New Directions for Foodwaste

Anaerobic digestion of food scraps establishes a beachhead in the US. BY BRUCE CLARK, P.E.

Anaerobic digestion (AD) has become a viable alternative method for disposal of the foodwaste portion of the solid wastestream.

Although long established and popular in Europe, AD technology has been slow to catch on in the US. This has been mostly a result of low tipping fees in many parts of the US relative to those in Europe. The European Union also effectively banned the disposal of organic wastes in landfills over a decade ago. The purpose of this article is to provide an overview of the basics of the technology, the attributes of some popular systems, and the factors that are critical and desirable to make the integration of this technology into a community feasible.

OWS

A dry anaerobic digester under construction in Bourg-en-Bresse, France

Background

AD technology has been used in the US wastewater treatment industry for decades, in the processing and treatment of raw liquid sludge. The process uses naturally occurring microorganisms in a series of biochemical reactions to decompose the organic fraction of the waste in an oxygen-free atmosphere, usually conducted inside a tank. Anaerobic digestion produces two desirable byproducts from the biochemical process: biogas with high methane content, and low-solids digested sludge. This liquid-based (or "wet") technology has been the first to be adapted to including foodwaste, along with other more traditional liquid feedstock, including fats, oils, and grease (FOG) and manure. And although there are several plants of this type successfully operating in the US, the focus of this article is on anaerobic digesters that have been developed to process a feedstock (i.e., foodwaste and greenwaste) that are considered "dry."

Composting is another method to process foodwaste that is more widespread in the US than AD. However, the basic attributes of an AD system, as opposed to aerobic composting of foodwaste, include the following:

- Production of renewable energy
- Reduction in the footprint of the main plant site
- Significant reduction of odor nuisance potential of the plant
- Reduction of CO_2 emissions
- Consistent high-quality of treatment

Operating US Systems

It was not until Europe adapted the technology to mix feedstocks with a far higher solids content—up to 50%—that the technology became viable for use on municipal solid waste. Several European companies have established US offices and technical representatives, including but not limited to Eggersmann Group, Organic Waste Systems (OWS), Eisenmann Corp., and Viessmann. Several US universities are conducting research and have teamed with private US companies to introduce adaptations of AD technology that work with foodwaste.

Viessmann's waste company, BIOFerm Energy Systems, has an operating plant in Oshkosh Wisconsin that started in 2011 and processes about 6,000 tons annually of foodwaste from the University of Wisconsin campus. Eggersmann Group, represented in the US by Zero Waste Energy LLC (ZWE), has a plant, based on its SmartFerm technology in Monterey, CA, that started operation in early 2013 and at the time was processing about 300 tons per month of foodwaste and greenwaste. ZWE also recently completed a plant in San Jose, CA, based on its Kompoferm technology system, that is operational and designed for a capacity of 90,000 tons annually of commercial organics. OWS has several plants in the planning stages across the US. These, however, are by no means the only companies active. Several other companies that have plants in the planning, permitting, or construction phases.

Table 1. General Features and Performance of Three Types of Dry Digesters

Criteria	Vertical Flow Digester	Static Pile (Heap) Digester	Horizontal Flow Digester
Estimated biogas production potential (ft^3/ton)	Greater than 4,400	Greater than 3,000	Not available
Estimated biogas energy production potential (kw-hr/ton)	up to 200	Up to 150	Not available
Solids handling	Up to 50%	Up to 35%	Not available
Process	Continuous	Batch	Continuous
Feedstock preparation	Grind to less than 1-1/2 inch	No pre-grinding of feedstock	Grind to less than 1-1/2 inch
Redundancy	None—Typically single chamber	Multiple chambers provide some redundancy	Multiple chambers provide some redundancy
Feedstock heating	Feedstock heating	Continuous heating of waste	Continuous heating of waste
Process mechanical complexity	Medium	Low	Low-Medium
Leachate management	Leachate not produced	Storage tank and circulation system required	Storage tank and circulation system
Relative energy input	Medium	Low	Low-Medium

Technology Overview

Although all of the established vendor systems are based on the same basic biochemical process, there are some significant design and operating variations between systems. In a "dry" system the truly low-solids content materials are limited in quantity, so that the feedstock mixture is dry enough that it can be managed as a solid material. This has resulted in other design options for the container where the foodwaste is processed. In the systems from BIOFerm, ZWE (SmartFerm), and Eisenmann, wastes in bulk are placed in long, rectangular chambers usually constructed of reinforced concrete, however, the Eisenmann system also uses stainless steel tubular vessels.

