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ENERGY INFORMATION

Texas Agricultural Extension Service

METHANE PRODUCTION FROM LIVESTOCK WASTE

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Methane production is currently the hottest topic in the field of livestock waste management, both domestically and abroad. According to U.S. Department of Agriculture estimates, the total quantity of livestock and poultry manure in Texas is 10.6 million tons of dry matter annually, about 11 percent of the nation's total. Only 4.1 million tons of dry manure is "economically recoverable" however. From this manure tonnage, roughly 14 trillion BTU's of energy per year in the form of methane could be produced.

System Isn't Foolproof

Advantages of methane production from livestock manure are that essentially none of the plant nutrients are lost, the odor-causing potential of manure is reduced, and substantial amounts of animal feedstuffs can be derived from digested slurry.

There are drawbacks, too, however. Since commercial prototype digesters are not available, farmers and their consultants would have to design their own methane production systems. Methane is explosive at concentrations of 5 to 15 percent. Corrosion of pipes, pumps, valves and digester parts is a problem, as is gas leakage from the digester. Methane is difficult to store, requiring a pressure of 5,000 psi for liquefication. This is 30 times the pressure needed to produce liquefied petroleum gas (LPG). Thus, use of methane is limited to continuous, stationary sources such as heating or operation of electric generators. On a farm or feedlot, it may be difficult to satisfy energy needs through methane production alone.

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Methane Production Complex

Methane (CH_4) is the primary component of natural gas. Like natural gas, pure methane has an energy content of 1,000 BTU's per cubic foot. Bacterial degradation of manure under anaerobic (without oxygen) conditions releases a mixture of gases (biogas) which usually consists of 60 percent methane, 40 percent carbon dioxide and numerous trace gases such as hydrogen sulfide. This gives raw biogas an energy content of only 600 BTU's per cubic foot. Carbon dioxide and trace gases can be removed by chemical means, yielding pipeline quality gas.

Anaerobic digestion of manure is a two-phase process. In the first phase, bacteria degrade organic solids into organic acids. In the second phase, which occurs simultaneously, bacteria convert these organic acids into methane, carbon dioxide and

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water. Changes in the manure loading rate, temperature fluctuations and the presence of toxic elements or oxygen frequently cause problems in the functioning of the digester.

The amount of methane obtainable from manure varies widely depending on the feed ration, type of animal, manure collection procedures, digester design and operating conditions. The amount of wet manure (feces and urine) produced daily by livestock and poultry amounts to 4 to 9 percent of their body weight. Only 9 to 25 percent of this wet manure is solids, and only 70 to 85 percent of the solids fraction can be used to produce methane. The other 15 to 30 percent of excreted solids is ash.

As a general rule, 12 cubic feet of biogas is released for every pound of solids destroyed in the digestion process. Usually only 35 to 60 percent of the solids are destroyed within a practical digestion time of 10 to 18 days. This means gross biogas production can amount to 25 to 60 cubic feet per day per 1,000 pounds of animal liveweight. From 20 to 75 percent of the energy from methane production is needed to heat the digester and to operate pumps and mixing equipment. Thus, the estimated net energy yield from methane generation could range from 11,000 to 25,000 BTU's per day per 1,000 pounds of liveweight for dairy cattle and poultry, respectively. By comparison, the average family of four uses 32,000 BTU's per day just in meal preparation on a gas range.

Estimated Methane Production Potential from Fresh Manure (per 1,000 pounds animal body weight)

	Swine	Dairy cow	Beef cattle	Poultry (layers)
Volatile solids excreted, lbs./day	4.8	8.6	5.9	9.4
Estimated reduction of volatile solids, percent	50	35	45	60
Gas yield per pound volatile solids destroyed, cu. ft./lb.	12	9	13	11
Biogas production, cu.ft./day	29	27	35	62
Gross energy production, BTU/day	17,400	16,300	20,700	37,200
Net available energy, BTU/day	12,000	11,000	14,000	25,000

Collection Affects Production

Biodegradation of volatile solids begins as soon as manure is excreted. Delays in collecting manure and putting it in the digester reduce methane production potential. Ideally, manure for methane production should be collected fresh daily. But more than two-thirds of the collectable manure produced in Texas is deposited on open dirt-surfaced feedlots and collected once or twice a year. Meanwhile, decomposition destroys an estimated 30 percent of the volatile solids, and soil collected during the pen cleaning operation can increase the ash content to as much as 30 to 50 percent. Soil particles, as well as assorted debris often collected with cattle feedlot manure, not only reduce methane production potential but also cause problems with the mechanical aspects of methane production (mixing, pumping, agitation, residue disposal, etc.) Therefore, most of the collectable manure produced in Texas is of relatively low quality for methane production.

