Chapter 16
Feedlot Biomass

Introduction

The development of large feedlots for livestock, also known as concentrated animal feeding operations or CAFOs, has created economic opportunity for agribusiness in Texas. Hogs, beef and dairy cattle and poultry at CAFOs are fed in close proximity to maximize efficient production and keep costs low. At the same time, however, CAFOs produce large amounts of animal manure that may emit odors, methane, nitrous oxide, carbon dioxide, antibiotics and ammonia. Manure can also produce water pollution from uncontrolled runoff of phosphorus and nitrates.[1]

Growing environmental concerns coupled with higher energy prices have led to a renewed interest in using animal manure, also known as feedlot biomass, to produce power. This can be accomplished either by burning manure directly for fuel, gasifying it with heat or by turning it into "biogas" through biological decomposition. The best approach to using animal wastes for power depends on the amount of moisture and essentially non-biodegradable solid materials including dirt (generally called ash) mixed with the manure to be used as a feedstock. Each of these methods disposes of large accumulations of manure while mitigating its possible negative environmental effects.

Manure also can be used to reduce emissions from traditional fuels. A recent scientific study by the Texas Engineering Experiment Station and Texas Agricultural Experiment Station found that co-firing coal plants with manure lowers their emissions of nitrous oxide (NO_X). The reburning process involves a second combustion process to reduce these air emissions.[2]

Manure-based power plants can boost rural economic development and provide dairy farmers and feedlot operators with another source of revenue, or at least cut their disposal costs.[3] Although Texas is a leading beef and dairy cattle producer, use of manure for energy is just beginning in Texas. There are promising new plants in Central Texas and the Panhandle both under construction and on the drawing board which have the potential to bring jobs and income to rural Texas, although there are no estimates of the current or potential effects available.

History

Man has burned animal waste for warmth for millennia. It is still used as a cooking and heating fuel in some traditional societies.

The use of biogas derived from waste traces it roots back to early experiments in England and its colonies. The first plant built to process gas from human sewage was constructed in Bombay, India in 1859. Subsequently, gas from a sewage treatment facility was used to fuel streetlights in Exeter, England in 1895. Later, Europe saw extensive use of biogas in the wake of energy shortages following World War II.[4]

In the U.S., interest in biogas peaked during the energy crisis of the 1970s. In that era, biogas systems were built at swine, dairy and laying hen production facilities. Some facilities fared better than others. Successful operations were found at farms that had the right kind of system installed and an owner/operator with the technical expertise to make it work.

In many cases, however, these operations failed, for reasons including the indiscriminate use of systems that were inappropriate for a specific farm setting; lower than expected manure production; high maintenance expenses; low returns; dependence on government grants for construction incentives; and the farmer's lack of skills with the system.[5]

Uses

Manure can be used to create gas or electricity. It is not currently used as a transportation fuel. Manure can be used as fuel for a boiler or burned directly for cooking or lighting purposes. It can be converted into combustible gases using thermo-chemical processes or into biogas through biological processes, in

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a device called an anaerobic digester. It can be used to generate electricity for power needs on the farm or ranch or sold to the local power grid. Dairy farms use a considerable amount of energy for refrigeration, and some use biogas-fired chillers to cool milk.[6]

Feedlot Biomass in Texas

Texas is the nation's leading cattle state and has significant potential resources for the use of manure to create energy. In 2006, there were 14.1 million beef cattle in the state as well as 334,000 dairy cows.[7] Thus far, however, using manure to create energy is relatively rare in the state.

Economic Impact

Because this practice is new and not yet commercialized, there is no estimate of the economic impact of using manure for energy purposes in Texas. One plant that uses manure from dairy cattle to create gas at Huckabay Ridge, near Stephenville, has created seven full-time jobs. Construction of the $18 million plant also employed an average of 12 to 14 workers for nine months.[8]

A Panda Ethanol plant already under construction near Hereford that will use 1,400 tons per day of manure as a fuel will create 61 permanent jobs and 500 to 600 construction jobs. The $120 million facility is expected to produce 105 million gallons of ethanol per year.[9] Panda has also announced two other Panhandle projects. (See below for more on these facilities.)

