4.2.2 METHANE REDUCTION OPTIONS FOR MANURE MANAGEMENT

Technology Description

Construction of a complete mix anaerobic digestion system

The livestock and poultry industry produces large quantities of manure each year. Pollutants from improperly managed waste can damage the environment in terms of water, air, and health quality. Methane and other gases are produced when manure is managed under anaerobic conditions typically associated with liquid or slurry manure-management systems such as lagoons, ponds, tanks, and basins. Methane reduction and other environmental benefits can be achieved by utilizing a variety of technologies and processes including aeration processes to remove and stabilize some pollutant constituents from the waste stream; anaerobic digestion system that collect and transfer manure-generated off-gases to energy producing combustion devises (such as engine generators, boilers, or odor-control flares); and solids-separation processes to remove some pollutant constituents from the waste stream.

System Concepts

- *Anaerobic digestion* provides a high level of manure treatment that mitigates water and other air pollution by biologically stabilizing (treating) influent waste materials and capturing methane emissions. Captured gas can then be combusted to produce electricity, heat, or vehicle fuel. Anaerobic digestion technologies can be applied at various scales (i.e., farm or centralized) and require separate effluent storage and a gas use device. Centralized anaerobic digestion technologies can be cost-effectively integrated into high-density livestock regions, where a number of farms would transfer manure to a dedicated processing facility. Centralized systems can produce very large power outputs (1-20 MW) depending on the manure volume and quality. Comparatively centralized systems can use technologies with greater complexity, because these plants typically have a professionally trained team available to operate the system.
- *Separation processes*, typically used in dairy operations, remove particulate matter from manure handled as liquid or slurry through gravity, mechanical, or chemical methods. These processes create a second waste stream that must be managed using techniques different from those already in use to manage liquids or slurries. Separation processes offer the opportunity to stabilize solids aerobically i.e., to control odor and vermin propagation.
- In *aeration processes*, oxygen is transferred to a liquid primarily by mechanical equipment. The equipment serves to a) provide the oxygen needed by the microorganisms to oxidize the organic matter and b) keep the solids in suspension by mixing. A residual-dissolved oxygen concentration of at least 1-2 mg/L is an indicator that the rate of oxygen transfer is adequate to satisfy this oxygen demand aerobically for livestock waste. This requirement is usually met by large pumps operating in the range of about 50-125 HP.

Representative Technologies

- *Centralized digester technologies* include both mesophilic and thermophilic mixed digesters and other advanced environmental processes such as reverse osmosis and gas compression. Thermophilic digesters operate at high temperatures (140ºF). Mesophilic operate at lower temperatures (about 105ºF) and have greater process stability. Currently available combustion devices include medium-BTU reciprocating engines with heat recovery (cogen), turbines, boilers, absorption cooling, and furnaces. Flares also can be used to control odor and other air emissions in nonenergy applications. Emerging technologies include microturbines, sterling engines, and fuel cells.
- *Farm-scale digesters* are typically simpler systems operating at ambient and mesophilic temperatures and include mix, plug, and inground covered systems.

- *Separation process technologies* include gravity separation (shallow pits where solids settle and liquids run off to a treatment lagoon), mechanical separators (use external energy sources to remove solids), and flocculation or precipitation (chemical additions are used to help precipitate particulate and colloidal materials).
- A variety of *aeration process technologies* exist, including aerobic digestion (a suspended growth process operating at ambient temperature), autoheated aerobic digestion (utilizes heat released during the microbial oxidation of organic matter to raise process temperature above ambient levels), sequencing batch reactors (combine the conventional activated-sludge treatment process with secondary settling/clarification in a single tank), attached-growth processes (trickling filters, rotating biological contactors, and packed bed reactors use inert media to stabilize organic matter and limit organic loading rates), and composting (a solid-waste treatment process that requires oxygen and appropriate carbon:nitrogen ratios to heat and stabilize waste material.)

