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AgSTAR Digest

Inside

AgSTAR 2002 Highlights

Development of anaerobic digesters for livestock manure treatment and energy production has accelerated at a very fast pace over the past few years. In the last two years, the number of operating digesters has increased by nearly 30 percent, from 31 to 40, with an additional seven currently in start-up or under construction. Most of these digesters are farm-scale systems; however, centralized digester applications for dairy operations are also emerging. One centralized system is already operating in California, and another is being developed in Oregon. To help support these activities, the AgSTAR Program is developing the second edition of the *Industry Directory for On-Farm Biogas Recovery Systems*, which provides information on system designers and developers and equipment manufacturers and distributors responsible for expanding the use of digestion technology in the livestock industry. Look for this publication on the AgSTAR Web site (www.epa.gov/agstar).

State anaerobic digestion programs also play a significant role in this expansion as they continue to grow and support digester projects in a number of innovative ways. For example, a $10 million cost-share program for commercially demonstrated anaerobic digestion technologies is available to dairy farms through the California Energy Commission (CEC). In addition, the CEC administers a sister program that provides funding for the demonstration of emerging technologies at commercial scale. The New York State Energy and Research Development Authority (NYSERDA) and the Wisconsin Energy Bureau have similar programs available to assist livestock producers in establishing digester technologies at their farms.

Some states are addressing key energy policy issues in order to foster further expansion of biogas energy technologies. For example, California and New York have recently enacted net metering laws that enable utility customers to use their own electricity generation to offset their consumption over monthly billing periods.

Federal funding opportunities will also be playing a larger role in supporting the development of anaerobic digestion systems. The Federal Farm Security and Rural Investment Act of 2002 will provide funding under the Environmental Quality Incentives Program (EQIP) and the Renewable

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Energy Systems sections of the Energy Title. Potential applicants are encouraged to visit www.usda.gov/farmbill or to contact local USDA officials for more information on these opportunities. Also, check the AgSTAR Web site (listed on page 1) for updates on this important funding mechanism.

AgSTAR has completed the first of a series of ***comparative environmental performance*** evaluations to provide the agricultural community with key information necessary to make informed waste management selection and upgrade decisions. A summary of this first assessment, which compares the environmental performance of covered lagoons to open treatment and storage lagoons for swine manure, is found on page 12. AgSTAR conducted this evaluation over a two-year period at commercial swine farms in North Carolina, working in conjunction with North Carolina State University. Other evaluations are in progress, including a collaborative effort with NYSERDA that compares a conventional dairy separation and waste storage system to a dairy plug flow digester with fiber recovery and liquid storage. These results are expected to be available sometime during the winter season. AgSTAR is also in the initial stages of a collaboration with the Wisconsin Biogas Development Group on a similar evaluation.

A ***new digester technology*** applicable for flush manure handling appears to be ready for commercial application following four years of development. Details about this fixed-film digester, up and running in Alachua County, Florida, and developed by Dr. Ann Wilkie of the University of Florida, appear on page 10.

Finally, AgSTAR has been busy updating information about the ***current status of anaerobic digesters*** in the United States. We completed our first update in late 1999 (*AgSTAR Digest*, 2000 edition) and the second during the summer of 2002. A summary discussion and tables listing all operating and under-construction digester systems can be found below and on pages 3–7.

Current Status of Farm-scale Digesters

In the past two years, the number of operating farm-scale digesters has increased by nearly 30 percent. In addition, seven additional systems are currently under construction or in start-up. Of the 40 operating digester systems, nine are at swine farms, 29 are at dairy farms, one is at caged layer farms, and one is at a duck farm. Three of these are centralized systems that provide manure treatment for surrounding farms. Tables 1 and 2 provide information about each of these digester systems. In addition, AgSTAR estimates that at least 40 additional systems are currently in various stages of planning and should come on line during the next year or so.

