Western Dairy News
March 2010
Vol. 10, No. 2
for the West, about the West, from the West

Making smart choices about "cow power"

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Across the Western United States over $150 million may be lost every year in untapped energy generation. Not from solar or wind or natural gas sources, but from cow manure.

An interdisciplinary team of researchers from Colorado State University's Institute for Livestock and the Environment is working to help dairy producers decide if and when to use technologies that convert manure into useable energy and, thus, increase "cow power".

Although dairies in the Western U.S. have an ample supply of manure, producers have been reluctant to adopt anaerobic digestion technology that would convert it into methane-rich biogas which could potentially be used to power farm operations or heat on-site buildings, thereby decreasing operating costs. It could also be sold as a replacement for natural gas, thereby diversifying revenue for dairies at a time when milk prices are often fluctuating. In addition to these financial benefits, recycling manure would help to reduce greenhouse gas emissions, decrease unpleasant odors, and improve water and air quality.

"The technology is out there," says Sybil Sharvelle, an associate professor in CSU's Department of Civil and Environmental Engineering and an expert on biological waste processing. "Farmers just need tools to help make smart choices about how and when to use it."

In a two-stage anaerobic manure digestion system the process is separated into distinct portions, mirroring the biological process. High solids waste are placed in a concrete bay where water is passed through, effectively leaching out organics that are later converted into methane gas.

In collaboration with economist Catherine Keske and biowaste specialist Jessica Davis, all from CSU's Institute for Livestock and the Environment, Sharvelle is developing an on-line decision-support tool for producers considering on-farm bioenergy conversion. The web site will guide them through a series of yes/no questions designed to help determine if the technology is technically and economically feasible and meets their needs. Users will also receive advice on selecting the right technology, finding an equipment provider, and how to operate and maintain the equipment.

The Environmental Protection Agency estimates there are 140 anaerobic digesters operating at commercial livestock operations across the U.S.; 126 of which generate electrical or thermal energy from the captured biogas. Of the 17 Western states, 10 (Washington, Oregon, California, Idaho, Montana, Wyoming, Utah, South Dakota, Nebraska, and Texas) have anaerobic digestion projects in place, generating nearly 150,000 combined megawatts of electricity per year. There are 29 dairies in the Western U.S. with systems installed, 16 in California alone. Nationwide, dairies account for 116 of all anaerobic digestion projects.

Decision support tools similar to the one being developed at CSU have been developed for Eastern dairy farmers to help advance the use of this technology, especially in Vermont where seven dairies now provide electricity generated from manure-derived methane gas to the state's utility customers.

In a recently published study, University of Texas at Austin researchers estimated that converting manure into renewable energy could meet up to three percent of electricity consumption needs in North America, leading to a substantial reduction in greenhouse gas emissions.

Part of the reason why Western dairy producers have been slow to adopt anaerobic digestion technology is that unlike their Eastern counterparts, Western dairies typically collect manure by scraping drylots rather than flushing indoor barns, which requires a high volume of water. Add to that a naturally dry, moisture-evaporating climate and what do you get? Manure that is too dry for traditional technologies.

How dry is too dry? Conventional anaerobic digestion technology (complete mix, plug flow, fixed film, and upflow sludge blanket) all require inputs to be over 85 percent liquid. In Colorado, for example, dairy manure scraped from dry lots can contain as much as 88 percent dry solids.

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To use conventional anaerobic digestion technology, waste products would have to be diluted with water. For example, to digest 1,000 metric tons (2.2 million pounds) of waste with 90 percent total solids, a conventional digester would require the addition of almost 2.4 million gallons of water. Not only would the expense associated with pumping and heating that much water be enormous, but that much water is simply not there to use. In addition, clean water is contaminated by the process.

Sharvelle is also developing new anaerobic digestion technology that can help make the process of converting animal waste into energy more efficient. She is studying the feasibility of using a multiple-step process in which a small amount of water, typically from existing on-site wastewater, is percolated through dry manure until it has leached out as much organic material as possible. That water, now saturated with energy-rich organic compounds, is then converted into methane gas using microbes.

Having tested this new technology at a small scale, Sharvelle, in cooperation with CSU's Kenneth Carlson and Stacey Simms of the Governor's Energy Office, is now working to develop a "plant scale" demonstration version. It will be built at the Colorado Correctional Facility in Cannon City where horse, cow, and aquaculture wastes are all readily available and on-site facilities exist to manufacture all of the materials needed to set up the system.

Conversion of manure to methane is a multi-step process. First, in a process called "hydrolysis," enzymes released from microorganisms naturally present in the manure break down the organic compounds in manure (in this case, "organic" means the compound at the molecular level contains a carbon atom) into simpler compounds which dissolve more readily. It is this initial step that is often the biggest hurdle to anaerobic digestion in the West because at a molecular level it requires water to break apart chemical bonds.