The Viessmann dry technology is based on bulk feedstock being loaded into a pile inside the unit with a front-end loader. Feedstock can be ground up, but this is not necessary. Heat is applied with a convection system in the walls and floor. Leachate is continuously collected in a large underground storage tank, heated, and sprayed over the pile with header pipe to hasten decomposition. Biogas is collected in a flexible membrane holder located above the chamber and then piped to a combined heat and power (CHP) plant.

The Kompoferm system is unique in that it has the flexibility to integrate several waste processing technologies, if desired, for the

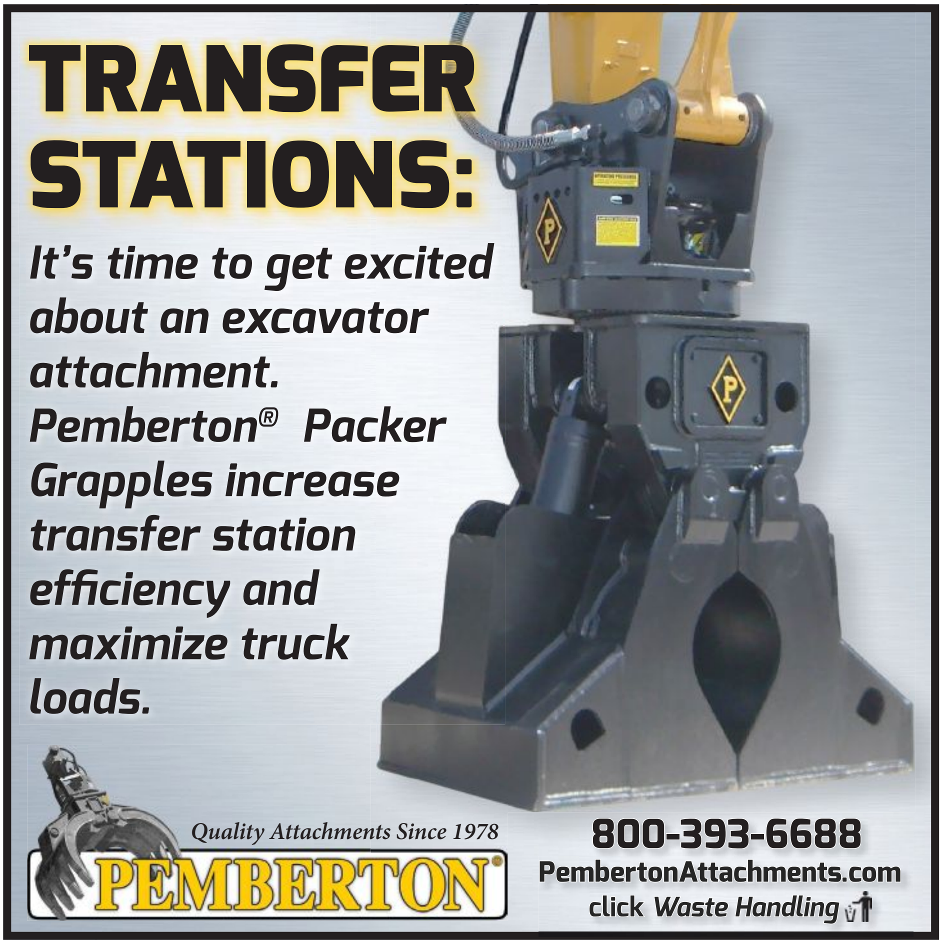
production of refined materials and multiple energy sources to serve a variety of markets and to meet restrictions on the landfilling of residual materials, if required. The components of the system include; automated mechanical pre-processing (i.e., bulk separation of inerts), fine separation of recyclables, production of refuse-derived fuel (RDF), aerobic composting, a wet digestion element, and a dry AD process.

