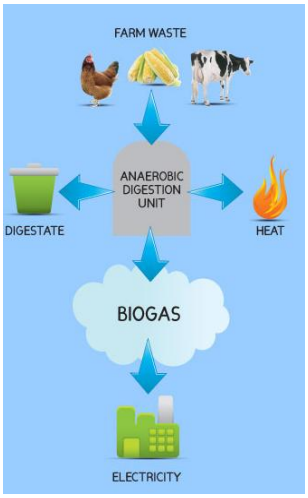
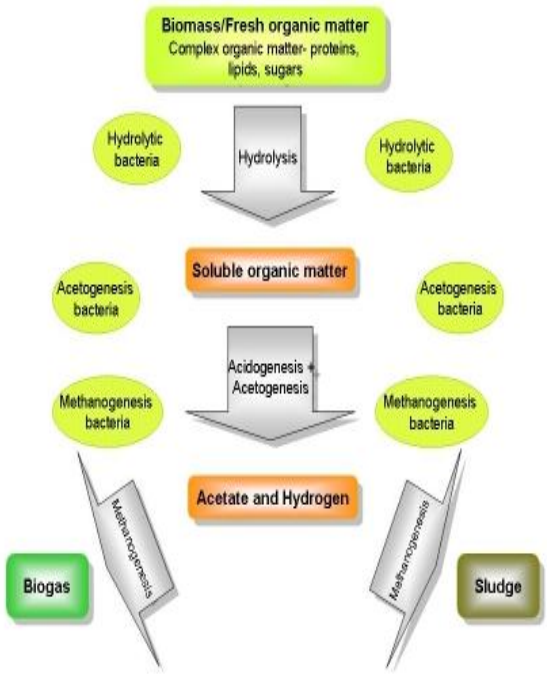
WHAT IS ANAEROBIC DIGESTION?

It is the controlled microbial process which breaks down organic matter into simpler chemical components in the absence of oxygen, resulting in the production of biogas (60% CH_4. 40% CO_2) together with liquid and solid digestate.



Anaerobic Digestion is a four part process converting organic waste to methane and digestate. During **Hydrolysis**, the organic waste is broken down into simple soluble organic compounds by enzymes similar to those found in the mouth. Through **Acidogenesis** these are fermented into intermediate products such as acetic acid. During **Acetogenesis**, the compounds that have not broken down into acetic acid break down into long chain volatile fatty acids. Finally methanogenic bacteria produce biogas



TYPES OF ORGANIC WASTE

Organic feedstocks range from farm manure and slurry for example pig, cattle or chicken to catering wastes, food wastes, energy crops, silage. The more putrescible the material, the higher the gas yields possible from the system. Slurry and manure are not the materials with the most potential for AD as much of the energy content is taken out by the animal that produced it. Therefore many digesters operate with co-digestion of two or more types of feedstock ie maize, foodwaste, food processing residues.

ANAEROBIC DIGESTION RESULTANT PRODUCTS

Biogas, digestate and water are the main resultant products of Anaerobic Digestion. Biogas consists of 60% methane with carbon dioxide and some minor gases such as hydrogen sulphide, ammonia as well as moisture.

Digestate is the solid residue of the original input material to the digester that the microbes cannot use and also consists of the mineralised remains of the dead bacteria from within the digesters. Digestate comes in three forms; fibrous, liquor or a sludge-based combination of the two fractions. The solid residue - a useful soil conditioner for the farmer as it has a neutral pH value and has no caustic action when applied to plants. The

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However, the liquid slurry component has the high nutrient value.

The regular use of digestate offers the following:

- improves the workability and drainage of heavy soils so reducing the risks of soil compaction
- improves the nutrient retention and water holding capacity of light soils thus reducing drought in periods of prolonged dry weather and soil erosion risk
- improves soil biological activity – bacterial, fungi earthworm numbers
- increases fertility
- In arable soils with low organic matter it can increase crop yields
- diverts phosphorus away from landfill

Biogas Use

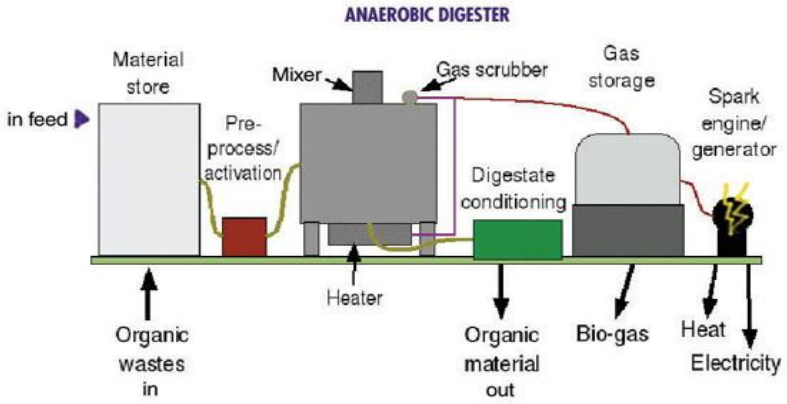
Biogas can be used in many applications including:

- Electricity generation using a generator unit
- Heat production which is used for maintaining raising the temperature of the digester and can be used in buildings via a direct heating scheme.
- CHP – the combined production of heat and electricity.
- Transport
- Injection into the grid

To utilise the biogas for transport or for injection to the grid, it will need to be cleaned and purified removing the carbon dioxide, hydrogen sulphide and water vapour. There are various methods for doing this detailed below.

