



Anaerobic Digestion

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WSU Center for Sustaining Agriculture and Natural Resources
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Background

About 65% of the methane in the atmosphere is attributable to agriculture (Duxbury, 1994), with a significant portion arising from dairy cows. The Intergovernmental Panel on Climate Change has estimated that the concentration of methane in the atmosphere has increased by more than 150% in the last 250 years. In addition, they estimate that methane is 23 times as potent as a greenhouse gas than CO₂ (IPCC 2001).

Most modern dairies utilize a lagoon system for animal waste storage, a practice that leads to large emissions of methane and nitrous oxide. Closed-system anaerobic digestion (AD) of the manure has the potential to eliminate most of the lagoon emissions while conserving more nutrients, while producing a renewable energy source as an additional benefit. Anaerobic digestion is a process in which organic matter in the manure is converted into methane by bacteria in the absence of oxygen. The methane is then collected and may be used to generate electricity. In addition, the AD process creates potentially valuable by-products, such as the solids fraction - fiber, and liquid with available nutrients.

The US Environmental Protection Agency's AgSTAR program has calculated that more than 2000 livestock facilities in the US could capture an economic benefit from installing an anaerobic digester (Ag STAR Handbook). In Washington State alone, if half of the 250,000 dairy cows were on a farm with AD, as much as 100 million pounds of methane could be captured each year (about 3.15 million tons C equivalent). Currently, there is only one commercial digester operational on a dairy farm in Washington State. In 2002, there were 40 operational digesters in the US, with at least 40 more in the planning or construction stage (AgSTAR Digest 2002). Capital costs are a major barrier to AD technology, but research is currently being conducted on reducing these costs as well as improving revenues generated by the development of complimentary products – or co-products – to energy, through use of the fiber and liquid effluents of the digester.

What is the "State of the Art"?

Covered lagoon, complete mixed, plug-flow and fixed-film digesters are four existing representative technologies. Covered lagoons are a low-cost manure treatment facility that can produce biogas from manure if external temperatures are sufficient, with a residency time of approximately 40 days (AgSTAR Handbook). Complete mix digesters can treat manure with 3 – 10% solids with a residency time of as few as 15 days, by using supplemental heat to facilitate the digestion process (AgSTAR Handbook). Plug-flow digesters are lower-technology digesters that treat dairy manure that usually is high in solid content, 11-13%, with a residency time as few as 15 days (AgSTAR Handbook). Fixed-film digestion, using active bacteria "fixed" in place on inert media, can be used to decrease the residency time of the manure stream in the digester, or for manure slurries that are too low in solids for more traditional AD technologies (Wilkie 2003).

In addition to these existing technologies, there are a number of research and technology development efforts under way in both the public and private sector.

Washington State University's Climate Friendly Farming™ Project, through partnerships with Whatcom County Extension and the Center for Bioproducts and Bioenergy, is conducting research on a novel AD system to optimize manure treatment, energy production, greenhouse gas mitigation, and co-product quality as well as market development for co-products from existing AD technologies.

Questions and research issues

Key obstacles to the implementation of anaerobic digesters are related to economic viability. Individual dairies must be large enough to capture economies of scale for the construction costs associated with the digester's physical plant. Cooperation between multiple dairies clustered near one digester can alleviate concerns of economies of scale. However, this introduces new concerns, such as regulatory requirements, costs associated with transporting manure to the digester, and ownership and management arrangements.

Another economic concern is the marketing of the products of the digester, such as the energy generated from the biogas. If the methane is used to generate electricity, the digester needs to be connected to the power grid, requiring that the sale and delivery of electricity to the power utility be negotiated with the electrical utility. With a de-regulated power system, the success of negotiations can depend on the willingness of the local utility to negotiate. Some states, including Washington State, do require electrical utilities to offer renewable energy source options, at some increase in rate, to their customers. In the Pacific Northwest there is an additional concern – cheap hydro-electric power which reduces the price that power companies are willing to pay for electricity. There are potential premiums for “green tags” and carbon credits that could also factor into the price that could be negotiated with the utility (or another group). Under the State of Washington House Bill 2247 (signed into law in May of 2001), utility companies are required to offer customers the option to buy “green tag” energy, also known as Renewable Energy Certificates (RECs). In Washington State, biogas energy qualifies for this “green tag.” There is also a market developing for carbon credits, or the off-set of greenhouse gas emissions, available to digester projects because they reduce methane emissions from dairies. One of the first “carbon credit” agreements on a digester was recently signed between a South American swine facility and Canadian and Japanese energy utilities.

Other co-products from various digester designs include fiber, nutrient water, heat, struvite and CO₂. The fiber can be used for lower-value products, such as organic soil amendments and animal bedding, or potentially for higher-value products such as a replacement for peat moss used in the growing medium for plants by greenhouses and horticultural nurseries. The nutrient water has potential to be used as fertilizer, because the nutrients in the water are readily available for use by plants. Struvite is a precipitate that is a high-quality fertilizer, and the waste heat and CO₂ can be trapped and used. Research is being conducted by WSU and others on many of these co-products to improve the quality and consistency of the products resulting from anaerobic digestion and in developing markets.

Resources

The US Environmental Protection Agency's AgSTAR program is a clearinghouse of information and resources related to anaerobic digestion. They have published a handbook and decision support software package to help farmers determine if an Anaerobic Digester is appropriate. They also maintain a guide to operational systems and to commercial

technology providers. The web address for AgSTAR is <http://www.epa.gov/outreach/agstar/>,

The Washington State University Extension Energy Program maintains current information about anaerobic digestion activity in the state of Washington. They are also available to answer questions and provide technical assistance for issues related to anaerobic digestion, bio-energy, renewable energy and alternative fuels. The web page for the WSU Extension Energy Program is <http://www.energy.wsu.edu/projects/renewables/>.

The Washington State University Center for Sustaining Agriculture and Natural Resources' Climate Friendly Farming™ Research and Demonstration Project is a resource for research and educational outreach on Anaerobic Digestion and on the co-product utilization and marketing. The web page for the Climate Friendly Farming™ Research and Demonstration Project is <http://cff.wsu.edu/>.

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