Cooperative Anaerobic Digestion as a Manure Management Alternative in Northeastern Wisconsin

A Research Study Summary

9/5/03

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Is it possible?

What are some factors to consider?

A Research Study Summary

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This summary is based on a thesis report written by Kristin Kubsch as part of the requirements a M.S. degree at the University of Wisconsin-Green Bay. The complete report is available for check out at the UWGB Library If you would like more information please contact:

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Environmental concern regarding dairy farm manure management has grown considerably in Wisconsin over the last few years. As more and more dairy farms expand, these environmental concerns become more apparent as the increased manure quantities contribute to the potential for groundwater and surface water contamination, air pollution, and farm odors.

Plug Flow Anaerobic Digester
Source: Environmental Protection Agency

Traditional manure management techniques (i.e., field application and on-site or off-site storage basins and lagoons) are responsible for many of the environmental concerns and can lead to operational inefficiencies that contribute to the economic hardships faced by many farmers. It has been noted that dairy farming, when compared to other types of farming, requires the highest level of initial investment and as a result has the highest level of indebtedness in the farming industry. Overall, 11.3% of Wisconsin dairy farmers reported significant debt levels (40% or greater) raising concerns with many farm economists (Wisconsin Dairy Task Force [WDTF] 1995).

Anaerobic digestion, or the process of converting dairy manure under anaerobic conditions to methane and useful byproducts, is an alternative to traditional manure management. When using a fully engineered system, anaerobic digestion provides pollution prevention, allows for sustainable energy generation, and offers the potential for nutrient and water recovery. A successful anaerobic digestion plant can turn a waste problem into a financially beneficial process. There are a number of environmental, social, economic and political benefits of anaerobic digestion and biogas production (Focus on Energy [FOE] 2003).

The Biochemical Process of Anaerobic Digestion

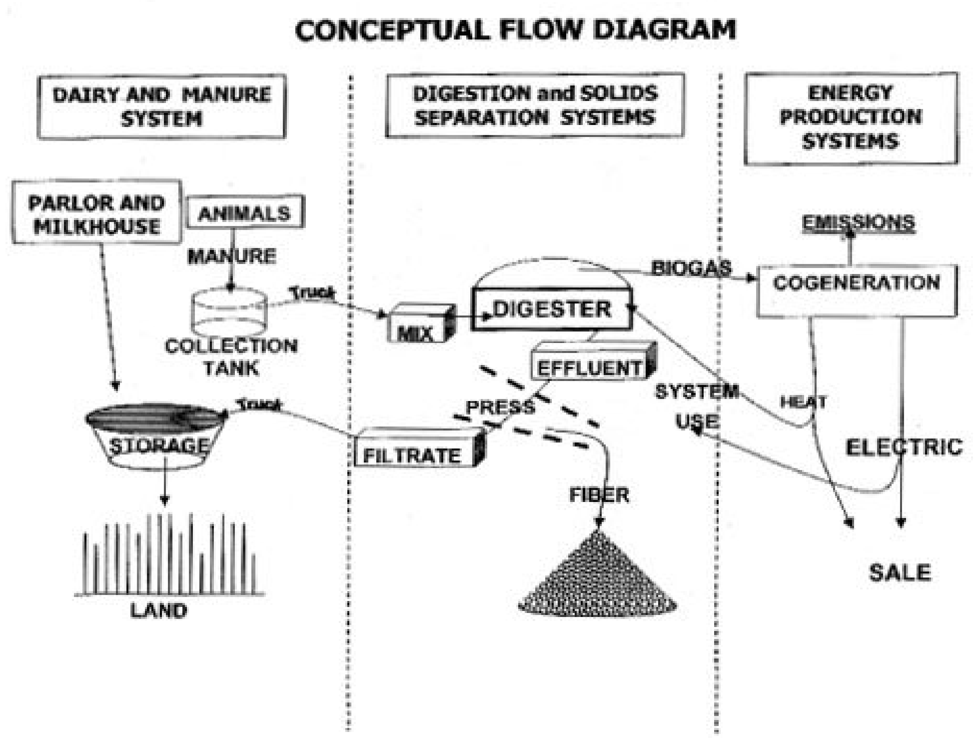
Anaerobic digestion is defined as a controlled decomposition of organic waste in an oxygen-free environment. The decomposition relies on specific types of bacteria (hydrolytic and fermentive) that digest the waste. These bacteria successively break down the organic matter to methane (CH4), carbon dioxide (CO2), and trace gases. Proper liquefaction or fermentation of manure requires a two-stage bacterial reaction in the presence of necessary enzymes, and suitable environmental conditions. In the first stage, manure must be degraded by transitional or acid-forming bacteria. The second stage, methanogenisis, occurs when methane-forming bacteria convert acetate (hydrogen and carbon dioxide) into biogas (primarily methane and carbon dioxide) (Council of Great Lakes Governors [CGLG] 1995).