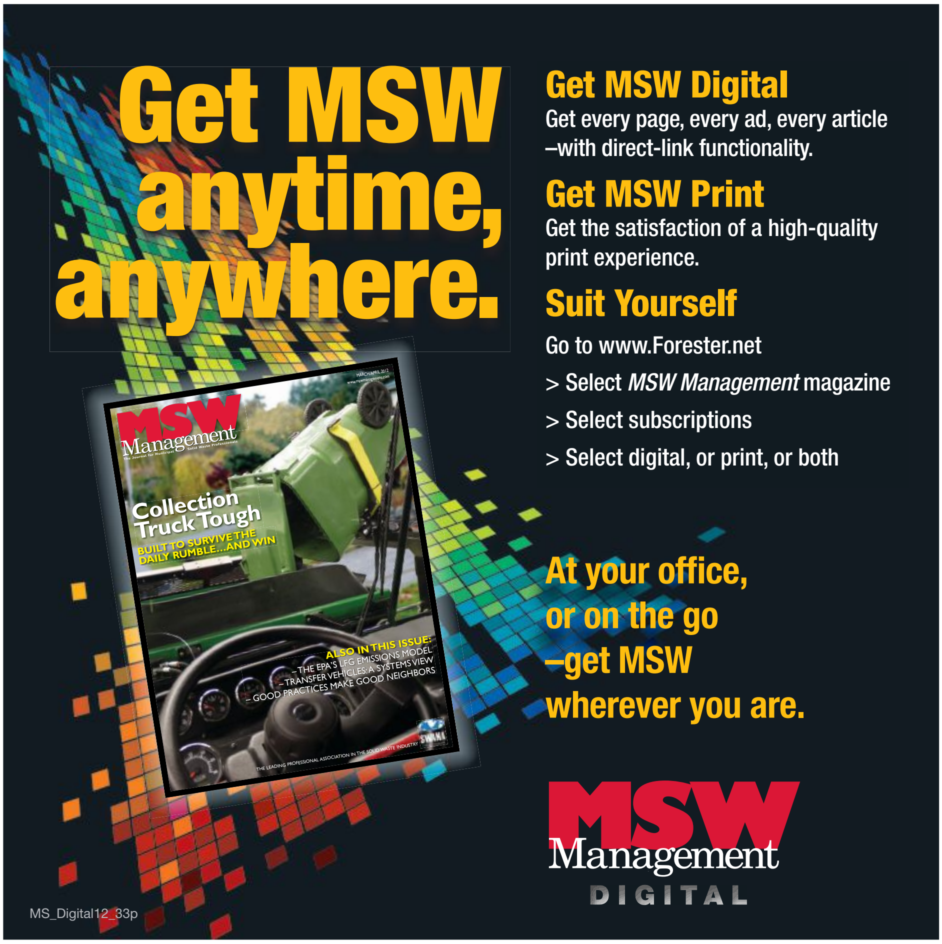
The SmartFerm dry technology is based on the Kompferm dry anaerobic element process, but is optimized for compact, smaller-scale applications. In a general sense, the SmartFerm system design is somewhat similar to the Viessmann system.

The Eisenmann technology applied to foodwaste is based on a horizontal flow model that consists of the processing chamber fitted with a mixing element. Feedstock is first reduced to less than 1.5-inches in size. Liquid, usually leachate generated from the process, is added, and then the mixture is fed into the digester and slowly pushed through it by a paddle system fixed to an axle turned by an electric motor. The axle runs the length of the vessel. Similar to the Viesmann technology, heat is supplied by convection from a piping system in the walls. Leachate is collected at the end of the chamber in a separate tank and may be recycled to the pile or sent to a secondary digester where additional biogas is produced. Biogas generated from the processes can be sent directly to a CHP plant. The input of the energy from the continuous mixing action has the potential for relatively high biogas production.

In the OWS system, a unique vertical system, wastes are ground up to about 1.5 inches, injected with steam, and pumped using a high-pressure unit (not unlike a concrete pump) into an elevated steel silo tank, where the decomposition takes place and the processing waste moves downward in a compact mass by gravity. Digestate is drawn off the bottom of the digester, and some of that is diverted back to the mixing pump to seed incoming feedstock. The OWS system's design combining a high solids tolerance with the weight of the waste providing a high degree of contact has the potential for higher biogas production.

A general summary of the features and performance of three types of digesters is provided in Table 1. All of the systems process a full waste load in about 20 to 28 days, and operate in the thermophilic range (a temperature of at least 50°C to 55°C, or 122°F to 131°F), which provides for maximum biogas





production and pathogen kill. The anaerobic digestion of foodwaste and greenwaste also produces digestate, which can be a low- to medium-solids liquid or more like a cake. The digestate can be used as a liquid soil conditioner or composted with additional organic solids into a soil conditioner.