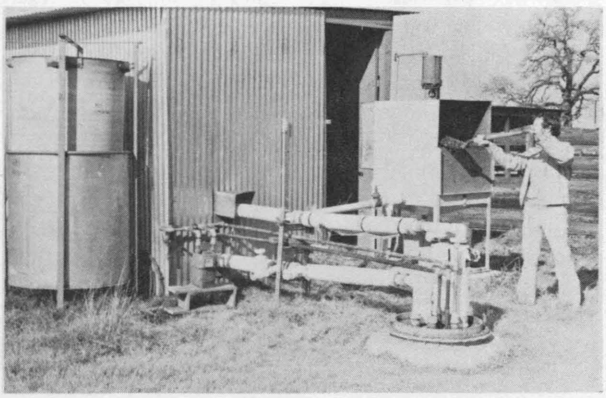
Another "contaminant" often present in manure is washwater, which is increasingly used in dairy, swine and poultry operations to reduce labor requirements for manure removal. Modern hydraulic flush systems dilute the solids content of manure to 1.5 percent or less. Agricultural engineers at the University of Missouri have developed a system for concentrating solids from flushed swine manure for anaerobic digestion. Nevertheless, 30 to 50 percent of the volatile solids are never recovered from the flush water.

Simply stated, most large livestock feeding facilities are designed for efficient, low-cost manure removal, and such collection procedures limit the potential for methane production. However, significant quantities of methane can still be produced from most livestock operations.

Experimental Designs Studied

A variety of designs and operating conditions have been used in experimental methane production systems across the country. Experiments with digesters (one component of the system) have focused on optimum temperature ranges, detention times, loading rates and pH conditions. All of these are crucial factors in methane production.

Texas A&M University's Department of Veterinary Microbiology and Agricultural Engineering have installed a pilot plant digester which produces methane from four dairy cows. Research objectives include determining optimum microbial populations and loading rates. The 750-gallon digester is loaded daily with 334 pounds of fresh manure (34 pounds of volatile solids) plus 30 gallons of dilution water. The digester is insulated and buried to minimize heat loss. Hot water is circulated through copper coils inside the digester to maintain a 95-degree F operating temperature. The digester produces 175 cubic feet of biogas per day. Plans are to use the bottled gas produced to supplement fuel requirements for a pathological waste incinerator at the College of Verterinary Medicine. Researchers are studying operating conditions that will allow a battery of batch-loaded digesters operated in parallel to provide peak sustained methane yields. This project is funded by the Texas Agricultural Experiment Station and the Center for Energy and Mineral Resources.



This pilot plant methane production system at Texas A&M University produces 175 cubic feet of biogas per day from manure from four dairy cows. The anaerobic digester is buried in the foreground.

More Methane Plants Planned

Thermonetics, Inc. of Oklahoma City has announced plans to construct three large-scale methane generation plants in the Texas Panhandle — two at Hereford and one at Dumas. Neighboring feedlots will receive $1.00 per ton from manure sales to the plants for 10 years. These plants will be patterned after the company's Calorific Recovery Anaerobic Process plant near Guymon, Oklahoma, which converts 500 tons of manure per day into 1.6 million cubic feet of methane. This is enough gas to heat 3,500 Chicago homes, where the gas is shipped via interstate pipeline. The same pipeline runs northward through the Texas Panhandle.

Gas produced at the Calorific plant contains 99.8 percent methane, which is above pipeline specifications. Carbon dioxide, hydrogen sulfide and other impurities are removed by bubbling the biogas through a column of heated amine solution. The solution is reprocessed to drive off CO_2 (vented to the atmosphere) and to precipitate a sulfurous residue.