Consumption

Thus far, manure is not a major source of electricity generation in Texas or the U.S. According to AgSTAR, an EPA program that promotes such uses as a means of managing livestock waste and generating new sources of farm income, 111 anaerobic digesters operating across the U.S. at the end of 2007 produced electricity, gas to fuel boilers, and in some cases just flared the gas.[10] Texas' Huckabay Ridge digester produces biogas that is treated and sent via pipeline to the Lower Colorado River Authority (LCRA) to run electric generators.

Production

The increase of confined animal feeding operations has created the need for management systems to collect, store and dispose of the manure for sanitary and environmental reasons.

Manure occurs in forms ranging from solid to slurry to liquid. Dairy cattle and hogs confined

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in enclosed areas produce wet manure that can be collected for processing into biogas. Dry manure, such as that often produced in beef cattle feedlots, can be accumulated and transported for burning, gasification or conversion into biogas.

The collection method for liquid manure typically involves flushing the livestock pens with water. Slurry manure is collected using a mechanical scraper system. Solid manure can be handled using a wheel loader or mechanical scraper.[11]

The Texas Agriculture Experiment Station and Texas Cooperative Extension have conducted field research on the energy potential of manure. They estimate the heating value of dry, ash free manure at 8,500 British thermal units (Btu) per pound and from 2,500 to 6,000 Btu on an as received basis depending on ash and moisture content. This is below that of Powder River Basin coal from Wyoming widely used in Texas for power generation. By contrast, Texas lignite ranges from 3,500 to 4,000 Btu per pound.

Biogas produced by digesters typically is 60 percent to 65 percent methane after moisture and other materials have been removed. Biogas's heating value is about 600 Btu per cubic foot. (A thousand cubic feet of methane is equivalent to 600 cubic feet of natural gas, 6.6 gallons of propane or 4.7 gallons of gasoline.)[12]

Researchers at agriculture colleges such as Purdue University and the University of Missouri have examined the potential for livestock methane production. For example, a 1,000-pound dairy cow can produce about 28.4 cubic feet of biogas per day, as can three hogs weighing 240 pounds each.[13]

Selecting an appropriate technology for energy production from animal manure depends on its moisture content and other qualities. These factors in turn depend on the type of animal being fed and the way it is fed. Cost is an additional factor that, combined with physical characteristics of manure, dictates the best collection method for the manure. There are some variations in the characteristics of beef and dairy cattle manure. For example, dairy manure contains more volatile solids. But the key factor in how it is used for energy is the manure collection and management system.

Animal waste in a slurry or liquid form can be converted to methane gas using an anaerobic

Texas' Huckabay Ridge digester produces biogas that is treated and sent via pipeline to the Lower Colorado River Authority to run electric generators.

digester, a piece of equipment that ferments the manure and promotes its decomposition in the absence of oxygen. This process often is used for animal waste with relatively high moisture content, such as that from dairy operations. Microbes in the digester break down the organic matter to produce methane, the major component of natural gas. Operations employing this technique include four common elements: a digester, a gas handling system, a gas-use device such as an engine or a flare and storage tank for treated effluent.

One type of digester is the *covered lagoon*. Liquid manure flushed from dairy or swine operations is held in earthen lagoons, typically 12 feet deep or greater and covered with reinforced plastic fabric. The biogas is collected using manifolds or covers. Covered lagoons can recover biogas in warm climates any time of the year. In colder climates, however, where biological reactions slow down in cold weather, they may work only on a seasonal basis.

According to a Texas A&M University study, the Texas Panhandle region, including parts of neighboring Oklahoma and New Mexico, produces more than 7 million fed beef cattle per year, or 32 percent of the U.S. total.

Complete mix digesters are steel or concrete tanks in which slurry manure is heated to speed biological processes. The contents are mixed occasionally with a pump.

