Anaerobic Digestion

FEEDSTOCK CLASSIFICATION

Manures, starches and sugars, fats, grease & offal, lignocellulosic biomass

FEEDSTOCK EXAMPLES

- alfalfa
- beef tallow
- corn stover
- crop residues
- edible offal
- field corn
- forage grasses
- inedible offal
- manure (dairy)
- manure (swine)
- manure (poultry)
- municipal solid waste
- paper mill residue
- pomace, scrap and spoilage (fruit & vegetable processing)
- scrap/spoilage (meat packing)
- spent grains
- spent hops
- spent yeast
- sugar crops
- sweet corn
- switchgrass
- waste beer
- wastewater (fruit & vegetable processing)
- wastewater (meat packing)
- wastewater (pulp & papermaking)
- whey

FEEDSTOCK RESTRICTIONS

Must be organic

PROCESS DESCRIPTION

Organic matter is decomposed by bacteria in the absence of oxygen, producing methane (biogas) and other byproducts. Variables affecting anaerobic digestion include temperature, retention time, pH chemical composition of the influent, competition of methanogens with sulfate-reducing bacteria, and the presence of toxicants. Operation at the mesophilic range requires temperatures from 77°F to 104°F and is optimized at approximately 95°F. Thermophilic digestion operates at temperature ranges of 122°F-149°F. Thermophilic operation more completely digests the influent. In temperature-phased anaerobic digestion, thermophilic and mesophilic digestion occurs in sequence, and can produce as much as 25 percent more biogas than single-phase digestion.

The retention times of mesophilic and thermophilic digesters range between 25 and 35 days but can be lower. If the organisms live on a surface that comes into contact with the influent, rather than living in the influent itself, then the retention time can range from 1-10 days; this is called attached growth anaerobic digestion. Anaerobic digestion runs optimally at pH 7.0-7.2, and the process may fail if the pH is near 6.0. Sand bedding mixed with manure is not recommended, as it accumulates in the digester.

Not all waste streams are appropriate for anaerobic digestion. First of all, the process can only degrade the organic fraction of the feedstock (for instance, sand bedding mixed with manure will accumulates in a digester). Also, some organic fractions, such as lignin, require longer retention times and high concentrations of primary substrates. It is possible to mix feedstocks such as fruit or vegetable waste with manure. Organic feedstocks used in anaerobic digestion could vary from manure to mayonnaise. In fact, feedstocks with a higher fat content often produce more biogas than non-fatty inputs.[1]

An emerging technological advance in anaerobic digestion that may lead to increased biogas yields is the use of ultrasound to increase volatile solids conversion. This process, called sonication, disintegrates solids in the influent, which increases surface area and, in turn, allows for more complete digestion.[2]

PRIMARY BIOBASED PRODUCTS

Biogas, which can be converted into electricity

PROCESS BYPRODUCTS

Anaerobic digestion effluent (fertilizer, bedding), heat

MAJOR EQUIPMENT

Manure collection equipment, anaerobic digester (lagoon, tank, etc.), effluent (liquid byproduct/fertilizer) storage, gas handling equipment (biogas-fueled equipment such as boilers, chillers, generators, microturbines)

ENERGY REQUIRED

Mixing, heating

CAPITAL AND OPERATING COST

For dairy cattle, a rule of thumb is approximately $400/head.[3] Many experts suggest about 300 cows or 2000 swine are needed to make the process profitable from electricity generation alone. Examples range from a $75,000 project at a 175-cow farm and a $525,000 project at a 1900-cow farm to a $1 million project at a 1500-cow farm and a $1.5 million project at a 6000-cow farm.[4] As an example of a cost breakdown, a 675-cow farm in Clymer, NY reports spending $260,000 for the digester, $77,000 for the mixer and pumps, $128,931 for the engine-generator set, $61,689 for solids and liquids separation and $45,000 for liquid storage, as well as annual costs of $20,663 for maintenance, insurance and repairs and $800 water treatment for heat exchange system.[5] The digester requires constant monitoring, but computer applications can streamline this.

COMMERCIALIZATION STATUS

Established

COMMERCIAL SUPPLIERS

National, comprehensive lists are available at http://www.epa.gov/agstar/library/handbook/appendixi.pdf and http://www.michiganbioenergy.org/areas/AgriculturalBiogasCasebook.pdf. Some representative suppliers are listed.

Temperature-phased anaerobic digestion is patented by the Iowa State University Research Foundation, Inc., 310 Lab of Mechanics, Iowa State University, Ames, IA, 50011 (515.294.4740). Sonication is being investigated in the US by Bioenergy & Environmental, LLC, 211 East Illinois St., Wheaton, IL 60187 (630.588.8776).

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