Once collected, biogas can be utilized in a variety of ways. Recovered biogas is generally 60%-80% methane with a heating value of 600-800 Btu/ft3 (USEPA 1997). Biogas has been used to generate electricity and as fuel for boilers, space heaters, and refrigeration equipment, lighting, and cooking. Heat is also generated in the electrical production process which is typically used to heat the digester to maintain the optimum temperature for anaerobic digestion to occur (Yoshitani 2003).

Cooperative Anaerobic Digestion

Typically, anaerobic digestion facilities are constructed on individual dairy farms and operated with a family or single business arrangement. Cooperative anaerobic digestion (CAD) allows for shared input, responsibilities, and costs for farmers. Anaerobic digestion of dairy manure by a cooperative of farms has the potential to maximize farm resources so farmers can reduce costs, remain competitive and environmentally sustainable in today’s livestock industry.

Due to the large number and often close proximity of dairy farms within Wisconsin, a CAD facility could prove to be a viable manure management option. A conceptual flow diagram demonstrating the CAD process is displayed in the following diagram:



Conceptual Flow Chart of a Cooperative Anaerobic Digestion Facility
Source: Port of Tillamook Bay, 2003

The CAD process begins when manure is collected in a collection tank at each individual dairy farm. Second, the manure is transported (via truck or pipeline) to a centrally located digester. Third, biogas is collected from the digester and used to fuel a generator to produce electricity. Finally, the effluent collected from the digester is processed into useful byproducts (fertilizer, animal bedding, potting soil, and others). These byproducts can be used by the farm or sold to the local market.

Study Results

To determine if a CAD facility would be a possible manure management alternative for northeastern Wisconsin, a feasibility study was conducted within a nine county study area. To obtain information, 250 farmers located in Brown, Door, Calumet, Manitowoc, Sheboygan, Fond du Lac, Outagamie, Kewaunee, and Winnebago counties were randomly selected and invited to participate in the study.

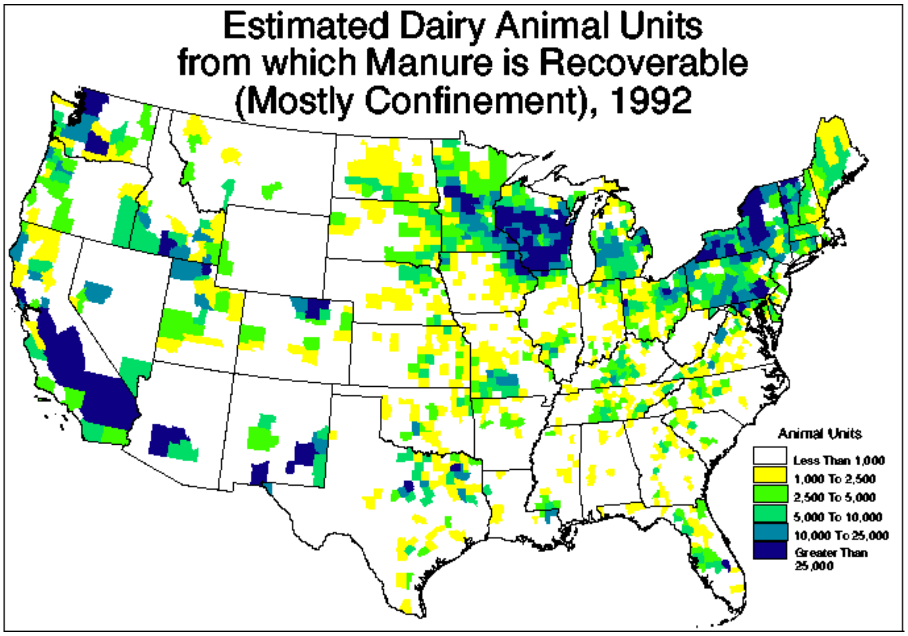
This research project addressed the following questions:

