

Biowaste to Biogas

BIOGAS Know-how_1

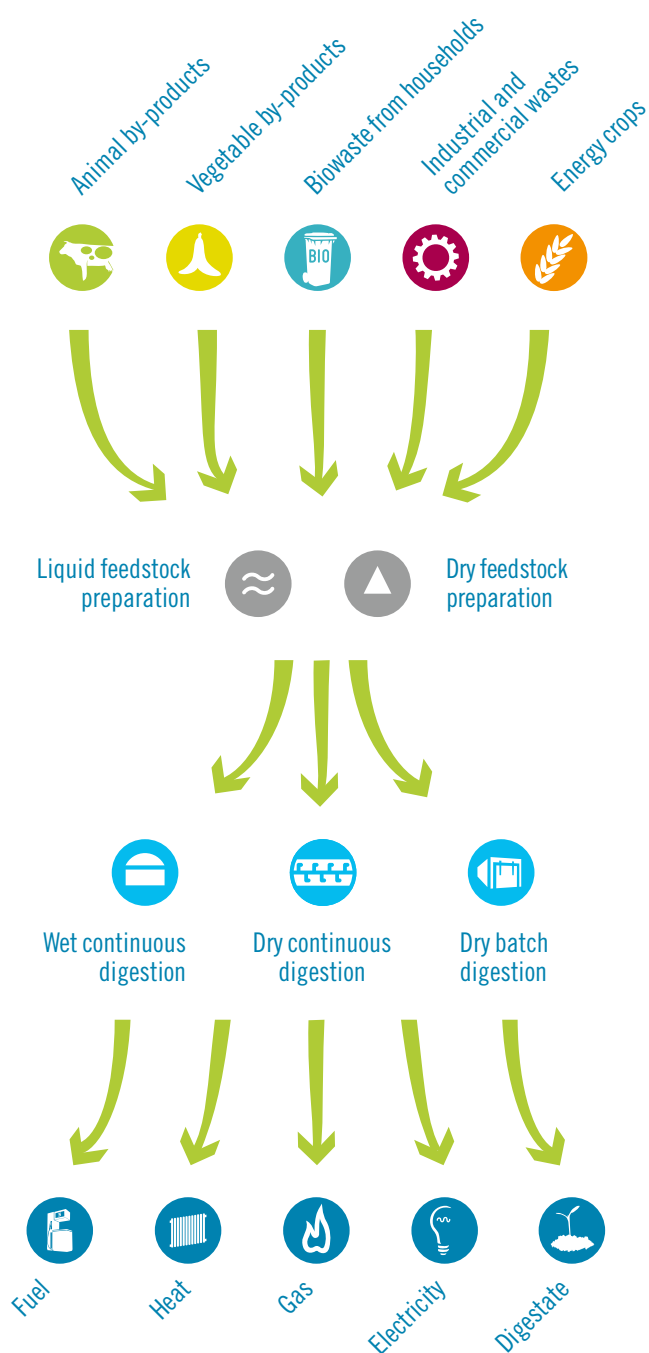


Fachverband
BIOGAS

German Biogas Association
www.biogas.org

BIOWASTE TO BIOGAS

Production of energy and fertiliser from organic waste



The depicted symbols are consistently used throughout the booklet and as a classification system of the different companies in the directory.

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Statements



'A future-oriented and sustainable energy supply is possible only if the particular advantages of each kind of renewable energy source are combined in an optimal way. Biogas offers flexibility: it can be used when wind or sun are lacking. And the opportunities for biogas are manifold: it provides power, heat, fuel and fertiliser from organic resources - regional, reliable and climate friendly. Biogas is the way forward!'

– **Horst Seide, President of the German Biogas Association**



'Energy is a fundamental part of sustainable development. From a development policy perspective biogas offers many advantages: from the creation of jobs and provision of decentralised clean energy to rural development and the reduction of greenhouse gases. By improving solid waste management practices, substantial co-benefits can be provided, such as minimizing threats to human health and better resource efficiency.'

– **Dr Christoph Beier, Vice-Chair of the GIZ Management Board**



'Biowaste digestion is simply the most logical pathway to follow. Whether you look at it in terms of efficiency, related transportation, emissions reduction or energy yield, anaerobic digestion is a clear winner on all these fronts.'

– **Dr Jan Štambský, President of the European Biogas Association**



'The genius of anaerobic digestion is that it recovers energy and nutrients from the organic waste cycle. Too much food waste is still landfilled without the energy and nutrients it contains being recovered through composting and anaerobic digestion. Policymakers commitments to reduce their GHG emissions in line with the Paris Climate Accord will feed into national policies on waste management and the reduction of methane emissions in particular.'

