# Overview of different types of biogas installations

## Technical Article: TA41

SOWTech

***Biogas derived from waste has been used as a fuel for thousands of years and is now used worldwide in many different types of installations as a replacement for fossil fuel derived natural gas. This technical paper gives a brief overview of some of the types of biogas installations and the technologies used. It does not claim to be comprehensive or inclusive of all types of biogas installations. A brief historical perspective and glossary are also included.***

## Introduction

Anaerobic digesters or biogas digesters as they are commonly known have been used worldwide for hundreds of years. In the western world they have become increasingly more complex with additions to the basic plant to optimise and enhance biogas production. These plants, with add-ons including front end preparation of the waste, heating of the tanks for pathogen kill and to ensure that the process works at optimum rate 24/7 in all seasons, mechanical stirring and biogas clean-up, are large, power hungry, visually intrusive and cost millions of pounds to build with high maintenance and operational requirements.

This contrasts greatly with the anaerobic digesters that are built and used in the low-income countries as found in Africa. The digesters used in such places are simple with low cost maintenance and operational costs and no power requirements. However they all perform the same function - the treatment of waste organic matter, solid or liquid, into biogas and a nutrient rich liquor.

## Biogas installations around the world

In this section the different approaches and types of biogas facilities will be discussed. It will be divided into three subsections based on size, scale and complexity of the biogas plant. This is an arbitrary classification devised to aid the reader to understand the differences.

### SIMPLE SMALL-SCALE DIGESTERS

This includes most of the digesters in sub-Saharan Africa and Asia including India, Vietnam, Nepal and Cambodia.

The biogas digesters in these countries are characterised as being small scale household plants that general utilise animal manures and plant vegetation. They are normally a simple design with an input pipe, an output that is an overflow and a simple method to collect gas either in gas tight bags or piped directly to where it is to be used. There are two main types of digester built - fixed dome digesters and floating domes digesters. They are traditionally built of bricks and mortar or concrete by skilled masons. However recently there have been a number of companies providing digesters that can be bought ready made from the manufacturer or distributor. Most of these are blow-moulded plastic digesters but it also includes the SOWTech Flexigester.

#### Examples of simple small-scale digesters

Fixed Dome Digesters

Fixed dome digesters are normally spherical or oval in shape and are most often constructed from bricks and mortar. This type of digester has been used for many years in Asia, predominantly India and China. New materials are coming into the market including, pre fabricated concrete slabs, blow moulded plastic and fibre glass.

The concept of the fixed dome digester is that waste is fed into the bottom of the digester and as biogas is produced it collects in the top of the digester. The pressure produced by the gas forces the liquid waste in the digester down and out of an overflow system.

Fixed dome biogas plant in India



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## Floating Dome Digester

The floating dome digesters have been mainly used in India. The structure is normally a brick or concrete digester with an inlet feed to the bottom and an overflow type outlet for the digestate. The biogas collects in a moving dome, normally made of steel, which floats either on the digesting waste material or in a separate water jacket to produce the gas tight seal. A steel framework guides the dome to prevent it tilting.

Floating dome biogas plant in India

The concept is that the dome moves up and down as the gas is produced and consumed. As with the fixed dome the pressure created by the biogas produced forces the digestate out into the overflow.

Companies such as SimGas in Tanzania not only sell and install the digester but also sell the fixtures and fittings needed to use the gas including stoves and lamps.

SimGas moulded plastic digester

Pragati Biogas Energy Pvt Ltd was established 23 years ago in Nepal and has built over 11,000 biogas plants of below 20 cubic metres. It is now developing 25 large biogas plants of 20 to 30m3 in the western region of Nepal[1].

Pragati floating dome digester

## Flexigester

The Flexigester, created by SOWTEch, is made of Butyl rubber. Waste enters at the bottom at one end and the digestate is removed by an overflow system that does not rely on the gas pressure. It is a plug-flow type digester with a unique gas pressure regulator to maintain a constant low pressure with in the digester.

Flexigester in Malawi

The concept is that waste enters at one end, moves along the digester as it breaks down and the treated digestate overflows out into a collection vessel. The gas is continually removed and stored in a separate gas storage bag until it is reused.

