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Dairy manure to energy: Opportunities disguised in challenges

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Increasing world demand for energy and the high cost of oil and natural gas have elevated interest in alternative and renewable energy sources such as biofuels, forests, wind, solar and animal manure. While demand for hydrocarbon energy from crude oil, natural gas and coal will continue to rise, renewable energy will become more important in coming years.

Researchers are looking for alternate fuel sources to replace fossil fuels and many are focusing on animal manure as a renewable energy source. Dairies have grown in size and in some regions their high concentration, limited surrounding crop or pasture land, or soils high in phosphorous (P) may require reduced amount of manure application on adjoining farmland. This reduced use of dairy manure as a nutrient source for plants may require either increased on-site manure storage, or its transport and application to cropland at greater distances from the dairy operation.

Dairy producers facing this challenge will benefit from opportunities that enable economically moving large amounts of manure off site, or utilizing it beneficially on-farm. To meet these management challenges, engineers and scientists with Texas AgriLife Research, Texas AgriLife Extension, and Texas Engineering Experiment Station are exploring different options of converting manure to energy.

Opportunities exist for converting manure to syngas on-site or on-farm. Small and modular gasification and anaerobic digestion units could be installed on the facility to eliminate issues associated with transport of high moisture manure off site.

Combustion

Dairy manure as a fuel has the potential to be burned directly. However, scraped manure from dirt lots or manure mixed with sand bedding has a higher ash content (inorganic residue such as soil or other inorganic material that remains after combustion) than other biomass (e.g., wood and straw) or fossil fuels (e.g., coal). Therefore, direct combustion of manure is not practical and efficient, and it is desirable to mix it with other less variable fuels.

One means of doing this is co-firing, which refers to mixing dairy manure and fossil fuels in conventional power plants. Significant reductions in emissions from sulfur dioxide (SO^2) – an air pollutant released when coal is burned – are achieved with co-firing systems in power plants that use coal as fuel.

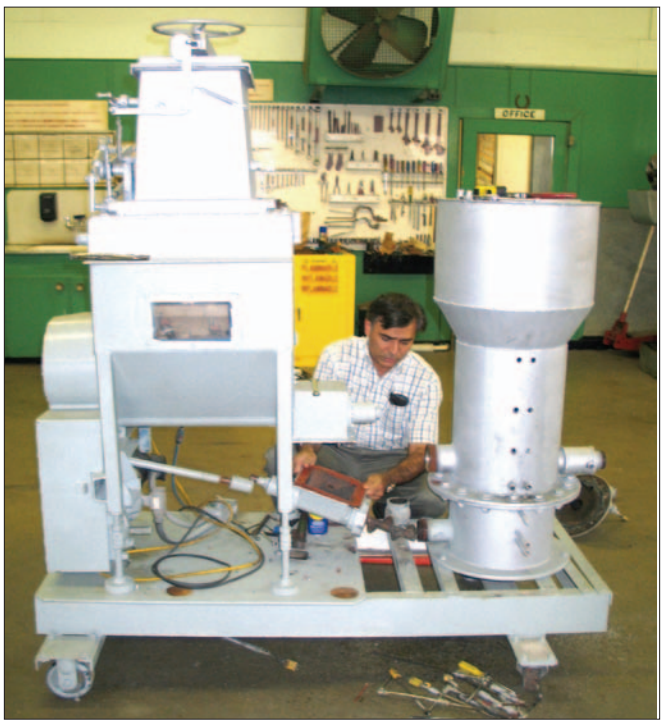
Transporting a low-value product such as manure over long distances is expensive, so using access dairy manure as a co-fired fuel source instead of as a fertilizer could save not only money but also the environment.

Small-scale studies at Texas A&M University show that co-firing of manure with coal may also reduce nitrogen oxide (NOx) emissions from coal, which also contribute to air pollution.

Anaerobic Digestion

It is the treatment of manure with naturally occurring microorganisms (bacteria) in the absence of air (especially oxygen) to produce biogas. Biogas, which is produced from degradation of organic matter in manure by the bacteria, contains primarily methane (CH^4) and carbon dioxide (CO^2). Other gases, such as nitrogen , hydrogen sulfide (H_2S) and trace organic components are also present in relatively small quantities. Typically, 60 to 65 percent of biogas is CH^4. Methane and CO^2 represent more than 90 percent of biogas.

Methane produced from anaerobic digestion and utilized as a source of energy also reduces its natural emission, which has much greater global warming potential than CO^2. The heating value (energy re-



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leased from a given mass of a fuel) of biogas containing 65 percent CH^4 is approximately 600 BTUs per cubic foot (ft^3). For comparison, 1,000 ft^3 of biogas with 65 percent CH^4 will be an approximate equivalent of 600 ft^3 of natural gas, 6.6 gallons of propane and 4.7 gallons of gasoline.