– **David Newman, President of the International Solid Waste Association**

Preamble

This booklet focuses on biogas production from different waste sources including biowaste produced by households and industrial and commercial operations, and in the form of animal and vegetable by-products. By 2015, around 400 biogas plants in Germany were using biowaste as feedstock and, in that year alone, some 100 of these plants used a total of two million tonnes of source-separated organic waste from households.

Given that interest in and need for biogas technology deployment is currently rising in many countries, this publication by the German Biogas Association is timely. It is undoubtedly the case that plenty of organic waste and residues are currently available for such uses, but they often go unexploited. Left to degrade in an uncontrolled way, these materials instead end up emitting methane and, in so doing, contribute to climate change.

This booklet provides an introduction to biogas technology that uses waste as feedstock, setting out how it is used and its various applications. It covers, among other things, a description of the biological process, the different ways to efficiently use biogas, a comparison of the energetic potential of different feedstocks, and the handling and preparation of feedstocks. It provides an overview of the digester technologies in use and tackles the safety issues involved in operating biogas plants. The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, a partner of the German Biogas Association, promotes the use of biogas systems by the energy sector, shares the experience it has gained in installing integrated waste management systems and adds its voice to the debate on the role of biogas in developing and emerging countries.

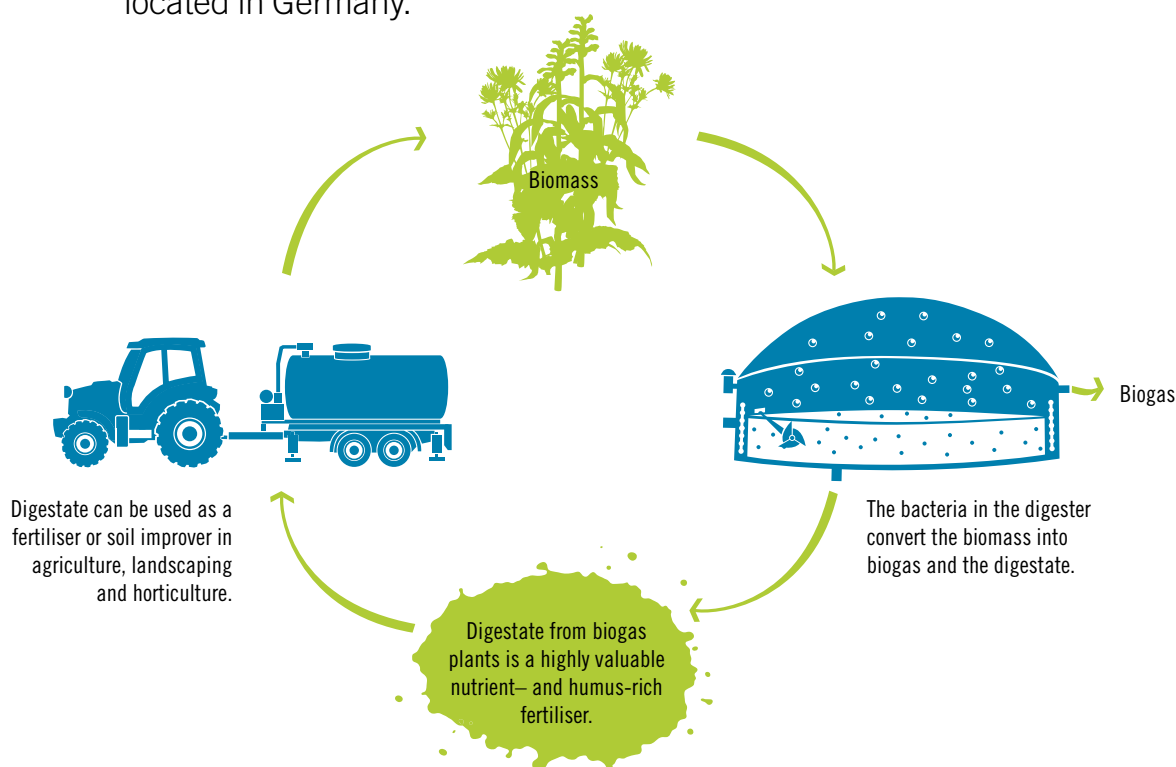
Moreover, this booklet contains several case studies and a directory of experienced companies that includes turnkey system providers, engineering offices, manufacturers of feedstock preparation systems, and component producers operating in the field of anaerobic waste digestion.

