Benefits, Costs and Operating Experience at Seven New Agricultural Anaerobic Digesters

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ABSTRACT

Farmer motivation for building and operating anaerobic digesters has expanded from solely energy benefits to include manure treatment cost savings, nutrient conversion, odor and pathogen control, and byproduct recovery. The AgSTAR Program is sponsored by the USEPA, USDA and USDOE to encourage farm methane recovery from anaerobic digestion. AgSTAR has provided technical assistance to seven farms to assist them through the development, installation, start-up and operating phases of their anaerobic digestion projects. Three dairy plug flow digesters (NY, CT, OR), three covered pig manure lagoons (NC, VA, IA) and one heated mixed pig manure digester (IL) have been placed in operation, since January 1997 with AgSTAR technical assistance. The farms and their digester systems are described. The cost of the digester systems are summarized. Biogas recovery and use in boilers or engine-generators is discussed for each farm. Start up and operational lessons learned are presented. References and calculations are included.

Keywords: Biogas, methane, odor, anaerobic digestion, digester, covered lagoon, nutrient management, pathogens

OVERVIEW

Anaerobic digestion is more extensively used outside of the US where treatment of animal waste has been a concern for a longer time. An anaerobic digester is a vessel designed to retain decomposing manure for sufficient time at the designed operating temperature to allow the growth of methanogenic bacteria in a "steady-state". Electricity and heat production are direct benefits of anaerobic digestion. The effluent of a digester has an earthy smell with some ammonia present.

The first dairy digester systems in the US were installed principally to produce energy during the energy crisis. The first pig manure digester systems in the US were installed principally to control manure odors. The changing face of agriculture with larger animal production units and recognition of the pollution potential of these farms has resulted in greater regulation in the US. The new rules and guidelines make manure treatment a cost item to be accounted for in modem farming. In 1998 farmer motivation for building and operating anaerobic digesters has expanded from direct energy benefits to include key non-energy benefits such as: odor control, improved manure handling, mineralization of organic nitrogen, weed seed destruction, pathogen reduction and byproduct production such as digested dairy solids.

AgSTAR is a voluntary program sponsored by the US Environmental Protection Agency (EPA), the US Department of Agriculture - Natural Resources Conservation Service (NRCS) and the US Department of Energy (DOE), to encourage methane capture as a part of manure management. Since 1996, AgSTAR provided technical support to 7 AgSTAR Partner farms who were developing anaerobic digester systems. From 1996 - June 1998, AgSTAR assisted in the realization of 7 farm scale digesters that have desirable environmental performance. Three ambient temperature covered hog lagoon digesters, one heated mixed hog digester and 3 heated plug flow digesters were built by AgSTAR partners. AgSTAR is assisting 5 new projects in 1998.

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PLUG FLOW DIGESTERS

Craven Dairy Farm

Craven Farms of Cloverdale, Oregon finished a heated, unmixed, plug flow digester sized for the daily manure production of 1000 cows in December 1996. Funding included farm monies, a grant from the Pacific Northwest and Alaska Biomass Program, and a loan from the Oregon State Energy Office. AgSTAR provided technical assistance during construction and startup. The construction bogged down in fall 1996 during the rainy season. The winter startup was not a difficult problem. The farm currently treats manure from up to 1,000 cows though there are only 750 on site.

Benefits - The farm is currently producing about $ 24,000 of electricity and $ 30,000 of digester fiber yearly. The value of digested solids is twice the original estimates. The digester has eased manure handling and reduced the cost of application. It appears that the digested liquids are producing a higher quality hay than previous manure nutrient management. Pathogen concentrations are reduced. Odors are reduced substantially as reported by the neighbors.

Table I

Craven Farms Digester Current Benefits

Electricity sales	$24,000/yr
Digested fiber sales	$30,000/yr
Hot water	$0/yr
Total Benefits	$54,000 /yr

Costs - Costs of construction are shown in Table 2.

Table 2. Craven Farms Plug Flow Digester Cost

Lift station/mix tank		$ 9,500
Digester		$ 128,000
Miscellaneous		$ 6,400
Gas/hot water piping		$ 5,300
Gas pump, meter		$ 8,400
Used engine-generators		$ 50,000
Electrical		$ 12,200
Engine-generator building		$ 4,000
Subtotal		$ 217,950
Engineering	$ 24,000	
Startup	$ 5,500	
Total Cost		$ 252,848

AA Dairy

AA Dairy Farm of Candor, New York built and started up a 1000 cow digester at their 550 cow facility, completing a boiler fired system in October 1997. AgSTAR provided technical assistance in all phases of the project. Issues with New York State Electric and Gas Co. over a used intertie panel previously approved in Pennsylvania delayed engine-generator startup until June 1998. Modifying the previously approved panel to conform to

NYSEGwishescosttheowner$21,000. Fundingincludeda$90,000grantfromthelocal Soil Conservation District to improve manure management and the balance of the cost from the owner.