Plug flow digesters are a form of heated tank used for dairy waste. These are typically long, narrow and built below ground level.

Fixed film digesters are made using a tank filled with plastic that holds anaerobic bacteria called biofilm. As the waste passes through the biofilm, biogas is produced.[14]

Different types of digesters work better under different climatic conditions and with different types of manure. Covered lagoons are not heated and are more suitable for warmer areas; they are best used with manure having a lower level of solids. Fixed film digesters also are better for warmer climates and are best used with slurry manure. Plug flow and complete mix digesters are heated; these are typically used in cooler climates and can process manure with a higher solid content and at much higher rates. As the temperature of the reaction increases, the size of the digester can decrease.

Drier manure, such as that from beef cattle feedlots, can be turned into gas via high-temperature thermochemical processes. These heat-based methods are differentiated by the oxygen environment applied in each one. *Combustion*, for example, depends on a plentiful supply of air; *gasification* depends on adequate amount of air (described in technical terms as *stochiometric*). The resulting product, called syngas, can be used like natural gas but has a lower Btu content, in the range of 250-300 Btu per cubic foot.

In a related process called *pyrolysis*, manure is heated with very little oxygen to produce gas, oil and charcoal. Manure also can be burned directly, but this can be impractical due to its high and variable ash content, which can cause the manure to burn unevenly unless it is ground or pulverized. It can be burned more successfully when mixed with other fuels, such as coal, in a method called *co-firing*.

Another process called *reburning* may have significant implications for manure management and the use of coal for electric generation. Reburning refers to the addition of a secondary combustion process to a coal-fired plant. This is intended to eliminate nitrous oxide (NO_X), a source of air pollution. This is typically accomplished using natural gas as a reburn fuel. In small-scale experiments conducted by engineers at Texas A&M University, the use of feedlot biomass as a reburn fuel resulted in lower NO_X levels.[15]

Transporting manure long distances to be used as fuel is impractical, since doing so can use more energy than the manure can generate.[16] As a result, manure generally is used close to its source to generate gas for use on site or for localized distribution, or to make electricity. Once converted, biogas can be transported via pipeline or used to generate electricity that can be sold to the local power grid. Long-term storage of manure can result in loss of methane, carbon dioxide and ammonia into the air, resulting in more greenhouse gas emissions as well as lowering the fuel value of the manure and contributing to lingering odor problems.

Availability

As a result of Texas' large livestock industry, manure is available in significant quantities at some locations in the state. It is useful as a fuel only where it is found in large concentrations, such as the Panhandle (beef and dairy cattle) or Bosque River Basin (dairy cattle). According to a Texas A&M

University study, the Texas Panhandle region, including parts of neighboring Oklahoma and New Mexico, produces more than 7 million fed beef cattle per year, or 32 percent of the U.S. total.[17]

The manure produced in Texas could produce a theoretical amount of energy equal to 12 billion to 25 billion cubic feet of natural gas.[18] Practically speaking, however, it can be used for energy production only in those areas where it is found in high volumes in close proximity, such as the Texas High Plains (**Exhibit 16-1**).

Using the abundant manure resources of the Bosque River Basin, Environmental Power Corporation, through its Microgy Inc. subsidiary, has built what it claims is the largest renewable natural gas plant in the U.S., and perhaps the world. The company's Huckabay Ridge plant near Stephenville puts it in reach of dairy producers in Erath County, Texas' leading dairy county.

Microgy combines manure from local dairy farms with "substrate" — fats, greases and oils from restaurants and other sources — to produce gas. The gas is treated and compressed and then delivered by to the Lower Colorado River Authority (LCRA), which uses it to generate electricity.

Comptroller staff visited the Huckabay Ridge facility in summer 2007 to observe its operations (**Exhibit 16-2**). The facility has eight digester tanks that hold 916,000 gallons each, six of which were operating at the time of the site visit. The tanks are heated to speed up bacterial reactions. The contents are mixed to aid processing, and fats and oils are added to the manure to enhance the amount of energy produced. The process used is technically described as an above-ground, thermophilic, complete mix, co-digestion system. Microgy attributes the project's success to its patented Danish technology and innovations from previous projects.