This booklet aims to contribute to safer and more efficient biogas plants that use different kinds of organic waste feedstocks to produce biofertiliser, electricity, heat or biomethane (which can even be used as vehicle fuel). Plenty of experience has already been gained in this field, so entrants do not need to start from scratch. If biogas projects are to be successful and the market is to be developed, it is vital to create partnerships with the companies and organisations that promote and deliver biogas projects and to benefit from their wealth of know-how and experience.



1 Introduction

The use of biogas technology has increased tremendously over the last 15 years, especially in Germany. By the end of 2014, nearly 9,000 of the 12,500 biogas plants digesting energy crops, manure and biowaste in the European Union (excluding plants producing landfill and sewage gas) were located in Germany.



These biogas plants not only supply five per cent of Germany's gross electricity production (i.e. over four gigawatts of installed electrical capacity), they also provide households, industries, farm units and other buildings with heat. Biogas can even substitute natural gas and fuel when it is upgraded to biomethane. There are around 370 biomethane upgrading plants in the European Union (with over 190 of these located in Germany) feeding approximately 1.8 billion cubic metres of biomethane into the gas grid every year. Currently there is also a trend to use biomethane as fuel for gas-powered vehicles (e.g. for waste collection trucks). In some developing or emerging countries biomethane is used to fill gas cylinders, thus substituting fossil fuels in off-grid power supply as well as in the transportation sector.

The simplest and most common use of biogas is, however, the direct production of electricity and heat in combined heat and power plants (CHP). In this context, biogas technology offers a distinct advantage as it makes it possible to store energy in the form of biogas or biomethane and produce electricity on demand. Additionally, biogas is a perfect solution for decentralised

off-grid electricity situations, especially rural areas that are not connected to the electricity grid but have an abundance of biomass. In developing countries biogas is often directly used for cooking, heating or gas lighting.

Besides renewable energy, biogas plants produce highly valuable nutrient- and humus-rich fertilisers. All the nutrients contained in the feedstock remain in the post-processing digestate, which can be used as a fertiliser or soil improver in agriculture, landscaping and horticulture. In this way, the carbon and nutrient cycles are closed.

Additionally, biogas production substantially reduces greenhouse gas emissions by substituting fossil energy carriers and energy-intensive mineral fertilisers, and it avoids the emission of methane into the atmosphere that results from the storage of digestible organic material like manure or organic waste (e.g. in landfills, open lagoons or other modes of storage). The controlled use of biogas involves the capture of methane, which, during the energy generation process, is converted into renewable CO₂ (renewable because it is part of a closed capture-and-release cycle).

2 Production of biogas

Biogas production is based on a very natural process that can be observed in, for example, moors and swamps, but also in the digestive tracts of animals, especially the cow's rumen. When organic matter is decomposed by microbiological populations in the absence of free oxygen (anaerobic digestion), high-caloric methane is produced.

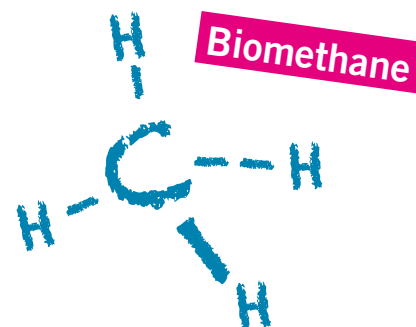
Biogas technology makes use of the natural process whereby organic material like biowaste, food leftovers or manure are transformed by different groups of microorganisms in airless (i.e. oxygen-free) situations into methane (CH_4) and digestate. Depending on the type of feedstock that is used, the methane content of biogas fluctuates between 50% and 70%. The second most abundant component is carbon dioxide (CO_2), which makes up between 30% and 45% of biogas. There are also small quantities of other components such as water, oxygen, traces of sulphur compounds and hydrogen sulphide.

Four successive biochemical processes are involved in the production of biogas. In **hydrolysis**, complex and long-chain compounds of feedstock, such as carbohydrates, proteins and fats, are broken down into lower molecular weight organic compounds such as amino acids, sugar and fatty acids. The hydrolytic microorganisms involved release hydrolytic enzymes that decompose the material biochemically outside the microbial cells. In **acidogenesis**, the above-mentioned intermediate products are then transformed into lower fatty acids like propionic acid, butyric acid and acetic acid as well as into carbon dioxide and hydrogen, which are by-products of the degradation process. In **acetogenesis**, acetogenic bacteria then convert the fatty acid into acetic acid, hydrogen and carbon dioxide, which are the basic materials for methane production. Finally, in **methanogenesis**, archaea, which are some of the oldest life forms on earth, produce methane by combining the hydrogen with the carbon dioxide or by cleaving the acetic acid.

