Frequently Asked Questions

Thermal Manure-to-Energy Systems for Farms

Manure Management ● Energy Production ● Water Quality

1. **Why are thermal manure-to-energy systems for farms worth considering and evaluating?**

   Thermal manure-to-energy systems for farms facilitate the transport of excess manure nutrients — particularly phosphorus — out of high-density animal production regions. This can potentially provide a cost-effective means of recycling excess phosphorus also providing renewable energy and revenue for farmers. Such systems also have the potential for providing abundant, renewable heat (or other forms of energy such as electricity or cool air) for use on the farm. In animal housing, the production of abundant, low-cost heat allows farmers to increase ventilation rates in the winter without worrying about the expense and greenhouse gas emissions typically associated with heat based on fossil fuels. Increased ventilation can improve indoor air quality and improve bird health and flock performance.

2. **Why are alternatives to local land application of manure important for farmers in high-density animal production areas and elsewhere?**

   Manure contains valuable nutrients and organic matter that improve soil fertility and promote healthy crop production when used as a fertilizer. However, long-term reliance on manure as the primary source of fertilizer can lead to an accumulation of phosphorus in soils and increase the risk that phosphorus in manure will be carried by rainfall, shallow groundwater flow, tile drains, and ditches to streams, rivers, and estuaries. Excess phosphorus in surface waters fuels the growth of algae in aquatic systems and contributes to water quality impairments.

   In places with high-density animal production, phosphorus often accumulates in soils far beyond levels required to support crops. However, many regions of the world have phosphorus-deficient soil and rely largely on inorganic phosphorus fertilizer to produce robust yields. Inorganic fertilizer is not only expensive; it is a limited resource, vital to the world's food supply. Technologies that facilitate the transport of excess manure phosphorus from high animal-density regions to phosphorus-deficient regions reduce reliance on mined inorganic phosphorus, provide producers with new sources of revenue, and help protect water quality.

3. **What does the term "excess manure" mean?**

   "Excess manure" refers to manure produced in excess of crop fertilizer requirements and in excess of the local farm soil capacity to retain nutrients for future crop production without contributing to water quality degradation. The term "excess" can be used in the context of an individual farm, when the farm produces more manure nutrients than required to sustain crop yields. These excess nutrients are in many cases considered a valuable commodity and sold to neighboring farms for use as fertilizer. Excess manure can also describe regional manure nutrient surpluses that occur in areas of concentrated animal production. In the regional context, livestock farmers collectively produce more manure nutrients than surrounding cropland requires as fertilizer. Where regional excesses occur, finding crop fields that can safely use manure nutrients becomes more difficult over time and requires transportation over greater distances.

4. **Why are thermal manure-to-energy technologies proposed as a solution for managing excess manure?**

Thermal technologies that use manure as a fuel have recently been developed for use on farms. Examples include combustion, gasification, and pyrolysis. These systems capture energy from manure or poultry litter and, at the same time, concentrate excess nutrients in the form of ash or biochar. These co-products can be cost-effectively transported longer distances compared to raw, composted, or anaerobically digested manure and sold to farmers located in nutrient-deficient regions. Depending on the process, the ash may contain as much as two to ten times the phosphorus and potash content of raw manure. Biochar produced by pyrolysis is less dense in nutrients but has shown promise as a beneficial soil amendment, fertilizer, and means of sequestering carbon and reducing N_2O emissions from agricultural production. Thermal processes also destroy any pathogens associated with raw manure. Field trials and laboratory analysis conducted by the Virginia Tech Eastern Shore Agricultural Research and Extension Center indicate that the resulting ash or biochar can be used as a replacement for inorganic phosphorus and potash on row crops as well as fresh market fruits and vegetables, where the use of raw manure can pose consumer health risks.

5. **Can anaerobic digesters be used to address excess manure at the farm or regional level?**

In environments with no oxygen and plenty of organic matter, anaerobic microbes can convert manure carbon into a combustible biogas gas. Similar to natural gas, biogas can be used as a fuel for production of heat or electricity. In addition to producing energy, microbes in anaerobic digesters break down volatile organic compounds that cause odor and they destroy pathogens, thereby reducing the risk of bacteria pollution from fields where digested manure is applied.

Anaerobic digestion has been successfully used on farms with liquid manure (like dairy or swine) to convert manure to energy for decades. Drier manures like poultry litter have also been converted to energy in anaerobic digestion systems.