When fully operational, the plant is expected to use the manure from 10,000 cows to produce a billion cubic feet of biogas per year, or 650,000 million Btu of energy. LCRA's contract calls for it to take as much as 2 million cubic feet per day from the plant for its power plants in Llano and Bastrop counties.[19] Microgy officials say the result is enough energy for 10,000 homes. The addition of substrate dramatically boosts the amount of energy in the gas and its volume.[20]

Microgy plans to build three more of these plants, one close to the existing plant, near Dublin, and the others near Hereford in Deaf Smith County at the Mission and Cnossen dairies.[21]

Broumley dairy farm in nearby Hico is the site of a demonstration project intended to reduce pollutants from dairy waste by using the waste to generate electricity. The project has been under way for several years and is expected to begin full operation in 2008.

The Hico project started in 2003 and at the time was envisioned strictly as a water quality project. It has since been modified to include electricity generation.[22] The project began in response to controversy over dairy waste washing into the Bosque River and concerns on the part of citizens of Waco who rely on the river for drinking water.

Numerous government agencies have partnered with Keith Broumley, owner of the dairy farm, to create a phosphorus removal project involving an anaerobic digester. The goal is to remove 80 percent of the phosphorus from the farm's waste

Exhibit 16-1

Texas High Plains Manure Resources

Type of Livestock	Number of Head of Livestock	Harvested Manure Millions of Dry Tons per Year	Higher Heating Value, Trillion BTU per year
Beef Cattle	2,750,000	4.7 million	30-50
Dairy	133,000	1.5 million	6-15
Swine	565,000	0.034 million	Not included in estimates

Source: Texas Agricultural Experiment Station.

Exhibit 16-2

Microgy's Huckabay Ridge Processing Plant

Source: Microgy.

Broumley dairy farm in Hico is the site of a demonstration project intended to reduce pollutants from dairy waste by using the waste to generate electricity.

stream while producing methane gas to generate electricity for sale to the grid.

The digester consists of a lined lagoon to hold the dairy waste. Biogas captured from the lagoon is used to generate electricity; the wastewater is then circulated to accumulate the phosphorus for land application. Leftover solids are used for compost.[23]

Renewable energy from manure is helping to support the development of another renewable fuel in Texas. Panda Ethanol is building an ethanol plant near Hereford that will gasify 1,400 tons of feedlot manure from beef cattle and cotton gin waste each day as fuel. The $120 million plant is expected to start production in 2008 and will convert corn and grain sorghum into 105 million gallons of ethanol annually. Panda expects that its construction will require more than 500 workers. After it opens, it will employ about 61 people.[24]

According to Panda, this plant will be the largest biomass-fueled ethanol plant in the U.S. By using more than a billion pounds of manure per year instead of natural gas, Panda estimates it will save the equivalent of 1,000 barrels of oil per day. Panda Ethanol also has announced plans to build similar ethanol plants near Stratford and Muleshoe.

The 2007 Texas Legislature directed the State Energy Conservation Office (SECO) to update a 1995 assessment of Texas renewable energy resources. This report, which will be released before the start of the 2009 Texas legislative session, will include up-to-date data on the availability of various renewable energy resources including feedlot biomass.

Costs and Benefits

Gasifying or burning manure is a way to avoid the monetary and environmental costs of its disposal. Producers usually are not paid for manure used as fuel in Texas; for example, cattle producers are planning to supply the manure to the Hereford ethanol plant for free to avoid disposal costs. Similarly, Microgy's Huckabay Ridge plant receives its manure free of charge from area dairy producers. Microgy has not publicly disclosed the price it receives for the gas it produces.[25] However, as more efficient methods of manure collection are crafted and produce higher quality manure for conversion, there may be more opportunities for agricultural producers.