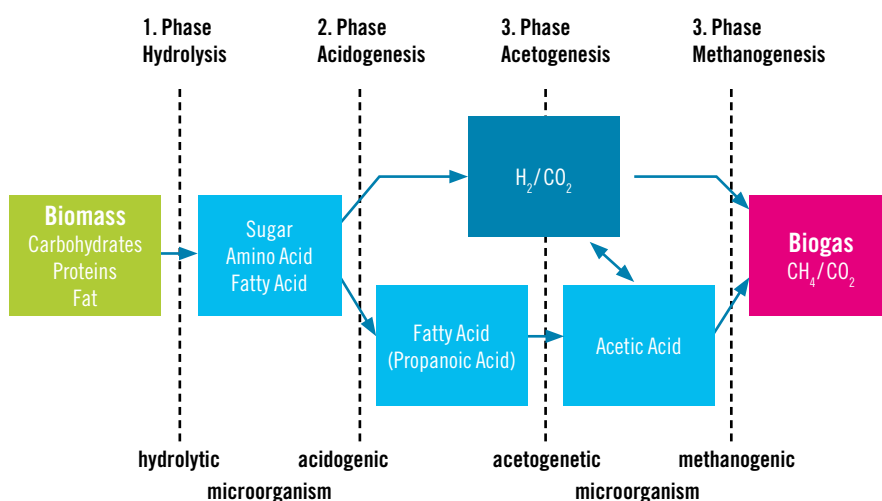
Usually, the four processes mentioned above take place at the same time in a hermetically sealed unit, the so-called digester. These biochemical processes are, however, performed by different kinds of microorganisms and each requires different conditions for optimal growth. To create optimal conditions for the different species, the processes can be performed in separate vessels. For example, some biogas plants have a separate hydrolysis tank to prepare biowaste for actual digestion. In this tank

the temperature, oxygen content and pH value are optimised for hydrolytic microorganisms, whereas the conditions in the main reactor are optimised for the methane-producing archaea.

Temperature is one of the most crucial factors in biogas generation. A distinction for different operating temperature levels is made between psychrophilic (less than 25°C), mesophilic (from 35°C to 48°C) and thermophilic (greater than 50°C). One advantage of low temperatures is that the amount of heat energy that needs to be added to the process is reduced, but in such conditions its methane-generating potential is unfortunately very low. When digesting waste and animal by-products, higher temperatures also play a particularly important role in neutralising harmful germs. Changing temperatures can, however, destabilise the biogas process and diminish or stop the activity of the microorganisms involved. Other factors can also hinder methane production: for example, high concentrations of free ammonia will soon inhibit the bacteria because the chemical reaction of ammonia and water generates ammonium and hydroxide ions inside the digester, especially at higher pH values. Continuous monitoring of the relevant parameters is therefore essential to prevent problems occurring while the plant is operating.

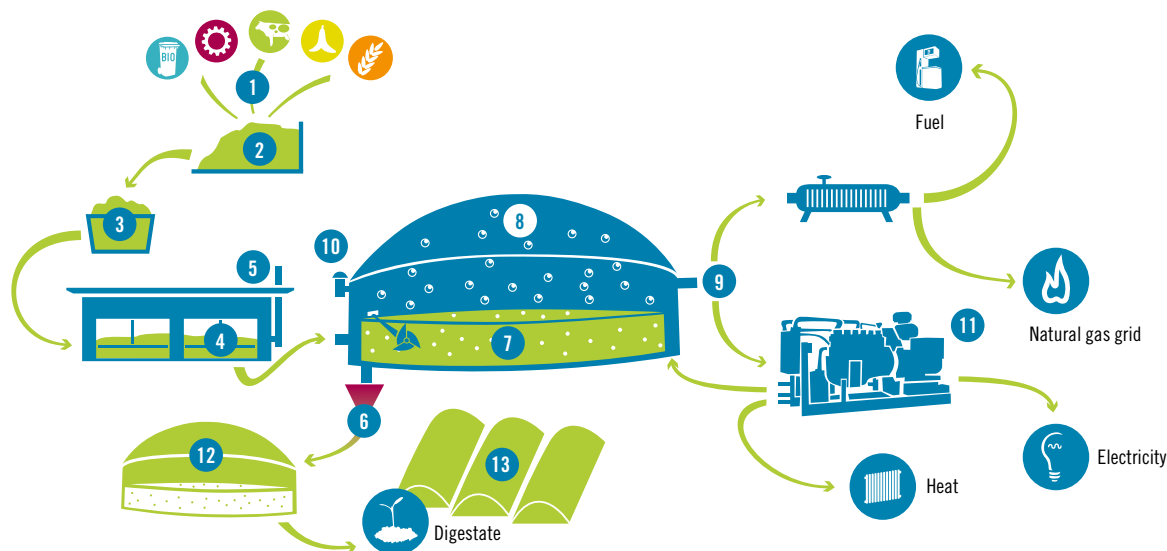


Process description



Components of a waste treatment biogas plant:

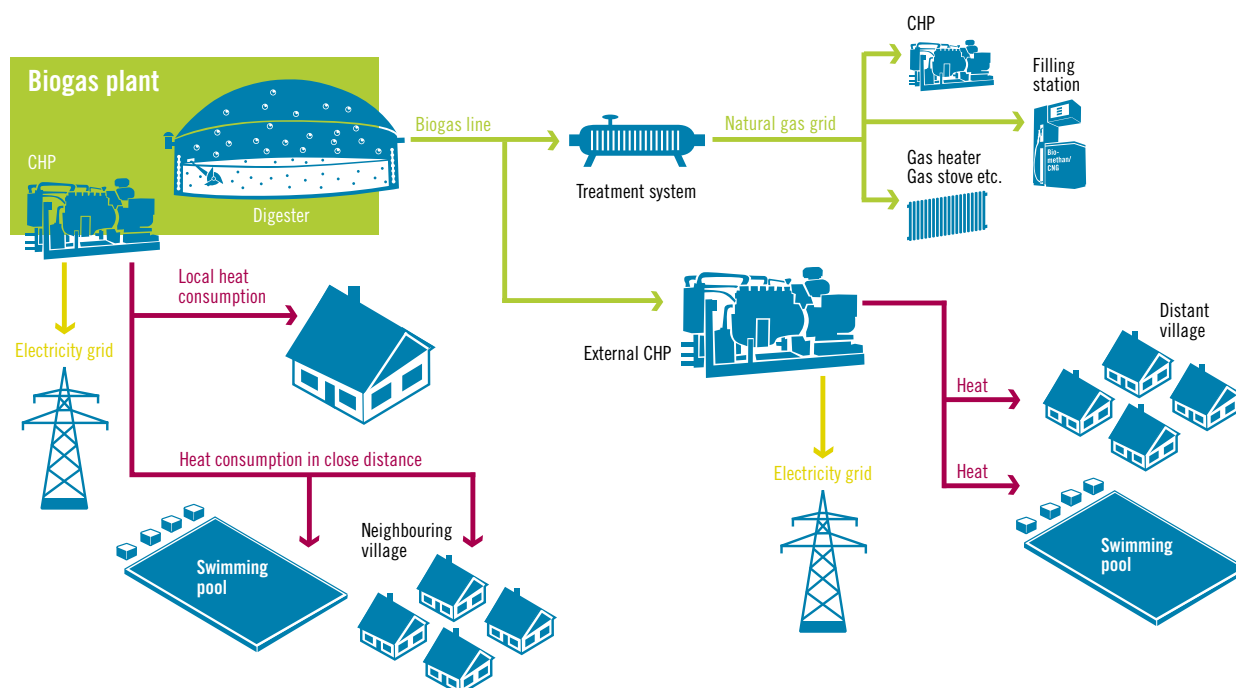
Typical waste treating biogas plants can consist of the following components depending on the composition and amount of the delivered feedstock and the digestion system:



- 1 Different feedstock (see chapter 4)
- 2 Reception and waste storage (bunkers, tanks, vessels, collection point, silos)
- 3 Preparation, processing, sorting and cleaning of the feedstock (see chapter 5)
- 4 Enclosed building for the acceptance, storage and preparation of putrescible waste with air collection system
- 5 Biofilter to reduce smells and organic compounds by passing the collected air through a bed or container of wood shavings, bark chips and compost layers
- 6 Sanitation unit (either in front of or after the digester), during the digestion at thermophilic temperatures ($> 55^{\circ}\text{C}$) or while post composting (see chapter 4)
- 7 Digester (could be one or several vessels operating in row or in parallel), equipped with heating system (see chapter 6)
- 8 Gas storage for the produced biogas available hermetically sealed on top of the digester and other vessels or as external gas storage
- 9 Gas cleaning system for desulphurization and dewatering (see chapter 3)
- 10 Safety equipment: pressure relief devices, safety valves, gas flares as well as instrumentation and control equipment for the entire plant (see chapter 7)
- 11 Combined heat and power unit (CHP) for generating power and heat (Alternatively biogas can be upgraded and fed into the natural gas grid or used as fuel for vehicles) (see chapter 3)
- 12 Digestate storage for the digested feedstock to collect digestate for times (e.g. winter) when it cannot be applied (see chapter 8)
- 13 Digestate upgrading e.g. separation, drying, pelletizing, post composting (see chapter 8)

3 Biogas use

Among the renewable energy technologies, biogas is the genuine all-rounder, providing electricity, heat, gas and fuel for gas-powered vehicles. This flexibility is achieved through the production of a primary energy source, namely methane.