Removal of all trace gases to create 100% methane. The simplest method of removing the carbon dioxide and the corrosive sulphides is to wash the gas with water under pressure. This process can be conveniently integrated with compression, using a 3 or 4 stage compressor and is capable of producing 100% pure methane.

Carbon dioxide removal. The simplest treatment is by scrubbing the gas using water. Other common methods include: polyethylene glycol scrubbing, carbon molecular sieves, membrane separation



Hydrogen sulphide removal. The easiest method is biological desulphurization which can be undertaken by introducing a small amount of air into the head space of the digester. Other methods include iron/iron oxide reaction, activated carbon and scrubbing and membrane separation.

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Electricity Generation

The electricity generated by the CHP is rated as 415V but is transformed to 11kV and exported to a local 11kV distribution network via metering and G59/1 compliant switchgear. However a farm's output must be a three phase electricity supply rather than single phase to allow this to take place. It must be noted that grid connection may be the most expensive part of the project

THE STAGES OF THE ANAEROBIC DIGESTION PROCESS

Feedstock preparation/treatment

For on-farm plants, feedstock is usually pumped or transported to the plant and can be immediately fed into the feed hopper or directly into the digester often via a macerator. For plants using municipal waste including animal by-products (ABPs) pasteurisation pre-treatment is necessary whereby waste is heated at 70^{o}C for an hour to kill the bacteria.

Digestion of feedstock

The feedstock will remain in the digester whilst it is being digested. Some plants incorporate mixing technology – using a physical mixer or pump biogas back into the tank to mix the contents. The retention time will depend on many factors including: the actual type of feedstock and the temperature the tank is maintained at as thermophilic digestion (50^{o} C) will require less time than mesophilic digestion (37-42^{o}C).

Digestate storage

The resulting digestate will be pumped into a digestate storage tank and will remain there until required. It can be separated into liquid and solid fraction - the latter can be composted further or spread directly to land.

Gas storage

The resultant biogas will be pumped into the biogas holder until it is required. The biogas has many applications – direct heat to a gas boiler to heat the farm buildings, or exporting electricity or heat back to the grid using a combined heat and power unit (CHP).

DESIGN CONSIDERATIONS

There are many design considerations when looking at AD plant design:

- **Moisture content of the feedstock**
  Dryer stackable substrates such as food and yard waste are suitable for digestion in horizontal plug-flow systems. This design also has near zero wastewater discharge. However the wetter material (animal manure) handled with pumps is more suitable for the vertical tank digesters.

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- **Configuration – Batch system v Continuous**

  A plant using a batch system receives the substrates in one go and is sealed for the duration of the process. This is a cheaper option as it requires less equipment. However, using a continuous supply system, as the substrates are added on a regular basis there is a continuous and more efficient production of biogas.

- **Mesophilic v Thermophilic**

  Mesophilic digestion is more robust and tolerant than thermophilic process but gas production is less, larger digestion tanks are required and sometimes sanitisation is required to kill bugs afterwards. Mesophilic digestion takes place around 32-41^{o}C

  Thermophilic digestion takes place at 50-52^{o}C produces greater amount of methane as it has a faster throughput , better pathogen kill but requires more expensive technology, greater energy input and a higher degree of operation and monitoring. There are also additional costs in maintaining the temperature of the tank at such a high rates.

- **High solids digester v Wet digesters – for high solids or low solids**

  There are three options for plant design when considering the state of feedstock. High solids digesters process material with a high solids content of 25-40%. They process solid substrates deposited in horizontal plug-flow systems. As they have few moving parts, they require minimal intervention and are therefore cheaper to run.

  Wet digesters can operate using high solids content or a low solids concentration processing a thick slurry which requires more processing energy.

  Wet digesters processing wet slurry can transport material through the system using standard pumps thus using less energy but due to the higher volume require a greater amount of land.

- **Single or multi stage digestion**

  Digestion systems can either be single or multi stage

  Single stage processing takes place within a single reactor and is therefore more economical to build, however less control is possible over the biological reaction as all parts of the process occur under the same operating conditions.

  Two stage digestion utilises different digestion vessels and allow a greater chance of optimisation of the process.

- **Retention Time**

The residence time within the digester varies greatly depending on the feedstock used, the configuration of the digestion system and whether it is one or two stage.

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