In the second step, called acidogenesis, the simple organic compounds are chemically converted into organic acids such as acetic, formic, and butyric. In the third step, the organic acids produced during acidogenesis are consumed by bacteria that produce methane as a waste product.

Unlike conventional technology, two-stage anaerobic digesters can handle material that is anywhere from zero to 50 percent solids, opening up new possibilities for Western waste-to-energy conversion endeavors. Several scenarios are possible.

Dairies with on-site two-stage anaerobic digesters could accept waste materials, including crop residue, leaves, and organic municipal wastes for processing, potentially profiting from both drop-off fees and the energy generated. Alternatively, independent large-scale digesters could be established that would handle diverse dry wastes from municipal and agricultural sources, and then pipe the biogas back to their regional communities as an alternative to home heating natural gas.

The potential for co-digestion is one thing that makes anaerobic digestion more economically attractive in the West.

Although new technologies are creating new possibilities for those who are thinking about adopting anaerobic digestion, economist Catherin Keske offers a word of caution. She recently completed a feasibility study of anaerobic digestion sponsored by the Governor's Energy Office in Colorado, to evaluate the experiences of those who have tried the technology, determine if and when anaerobic digestion makes economic sense for producers, and identify what could be done to make it more accessible in Western states.

Based on the technology currently available (two-stage digestion was not included because it is still in development and not yet widely available) and the current economic climate, her report concluded that Western dairy producers cannot make enough or save enough money from on-site use of biogas to generate electricity to make this a good decision.

It also said that adopting existing technology with the hope of turning a profit by selling carbon credits isn't realistic either, at least not until the market price of carbon goes up. She did say, however, that "There are situations that would make anaerobic digestion economically attractive."

One of these is when a producer is faced with nuisance lawsuit related to odor. According to case studies in Keske's research, producers can expect to pay on the order of $100,000 in legal fees to fight a lawsuit, and could potentially be ordered to pay damages of $50 million. Under conditions like this, installing anaerobic digesters starts to look good. In situations where the technology is primarily used for mitigation, generating electricity is merely an added bonus rather than a true cost savings.

In general, Keske determined that generating electricity from anaerobic digestion isn't a smart move for a couple of reasons. In the West, electricity rates are not very high, so generating your own electricity doesn't create huge cost savings. Similarly, supplying it to the grid is not a profitable option. Secondly, methane is a relatively "dirty" gas that often clogs generators, causing them to break down and need frequent maintenance or repair.

The best use for methane biofuel generated from anaerobic digestion appears to be as a heat source replacing natural gas, especially when it can be used on-site or piped to a nearby location. For example, a dairy with a neighboring facility that can use the biofuel to heat buildings.

But the most economically attractive option for anaerobic digestion at the present time and with currently available technology, according to Keske's report, is a regional-scale conventional digestion facility that relies on co-digestion.

As stated earlier, anaerobic digestion in the West is severely limited by the availability of water. Co-digestion overcomes that hurdle because by using a variety of inputs from agricultural and municipal sources, some with high solids content (like manure or grass) and some with low solids content (like paunch, the material left over from meat processing) ensures that inputs to the system will reliably have enough water content for the multi-step anaerobic digestion process to work.

Projections are that the entrepreneurial individual who decides to invest in a regional co-digestion facility could make between $700,205 and $8.9 million, representing between three and 46 percent return on the initial investment. But under a worst-case scenario the investment could lose over $5 million.

To maximize returns, Keske's report recommends using the biogas product on-site. For the Colorado Correctional Institution that's what makes investing in anaerobic digestion so attractive – it has on-site inputs from a dairy herd and a horse training and boarding facility, and it can use the methane biogas to heat buildings, including its goat nursery and tilapia barn.

The development of a separate stage anaerobic digester capable of processing dry wastes is expected to make this process more affordable, reliable, and practical for producers, industry, and municipalities in the Western U.S. As new technology becomes available, current technology is improved, and as markets change to make electricity or carbon more valuable, producers will need to know how to respond.

Remember the on-line decision-support tool we talked about earlier? That's where the web site designed by Sharvelle, Keske, and Davis to guide prospective investors through a process of identifying existing resources, potentially suitable technology, and anticipated outcomes, will be most helpful. Before taking the plunge and investing in anaerobic digestion technology, producers and others will be able to use it to assess their current situation and receive advice and estimates about conditions that could result in a profitable, positive endeavor.

Additional information on anaerobic digestion, with links to the reports and studies described in this article, can be found through the Institute for Livestock and the Environment at **www.livestockandenvironment.info**

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