The production of methane during the anaerobic digestion process means that the energy contained in the feedstock can be used in manifold ways. One of the most common methods is the conversion of gas into electricity and heat using a CHP (combined heat and power plant). However, before the gas can be used in engines, it must be cleaned. Raw biogas is saturated with water and contains hydrogen sulphide (H_2S), which would end up corroding the plant's engines and other metal, concrete or wood components that are exposed to the gas. To ensure the longevity of the biogas plant and to protect its components from H_2S , it is essential to desulphurise the biogas. This can be performed by

- ▶ putting metal salts into the digester,
- ▶ enabling internal or external biological oxidation (e.g. controlled air injection into the digester), or
- ▶ scrubbing the biogas with sulphur-adsorbing materials (e.g. activated carbon).

Drying the gas is another common step in the refining process. A popular method for doing this is condensation drying, which involves cooling the biogas to a temperature

where the water content condenses and is captured in a condensate tray. After this cleaning process, the biogas is suitable for burning in a CHP system in which an engine drives a generator. The heat generated in the combustion process can also be collected by heat exchangers. While around a quarter of the heat generated must be used to heat the digesters, the remaining part can be used or sold for manifold applications such as heating farm buildings and homes. This year-round heat energy is particularly useful for consumers who require heat throughout the year such as community buildings, swimming pools, greenhouses, breweries or other industrial operations. Heat energy can also be used to run cooling systems, which could prove attractive for countries with hotter climates.

A benefit of producing electricity from biogas is the flexibility the gas offers, as it is much easier to store biogas than electricity. Electricity can therefore be produced as and when it is needed. This has a stabilising effect on power systems because any drops in output from fluctuating energy sources (like wind power and photovoltaic systems) can be offset. An increasing number of biogas

plants in Germany no longer generate power around the clock but, instead, produce electricity according to demand. This approach also represents a great opportunity for off-grid solutions by enabling producers to generate electricity as and when needed.

Upgraded biogas, known as biomethane, can also be fed directly into the existing natural gas grid and be stored in gas reservoirs. To upgrade biogas to biomethane quality, the CO_2 contained in the biogas must be removed to ensure the CH_4 content of the gas mixture reaches 98%. Various upgrading techniques are available. Once biogas is upgraded to biomethane and is, for example, injected into the gas grid, it can fulfil the same tasks as natural gas. For example, it can be used as a fuel to run vehicles, compressed in cylinders (e.g. for domestic use) or used in a CHP at a location where the heat produced can be most efficiently repurposed. Biomethane can have very positive impacts on the sustainability of the transport sector in that CO_2 emissions from a vehicle running on pure biomethane produced from waste are around 90% lower than those of vehicles run on fossil fuels.

4 Feedstock

Biogas plants can be operated using all kinds of feedstock. The only requirement is that it consists of organic material that can be anaerobically degraded by the microorganisms inside the digester.

A huge variety of organic waste and residues are suitable for use as feedstock for biogas production. In this booklet, possible feedstocks are categorised using the following classification system. Even though the classification cannot always be 100% accurate, the symbols indicated below are used consistently throughout this booklet and serve to facilitate the identification of companies in the directory (see Company portraits, page 40) that are able to deliver suitable solutions for the feedstock in question.

Feedstock categories

-  Biowaste from households
-  Industrial and commercial wastes
-  Animal by-products
-  Vegetable by-products
-  Energy crops
(not covered in this chapter)

Biowaste from households is the organic fraction of household waste (ideally separately collected biowaste or garden and park waste). It can be collected in household 'bio bins' or in biowaste containers placed in the public realm. Refuse teams empty the bio bins or containers into trucks and bring the collected biowaste to a biogas plant. Garden and park waste is often collected at collection points or brought directly to the biogas facility. Organic residues from food, beverage or feed production, including catering waste and expired food, are designated as **industrial and commercial waste**. Liquid waste can be collected and transported in tanks. Kitchens and canteens also collect waste in bio bins, while supermarkets tend to use containers. **Animal by-products** mainly comprise liquid and solid manure, but also include slaughterhouse waste like blood, feathers, whey, fat separator contents and flotation tailings. Agriculture also generates a broad range of **vegetable by-products** like straw or harvest residues, but also brewers grains, molasses, husks, etc.

