TINEDALE FARM, a fifth generation dairy farm in Wrightstown, Wisconsin, is one of the largest dairy farms in the state with nearly 2,500 cows. These cows produce approximately 50,000 gallons/day of manure, which are increasingly becoming more difficult to manage in an environmentally conscious and cost-effective manner. Several years of research on anaerobic digestion technologies by Carl Theunis of Tinedale Farm resulted in the formation of Ag Environmental Solutions (AES). AES has recently constructed the first temperature phased anaerobic digestion (TPAD) system for the dairy industry at Tinedale Farm.

Farm based anaerobic digestion has typically been accomplished using covered lagoons or plug flow mesophilic digesters. However, one of the stated goals of AES is to maximize the conversion of the manure solids to methane used for power generation. Based on this goal, AES evaluated numerous anaerobic digestion technologies before determining that the TPAD system would be most suitable to the dairy. The solids content of the manure at Tinedale Farm generally ranges from seven to nine percent, which is below what is typically acceptable for plug flow anaerobic digesters, but is acceptable for complete mix systems such as the TPAD technology.

The TPAD system was developed and patented by Dr. Richard Dague of Iowa State University in Ames. Since his death, the patent belongs to the Iowa State University Research Foundation. The technology has been installed at some municipal wastewater treatment plants in the United States, including several in Wisconsin. Results from these facilities, as well as laboratory testing conducted at Iowa State University, indicate that the TPAD system achieves higher volatile solids destruction and produces more biogas than other types of anaerobic digestion systems. For example, the municipal wastewater treatment plant in Sturgeon Bay, Wisconsin reported an increase in volatile solids destruction on the order of 15 to 20 percent when it switched from a mesophilic system to the TPAD process. Additionally, full-scale installations have proven to be capable of producing Class A biosolids (meeting the U.S. EPA’s Process To Further Reduce Pathogens (PFRP) requirements). The same level of pathogen reduction can be achieved with the digested manure. A “Class A” solids would provide farms with the opportunity to develop value-added products such as animal bedding and soil amendments.

The power generated from the Tinedale Farm project is sold as “green power” to Wisconsin Electric Power Company (WEPCO). Wisconsin is one of several states that currently has Renewable Portfolio Standards requiring utilities to generate a specific percentage of their total production from renewable energy sources such as biomass. Therefore, utilities are actively seeking out, and in some cases providing significant financing for renewable energy projects such as the one at Tinedale Farm.

**SYSTEM DESIGN**

Manure from the free-stall barns at Tinedale Farm is collected continuously using a dry scraping system. The manure then flows by gravity from the barns to a continually mixed equalization basin that is located-

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**Wisconsin farm installs a two phase thermophilic/mesophilic digester and is pilot testing solids separation and water clarification technologies that will result in a more closed loop manure management system.**

John F. Katers
The TAPD system incorporates several key components including:
1) heat exchangers used to raise the manure to thermophilic temperatures, 2) an H₂S filter for the digester gas, 3) hot water recovery from the generators and 4) a pilot water treatment system for the digester liquid effluent.

This project represents an opportunity to obtain environmental benefits while also providing an additional profit center for the dairy industry.

ed adjacent to the anaerobic digestion system. The equalization basin acts as a storage tank that provides a continuous feed to the digester.

The manure is pumped from the equalization basin through a heat exchanger to achieve thermophilic temperatures (120° to 135°F) prior to entering the thermophilic phase of the TAPD system. (The digestion process doesn’t create enough heat on its own.) The heat exchanger utilizes recovered heat from the water jackets of the two 375 kW engine generators that operate on the biogas produced by the TAPD system. The water jackets cool the generators, which produce substantial heat while burning the biogas. In the tube-in-tube heat exchanger, a pipe carrying the manure runs inside a pipe with the hot water, thereby transferring the waste heat from the generators to the incoming manure.