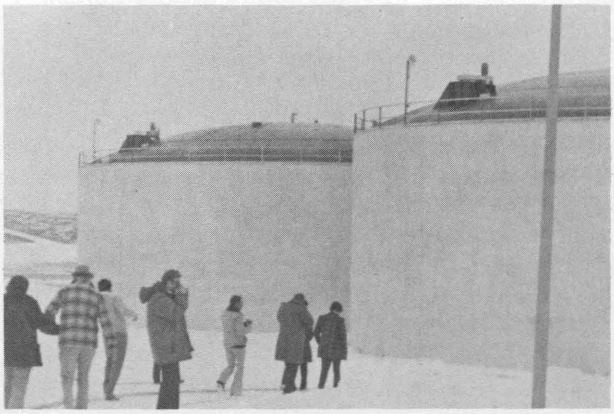
Economic feasibility of the Calorific plant is contingent upon the sale of feedstuffs recovered from manure slurry to furnish approximately half the gross revenue. Fiber containing 11 percent crude protein is screened from the manure slurry before it enters the digester. Then, a 26 percent protein filter cake is recovered from the digested slurry by centrifugation.

With protein recovery from animal refeeding, as well as normal nitrogen losses from the digested slurry storage pond, land area requirements for disposal of stored digested slurry are decreased by 70 percent as compared to the usual feedlot waste management operations. Only 6,000 acres will be needed for digested slurry disposal per 100,000 head of feedlot capacity.

Large Plants More Feasible

Economic projections for methane production plants are tenuous. The size and design of systems and the opportunity for sale of feedstuffs and/or digested slurry will have an enormous bearing on the capital and operating costs, and on net profit or loss.

Economics definitely favors large utility-scale systems. For example, construction costs for the Calorific plant in Oklahoma, sized for manure output from 100,000 head of cattle, were $24 per head. The sale of methane and feedstuffs will provide a steady year-round income with which to afford technically trained personnel, consultants and



The 2-million-gallon anaerobic digesters at the Calorific plant near Guymon, Oklahoma daily convert 400 tons of manure dry matter into 1.6 million cubic feet of natural gas. Three similar plants are planned for the Texas Panhandle.

a quality control laboratory. By contrast, a 500-hog methane production system in Manitoba, Canada was estimated to cost $40 per head, or 10 times more per pound of animal liveweight served than the Calorific system. This would necessarily be a farmer-operated unit, and would provide not quite enough methane to achieve energy self-sufficiency. Also, Texas A&M's pilot plant dairy manure digester, with a four-cow capacity, cost 35 times more per pound of animal liveweight served than the Calorific system.

Using the expected net gas yields in the table as a guide, estimated breakeven costs of methane production systems have been calculated as follows: swine (150 pounds) — $14 per head; dairy cows (1,200 pounds) — $103 per head; beef cattle (900 pounds) — $98 per head; and poultry (4 pounds) — $0.80 per bird. These breakeven cost estimates are based on a 10-year payback interval with 9½ percent interest. Natural gas price was assumed to be $1.75 per mcf with 10 percent per year escalation. Operating costs were assumed to be essentially offset by fertilizer and refeed credit. If a methane production system costs substantially more than these estimates, the operator could not hope to recover his costs with today's methane technology.

Future Advances Probable

Although production of methane from manure is a present-day reality, unfortunately farm-sized units are not yet commercially available. Methane production from livestock and poultry manure is not a do-it-yourself undertaking. Large-scale methane systems appear much more feasible than farm-sized units because of lower unit costs, higher process control and total usage of the methane gas and byproducts produced.

Mechanical aspects of manure handling (grinding, mixing, screening, pumping, etc.) and general plumbing problems (gas leakage, corrosion, etc.) have been the major sources of problems in methane production, rather than the chemical and biochemical processes themselves. These problems could be overcome by adequate financing and competent engineering design.

It is hoped that the large number of research and demonstration projects currently underway will provide breakthroughs in methane production technology that will assure economic feasibility for both commercial and farm-sized systems.

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