Environmental Impact

Concentrated animal feeding operations produce residual solids and flush water. For these reasons, both the Texas Commission on Environmental Quality (TCEQ) and the U.S. Environmental Protection Agency (EPA) regulate their operations. Biomass digesters can greatly reduce the effects of CAFOs. Residual products from digesters contain high levels of nitrogen and phosphorus, both common components of fertilizer. Biogas production can produce very localized unpleasant odors, however, and lagoon-based projects carry the potential for wastewater releases during flooding if they are not engineered properly.

Recent studies at Texas A&M University have shown that combining the fuel with pulverized manure, in a process called reburning, can reduce NO_X emissions from coal burning.[26]

In addition, electricity generation from waste can require some water. Estimates of water use place many biomass waste products – wood biomass, feedlot waste, municipal solid waste – in a single category. Depending on the plant type, electricity generation from waste requires withdrawals of between zero and 14,658 gallons per million Btu of heat energy produced. This is the amount of water extracted from a water source; most of the water withdrawn is returned to that source.

Water consumption refers to the portion of those withdrawals that is actually used and no longer available. Electric generation using waste consumes between zero and 150 gallons of water for each million Btu of heat energy produced.

Other Risks

A 2005 study commissioned by the SECO concluded that biogas is a viable technology but a precarious investment, and may be driven more by the need to deal with waste problems than the prospect of making a profit. Digesters can mitigate criticism for odor, surface water and contamination problems. In addition, any cost recovery at least helps pay for the biogas equipment.[27]

One Texas A&M University study examined a Johnson County biogas plant and found that it did not make a profit in the 1990s, although it did help to solve the environmental problems created by animal waste.[28]

State and Federal Oversight

The most significant federal law affecting manure management is the federal Clean Water Act, which includes a National Pollutant Discharge Elimination System that specifically covers animal feeding operations. In 2003, EPA introduced revised Clean Water Act regulations to protect surface water from nutrients released by CAFOs.[29] In 2006, TCEQ issued a general permit under the Clean Water Act setting out regulations and monitoring requirements for waste discharges from CAFOs.[30]

Microgy officials report that they were required to have three different kinds of permits for their plant: an air permit for the boiler; a water discharge permit for land application of wastewater (a permit dairies must obtain as well); and a permit to handle grease trap waste obtained from restaurants.[31]

The Hereford Panda ethanol plant was required to obtain an air quality permit. TCEQ grants permits for air and wastewater quality. It typically takes a year to obtain an air permit for a new ethanol facility in Texas. It can also take about one year to obtain a wastewater permit from TCEQ. These timelines can encounter significant delays, however, depending on public meeting requests or contested case hearings.[32]

Subsidies and Taxes

The 2002 federal Farm Security and Rural Investment Act (the "Farm Bill") contained a specific section encouraging the use of digester systems to produce biogas. Section 9006 of the bill provides partial funding for the installation of livestock waste digestion technology. EPA reports that $25 million was awarded under this program from 2003 to 2005.[33]

According to the U.S. Department of Agriculture, no federal money was committed to Texas digester

The number of digesters operating in the U.S. has more than doubled in the last two years.

projects until 2007, when a dairy south of Sulphur Springs received a $300,000 grant.[34]

In 2007, the Texas Legislature passed a bill to provide state subsidies for the use of biomass, apparently including manure, for electricity production beginning in 2009. No money was appropriated for this program, however.[35] Eligibility for these funds, if any are ever appropriated, would be determined by rules published by the Texas Department of Agriculture.

Other States and Countries

AgStar, a joint program sponsored by the EPA, USDA and the U.S. Department of Energy, encourages biogas production at animal feeding operations, particularly those that manage manures such as liquids and slurries. AgStar reports that the use of anaerobic digesters to produce biogas or methane has accelerated across the country in recent years, due to more reliable digester technology, concern over environmental issues, government incentives and state energy policies that allow producers to sell to the grid.[36]

Using manure for fuel is seen as a way to mitigate potential environmental problems associated with feedlots and dairy operations.