Among other things, the water content and degradability of the feedstock are particularly important factors to consider when it comes to choosing the right technology. For example, catering waste and other putrescible wastes that may be too wet and lack structure for com-



posting are actually excellent feedstock for anaerobic digestion. That said, not every kind of organic material can be degraded in a digester. One of the main limitations of the biogas process is its inability to degrade lignin (a major component of wood), which is something that can be accomplished with aerobic degradation processes (composting).

The characteristics of the feedstock used and how it is mixed have major impacts on the biogas process and biogas yield. If clean biodegradable feedstock is obtained, it will be possible to use the digestate as organic biofertiliser or soil improver in agriculture. If the quality of the digestate cannot be ensured – for example, because it contains potentially polluted feedstock like sewage sludge or the organic fraction of mixed waste is in some way contaminated – it must be disposed of in landfills or incinerated.

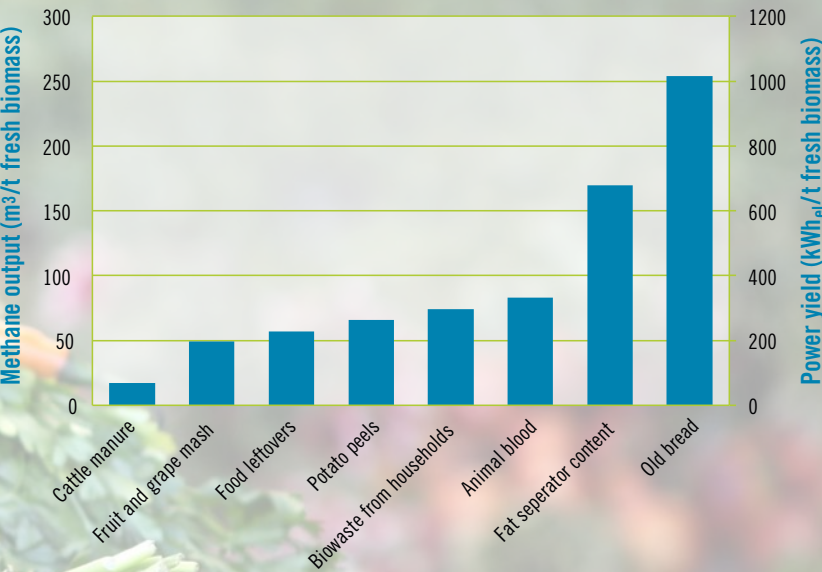
Most types of biowaste and animal by-products (except manure, which in practice can be spread directly) need to be sanitised to eradicate or reduce animal and plant pathogens or seeds to acceptably low, sanitary levels. This can be carried out using a full-flow pasteurisation unit, which heats material to over 70°C for one hour. The material (or parts of it if only certain input streams need to be sanitised) can be pasteurised either prior to processing in the digester or after the digestion process. Other possibilities are thermophilic digestion (using temperatures greater than 50°C) during the retention time of the process, a post-composting step or other methods like liming or damping. Whatever ap-

proach is employed, the biological activity in the biogas process will significantly reduce pathogens already at lower temperatures. As stated previously, it is only when complete sanitation is required that either longer retention times or higher temperatures are necessary.

The methane yield provided by each kind of feedstock depends on its composition and how much protein, fat and carbohydrate it contains. For example, the high proportion of carbohydrates found in stale bread provides a very high methane output per tonne of fresh biomass. Feedstock composition therefore significantly influences the viability of a biogas plant. Conversely, certain feedstocks can negatively impact on the microbiology in the digester. Anaerobically digesting lots of material with high protein content, such as rapeseed cake, could lead to increased concentrations of hydrogen sulphide (H_2S), which is harmful for the biogas-generating microorganisms and machinery. As such, it is essential to monitor how different feedstocks impact on the gas composition.

As we can see, the different kinds of feedstock used have a huge influence on how the plant operates, and they can also impact on the bottom line when their associated costs (like collection, transportation and handling, as well as ‘gate fees’ charged to those depositing material at the facility) are factored in. The biogas yield of the feedstock does, however, have an economic value due to the energy that can be generated from it. Therefore, the whole plant concept should be based around the feedstock it intends to use.

Energy yield of possible feedstock



5 Feedstock preparation

In order to prevent malfunctions in the digestion process and produce high-quality digestate, materials like plastics, glass, paper, metals, stones or oversized components must be removed from the biowaste before or during the biogas process.