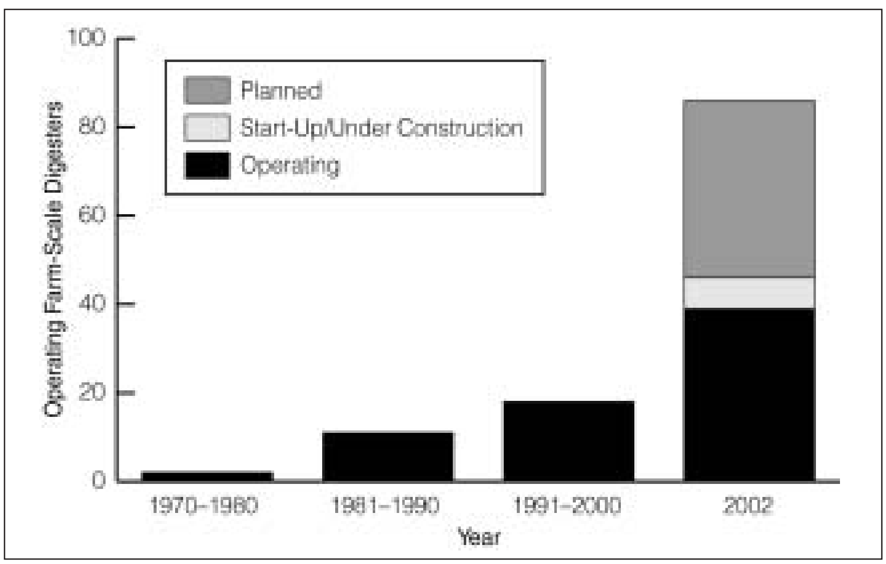

Figure 1. U.S. Farm-scale Digesters

In 35 of the 40 operational systems, the captured biogas is used to generate electrical power and heat. These produce the equivalent of appoximately 4 MW per year. The remaining systems flare the captured gas for odor control and reduce methane emissions by about 7,400 tons on a carbon-equivalent basis. In total, the operating digesters prevented nearly 124,000 metric tons of methane, on a carbon-equivalent basis, from entering the atmosphere.

Figure 1 above illustrates the historical trends and the large increases coinciding with the AgSTAR Charter Farm Program from 1997 to 1999 and continued growth as a result of state programs that emerged in the following years.

Table 1. Operating U.S. Digesters, October 2002

Location	Digester Type	Year Operational	Animal Type/ Population	Manure Handling Method	Approximate Total Installed Cost	Biogas End-use	Operational Output kWhr/hr	Methane Reduction ($MTCO_2E$/ year)
CA	Mesophilic plug flow, flexible top	1982	Dairy; 400 milkers	Scrape	$200,000	Electricity and hot water	40	1,186
CA	Mesophilic plug flow, flexible top	2002	Dairy; 650 milkers	Solids separator; scrape	$386,000	Electricity and hot water	100	2,965
CA	Unheated partially covered lagoon	1998	Dairy; 200 to 300 cows (includes dry stock and heifers)	Flush	$225,000	Flare	0	800
CA	Thermophilic-mesophilic complete mix tanks	2001	Dairy; 5,000	Vacuum scrape	Not available	Electricity and hot water	200	119
CA	Mesophilic plug flow, fixed top	2002	Dairy; 7,000 milkers, 3,000 other	Vacuum scrape	$1.8 M	Electricity and hot water	500	296
CA	Unheated covered lagoon	1982	Swine; 300 sows farrow-to-finish	Flush	$220,000	Electricity and hot air	25	741
CA	Unheated partially covered lagoon	2000	Dairy; 200 milkers, 50 dry	Flush and scrape	Not available	Electricity and hot water	25	741
CO	Mesophilic complete mix, flexible top	1999	Swine; 5,000 sow farrow-to-wean and 1,200 growing pigs (replacement stock)	Pull plug	$368,000	Electricity	50	1,482
CT	Mesophilic complete mix	1997	Dairy; 600 milkers	Scrape	$450,000	Electricity	55	1,631
CT	Mesophilic plug flow, flexible cover	1997	Dairy; 200 milkers	Scrape	$149,000	Hot water and flare	0	1,387
FL	Unheated fixed film	2000	Dairy; 500 cows	Hydraulic flush	$150,000	Hot water and flare	0	3,467