The number of digesters operating in the U.S. has more than doubled in the last two years.[37] Leading states include California, Iowa, Wisconsin, New York and Pennsylvania. These digesters typically produce electricity, although in colder climates they also produce heat for the dairy. Most of these systems are farm-owned and are most common at dairies, although some are used at swine- and duck-feeding operations.[38] EPA is currently preparing a new report on digester activity around the country. As of September 2007, preliminary data being developed for the report indicated that 103 digesters are operating around the country with an energy capacity equivalent to about 22 megawatts.[39]

Some states have incentives for using digesters to produce electricity. EPA reports that New York and Pennsylvania have net metering laws related to feedlot biomass that allow producers to sell energy they generate back to the grid, and California and Maryland are developing similar laws.[40] The Texas Public Utility Commission is currently conducting a rulemaking process that could significantly expand the use of net metering in Texas, as is described in Chapter 9.

California passed a law to extend net metering until the end of 2009. Under this program, electricity produced by biogas is credited against electricity consumed by the dairy farm. In addition, the California Dairy Power Production Program (DPPP) has approved grant funding of nearly $58 million for 14 projects with a generating capacity of about 3.5 megawatts.

Hilarides Dairy in Lindsay, California is one of these projects. The DPPP paid for half of the $1 million cost of its digester. Manure from 6,000 dairy cattle produces 90 percent of the dairy's power. In addition, odor is reduced, methane is captured before it escapes into the atmosphere and the plant reduces demand on the power grid.[41]

The Public Service Commission of Wisconsin has approved a plan by Wisconsin Energy to expand its renewable energy program. Farmers will be paid 8 cents per kilowatt-hour (kWh) for peak energy and 4.9 cents/kWh for off-peak energy. Animal feeders, food processors and wastewater treatment facilities also will be eligible.

Central Vermont Public Service (CVPS) offers a voluntary program for customers to support renewable energy. Ratepayers pay a premium on their bill to receive energy from renewable sources. In turn, CVPS pays farm-based generators the market price of their energy, plus four cents per kWh.[42]

Denmark has pioneered digester technology in Europe. The nation has large-scale plants that combine manure, municipal waste and organic industrial wastes to create electricity and hot water for use in heating systems. In addition, Germany has recently been expanding its number of digesters, a technology it experimented with in the wake of energy shortages following WWII.[43]

Outlook for Texas

No significant public controversy has arisen over the use of manure as fuel in Texas—or anywhere else, for that matter. Instead, using manure for fuel is seen as a way to mitigate potential environmental problems associated with feedlots and dairy operations. Texas has two digesters, one commercial and one experimental, operating in Central Texas. In addition, Panhandle ethanol plants planned or under construction will use manure as a fuel. Other plants are planned, but the industry is still in its early stages in Texas.

While the use of manure for fuel alone will not solve Texas' or the nation's energy problems, agricultural wastes including manure do have significant potential for power use. Livestock manure and other forms of agricultural waste including poultry litter, rice straw, peanut shells, cotton gin trash and corn stover have the potential to produce 418.9 megawatts of electricity (enough to power over 250,000 homes in Texas, based on average electric use in 2006) according to a recent report from the Houston Advanced Research Center.[44]

The Environmental Protection Agency cites a number of factors that are different today that can contribute to the success of using feedlot biomass for fuel.[45] These include more reliable technology; examples of successful operations to emulate; increasing subsidies; greater concern about environmental issues; state efforts to support the production of renewable energy; and more precise estimates of harvestable manure quantity and quality as a feedstock.[46]

Using manure as a fuel can help agricultural producers cut their disposal costs and earn extra income. It can help solve potential environmental problems associated with CAFOs. By providing another source of energy, it could yield positive economic development effects in rural Texas.

Finally, research indicates that co-firing manure with coal could mitigate the environmental effects of using relatively inexpensive but comparatively dirty coal. It is unclear whether these findings will ultimately result in a widely applicable commercial way to use coal for electricity in a more environmentally friendly way, but it is a very promising avenue for further research.

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