# RENEWABLE ENERGY INITIATIVES

energy
Department:
Energy
REPUBLIC OF SOUTH AFRICA

BIOGAS

## WHAT IS BIOGAS?

Biogas is produced through a biological process where waste organic matter is broken down by bacteria during decomposition which occurs in the absence of oxygen. This process is scientifically known as anaerobic digestion. Biogas is also called marsh or swamp gas because naturally it occurs in these places.

Most organic waste when left to decompose will produce biogas. Examples include waste water containing organics e.g. from sewage treatment works; agricultural waste (plant matter –fruits and vegetable, animal waste (manure and abattoir waste) etc.

Anaerobic Digestion occurs in four stages where different bacteria play different roles. Each stage requires specific bacteria and each bacteria requires certain conditions to be effective. These four stages are Hydrolysis, Acidification, Acetogenesis and Methanogenesis and they happen concurrently. Ultimately the steps required for biogas production can be looked at as a process done in reverse. Below we explain these concepts and how they assist the biogas production process.

The steps required for biogas production can be looked at as a process done in reverse. These concepts are explained below. Methane is produced through Methanogenesis, but in order for Methanogenesis to take place organic matter needs to be in a very simple form, this form is produced by Acetogenesis. Acetogenesis however, cannot be performed using the raw input waste and that is why Acidogenesis and Hydrolysis are required. Methane production requires very simple and small organic matter, the initial three processes break down the organic matter to a usable size"

- Hydrolysis – The process of reducing proteins, carbohydrates and fats into simple molecules such as amino acids, fatty acids and simple sugars using water. This step is required so that bacteria have the necessary food available to them to perform the next step.
- Acidogenesis – Bacteria further breaks down organic matter into various acids and ammonia. This is still not suitable for Methane production so one further process is required.
- Acetogenesis – In this step the acids created in Acidogenesis (carbonic acids, alcohol, volatile fatty acids) are further broken down into Acetic Acid, Carbon Dioxide and Hydrogen. Acetic Acid is a product that is suitable for the production of Methane.
- Methanogenesis – Methanogenic bacteria consume Acetic Acid and produce Methane and Carbon Dioxide which are the two main gasses in Biogas. Some of the intermediate products from previous steps are also consumed here, whilst other intermediate products will be present in the final gas.

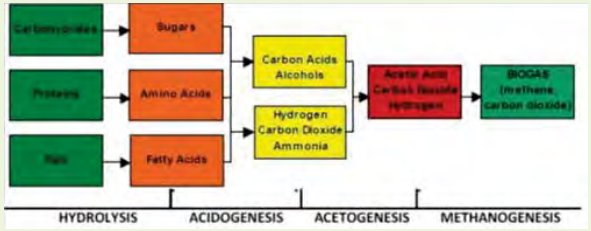


**Figure 1:** Anaerobic digestion process (source: NREL).

Cover Position

In order to ensure that the anaerobic digestion takes place effectively, digesters are required. A digester is considered a living organism where important set of parameters have to be controlled. These are temperature, pH balance, rate at which organics are loaded; time spent in digester, solid content, degree of mixing and carbon/nitrogen ratio. As David Cilliers explains, it is easier to look at a digester as a person's stomach. In order to keep the stomach healthy, we need the right amount of solids and liquids, acids and bases. Therefore we take in liquids and solids, the output is liquids, solid and gas!

## BIOGAS COMPOSITION

Biogas consists of a number of gases: Methane 45-65%; Carbon Dioxide 35-55%; and other gases make up less than 5% i.e. Water vapour, Hydrogen Sulphide, Nitrogen, Oxygen and Ammonia.

Since biogas is rich in methane, the focus when using it as an energy source is mainly on harvesting this gas. Methane is combustible and therefore valuable as fuel. It is also tasteless, odourless and colourless. Also, it is lighter than air which makes it relatively safe.

Cover Position

## BIOGAS APPLICATIONS

Biogas is a very versatile energy option with triple applications. It can be used in the following ways:

- As a heat energy source,
- For electricity generation, and
- In the transport sector as a fuel for vehicles.


**Figure 2:** Biogas can be installed neatly and piped into the house for domestic cooking (source: Ennovations).


**Figure 3:** An illustration of the value chain from waste to vehicle fuel (source: (SANEDI).


**Figure 4:** Combined Heat and Power (CHP) Waste Water Treatment Works in Diepsloot Johannesburg (source: WEC Projects).

