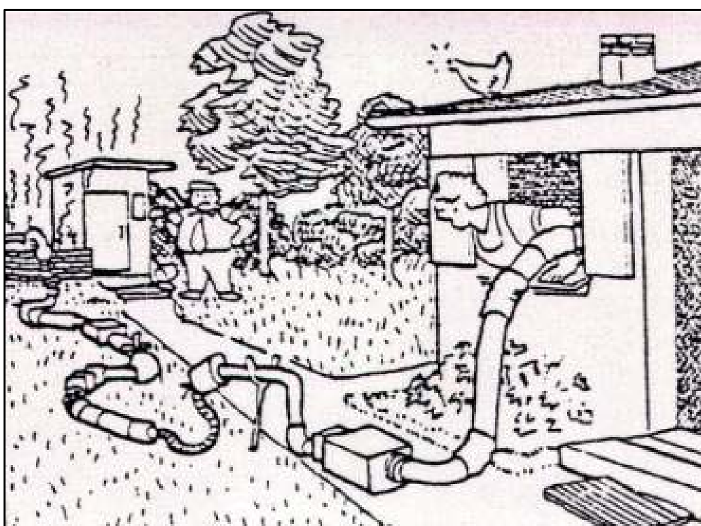
HISTORY OF ANAEROBIC DIGESTION

A Short History Of Anaerobic Digestion

Anecdotal evidence indicates that biogas was used for heating bath water in Assyria during the 10th century BC and in Persia during the 16th century. Jan Baptita Van Helmont first determined in 17th century that flammable gases could evolve from decaying organic matter. Count Alessandro Volta concluded in 1776 that there was a direct correlation between the amount of decaying organic matter and the amount of flammable gas produced. In 1808, Sir Humphry Davy determined that methane was present in the gases produced during the AD of cattle manure.

The first digestion plant was built at a leper colony in Bombay, India in 1859. [1] AD reached England in 1895 when biogas was recovered from a "carefully designed" sewage treatment facility and used to fuel street lamps in Exeter.[2] The development of microbiology as a science led to research by Buswell[3] and others in the 1930s to identify anaerobic bacteria and the conditions that promote methane production.

In the world of AD technology, farm-based facilities are perhaps the most common. Six to eight million family-sized, low-technology digesters are used to provide biogas for cooking and lighting fuels with varying degrees of success. In China and India, there is a trend toward using larger, more sophisticated systems with better process control that generate electricity.



In Europe, AD facilities generally have had a good record in treating the spectrum of suitable farm, industrial, and municipal wastes. The process was used quite extensively when energy supplies were reduced during and after World War II. Some AD facilities in Europe have been in operation for more than 20 years. More than 600 farm-based digesters operate in Europe, where the key factor found in the successful facilities is their design simplicity. Around 250 of these systems have been installed in Germany alone in the past 5 years.

There is enough for only one pancake and we have five people to feed. (Dates from WWII when energy supplies for private use were drastically reduced.)

Other factors influencing success have been local environmental regulations and other policies governing land use and waste disposal. Because of these environmental pressures, many nations have implemented or are considering methods to reduce the environmental impacts of waste disposal.

The country with the greatest experience using large-scale digestion facilities has been Denmark, where 18 large centralized plants are now in operation. In many cases these facilities co-digest manure, clean organic industrial wastes, and source-separated municipal solid waste (MSW).

Denmark's commitment to AD increased with an energy initiative[4] that will double biogas production by the year 2000, and triple it by the year 2005. One of the key policy tools used to encourage technology deployment is "green pricing," i.e., allowing manufacturers of biogas-generated electricity to sell their product at a premium. Interestingly, the sales of cogenerated hot water to specially-built district heating systems is becoming an important source of revenue for project developers.