Table 1. Operating U.S. Digesters, October 2002

Location	Digester Type	Year Operational	Animal Type/ Population	Manure Handling Method	Approximate Total Installed Cost	Biogas End-use	Operational Output kWhr/hr	Methane Reduction ($MTCO_2E$/ year)
IA	Unheated bank-to-bank covered lagoon	1998	Swine; 3,000 nursery pigs	Pull plug	$15,000	Flare	0	1,738
IA	Mesophilic complete mix, flexible top	1996	Swine; 5,000 sows farrow-to-wean	Pull plug	$500,000	Electricity	50	1,482
IA	Mesophilic plug flow, fixed top	2002	Dairy; 480 cows	Scrape	$348,000	Electricity and heat	80	2,372
IA	Mesophilic plug flow, fixed top	2002	Dairy, 800 cows	Scrape	$450,000	Electricity and hot water	100	2,965
IA	Mesophilic plug flow, fixed top	2002	Dairy; 170 (100 milkers, 20 dry)	Scrape	$200,000	Hot water	0	1,179
IL	Mesophilic bank-to-bank covered lagoon	1998	Swine; 8,300 finishing hogs	Pull plug	$140,000	Hot water and flare	0	2,380
IL	Mesophilic plug flow, flexible top		Dairy; 1,400 lactating	Scrape	$1.2 M	Electricity	360	10,673
IL	Mesophilic plug flow, flexible top		Dairy; 2,000 lactating	Scrape	$875,000	Electricity	246	7,293
MD	Mesophilic slurry loop tank	1994	Dairy; 120 lactating, 70 heifers	Scrape	$500,000	Flare	0	1,317
MI	Plug flow	1981	Dairy; 730 milkers	Scrape	$150,000	Electricity	0	5,061

Table 1. Operating U.S. Digesters, October 2002

Location	Digester Type	Year Operational	Animal Type/ Population	Manure Handling Method	Approximate Total Installed Cost	Biogas End-use	Operational Output kWhr/hr	Methane Reduction ($MTCO_2E$/ year)
MN	Mesophilic plug flow, flexible top	1999	Dairy; 850 milkers	Scrape	$355,000	Electricity and hot water	130	3,854
MS	Unheated bank-to-bank covered lagoon	1998	Swine; 145 pigs	Recycle flush	$27,000	Flare	0	84
NC	Unheated bank-to-bank covered lagoon	1997	Swine; 4,000 sows farrow-to-wean	Pull plug and gravity flow	$290,000	Electricity and hot water	41	2,317
NY	Mesophilic plug flow, flexible top	1998	Dairy; 500 to 550	Scrape	$295,700	Electricity and hot water	44	3,640
NY	Mesophilic complete mix tank	1985	Dairy; 295 milkers	Scrape	$500,000	Electricity and hot water	25	2,045
NY	Mesophilic complete mix, flexible top	2001	Dairy; 560 milkers, 40 dry	Scrape and gravity flow	$350,000	Electricity and hot water	130	3,854
NY	Mesophilic plug flow, flexible top	2001	Dairy; 850 milkers, 100 dry	Continuous scrape	$400,000	Hot water	0	1,779
NY	Mesophilic, fixed film tank	2001	Dairy; 100 milkers	Gutter flush with liquid solids separation	Not available	Hot water	0	693
PA	Mesophilic slurry loop, fixed top	1983	Dairy; 250 milkers	Scrape	$80,000	Electricity and hot water	45	1,334
PA	Mesophilic plug flow, flexible top	1985	Swine; 4,000	Scrape	$225,000	Electricity and hot water; flare	130	3,854
PA	Mesophilic complete mix	1985	Swine; 1,000 sows farrow-to-finish	Scrape	$325,000	Electricity and hot water	33	1,666

Table 1. Operating U.S. Digesters, October 2002

Location	Digester Type	Year Operational	Animal Type/ Population	Manure Handling Method	Approximate Total Installed Cost	Biogas End-use	Operational Output kWhr/hr	Methane Reduction ($MTCO_2E$/ year)
PA	Mesophilic plug flow, slurry loop, fixed top	1983	Chicken; 350,000 layers	Scrape	$125,000	Electricity and hot water	150	4,447
PA	Mesophilic slurry loop, fixed top	1979, 1981, 1984 (three digesters)	Dairy; 2,300 milkers	Scrape	$225,000 each	Electricity and hot water	350	10,376
VT	Mesophilic plug flow, flexible top	1982	Dairy; 340 milkers	Scrape	$300,000	Electricity and hot water (steam)	28	2,357
WI	Mesophilic plug flow, flexible top	2002	Dairy; 900 cows	Scrape	$425,000	Electricity and hot water	125	3,706
WI	Mesophilic complete mix, fixed top	1988	Ducks; 300,000	Scrape	$500,000	Digester heat and electricity	180	5,336
WI	Mesophilic two-stage mixed, fixed top	2002	Dairy; 600 milkers	Scrape	$550,000	Digester and dairy heat, electricity, and hot water	135	4,002
WI	Mesophilic two-stage mixed, fixed top	2002	Dairy; 750 cows	Recycle flush	$487,500	Electricity, heat, and hot water	160	4,743
WI	Mesophilic two-stage mixed, fixed top	2002	Dairy; 2,800 milkers	Scrape	$1.4 M	Digester heat, dairy heat solids drying, electricity, hot water, and flare	425	12,600