A Flexigester V10 with a capacity of 10m3 was installed at a school in Malawi in 2014. The digester is attached to the school latrines where the sanitation waste is fed directly into the digester. The biogas produced in stored and transported in butyl rubber bags to the kitchen where it is used as a wood alternative for cooking the nsima. The digestate from the process is dripped onto hard to rot down vegetation which aids the composting process. This is then used as a soil enhancer for the growing of crops[2].

Flexigester in Ethiopia

Flexigester V40 with a capacity of 40m3 is being used to process cattle manure from a herd of 25 Friesian cows in an orphanage in Ethiopia. The biogas produced is being collected and stored in a PVC storage vessel. It is then used in the kitchen as fuel for the biogas stoves for cooking the sauces to go with bread baked in an oven[3].



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**National Biogas Schemes**

Many of the countries who are in this category have national biogas scheme and national biogas associations aimed at promoting the use of biogas as a fuel alternative. Below are a few examples of these:

India Biogas Association - founded in 2011 to represent operators, manufacturers and planners of biogas plants, and representatives from science and research, its motto is "propagating Biogas in a sustainable way"

Nepal Biogas Promotion Association is the umbrella organisation of biogas construction companies and Bio-gas appliances manufacturing workshops in Nepal. It has more than 114 member companies.

Vietnam Biogas Programme has facilitated the construction of 158,500 domestic biogas digesters, resulting in access to a clean, renewable and reliable source of energy for more than 790,000 rural individuals across 55 provinces and cities of Vietnam (data March 2017)[4].

Tanzania Domestic Biogas Programme plans to install 10,000 biogas plants over a two-year period (2016-2017) with support from Tanzania's Rural Energy Agency in addition to the 12,000 bio-digesters already implemented.

## MEDIUM SCALE AND COMPLEXITY DIGESTERS

There are a number of countries and companies who have developed large scale biogas programmes which include medium sized plants for commercial enterprises and communities. These include areas such as South Africa, India and China.

These areas have well established biogas industries. The technologies used are still based around the fixed and floating dome style digesters but the use of alternative materials has enabled the industries to expand. The following are examples of how companies have turn biogas installation into a commercial industry.

**Examples of more complex medium scale digesters**

Biogassa, South Africa

BiogasSA[5] was established in 2009 to provide digesters for households. It then expanded into the commercial sector and built and commissioned its first large scale in 2016. This plant was for an abattoir in Springs and was built using pre-cast and post tensioned concrete panel tanks for the digesters and the digestate and mixing tanks were cast in-situ concrete mixing and digestate tanks. The plant is designed to produce 0.4MW of power. BiogasSA is also an agent for a number of international biogas equipment suppliers which is bringing quality products and expertise into the South Africa. It still continues to supply household digesters also.

Building the Biogassa plant in Springs, SA

Puxin, China

Shenzhen Puxin Technology Co. Ltd[6] was founded in November 2001. It started by developing household sized biogas plants built of concrete using a steel mould. Now it has self assembly household waste digesters and has expanded into commercial sized digesters. The latest of these is a digester in a shipping container.

Not only do Puxin supply the digesters but they also supply fixtures and fittings for installing and using biogas. They sell stoves, lights, generators and heaters powered by biogas as well as pumps and grinders to prepare the food waste.

Puxin digester in a shipping container



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Koyambedu Market, Chennai

The wholesale market in Chennai has a biogas plant that takes the market waste and treats it by anaerobic digestion. The biogas produced was being converted into electricity but more recently was to be supplied directly to local households as an alternative cooking fuel[7].

AD plant at Koyambedu Market

## LARGE SCALE COMPLEX DIGESTION FACILITIES

In the western world household sized biogas plants are relatively unknown although rural farm based facilities are widespread in Europe and USA. The majority of facilities are large scale taking organic waste from both the local and more wide spread communities. The plants usually accept one of three waste streams, kitchen/garden waste, biomass crops grown specifically to be processed by anaerobic digestion or waste water.