The use of the AD process for treating industrial wastewaters has grown tremendously during the past decade. Worldwide, more than 1,000 vendor supplied systems now operate or are under construction. It is estimated that European plants comprise 44% of the installed base. Only 14% of the systems are located in North America. A considerable number of the systems are located in South America, primarily Brazil, where they are used to treat the vinasse co-product from sugar cane-based ethanol production.[5]

A digester treating dilute wastewater at a fuel ethanol production plant in Brazil (photo credit: Paques BV)

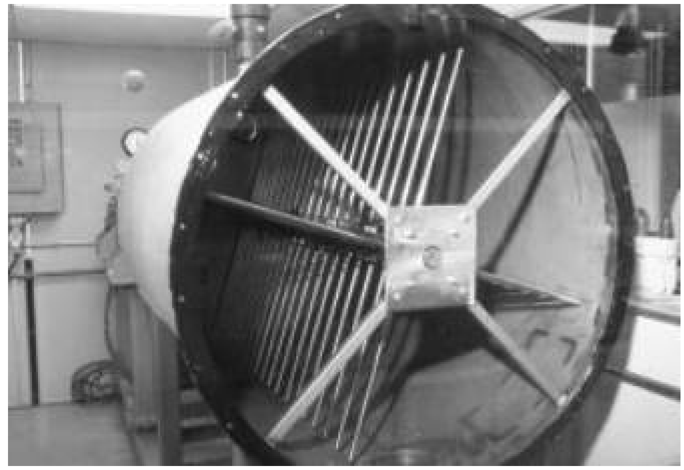
More than 35 example industries that use digesters have been identified, including processors of chemicals, fiber, food, meat, milk, and pharmaceuticals. Many use AD as a pretreatment step that lowers sludge disposal costs, controls odors, and reduces the costs of final treatment at a municipal wastewater treatment facility. From the perspective of the municipal facility, pretreatment effectively expands treatment capacity.

This MSW digester has operated continuously since 1988 (photo credit: Krijn Braber, NOVEM)

Although the first digester to use MSW as a feedstock operated in the United States from 1939-1974, it is receiving renewed interest. MSW processing facilities have made significant progress towards commercial use in recent years, with several in operation for more than 15 years. A number of types of systems have been developed; each has its own special benefits.

Processes such as AD and composting offer the only biological route for recycling matter and nutrients from the organic fraction of MSW. Composting is an energy-*consuming* process, requiring 50-75 kWh of electricity per ton of MSW input. Composting technology for MSW is commercially available and in use, but its further application is limited mainly by environmental aspects and process economics. AD is a net energy-*producing* process, with around 75-150 kWh of electricity created per ton of MSW input. MSW digestion technology is now being demonstrated and fully commercialized.

MSW digestion poses many technical problems, including an increase in HRT. High-solid digestion (HSD) systems have been developed with the potential to improve the economic performance of MSW systems by reducing digester volume and the parasitic energy required for the AD process. Several alternative HSD designs have been developed that operate with total solids (TS) concentrations[6] greater than 30%.[7] These designs employ either external or internal mixing, using biogas or mechanical stirrers. In general, all HSD systems have equivalent performance.



Prototype HSD system developed in the United States uses equipment adapted from the mining industry (photo credit: Pinnacle Biotechnologies)

1. Meynell, P-J. (1976). Methane: Planning a Digester. New York: Schocken Books. pp. 3.

2. McCabe, J; Eckenfelder, W. eds. (1957). Biological Treatment of Sewage and Industrial Wastes. Two volumes. New York: Reinhold Publishing.

3. Buswell, A.M.; Hatfield, W.D. (1936). Bulletin 32, Anaerobic Fermentations. Urbana, IL: State of Illinois Department of Registration and Education.

4. Danish Ministry of Energy and Environment (1996). Energy 21; The Danish Government's Action Plan for Energy 1996. Copenhagen, Denmark.

5. Lettinga, G.; Van Haandel, A. (1992). "Anaerobic Digestion for Energy Production and Environmental Protection." Chapter 19 in Renewable Energy: Sources for Fuels and Electricity. Covelo, CA: Island Press. pp. 817-839.

6. n.b., TS concentration is the fraction of total feedstock weight which is a solid material.

7. Rivard, C. (1995). "Anaerobic Digestion of Municipal Solid Waste." Second Biomass Conference of the Americas; August 21-24. Portland Oregon. Golden, CO: National Renewable Energy Laboratory, pp. 801-808.