Table 2. Digesters Under Construction and in Start-up, October 2002

Location	Digester Type	Animal Type and Population	Manure Handling Method	Estimated Installed Cost	Biogas End-use
IN	Mesophilic two-stage mixed, fixed top	Dairy; 3,500 cows	Scrape	$1.75 M	Digester heat, solids drying, dairy heat, electricity, hot water, and flare
MN	Mesophilic plug flow, flexible top	Dairy; 3,000 milkers	Scrape	Not available	Electricity
NY	Mesophilic plug flow, fixed top	Dairy; 1,100 cows	Scrape	$650,000	Electricity and hot water
NY	Mesophilic plug flow, fixed top	Dairy; 1,000 milkers, 200 dry	Scrape	$900,000	Electricity, hot air, and hot water
OR	Mesophilic complete mix, fixed top	Dairy; 325 milkers	Scrape	Not available	Electricity
OR	Mesophilic plug flow, flexible top	Dairy; 4,000 cows	Scrape	Not available	Electricity
WI	Thermophilic complete mix, fixed top	Dairy; 1,425 milkers	Scrape	Not available	Electricity

State Programs Foster New Farm-scale Digesters

A number of state programs provide support for biogas energy recovery systems. These programs are helping to advance biogas digester technologies and energy applications, meet local energy needs, and enhance environmental protection. This article profiles several of these programs and some of the projects that they are supporting. It also provides information on how farmers, local governments, and other entities can take advantage of these programs. Be sure to check the AgSTAR Web site (www.epa.gov/agstar) for updates on other state program opportunities that are emerging to expand the use of digestion technologies.

The New York State Energy Research and Development Authority (NYSERDA) supports energy analysis, research and development, and energy efficiency programs. NYSERDA offers funding through periodic competitive solicitations and interest rate reductions for renewable power sources. NYSERDA also sponsors annual conferences to discuss current projects and upcoming funding opportunities. NYSERDA has contracted with more than 20 agricultural projects designed to use manure for biogas energy or convert it to marketable compost. One of these projects was recently recognized as an AgSTAR Partner Farm. Some examples of biogas energy projects NYSERDA has supported are listed below:

- *Matlink Dairy Farm.* A demonstration project at Matlink Dairy Farm in Clymer, Chautauqua County, produces biogas from a complete mix anaerobic digester. This system is unique in that it utilizes a mixture of scrape dairy manure and food processing wastes for digestion, producing about 130 kW of electrical power and flaring excess gas. The total installed cost of the digester system is $623,000, including solids separation. Factoring in the use of separated solids for bedding, electricity cost savings, electricity sales to the local utility, revenues for treating food processing wastes, and costs of operation and maintenance, the farm is projected to realize annual net benefits of about $175,000. To use the excess biogas to improve farm profitability, the farm is now constructing a dryer to produce value-added animal feed from higher quality food process wastes. NYSERDA provided $200,000 for the construction and testing of the digester and an additional $250,000 for the demonstration of the food waste dryer. Matlink Dairy Farm, owned by Ted Mathews, is the second New York dairy farm to be recognized as an AgSTAR Partner Farm.

Ted Mathews (center) of Matlink Dairy Farm, recognized as an AgSTAR Partner Farm, with Ann Kurtis, Seneca Trail RC&D Council (left) and Joseph DelVecchio, State Conservationist, USDA/NRCS (right).

- *Dairy Development International, LLC.* NYSERDA is providing $200,000 for a demonstration project at an 850-cow facility in Little York, Cortland County. The project is hosted by Dairy Development International, LLC and is co-funded by NYSERDA and the F•A•R•M•E Institute, which is headquartered in Homer, New York. The system was started up in 2001 and is currently using biogas in a boiler to heat the digester. Excess biogas is combusted for odor control and greenhouse gas reduction in a flare. The digester produces enough biogas to generate the equivalent of about 500,000 kWh of electricity per year. NYSERDA is also providing additional funding to conduct evaluations of the biogas quality, alternative gas cleaning methods, the potential for microturbine applications, and the benefits, costs, and performance of the overall system. The cost of these studies will be shared by the New York State Electric and Gas Corporation, Cornell University, and EPA's Environmental Technology Verification Program.

- *Noblehurst Farms.* NYSERDA is contributing $250,000 to a project in Linwood, Livingston County, to construct and operate an anaerobic digestion system at a 1,100-cow farm. This collaboration with Noblehurst Farms, Inc. will produce almost 1 million kWh of electricity annually. Part of the funding will be used to evaluate the potential use of the digester as a centralized system to commercially treat livestock wastes from other farms.

