

INTRODUCTION TO

Anaerobic Digestion



Source: FNR, German Biogas Association

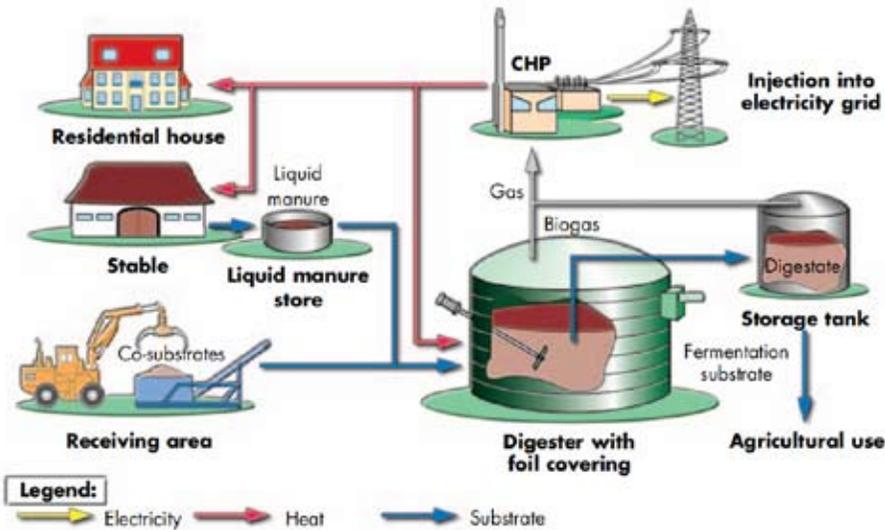
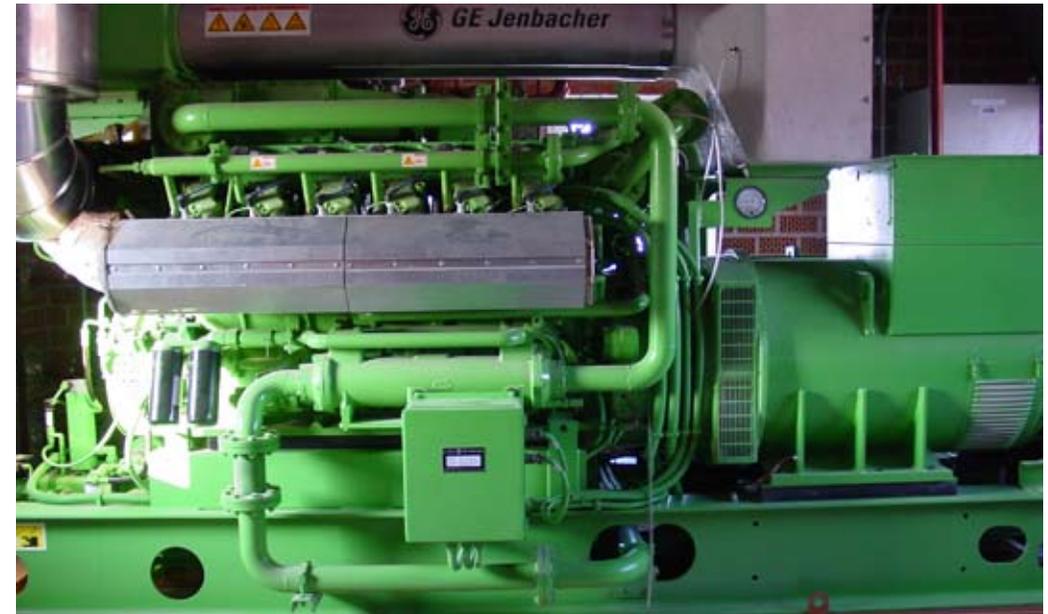


Figure 1: on farm digester model



The process of Anaerobic Digestion (AD) involves the breakdown of organic matter by bacteria and enzymes in an oxygen-free environment. This can occur in bogs, landfills, on the bottom of lakes, in stomachs of animals such as cattle or in purpose built vessels. The end product is biogas. Biogas is a mixture of the combustible gas methane (50-75%), carbon dioxide (25-45%) and small amounts of water (2-7%), as well as trace gases such as hydrogen sulphide, oxygen, nitrogen, ammonia and hydrogen.

The type of the feedstock varies and includes pig or cattle slurry, energy crops (e.g. grain, grass silage), canteen waste, vegetable oil, municipal solid waste (MSW) from households and organic solid waste from industry.

Organic products from industry used to produce biogas offer interesting opportunities for agriculture/farming. By using organic wastes or residues such as distiller's pulp, grease or food wastes, the natural material cycles (carbon and nitrogen) is closed and provides a recirculation of the nutrients into agriculture.

Feedstock is pumped into a closed vessel (digester) which has been inoculated with suitable bacteria. Anaerobic (0% oxygen) conditions are then maintained in the vessel and the temperature is held at a constant value (typically 40°C).