Figure 5

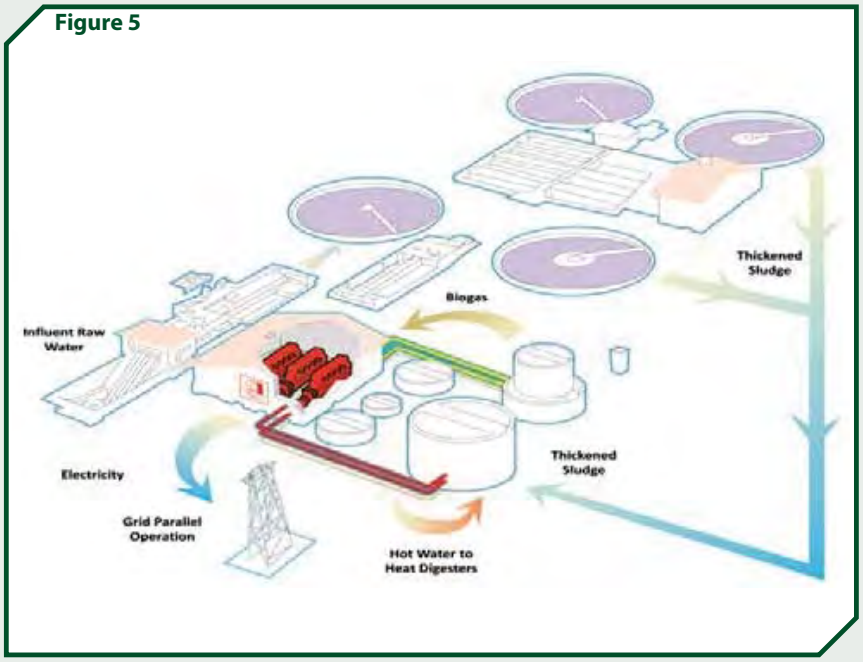


**Figure 5:** Flow diagram of Waste Water Treatment Works (WWTW) power generation plant: (source: WEC Projects).



## BIOGAS BENEFITS

**Promotes access to modern energy services & improves air quality**
Biogas is a good alternative fuel for cooking and lighting for domestic purposes. In rural areas switching to biogas can have significant health benefits since biogas is cleaner burning compared to a wood fire.

**It is a cheaper alternative to petrol and diesel in vehicle fleet.** Converting to biogas for transport is a good option particularly for public vehicle fleet and has a great positive impact on the environment through reduction of carbon dioxide from exhaust emissions. The Industrial Development Corporation says that costs savings of up to 76 cents per km have been realised for 71% substitution in the City of Joburg when commuter rail buses were converted to run on dual fuel (i.e. both diesel and biogas). Further, diesel dual fuel operation has no negative effect on engine durability and cost of maintaining vehicles compared to standard (diesel-only) operation.

**Industries can benefit from using biogas by generating heat for thermal applications and electricity either for own use.** Excess electricity can also be sold to other customers for additional revenue.

**Switching to biogas has the potential to reduce the electricity demand (at a national level) and to reduce electricity bills for consumers** including municipalities, agricultural sector and industries.

**The digestate which is by-product of biogas production is a nutrient rich fertiliser** which can be used for soil enrichment instead of mineral fertilisers. However, the quality will vary depending on the feedstock used.

**Biogas use can contribute immensely to reducing greenhouse gas (GHG) emissions** because it is produced from harvesting and converting the potent methane gas into useful energy.
Biogas production encourages responsible waste disposal and management which is also good for the environment.

Biogas is a renewable energy source which has the potential to **create jobs from low level construction to highly skilled equipment manufacturing, plant design and maintenance jobs within the Green Economy field.**

## BIOGAS DIGESTER DESIGNS

There are two main categories of digesters, i.e. continuously fed or batch fed. Both these designs can be either underground or above ground. Two common varieties are either the Chinese dome shape or the Indian Floating type.

Figure 6

**Figure 6:** A local builder constructing an 8m$^3$ biogas digester at the University of Fort Hare, Alice campus, this is part of job creation at local level. The builder was trained by scientists at the Fort Hare Institute of Technology to construct digesters (source: University of Forthare).

Figure 7

**Figure 7:** A 10m$^3$ digester at Fort Cox College (source: University of Forthare).

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