- *Town of Perry.* In 2001, NYSERDA provided funding to conduct a feasibility study with the Town of Perry for a central digester to serve four farms. This study evaluated the cost of implementing one or more biogas digesters to treat manure from 3,000 dairy cows. The project would recover enough biogas to generate more than 2 million kWh of electricity per year. The farmers determined that a central digester would involve more manure trucking than desirable but that costs could be saved by selecting and constructing a common digester technology to be built on each of three farms. NYSERDA supplied $50,000 to support the project, to match costs met by the Town of Perry, Cornell Cooperative Extension, and the participating farms. Building on data developed by the feasibility study, the Town of Perry and the three farms submitted a successful proposal for constructing three combined heat and power generator systems using biogas generated on these three farms. This selected proposal requested approximately $800,000 through NYSERDA's Combined Heat and Power Program.

Information about NYSERDA's competitive solicitations for manure management systems can be found at www.nyserda.org/funding.html, or by contacting Tom Fiesinger at (518) 862-1090 extension 3218 or via e-mail at twf@nyserda.org.

The California Energy Commission administers the $9.64 million Dairy Power Production program. The Western United Resource Development (WURD) Corporation is the contractor for this program. The program's goals are to:

- Help the development of biogas energy projects using commercial anaerobic digestion technologies at California dairies.
- Help California dairies meet energy demands and offset the purchase of electricity demands.
- Provide environmental benefits by reducing potential air and water pollutants associated with the processing of animal wastes.

Project funding is awarded through two vehicles: a buydown grant and an incentive grant. The buydown grant covers a maximum of up to 50 percent of the capital costs of the system based on estimated energy production, not to exceed $2,000 per installed kW, whichever is less. The incentive grant is based on 5.7 cents per kWh of electricity generated by the dairy biogas system, paid out over a maximum of five years.

An advisory group screens applications (modeled after the AgSTAR Program's Charter Farm initiative during the late 1990s), and then a due diligence review of pre-screened applications is completed. Finally, the advisory group reviews the comments from the due diligence review and decides which projects to approve. The core advisory group consists of representatives from the CEC, WURD, the AgSTAR Program, California Department of Food and Agriculture, Sustainable Conservation, State Water Resource Control Board, and the University of California at Davis. Ten projects have been approved, totaling more than $6.8 million in project costs. The total electricity generation capacity from the 10 approved projects is expected to be at 1.7 MW, over 12.6 million kWh per year of energy delivery. The approved projects are planned to be operational by the end of 2003. For more information on the Dairy Power Production Program, please contact Zhiqin Zhang at (916) 654-4063 or via email at zzhang@energy.state.ca.us. Additional information about the Dairy Power Production program is available at www.energy.ca.gov/pier/renew/anaerobic/anaerobic.html or www.wurdco.com.

In addition, the CEC's Public Interest Energy Research (PIER) Program supports development of innovative energy services and products. The program awards up to $62.5 million annually to individuals, businesses, utilities, and public or private research institutions for projects that benefit electricity ratepayers. The PIER Program provides funding for renewable technology research development and demonstration projects that convert waste to energy. In April 2002, the PIER Program released a biogas-targeted solicitation to support advanced research and demonstration projects using anaerobic digestion. The goal of the solicitation is to utilize renewable resources from solid wastes, including animal wastes and biosolids generated from other waste streams, for environmental and economic benefits using advanced technologies in California. A total of $5 million is available for the selected projects. For more information on the PIER Program, please contact George Simons at (916) 654-4659 or via email at gsimons@energy.state.ca.us, or visit the Program's Web site at www.energy.ca.gov/pier/index.html.

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State Programs Foster New Farm-Scale Digesters (continued)

The Wisconsin Division of Energy administers the Wisconsin Focus on Renewable Energy Program through a third-party non-profit consortium, the Wisconsin Renewable Energy Network. The program offers information, education, training, and technical and financial assistance to Wisconsin electric utility customers. Government, utilities, the energy efficiency industry, and the public are partnered in this alliance to promote the use of renewable energy, including biomass.

Installation grants, based on the amount of renewable energy produced, are available through the Renewable Energy Program. Commercially available renewable electric and thermal projects, such as systems that cogenerate electricity and heat from anaerobic digestion of organic waste, are eligible for funding through this program. These systems can be sited at agricultural, commercial, industrial, institutional, or residential customer locations. Marketing, demonstration, and research grants are also available for customer-sited renewable energy businesses, technologies, and projects.