The thermophilic reactor is completely mixed using two draft tube style mixers. The partially digested manure is then pumped from the thermophilic reactor through a cooling heat exchanger, which brings the temperature down to mesophilic temperatures (85° to 100°F), and into the mesophilic reactor. The mesophilic reactor, which consists of two equally sized compartments, is completely mixed using four draft tube style mixers. The digested manure then flows out of the TAPD system by gravity to the existing lagoons for storage and land application. The retention time of the entire TAPD system is approximately 15 days. Tinedale Farm also is evaluating further treatment systems for the TAPD effluent, including solids handling and water clarification processes.

The biogas from the digester is sent to the biogas handling system, which includes equipment to remove moisture and hydrogen sulfide, which can combine to form sulfuric acid that can significantly damage and shorten the effective life of the generators. The cleaned biogas is then sent to the two 375 kW generators where it is converted to electricity and sent to the power grid. A flare also is in place to handle any excess biogas from the TAPD system.

**INITIAL RESULTS**

The TAPD system at Tinedale Farm began operating in the late spring of 2001 as a mesophilic system. Only recently has the first phase of the TAPD system been converted to starting at thermophilic temperatures.

The sawdust bedding has been problematic for the digester system because of difficulties with pumping. It is hoped that eventual use of the Class A digested solids for bedding will eliminate this problem.

During the initial period of operation, a considerable amount of time has been spent evaluating the reliability of equipment to ensure that the TAPD system can handle the continuous operations needed for the initial project as well as those constructed at other farms in the future. Attention also was focused on minimizing the maintenance requirements of the various system components, as this is a critical concern for farmers interested in anaerobic digestion. Even though a thorough economic analysis of the project hasn’t been completed because steady-state operations under TAPD operating conditions have not yet been achieved, AES estimates that this project will have a payback period of approximately five to seven years.

One side benefit noted during the initial operation is that the monitoring and laboratory testing of the TAPD system has allowed Tinedale Farm to identify other operational issues such as water use. In several cases, small but noticeable changes in the flow rate to the TAPD system have alerted Tinedale Farm to the fact that a hose was left running elsewhere in the facility or there was a leaking valve that needed to be fixed. Although this seems to be a minor benefit, the costs associated with hauling this additional water off-site for land application can be significant. In effect, the monitoring of the TAPD system has provided a good indicator of the overall farm operations. Taking this a step further, as increased nutrient testing of the TAPD system is initiated, it is also possible that cattle feed ratios also can be modified based on the testing of the TAPD system influent.

**ADDITIONAL PROJECT PHASES**

According to Carl Theunis, the digester is just one component in the whole system to process the manure in a way that is economical for dairies. AES is focusing on peripherals, including solids separation; treat-
Dewatering digested manure for use as animal bedding, soil amendments or for composting with other feedstocks holds great promise.

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**A PARTNERSHIP APPROACH**

The Tinedale Farm project represents an innovative partnership between the public and private sector. STS Consultants, Ltd. was the local engineering firm utilized for the project design and start-up. In addition, a faculty member from the University of Wisconsin-Green Bay was actively involved in the design of the TPAD system. The University of Wisconsin System awarded a grant of $44,400 to the University of Wisconsin-Green Bay that has allowed graduate students from the Environmental Science and Policy program the opportunity to monitor and evaluate the overall TPAD system performance. The project's potential impact on Wisconsin's economy was among the criteria that led the University to fund the grant, according to Albert Beaver, interim senior vice president for academic affairs at the University of Wisconsin. It is anticipated that several additional research opportunities will emerge as solids management and effluent clarification components of the project continue to move forward. The project also has received considerable support from several other state agencies in Wisconsin as the level of interest in this area is extremely high.

Although the TPAD project at Tinedale Farm is in the preliminary stages, it appears to hold great promise for the agricultural industry. This will be particularly true as the additional project phases for solids separation and water clarification are advanced. This project represents an opportunity to obtain environmental benefits while also providing an additional profit center for the dairy industry.

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