Technology Status/Applications

- There are currently about 50 farm-scale anaerobic digesters producing heat and about 30 million kWh of electricity per year with currently available technologies at U.S. dairy and swine farms. A small number of farms also flare gas for odor control and GHG reductions. There are no centralized anaerobic digesters operating in the United States, although Europe has several of these systems.
- Separation is typically used in the dairy industry to remove nonbiodegradable material from treatment lagoons, but is rarely applied to managing wastewater from swine facilities because swine solids are small, heavy, tend to mat, and hold water. Additional equipment and management is required to maintain adequate air infiltration for aerobic conditions.
- Aeration processes are basically applied to low-strength and dilute waste streams due to energy requirements. Their use has been limited for livestock liquid and slurry waste streams.

Current Research, Development, and Demonstration

RD&D Goals

- Develop new types of digesters with reduced costs and biological efficiencies. A number of private companies are developing and testing newer gas combustion devices for medium-BTU gases.
- Modification to under-slat floors in swine buildings to separate solid and liquid fractions and chemical additions applied to swine manure.
- Develop, apply, and evaluate aeration process performance for manure waste streams. Identify appropriate pollution-control methods for confined livestock facilities.

RD&D Challenges

- Current R&D on anaerobic digestion technologies is done at bench or pilot scales. These processes often are operationally complex at commercial scales. This complexity may be justified under a centralized operating structure because dedicated expertise is available to control system processes. Continued work in this area needs to identify regional areas with greatest opportunity to implement this approach relative to farm distances, manure-handling method, and frequency of collection.
- Utility policies toward independent power producers impede development of digestion technologies for power generation. Increasing operational reliability and efficiency of electrical production equipment and increasing the number of equipment providers is needed. Controller logic for electrical-producing gas uses and digester type also is required.
- Improved separation processes need to be demonstrated at commercial-scale farms where operations are more complex.
- Challenges for the use of aeration processes for primary manure treatment today include high investment and operating costs (including energy) of treating waste streams aerobically. Aeration processes also increase the volume of residual solids depending on the operating conditions necessitating removal and additional management. Aeration may also volatilize 30%-90% of the nitrogen as N_2 or N_2O, which contribute to global warming and other environmental problems.

RD&D Activities

- EPA Region 9 is working with California to evaluate the feasibility of a centralized anaerobic project.
- USDA and DOE are currently funding research, development, and demonstration projects under the Biomass Research and Development Act of 2000. There are a number of projects focusing on technologies to generate energy from animal waste, convert biomass to hydrogen, and develop innovative biorefinery processes.

Recent Progress

- EPA's AgSTAR Program provides project development tools, performance evaluations, and general digester information. AgSTAR also collaborates with a number of state programs and various Farm Bill sections to expand the use of appropriate anaerobic digestion processes and gas uses. AgSTAR products and expertise have been used in the majority of animal waste digestion systems currently in operation.
- Currently, dairy manure handled as liquid and slurry is generally separated. Some dairies blend solids with other organic materials and market "brand" name compost materials for the nursery and home garden market.
- Aeration processes may be feasible for secondary or tertiary treatment of livestock waste, where greater pollution control is desirable – or to further reduce nitrogen availability for crop uptake.

Commercialization and Deployment Activities

- Currently, centralized digestion applications are being identified and some are in operation. The opportunities, however, may be limited because of farm distances and manure-handling practices. Biosecurity issues also may reduce the potential of this approach. Emerging gas-use technology development is limited for farm-scale anaerobic digesters because commercial applications have not been in operation long enough to make a performance determination by designers and vendors. However, applications at larger scales (such as landfill gas) will be relevant for centralized systems.
- There are several manufacturers and suppliers of mechanical separator equipment. USDA provides design guidance for gravity separators and technical resources to farms requesting assistance.
- A number of manufacturers and suppliers of aeration processes are available because it is used in municipal and industrial waste treatment. A number of low-rate aeration processes are emerging but have limited application because the dissolved oxygen requirements for microbial populations to oxidize organic matter are not met.

Market Context

- Cost-sharing and appropriate energy policies for independent power production could increase market penetration.