For more information on Wisconsin Focus on Energy's Renewable Energy Program, please contact Don Wichert at the Wisconsin Division of Energy at (608) 266-7312 or visit the Program's Web site at www.focusonenergy.com.

Fixed-Film Digesters: A Case Study

The Dairy Research Unit (DRU) at the University of Florida's Institute of Food and Agricultural Sciences is home to a new "fixed-film" anaerobic digester. This innovative system stabilizes wastewater, retains valuable fertilizer nutrients, and produces energy by turning waste into biogas. It can also reduce the offensive odors associated with dairy manure by as much as 90 percent. After four years in development, this new digester is up and running in Hague, Alachua County, Florida, and is poised for commercial deployment.

Dr. Ann Wilkie, an environmental microbiologist and associate professor with the Soil and Water Science department at the University of Florida, Gainesville, designed the digester to treat dilute waste from Florida dairies. The Florida Energy Office was the project's primary sponsor, and the digester serves as a model for the Florida dairy industry. The digester is a key component of the waste management system at the 500-milking cow DRU.

The fixed-film anaerobic digester consists of a 100,000-gallon tank filled with plastic media. The media supports a thin layer of anaerobic bacteria called biofilm (hence the term "fixed-film"). As the wastewater passes through the media-filled digester, the attached and suspended anaerobic biomass convert both soluble and particulate organic matter in the wastewater to biogas—a combination of methane and carbon dioxide. The unit is operating at a three-day hydraulic retention time at ambient temperature. (For North Central Florida, this corresponds to an average operating temperature of 68 degrees F in winter and 86 degrees F in summer.)

According to Wilkie, the partial decomposition of organic matter by anaerobic microorganisms is the main reason that livestock manure smells. Because it is a completely closed system, the fixed-film digester allows more complete anaerobic digestion of the odorous materials found in manure to less offensive compounds and minimizes gaseous emissions to the atmosphere. "Bacteria in the digester convert organic matter in the animal waste into methane and carbon dioxide. At the same time, the microbes convert materials that cause odor into nonoffensive compounds, so when the processed wastewater leaves the digester, it can be applied to the land without the problem of nuisance odor," says Wilkie. "In previous designs, bacteria flowed into a digester with the animal waste and then back out again. We retain the bacteria inside our system on the plastic media. When we bring in fresh wastewater, an army of bacteria are already at work."

Because the University of Florida's digester retains a large amount of fixed biofilm on the plastic media, the digester can treat dilute wastewater in two to six days. This retention time is much shorter than that of other anaerobic digesters, which retain wastewater for as long as 25 days. Anaerobic lagoons, a commonly used manure management system, can take even longer, depending on process water volume for a complete treatment cycle. The shorter hydraulic retention time means that, by design (after liquid solids separation), fixed-film digesters have a much smaller

Biogas flare burns at the University of Florida's fixed-film anaerobic digester.

footprint than conventional plug-flow, complete-mix, and covered lagoon digesters—an important factor where land availability is limited.

The fixed-film anaerobic digester offers other benefits, including energy generation, greenhouse gas reduction, and retention of important fertilizer nutrients (i.e., nitrogen, potassium, phosphate) in the wastewater effluent. The organically bound nutrients are mineralized to soluble forms in the digester, which transforms them into a more predictable fertilizer product. The digestion process also kills weed seeds and reduces microbial pathogens harmful to animal health, providing cleaner water for recycling back through the free-stall flush system. At the DRU, biogas from Wilkie's system is used directly to heat water for the milking parlor, providing an immediate payback in savings on propane fuel costs. Future plans include powering space heaters in the parlor during the winter months.

The fixed-film digester is simple to operate and easy to maintain. "There are no moving parts inside the tank," says Wilkie. "The system is continuously fed and it does not need daily attention." According to Wilkie, anaerobic digestion under controlled conditions offers producers a holistic solution that allows them to coexist with their neighbors without limiting the enterprise. The system can be easily integrated into any livestock operation (dairy or swine) that uses a flush-type manure handling system.

For further information on the fixed-film digester, contact:

Dr. Ann Wilkie

Soil and Water Science Department

University of Florida

P.O. Box 110960

Gainesville, FL 32611-0960

Phone: (352) 392-8699

E-mail: acwilkie@mail.ifas.ufl.edu

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Comparing Three Swine Waste Management Systems

(The following article is excerpted from "Covered Anaerobic Lagoon Systems for Swine Waste Treatment: Concepts and Performances on an AgSTAR Charter Farm in North Carolina," K.F. Roos and J.A. Martin, Jr., Conference Proceedings, Water Environment Federation, March 2002.)