In the digestion process, microbes also convert a portion of the nitrogen and phosphorus in the organic form — which is not immediately in a form that plants can use — to inorganic nitrogen and phosphorus that is immediately available for plant uptake. However, the total amount of nitrogen and phosphorus is generally not changed by the process. While anaerobic digestion reduces the volume of manure, nutrient concentration and bulk of the material generally do not support long distance transport to end users; this means that anaerobic digesters are not typically recommended as a solution for addressing regional nutrient imbalances. That said, because the digestion process reduces pathogens and odors, it can expand the local acreage to which manure can be applied.

Some emerging technologies for anaerobic digestion include advanced solid-separation techniques that could achieve a higher degree of phosphorus removal.

6. What are the key criteria for successful, farm-scale, manure-to-energy technology?

Any form of thermal manure-to-energy technology appropriate for farm-scale deployment should meet key performance objectives in at least three critical areas: 1) technical, 2) financial, and 3) environmental.

With respect to technical performance, the vendor should be able to demonstrate ample experience using poultry litter or manure as a fuel source on a farm setting. The entire system should be integrated with the farm's existing energy system, which will be needed as a back-up or supplemental source of energy should the thermal system require repairs or routine maintenance. The system should be easy to operate and maintain, and robust enough to handle manure or poultry litter as a fuel source (including rocks and other large objects that are often found in manure); it should also require a reasonable amount of time and expense to operate.

Financially, the system should be priced for a reasonable return on investment. Most commercial farm lenders recommend a return on investment two to three years. Financial considerations should also take into consideration operation and maintenance costs (labor and expense), as well as potential revenue opportunities.

Environmentally, the system should limit air emissions of criteria and hazardous air pollution. Vendors should be able to provide farmers with data necessary to determine whether the system will comply with state regulations.

7. How can a farmer decide if a thermal manure-to-energy system is right for a specific farm?

Determining whether a thermal manure-to-energy system is the right fit for an individual farm requires careful consideration and planning. Farmers should consider whether or not they can invest the time required to plan, oversee installation, operate, and maintain the system. Fuel characteristics and availability of excess manure are also critical issues. Farmers should work with potential vendors to determine whether the manure or litter produced on the farm will be suitable for use in the proposed system. They should ask how well the system can handle the moisture content in the manure or litter produced on the farm, as well as rocks or other debris that may be found in the manure. Vendors should have a proven track record for customer service and long-term maintenance.

To off-set the cost of installing, operating, and maintaining the system, farmers should consider the potential energy savings as well as the availability of cost-share funding and established markets for the ash or biochar co-products.

8. Will thermal manure-to-energy technologies simply transfer nutrient pollution from land and water to the air?

Ensuring thermal manure-to-energy technologies do not create actual or perceived local air pollution problems is important. Currently, little information is available on hazardous air pollutants associated with farm-scale, thermal manure-to-energy systems. In the Chesapeake Bay region, the Farm Manure-to-Energy Initiative is evaluating the environmental performance of several thermal manure-to-energy technologies, including hazardous air emissions. Data will be posted on the thermal manure-to-energy clearinghouse website when it is available.

To date, information provided by vendors working with the Farm Manure-to-Energy Initiative suggests that some thermal manure-to-energy systems can achieve low emissions. However, as with other biomass thermal energy technologies, the control of particulate matter is critical — especially fine particulate matter, which is the most damaging to public health. Like other biomass systems, thermal manure-to-energy systems tend to produce fine potassium-based particulate matter that needs to be treated with emission control systems. A number of technology providers use baghouse emission controls, while others use cyclone separators. However, capturing fine particulate matter improves the value of the ash co-product, as it often contains high concentrations of potash (for example, 80 percent).

Emissions of nitrogen oxide in thermal manure-to-energy systems — even those that use oxygen in the conversion process — are often low. This is because manure contains organic and inorganic forms of nitrogen, which is converted to ammonia (NH_4) in the thermal conversion process. In the presence of nitrous oxide species, hydrogen atoms in ammonia react with oxygen atoms in nitrous oxide to form water vapor and N_2. N_2, a non-reactive species of nitrogen, is stable and comprises approximately 70 percent of the earth's atmosphere. Due to this reaction, ammonia injection is sometimes used as an emission control treatment to reduce nitrous oxide.

For more information, visit the thermal manure-to-energy section of the eXtension website, or contact Kristen Hughes Evans of Sustainable Chesapeake at kristen@susches.org or 804-477-7683.

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