading Cost $384,345 **Net Annual Cost/Cow $316**	Treatment Plant Capital Cost $2,105,610 Effluent Lagoons Capital Cost $275,000 Two way Manure Hauling $490,560 Spreading Cost $384,345 **Net Annual Cost/Cow $299**
5 Pumped off-site to 6-month storage	Treatment Plant Capital Cost $3,170,310 Pump & Lagoons Capital Cost $625,000 One-way Manure Trucking $384,345 Spreading Cost $384,345 **Net Annual Cost/Cow $288**	Treatment Plant Capital Cost $3,380,910 Pump & Lagoons Capital Cost $625,000 One-way Manure Trucking $384,345 Spreading Cost $384,345 **Net Annual Cost/Cow $300**	Treatment Plant Capital Cost $2,105,610 Pump & Lagoons Capital Cost $625,000 One-way Manure Trucking $384,345 Spreading Cost $384,345 **Net Annual Cost/Cow $282**

Assumptions:
Based on 3,685 cows (not including youngstock). Capital Recovery Factor = .0959
Annualization based on 5% interest for 15 years. Annual treatment cost based on 5% of capital cost of treatment plant.
Value of bedding based on $6/cubic yard, 50% of solids composted to bedding.
Trucking costs to municipal wastewater treatment plant based on 30 miles, $2/loaded mile.
Electricity sales figures based on 5 cents/kWh plus 1 cent green attribute.
Net annual cost/cow takes into account value of bedding and electricity sales.

Environmental Permits

If the facility was not constructed on a farm, it might not qualify for agricultural exemptions from environmental regulations. The following permits might be required:

1. Air discharge permit for the biogas boilers and the engine generator set.
2. Water discharge permit, if the New York State Dept. of Environmental Conservation (NYSDEC) ruled that stormwater runoff from the treatment facility is regulated under the State Pollutant Discharge Elimination System general permit (which would require monitoring and reporting).
3. Solid waste discharge permit for processing the separated manure solids (NYSDEC Part 360).

An application would need to be filed for approval under the State Environmental Quality Review Act, which regulates whether or not an environmental impact statement is necessary.

Odors

Odors generated during transportation of manure and possibly from composting would still remain. Odors from the composting building could be mitigated with aerobic biofilters. Odors from the receiving pit could be controlled by enclosing the pit and directing the gases to the biofilters.

Conclusions

1. Technologies for anaerobic digestion and solids separation are available; however, the construction of a central digester is not economically feasible for the Salem Dairy Farmer Manure Group at this time.
2. Trucking costs were a significant component of the total annual cost for all options.
3. Economic feasibility could be improved by finding additional use for the excess energy available. The potential energy generation is currently beyond the feed mill's electrical needs.
4. Further negotiation with the local power utility would be required for the sale of excess electricity at a more attractive rate.
5. Additional grants and funding opportunities might improve the economic feasibility.
6. In some situations, off-site disposal of separated manure solids might be less expensive than composting the material for bedding.

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. Single, paired, and aggregated anaerobic digester options for four dairy farms in Perry, New York. Fact Sheet FS-2. Dept. of Biological and Environmental Engineering, Cornell University, Ithaca, NY. http://www.manuremanagement.cornell.edu/HTMLs/FactSheets.htm

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