AgSTAR recently completed the first in a series of evaluations to quantify the environmental performance of conventional waste management and anaerobic digester systems used in commercial swine and dairy production facilities. The overall objective of this effort is to develop a better understanding of:

- The potential of individual system components and combinations of these components to reduce the impacts of swine and dairy wastes on environmental quality.
- The relationships between design and operating parameters and the performance of the biological and physical/chemical processes involved.

A clear understanding of these issues is essential for the planning and design of these waste management systems. This information can also facilitate the identification of specific processes or combinations of processes that will effectively address air and water quality concerns. Figure 2 shows the standardized methodology used in these comparative evaluations.

This evaluation focused on swine waste management systems in North Carolina. A covered anaerobic lagoon (see Figure 3 on page 13) was compared to a conventional anaerobic lagoon in which the treatment and storage functions are combined. This study also evaluated a third system, a minimally aerated single cell lagoon with ozone injection. Because this system performed about the same as a conventional lagoon, it is not discussed further in this article.

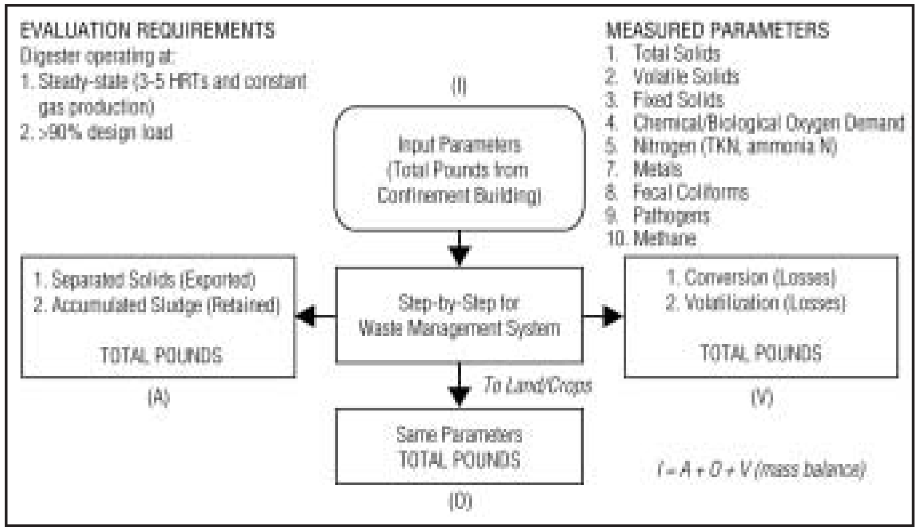

Figure 2. Standardized Methodology Used for AgSTAR Comparative Evaluations

Table 3 summarizes the characteristics of these farms and systems. Table 4 summarizes the costs and revenues of the covered anaerobic lagoon.

Table 5 summarizes the environmental performance of the covered anaerobic lagoon system. AgSTAR based this performance characterization on results of analyses of influent and effluent samples collected semimonthly over a 12-month period beginning in May 1999. In this evaluation, more than 96 percent of the total solids, volatile solids, chemical oxygen demand, total phosphorus, and orthophosphate phosphorus and more than 92 percent of the total Kjeldahl nitrogen (TKN), organic nitrogen, and ammonia nitrogen entering the system was accounted for in the material balances that were developed.

When compared to conventional anaerobic lagoon, covered anaerobic lagoons demonstrated the following additional environmental benefits:

- Reduced pathogen densities (1 to 1.5 log reductions, 3.5 log total reduction), including reductions

Table 3. Characteristics of Study Facilities

System	Waste Stabilization System	Swine Operation Size/Type	Estimated Capacity (m3)
1	Covered anaerobic lagoon followed by an effluent storage pond	4,240-head farrow-to-wean	26,000 (lagoon) 52,000 (pond)*
2	Minimally aerated single cell lagoon with ozone injection	5,400-head finishing	27,500 (lagoon)
3	Conventional anaerobic lagoon	8,100-head finishing	33,000 (lagoon)

*This pond was originally used as a combined anaerobic stabilization and storage lagoon. It is oversized for its current application (storage only).