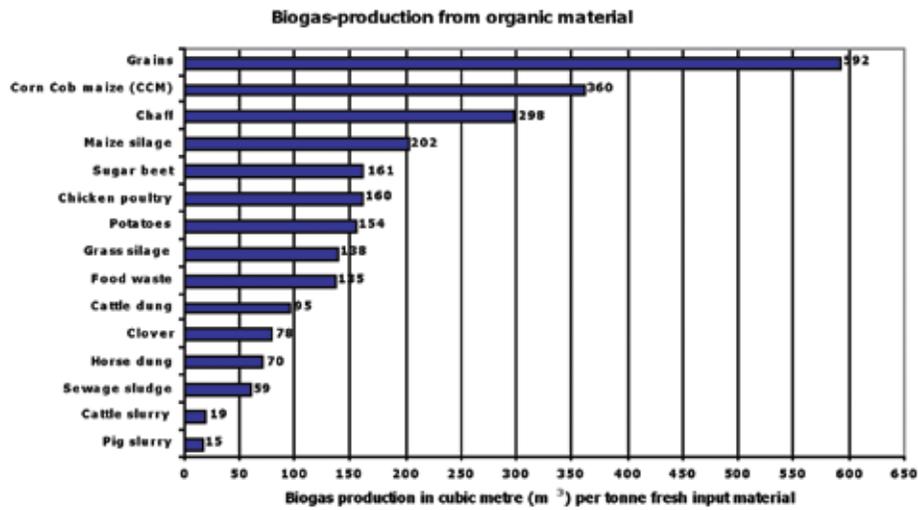
Materials with a high lignin content, for example any kind of wood, are not suitable for biogas production. The basic materials used in agricultural biogas plants are cattle and pig slurry.

The biogas produced can be upgraded to natural gas (fossil) quality and injected into the gas grid or used as a vehicle fuel, but is normally used on site to generate heat and electricity.

The AD process residue or digestate can be separated into a liquid and fibrous fraction. The liquid can be returned to the land as a high value fertiliser and the solid fibre used as a soil conditioner.

Component	Chemical symbol	Concentration
Methane	CH ₄	50 – 75%-vol.
Carbon dioxide	CO ₂	25 – 45%-vol.
Water vapour	H ₂ O	2 - 7%-vol.
Oxygen	O ₂	< 2 %-vol.
Nitrogen	N ₂	< 2 %-vol.
Ammonia	NH ₃	< 1 %-vol.
Hydrogen	H ₂	< 1%-vol.
Hydrogen sulphide	H ₂ S	20–20.000 ppm

ppm: Parts per million; %-vol.: Volumetric percentage



These charts are only intended to provide indicative results. All values are approximate and can vary significantly. Gas yields are strongly dependent on dry matter and organic dry matter content, storage and handling of the feedstock.



Source: Schmack Biogas GmbH

Biogas yields

The biogas yield depends on the composition of the substrates used and on the ambient conditions in the digester (e.g. temperature, retention time). It is possible that the same input materials/substrates could have different gas yields.

From 1 cubic meter biogas app. 2 kWh electricity and 2 kWh heat can be produced depending on the CHP unit (55% CH₄ content biogas, 20 MJ/m³, 38% electrical and thermal efficiency CHP unit).

What are the environmental benefits of biogas production?

The most important contribution of biogas technology to environmental protection is that it avoids additional carbon dioxide (CO₂) emissions compared with fossil energy sources. Producing energy from biogas is largely CO₂ neutral, i.e. the CO₂ released by burning biogas was previously removed from the atmosphere during the generation of biomass

through photosynthesis. The fermentation of manure also reduces emissions of methane, a gas that has an effect on the climate and would otherwise escape uncontrolled from raw liquid manure with far more damaging effects for the climate than CO₂. New research suggests that emissions of laughing gas (N₂O) – which also has an effect on the climate – can also be reduced by fermentation. Furthermore, fermentation reduces the development of odours during liquid manure storage and spreading since the odours contained in it are broken down and neutralised during the fermentation process. In addition, fermentation improves the quality of manure as pathogens and weed seeds are killed and nutrients made more available for plants, enabling the manure to be applied in a more targeted fashion as a substitute for inorganic fertilisers. Therefore the digestate is an ideal fertilizer in arable farming/crop production and a good soil conditioner.

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Abbreviation:

%	Percent	kWh	Kilowatt hours
%-vol.	Volumetric percentage	m ³	Cubic meter
AD	Anaerobic digestion	MJ	Mega joule
CHP	Combined heat and power	N ₂	Nitrogen
CH ₄	Methane	NH ₃	Ammonia
CO ₂	Carbon dioxide	°C	Degree Celsius
H ₂	Hydrogen	ppm	Parts per million
H ₂ O	Water		
H ₂ S	Hydrogen Sulphide		

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