1. What is the total amount of manure produced by dairy cows in the nine county study area?
2. Is construction and operation of a CAD facility cost-effective for farmers?
3. To what level are dairy farmers in northeastern Wisconsin motivated to participate in a CAD? What factors may affect their level of motivation?

Manure Resource

In order for an anaerobic digester to operate properly a constant supply of "recoverable" manure is needed. Not all types of dairy manure are appropriate for anaerobic digestion purposes. Manure collected through a continuous scrape or other means from cows on cows kept on hard surfaces is better suited for use in an anaerobic digester. Manure which is left to dry in the pasture or drylot is not as useful for anaerobic digestion since drying reduces the methane producing properties. Also, hauling manure with a tractor to a digester from pasturelands is not considered to be economically advantageous (Richard Vetter, personal communication, March 2003).

According to the Department of Agriculture, most of the land are in northeastern Wisconsin has greater than 25,000 animal units producing recoverable manure. This can be observed in the map below:



Estimated Dairy Animal Units from which Manure is Recoverable
(Mostly Confinement) Source: USDA 2002

Manure Production Factors utilized in nutrient management planning were also used to calculate the approximate amount of manure produced within the nine northeastern Wisconsin counties. Estimations revealed that approximately 316,995,200 gallons of manure are produced annually by milking herds in the study area.

Economic Considerations

Economics are important to consider when determining the level of success a CAD facility in northeastern Wisconsin will have. Although costs are shared among participants, a

CAD is still a considerable financial investment for those involved. A cost-benefit analysis was conducted to determine the economic feasibility. The economic forecasting model known as the net present value method (NPV) was conducted to estimate the economic feasibility of a hypothetical medium-sized CAD facility. The estimated costs and benefits used in the analysis were obtained from local contractors, anaerobic digestion researchers, and university professors. Three different interest rates (2%, 5% and 10%) were tested in order to determine a “critical rate”. The critical rate is the “critical” rate of interest where the NPV value calculated is greater then zero, indicating an economically worthwhile project.

Cost-benefit analysis was also conducted with the inclusion of digested byproduct sales and the use of a government tax incentive. Digested byproducts such as fertilizer and potting soil were calculated to be produced a both low (5,000 yd^3/year) and high (10,000 yd^3/year) production levels. For both levels of production, the digested fibers were estimated to be sold for \$19/yd^3. When utilizing the extra benefits obtained through digested byproduct sales (for both high and low levels of production), positive NPV rates were observed indicating an economically worthwhile project.

The Renewable Energy Production Credit (REPC)*, the government tax incentive included in the analysis, provides \$0.015/kWh for electricity produced for the first ten years of CAD operation. When utilizing the REPC tax incentive a positive NPV value was reached indicating an economically worthwhile project. The following table reveals the NPV values for a 4,000 cow hypothetical CAD facility utilizing 2%, 5%, 10% interest rates, high and low digested byproduct sales, and the application of the REPC tax incentive.