Table 4. Cost and Benefits of Covered Anaerobic Lagoon (Moser and Roos, 1997)

Manure transfer pipe	$3,500
Excavation	$57,400
Digester cover	$39,300
Gas/hot water piping	$4,600
Gas pump, meter	$3,200
Engine-generator	$87,540
Boiler and hot water use	$7,600
Engine-generator building	$8,200
Heat loop, farm labor, electrical	$21,134
	$232,474
Engineering	$25,000
otal Cost	$257,474
Annual Electricity Production	$35,000/yr
Value of propane offset	$11,000/yr
otal Benefits	$46,000/yr

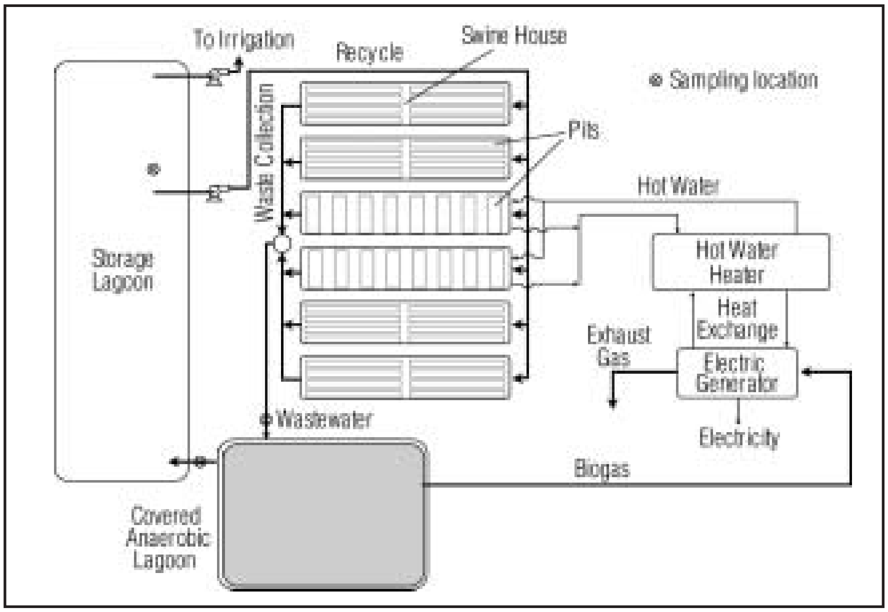

Figure 3. Schematic of Covered Anaerobic Lagoon System Investigated in Study

in *Salmonella* and other indicator organisms.

- Land requirement reductions of at least 50 percent, on a nitrogen application rate basis, for disposal of effluent withdrawals.
- Atmospheric methane emission reductions of approximately 10 million cubic feet/year. Methane is a potent greenhouse gas.

All other values for conventional anaerobic lagoons were comparable to those shown in Table 5.

The results of this study demonstrate that covered anaerobic lagoons can reliably provide excellent odor control and, through anaerobic stabilization, can substantially reduce the water and air pollution potential of swine wastes. As shown in Table 4, the study results also demonstrate that the initial investment can pay for itself within a five- to six-year period when biogas is combusted for energy production. A complete evaluation report will be made available on the AgSTAR Web site (www.epa.gov/agstar).

Table 5. Summary of Covered Lagoon and Storage Pond Performance (Martin, 2002)

Parameters measured	Net loads, kg/day	Covered lagoon reductions, kg/day	Covered lagoon reductions, %	Storage pond reductions, kg/day	Overall reductions,%
Total solids	1,667	1,502	90.1%	129	97.8%
Total volatile solids	1,194	1,139	95.4%	44	99.1%
COD	2,813	2,729	97.0%	79	99.8%
TKN	217	81	37.3%	138	100%*
Organic nitrogen	94	79	84.0%	16	100%*
Ammonia nitrogen	127	5	3.9%	122	100%*
Total phosphorus	57	47	82.5%	9	98.2%
Orthophosphate phosphorus	27	18	66.7%	7	92.2%

* This is an overestimate as indicated by the closure errors in the mass balances of less than eight percent for TKN, organic nitrogen, and ammonia nitrogen.

AgSTAR Program Information

All AgSTAR Program information is available through the **AgSTAR Hotline (1-800-952-4782)** and Web site (**www.epa.gov/agstar**). You can download fact sheets, brochures, and other informational materials from the Web site, or call the Hotline to request hard copies. The Web site also has direct links to related industry, vendor, and utility sites, as well as an online directory of technology providers, including consultants, developers, and manufacturers and distributors of covers, tanks, and engines.

For more information about methane recovery technologies or the AgSTAR Program, contact an AgSTAR representative at:

EPA AgSTAR Program

1200 Pennsylvania Ave., NW (6202J)

Washington, DC 20460

1-800-95AgSTAR (1-800-952-4782)

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