Benefits - The system is currently producing 70 kWh, hot water and about $60/day of digested fiber. Odor has been controlled. The cost of manure application is substantially reduced.

Table 3. AA Dairy Estimated Current Benefits

Electricity offset	$30,000/yr
Digested Fiber Sales	$21,900/yr
Hot water	$3,500/yr
Total Benefits	$55,400/yr

Costs - Costs have been restated from those previously published (Moser and Roos) by substituting the cost of the used engine-generator and intertie panel.

Table 4. AA Dairy

1000 Cow Digester Costs

Lift Station/Mix tank		$ 12,500
Digester		$ 92,000
Miscellaneous		$ 6,400
Gas/hot water piping		$ 5,300
Gas pump, meter		$ 8,400
Engine-generator (used)		$ 40,000
Electrical/ intertie		$ 33,200
Engine-generator building		$ 14,000
Subtotal		$ 211,800
Engineering (AgSTAR)	$ 24,000	
Startup	$ 4,500	
Total Cost		$ 240,300

Freund Dairy

Freund Dairy of East Canaan, CT installed a plug flow digester at their 200 cow dairy during a complete rebuild of the waste management system. The purpose of digester installation was to improve manure handling while recovering energy. The cows are pastured in the summer and kept in the barn during the winter. Digester gas production varies seasonally. The digester started up in fall 1997. Gas is used in a boiler or flared. Hot water is used to keep the digester warm. The boiler also maintains 6,000 gallons of 180 degree hot water for thermal uses.

Benefits - The intended use of the excess digester hot water is to provide heat in the farmhouse and several greenhouses during the winter. It is expected that the required interconnection piping will be installed before winter of 1998. Digested solids are separated for use as bedding or sale as a soil amendment

Costs - The digester system estimated cost was between $64,000 and $85,000 depending on equipment selection. (Lusk, AgSTAR 1996). A solids separator and a new lined storage basin were constructed concurrently with the

digester. The whole system is estimated to have cost $125,000. (Lusk) A final cost/benefit summary is not available as final partitioning of costs between the components is not complete.

COMPLETE MIX DIGESTERS

Apex Pork

Apex Pork of Rio, IL is a 8,900 head continuous flow pig finishing facility in Rio, IL with pull plug manure collection. The farm, started up an innovative digester June 1998 - a heated, mixed covered earthen lagoon, for the sole purpose of operating the system to biologically stabilize waste prior to discharge to the existing storage. The heated digester volume replaces almost 20 times the same volume that would have been required for an ambient temperature lagoon. Seasonal odor episodes from the storage basin were not acceptable to downwind neighbors. The digester started up, matured at about 36,000 ft3/d and was running well when a windstorm damaged the gas collection cover. The cover is being replaced and digester operations should resume in September 1998.

Benefits - The primary benefits to the owners are odor reduction both from stored manure and equally as important, field applied manure. Odor is reduced substantially in the stabilized digester effluent. The improved odor situation will allow the owner to use the manure on a wider variety of fields.

Costs - The originally estimated cost was $108,000. Plans, excavation, permeability testing, and new permitting procedures added about $20,000 to the excavation cost for a total of $128,000. Replacing the damaged cover will cost about $7,000 more than the original cover, because of the change in type of material and anchoring selected for the new cover.

COVERED LAGOON DIGESTERS

Barham Hog Farm

Barham Farm of Zebulon, NC is a 4000 sow farrow to wean pig farm with pit recharge. AgSTAR provided design, installation and troubleshooting support and worked with NRCS to design the lagoon. Lagoon construction began in July 1996. The lagoon cover, 400,000 Btu boiler and a 120 kW generator were installed in December 1996. Biogas use for heating water began in January 1997. Lagoon cover manufacturing problems limited biogas recovery and the production of electricity, however the boiler has operated almost continuously, providing hot water for pig mats under farrowed pigs. The owner was refunded his money and has purchased a new 40 mil HDPE cover. Preliminary results from July 1998 showed recovery 28,000 ft3/d of biogas and operations of 12 hours of 90 kW daytime generator operation with 12 hours of nighttime boiler operation. Odor is virtually non-existent, the effluent is stable and nutrient content of the second lagoon has been reduced substantially.

Benefits - Due to the problems with the original cover manufacture, the direct monetary returns to the farm have been limited to about $12,000 per year in reduction of propane purchases. However, odor control benefit is very important to the owner because large subdivisions are being built within one mile of the farm. Also, the improved biological stabilization and nutrient mineralization in the digester resulted in the effluent from the storage lagoon containing 60% less nutrients than before. Consequently, the farm manure treatment and nutrient application complies with the 1997 manure management regulations without additional investment.

Table 5. Barham Covered Lagoon Estimated Benefits

Annual Electricity Production (est)	$35,000/yr

Value of reduced propane use	$11,000/yr
Total Benefits	$46,000/yr

Costs - Costs have been restated from those previously published (Moser et al) by substituting the cost of the cover currently in use, rather than the failed cover.