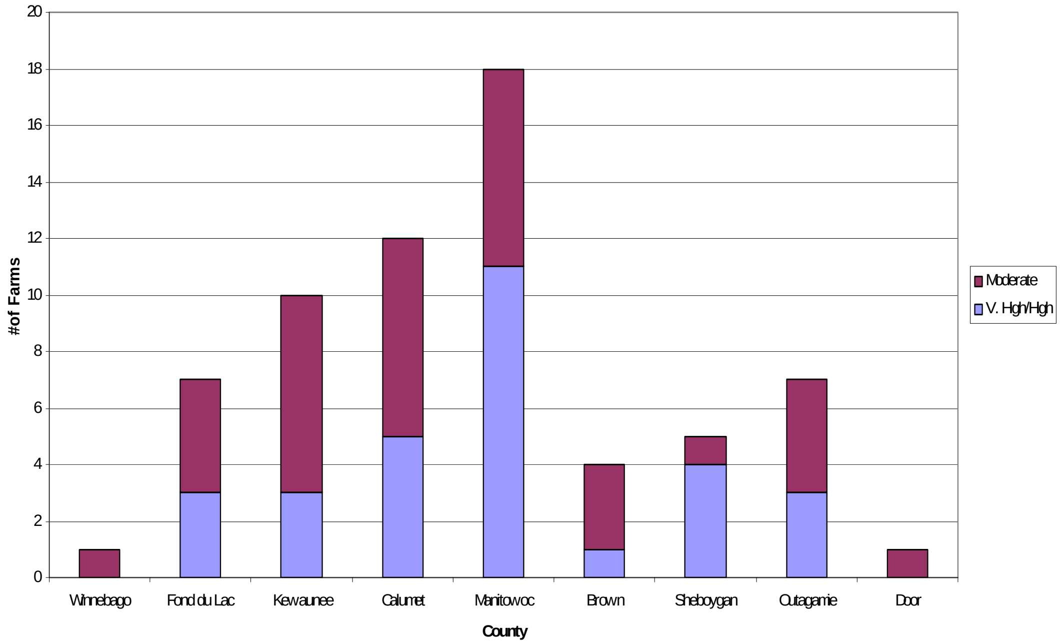
** At this time (Fall 2003), the REPC tax credit is only applicable to poultry biogas and wind facilities. Bovine facilities have not yet been approved to utilize the REPC tax credit, but may be considered in the near future.*

Di Byproduct Used		
10% discount rate	-108,851	no
5% discount rate	-81,743	no
2% discount rate	-16,600	no
REPC Tax Incentive (10% discount rate)	367,457	yes
5,000 yd^3/year digested byproduct sales (10% discount rate)	372,264	yes
10,000 yd^3/year digested byproduct sales (10% discount rate)	1,158,672	yes

Motivation Considerations

A CAD facility would be beneficial only if farmers were motivated to utilize a facility as part of their manure management plan. As part of the research study survey, farmers were asked to rate their level of motivation to participate in a CAD facility, ranging from “no motivation” to “very highly motivated”. Survey results determined that most of the very highly, highly, and moderately highly farmers resided in Calumet (11%), and Manitowoc (16%) Counties. The following graph displays this motivational information.

Overall Motivation of Farmers to Participate in a CAD Facility.
Number responding = 105 (91%)



To determine the factors that significantly influence farmer motivation to participate in a CAD two non-Parametric statistical tests (i.e., Spearman's Rank Correlation and Chi-Square) were conducted. Factors hypothesized to possibly effect farmer motivation included: farm size, location (i.e. county), type of manure collected (i.e. solid, semi-solid, liquid), the amount of prior knowledge a farmer held regarding anaerobic digestion, potential barriers to participation (i.e. large time commitment, high cost), the farmer's opinion regarding anaerobic digestion (i.e. favor or oppose), and the degree that farmer's were satisfied with their current manure management plan. Chi-square and correlation tests determined that the size of the farm, the location of the farm, the amount of knowledge a farmer possessed regarding anaerobic digestion and the farmer's overall opinion regarding anaerobic digestion significantly effected a farmer's level of motivation to participate in a CAD, while perceived barriers and farmer satisfaction level with current manure management plan did not significantly effect motivation levels of the farmer's surveyed.

Conclusions

In summary, there are many different social, economic, and technical aspects to consider regarding CAD system possibilities in northeastern Wisconsin. Research indicates that CAD facilities have the potential to use manure as a source of energy, to help reduce the environmental drawbacks associated with traditional manure management, while limiting the risks to farmers through cooperative se-up and the pooling of resources.

This study demonstrated that a CAD facility has the potential to provide economic benefits to farmers if digested byproducts are produced and sold and/or a government financial incentive is utilized. Enough recoverable manure is present within the nine county study are and moderate-very high levels of motivation are present in certain counties.

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