Gasification

This is the process by which fossil or biomass fuel consisting of or containing carbon is converted to a useable gaseous product without complete combustion of the fuel. It is a process that occurs in an oxygen deficient environment at high temperatures. The resulting fuel is a gas product called syngas that consists primarily of varying ratios of hydrogen and carbon monoxide (CO). Syngas can be further processed into other fuels or products by chemical conversion, or burned to heat a conventional boiler. It can also replace natural gas in a gas turbine.

Opportunities exist for converting manure to this type of energy on-site or on-farm. Small and modular gasification and anaerobic digestion units could be installed on the facility to eliminate issues associated with transport of high moisture manure off site. Dairy operators could build these systems to process and convert part of their manure streams, such as separated solids or composted manure, to produce auxiliary energy and power, including bio-fuel for farm use. As they learn to work these systems they could add more units and increase the amount of waste to process.

A recent grant from the USDA Natural Resources Conservation Service (NRCS) is funding assembly and testing of a portable anaerobic digester and gasifier system at the Biological and Agricultural Engineering Department at Texas A&M. The idea is to use liquid manure to generate methane gas with the anaerobic digester, and dried separated solids from the manure as feedstock for the gasifier, to generate energy that could be used to produce electricity for a producer's home, barn or irrigation pump. Energy production from the portable gasifier may be as high as 11 million BTUs per day, or a fuel equivalent of 75 gallons of diesel or 116 gallons of propane. When completed, both units will be on skids and could be taken from farm to farm for educational demonstrations.

Essentially all manure-to-energy conversion processes will result in residues that will be reduced in volume but might not have immediate value. For instance, most if not all of the plant nutrients will remain following anaerobic digestion. Also, char will be produced by the gasification process. Challenges ahead will involve finding processes, uses and markets for these co-products. Possibilities may include animal feed, fertilizers, soil conditioners, construction materials or chemical extraction.

Dairy manure could be an excellent feedstock for alternative energy systems to generate heat, power or fuel. The heating value of dairy manure on a dry ash free basis is estimated at 8,500 BTUs per pound, according to extensive field research by the Texas AgriLife Research and Texas AgriLife Extension. This heating value is comparable to as-received low grade coal. In addition, the use of dairy manure for alternative fuel could be an excellent mitigation measure to reduce excessive nutrient loading of land, groundwater and waterways.

Questioning the benefits of biofuels

by Ragan Adams, MS, DVM, Colorado State University

Since the biofuel industry blossomed based upon the hope that plant-based fuel use can reduce U.S. dependence on foreign oil, dairy producers have been plagued by skyrocketing feed costs. However, the rush to support biofuel use as the answer to energy independence in the U.S. has come under substantial question in the past several months.

Plant-based fuels were originally billed as better than fossil fuels because the carbon released when they were burned was balanced by the carbon absorbed when the plants grew. Study after study recently published question the promotion of biofuels, regardless of their origin, as the most rational answer.

The impact of biofuel use differs depending upon the model used to analyze their benefit. Initially, the concept of making fuel from plants that are a renewable resource seemed sound, but the analysis was simplistic because the process of turning plants into fuels causes its own emissions.

Among the mounting evidence questioning the benefit of biofuels are two articles published online in the February 7, 2008 issue of *Science* magazine, which declare that biofuel use cause more greenhouse gas emissions than conventional fuels if the full emissions costs of producing them are taken into account.

These studies include in their models the global environmental cost of biofuel production. When crops are used to manufacture biofuels, more land must be put into crop production to meet the additional needs. The destruction of natural ecosystems – whether rain forest in the tropics or grasslands in South America – not only releases greenhouse gases into the atmosphere when they are burned and plowed, but also deprive the planet of natural ecosystems that absorb carbon emissions better than cropland.

In a conversation with reporter Elizabeth Rosenthal published in the *New York Times* February 8, Timothy Searchinger, lead author of one of the studies and a researcher in environment and economics at Princeton University said, "Most of the biofuel that people are using or planning to use would probably increase greenhouse gasses substantially. Previously there's been an accounting error: Land use change has been left out of prior analysis."

Joseph Fargione, lead author of the second paper and a scientist at the Nature Conservancy said, "The clearance of grassland releases 93 times the amount of greenhouse gas that would be saved by the fuel made annually on that land. So for the next 93 years you're making climate change worse, just at the time when we need to be bringing down carbon emissions."

Dr. Searchinger's study shows the purchase of biofuels in Europe and the U.S. leads indirectly to the destruction of natural habitats far afield. For instance, if vegetable oil prices go up globally as they have because of increased demand for biofuel crops, more new land is inevitably cleared as farmers in developing countries try to get in on the profits.

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Dr. Fargione also said that the dedication of so much cropland in the U.S. to growing corn for bioethanol had caused indirect land use changes far away. Previously, Midwestern farmers had alternated corn with soy in their fields from one year to the next. Now, many grow only corn – meaning that soy has to be grown elsewhere.

In the wake of the new studies, 10 of the United States's most eminent ecologists and environmental biologists recently sent a letter to President Bush and Speaker of the House Nancy Pelosi, urging a reform of biofuels policies. "We write to call your attention to recent research indicating that many anticipated biofuels will actually exacerbate global warming," said the letter.

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