Information in Table 1 is not meant to be specific to any of the vendors mentioned. The author advises to contact the vendor directly (some contacts are provided at the end of this article) for specific data, costs, and performance of their particular technology and system configurations, which may differ from that indicated. Some, but not all of the information was obtained from vendor websites and their reference publications.

Frequently Asked Questions

Some of the key questions that often are asked, especially when a relatively new technology is introduced, include the following.

What is the ideal scenario for considering use of an AD system?

Positive factors would include these:

- Relatively high tipping fees for traditional waste disposal facilities (i.e., landfills and waste-to-energy plants). One company indicated its system is competitive when the tipping fees for traditional methods hit about $75 per ton, including such other factors as higher utility power costs.
- Relatively high power costs from traditional sources. One company indicated its preference for a rate at least $0.12 per kilowatt-hour.
- A power utility that is receptive to offering a long-term power purchase agreement (PPA) for the energy produced from the biogas, or an onsite use, or a nearby industrial customer for the power.
- A sufficient volume and sustainable source of high-quality feedstocks. For foodwaste, these preferably would be such commercial production facilities as vegetable and fruit canning, bakeries, dairy products, and supermarkets. Less desirable, but usable sources, include restaurants, mall food courts, and residential collection programs.
- Local resources for composting the digestate and a viable market (as in the ability to charge for the product) for the compost.
- An agricultural region with infertile soils and/or a farming community that understands the value of compost to soil.

What are the key economic factors for an AD system?

A summary of key economic factors to include in an economic pro forma and feasibility study would include those in Table 2.

A review of reports by others and discussions with some vendors indicate that AD system capital cost (including design, engineering, construction, and commissioning) can range from around $175,000 per daily ton of capacity, for a basic system without extra equipment such as temporary raw waste storage areas that have a negative air capture and biofilter odor removal system, to upwards of $230,000 per daily ton for a more sophisticated AD system with options.

Is one system any better than the other?

There is no definite answer to this question: Each system has its pros and cons and trade-offs. So far in the US, for feedstock primarily of food scraps, there is no one dry system that is dominant, although several static pile systems have been the first to become operational. The first few systems

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Follow us @ ForesterU Like us @ Forester.University Subscribe @ ForesterUniversity Add us @ Forester.University being operated are multiple-chamber designs that, because of the redundancy provided by multiple processing chambers, may be perceived to be easier to recover if a batch of feedstock goes bad. And mechanical complexity is somewhat less.

Batch systems however, inherently require more space to process a ton of waste versus continuous feed systems. On the other hand, the vertical process reactor system has a design that has the potential to produce more biogas per ton of feedstock, up to approximately 30% more, based on vendor operating reports. All of the systems mentioned are successful, popular, and have had multiple plants operating in Europe for many years, even decades.

Vendors with outlets for supplying parts within the US may offer an advantage as plants get larger in capacity.

Closing

Any community or company interested in AD technology should consider conducting an initial feasibility study. This would include an economic pro forma of one or more representative systems. Plants will vary in capital and operating costs, complexity of operation, energy outputs, and the level of technical service provided by the vendor. The initial reports clearly indicate that the dry AD systems up and running in the US are working well. However, also visiting operating plants can provide a wealth of key details and better understanding that diagrams and pictures alone cannot convey, and should also be high on the list when evaluating different systems and vendors. **MSW**

Table 2. Summary of Key Economic Factors for Dry Anaerobic Digesters

Revenue Streams	Operating Costs
Tipping Fees	Feedstock processing and conditioning
Sale of energy from biogas (power, heat)	Biogas cleaning for power and heat production or use as pipeline gas
Sale of compost and liquid nutrient (if any)	Equipment O&M
Sale of biogas (i.e., for conversion to pipeline gas or liquid fuel)	Labor
	Biogas conversion to liquid fuel
	Digestate / Compost site operations, including replacement of air emissions filter (i.e., wood chips)
	Disposal of digestate (if not used as a liquid nutrient or converted and used as compost)

To Learn More

Sales representatives for the vendors mentioned in this article include:

- OWS, Norma McDonald, 513-535-6760, **www.ows.be**
- BIOFerm Energy, Nadeem Afghan, 608-467-5523, **www.biofermenergy.com**
- Eisenmann, Kyle Goehring, 815-900-1443, **www.eisenmann.us.com**
- Zero Waste Energy, Dirk Dudgeon, 415-265-1339, **www.zerowasteenergy.com**

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