Table 6. Barham Covered Lagoon Costs

Manure transfer pipe	$ 3,500
Excavation	$ 57,400
1998 Digester Cover (est)	$ 57,300
Gas/hot water piping	$ 4,600 *
Gas pump, meter	$ 3,200 *
Engine-generator	$ 87,540
Boiler and hot water storage	$ 7,600
Hot water use equipment	$ 14,000
Engine-generator building	$ 8,200 *
Heat loop, farm labor, electrical	$ 21,134
Subtotal	$ 264,474
Engineering (AgSTAR)	$ 25,000
Total Cost	$ 289,474

* - farm labor not included

Martin Family Farm

Martin Family Farm of South Boston, VA is a 600 sow farrow to feeder pig farm with recycle flushing. The farm covered the first cell of a two cell lagoon in 1993 and began engine-generator operations in spring 1994 with a matching grant from the Southeast Regional Biomass Energy Program (SERBEP). The first cover slowly sank and collected less gas each year. In 1997, Engineered Textile Products of Mobile, AL and Scamens Corporation contributed a demonstration XR-5 modular cover system to replace the original failed cover design. Martin Farms installed the new cover and replaced the corroded lagoon heat loop with radiators. Methane recovery has been continuous throughout the project, though gas use has not been. The farm has produced up to 14,000 ft3/d of biogas and 600 kWh/d during the summer. Winter gas production drops off to less than 6,000 ft3/d collection and use has been problematic. In fall 1998, the farm is converting to a hot water boiler for pig mats under farrowed pigs. A boiler will more closely match the farm labor skill and availability. Odor is virtually non-existent, the effluent is stable and nutrient content of the second lagoon has been reduced substantially.

Benefits - The major benefit to the farm has been odor control and elimination of objections by neighbors. The benefit of electricity production and heat recovery were reduced by the failure of the original cover. The farm has produced several thousand dollars worth of electricity. A secondary benefit from the two cell approach has been nutrient reduction in the second lagoon and ease of management of that effluent in sprinklers on fields that are closer to the neighbors than the farm is.

Table 7. Martin Covered Lagoon Estimated Benefits

Annual Electricity Production (est)	$10,000/yr

Value of reduced propane use	$ 6,000/yr
Total Benefits	$16,000/yr

Costs - Costs have been restated from those previously published (Gettier and Roberts) by substituting the cost of the equipment currently in use, rather than earlier abandoned efforts that were part of the project development. The cost of the new cover is estimated

Table 8. Martin - Costs of Equipment in Use

Excavation	$13,000
1997 Digester Cover (est)	$40,000
Gas pump, meter	$1,800
Engine-generator (used)	$8,000
Radiators/controls	$1,200
Hot water use equipment	$0 *
Engine-generator building	$7,200
Farm labor, electrical	$9,000
Subtotal	$80,200
Engineering (est)	$ 15,000
Total Cost	$95,200

* - future

Boland Farm

Boland Farm of Williamsburg, IA installed a low cost Permalon cover in May 1998 over their 2,400 head nursery storage basin to capture odorous gases. Gas use will not be attempted and a flare has been installed to combust the gases. AgSTAR provided technical assistance during construction and startup.

Benefits - The cover has almost eliminated odor from the basin. The owner commented that they have been able to hang the wash outside for the first time in years.

Cost - The project budget was $15,000 with grant participation from Iowa State University.

AgSTAR

AgSTAR is a voluntary program that promotes recovery and use of methane from animal manure. AgSTAR is one of many voluntary initiatives under the US Climate Change Action Plan to Reduce Greenhouse Gases. The program provides technical support, compiles and distributes information, and maintains the AgSTAR hotline (1-800-95AgSTAR). AgSTAR has supported development of standards for anaerobic digestion systems and decision support software. AgSTAR enrolls farms and industry in the AgSTAR program with a signed Memorandum of Understanding (MOU) as AgSTAR Partners and Allies. In some cases, Partners and Allies may be supported with direct technical assistance. In addition, AgSTAR provides speakers at symposiums, conducts training workshops and exhibits a display booth as part of its outreach and education component.

SUMMARY

AgSTAR assisted in the realization of 7 farm scale digesters since 1996. All digesters have started up and functioned well. All have recovered biogas as expected. There have been some modifications to gas uses. Some of the covered lagoon projects have required new floating covers due to materials assembly or cover design problems.

Electricity and heat production are direct monetary benefits of the projects. Key non- energy benefits and byproducts from anaerobic digestion of manures such as digested dairy solids, contributed significantly to the desire of farm owners to install anaerobic digesters. Odor control, mineralization of organic nitrogen, weed seed destruction, pathogen reduction and improved manure handling are non-monetizable benefits demonstrated by existing digestion systems. These factors are increasingly important in sustaining farm viability in rural areas and are appreciated and desired by farm owners.

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