The plants are sophisticated multi-million pound facilities that incorporate large mixing and storage vessels, methods of heating and regulation of temperature, powered stirring of the vessels and automatic monitoring of the complete process. In addition to the anaerobic digestion process the biogas produced is normally further processed on site to produce a gas of sufficient quality and calorific value to be added to the gas grid, purified and compressed to make liquid natural gas (LNG), processed to be used as a vehicle fuel or burnt in a gas engine to produce electricity.

**Examples of complex large-scale digesters**

Large scale municipal facility

Biogen[8] in the UK are working with local authorities to process food waste that is collected from households and commercial companies. Their facility in Baldock processes 45,000 tonnes of food waste per year. The biogas produced is cleaned up and generates 2.6MW of green electricity which is enough to power around 4,500 homes.

Biogen facility at Baldock

Minworth Sewage Treatment Works

This is a municipal sewage treatment works (STW) operated by Severn Trent Water Company. At the STW the sanitation waste is treated by anaerobic digestion to produce biogas. Traditionally this biogas has been converted into electricity but more recently the processing has changed so it is now injected directly into the national gas grid[9]. To achieve this the gas had to have all impurities removed to make it 96-98% methane and it had to be compressed to 15 to 50 bar to match that of the national grid. The remaining sludge is fed into a combined heat and power plant where it produces electricity. This plant cost £12million to build in 2014.

Biogas converted to vehicle fuel

The biogas produced by anaerobic digestion can be compressed to produced compressed natural gas or CNG. First it has to undergo a cleanup procedure to remove all the impurities before it can be compressed. The vehicles using CNG have to be adapted to run on this gas. Public service vehicles running on CNG are now running in a number of cities including Delhi where both buses and taxis run on CNG. In Sweden there is an estimated 52,000 vehicles running on CNG[10] (figures from 2015)

For some applications the production of liquified natural gas or LNG is appropriate. The energy density of this fuel is higher than CNG so it suits applications such as lorries doing long haul journeys.



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## A brief history of biogas digesters

It is believed that the first utilisation of the gas produced from rotting vegetation was in Assyria in the 10th century BC when it was used to heat bath water and by the Persians in the 16th century BC[11]. Marco Polo is credited with observing pots of sewage stored to create energy in the 13th Century and Daniel Defoe wrote about it in the 17th century[12].

The building of the first anaerobic digestion plant is credited as being in India in 1859. It was built in a leper colony in Bombay (Mumbai) where they treated sewage waste to produce gas which was used to provide lighting[13].

The UK's first anaerobic digestion plant was built in Exeter in 1895 when the gas from a new style sewage treatment plant was used to light the lamps in Exeter[14].

Most biogas installations worldwide are farm based rather than large scale, with China and India leading the way in terms of numbers of installations and take up of the technology. However in the western world recent advances in technology have focused on large scale installations. The largest biogas plant in the world is under construction in Korskro, Denmark. At full capacity it will process 1,050,000 tons of agricultural biproducts and organic waste and expected to produce 41 million Nm3 of biomethane (equal to 45.4MW) per year to the Danish gas grid[15].

## Definition of terms

It is important to understand the difference in terms used for the gas produced from anaerobic digestion.

Biogas - this is the raw gas produced from the breakdown of rotting waste. It is a gas that is predominantly a mixture of methane and carbon dioxide. The ratio of methane to carbon dioxide varies considerably depending on the effectiveness of the breakdown process and the feedstock used. The more efficient the process the higher the methane content. This can be as high as 80% but is typically 50-60%. Whereas methane is flammable carbon dioxide is not making this gas more difficult to burn than pure methane.

Methane - this is a pure gas consisting of one carbon atom and four hydrogen atoms. It is flammable in air at concentrations of 5.4-17% and can form explosive mixtures in air.

Natural gas - this is gas that forms naturally in the earth from the breakdown of organic matter. It is primarily methane but also contains other alkanes. This is the gas in "mains gas". It can also be compressed to give LNG (liquified natural gas).

Biomethane - this is biogas that is produced from anaerobic digestion of organic waste but which his then treated to remove the carbon dioxide increasing the methane content and making it suitable to mix with natural gas and to be supplied as "mains gas".

**for references cited see overleaf**



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