Clean feedstock from controlled sources, such as industry or agriculture, is optimal for the biogas process and the quality of the digestate and compost produced. However, biowaste is not always free of non-biodegradable or unsuitable materials and contaminants. Expired food from supermarkets, for example, might still be packaged in glass, plastic or cardboard containers. Catering waste might contain cutlery or bones. One

To ensure operating conditions remain stable and produce the best possible biogas yields and to maintain the intended lifespan of the equipment and machinery, it is essential to use an optimal feedstock mixture in the digester. To do this, feedstock can be improved prior to the digestion process with efficient pre-treatment stages, which can also prevent the build-up of contaminants over time.



kind of feedstock that can be particularly challenging is source-separated biowaste from households, because its cleanliness depends on the motivation of individuals to properly separate waste at source and not throw inorganic materials (such as batteries or yoghurt pots) into biowaste bins. The quality of this kind of biowaste therefore varies considerably according to a number of factors including social structure, education, location (rural or urban) and population density. Small amounts of impurities are already proving problematic and the removal of 100% of the impurities is not technically feasible. As such, the quality of inputs is of the utmost importance, especially if the intention is to spread the produced digestate and compost on farmland.

Removing solids like sand and stones will minimise the downtime required to de-silt the system and maintain an effective working volume in the digesters. This can also be combined with additional removal steps at the back end or other stages of the process to achieve the best digestate quality. In some cases, where the anaerobic digestion step is less sensitive to impurities (normally dry digestion processes), the removal of physical contaminants can also be carried out after the biogas process instead of before (e.g. by sieving the compost in rotating drums). As a result, impurities may be concentrated in the oversized grain captured during the sieving or in the solid fraction extracted during the separation step. Fractions that are too polluted should not be used as fertiliser and will need to be disposed of in an alternative way, such as incineration.



Waste truck is unloading biowaste into the bunker



Loading crane is grabbing biowaste for feeding the biogas plant

Following this, different feedstock preparation technologies can be applied, with different approaches used depending on whether the feedstock is wet or dry. In this booklet the following symbols for wet and dry techniques are used to facilitate the identification of relevant manufacturers of feedstock preparation systems in the directory.

≈ Wet feedstock preparation

▲ Dry feedstock preparation

In both cases, the first stage in the process usually involves reducing particle size and creating a more homogenous material. This can be achieved using screwcutting, milling, drumming or shredding machines. Techniques for extracting organic material from packaging include breaking glass with presses or opening plastic sacks with cutters.

Dry technologies separate impurities by sieving out oversized components or wood and roots that will need to be composted or incinerated. Plastics are blown out of the material using air separation techniques and metals are removed with magnets or eddy current separators (for nonferrous metals). For heavily heterogeneous biowaste, such as that from households, sorting units can be installed where (human) operatives, often working along a conveyor belt, pick out unwanted material.

If the biowaste is delivered in liquid form or broken down into small particles and mixed with water or liquid biomass for wet digestion, impurities can be removed

through hydro-mechanical treatment. With sink-float separation, heavy materials like stones and bones sink to the bottom of the unit and light impurities like textiles and plastics float to the surface, where they can be removed. This approach can also be used with pulpers, which break down the feedstock but also enable the separation of unwanted materials. Grit and sand can be removed using hydrocyclones. Another way is to press liquid biowaste through a fine sieve to produce a clean organic fraction.

Ensuring the quality of the fertiliser – its visual cleanliness and absence of contaminants and harmful impurities (e.g. sharp objects) – is paramount when it comes to marketing the product and to fostering public acceptance of biogas technology as a waste treatment option. To create this kind of clean end-product, a combination of both high-quality feedstock that is (practically) free of impurities and the application of appropriate technologies for treating each kind of impurity are essential.

6 Digester technology

The digester is the main component of a biogas system. A number of the technologies for digesting biowaste that are available on the market are suited to processing the feedstock discussed in this publication. Making the right choice depends on the feedstock and the local conditions.

Choosing appropriate technologies depends on many factors, such as: the availability and characteristics of the feedstock, its quantity and quality, dry matter content and need for sanitation; energy use and incentives (e.g. feed-in tariffs) and local energy demand; gate fees charged for incoming material; transportation conditions; the intended end-uses of the digestate; operators' skills and knowledge; and, of course, the financial resources available.

There is no general rule for identifying the best technologies so, before developing a plant, it is essential to get expert advice on the selection of the most appropriate technology. For outline guidance, several of the most common options are briefly summarised in this chapter.

The technologies and components adopted must be reliable, robust and interoperable so that the overall system is durable, delivers a high level of performance and is designed to prevent accidents and thus ensure safe operation. It should be remembered that malfunc-

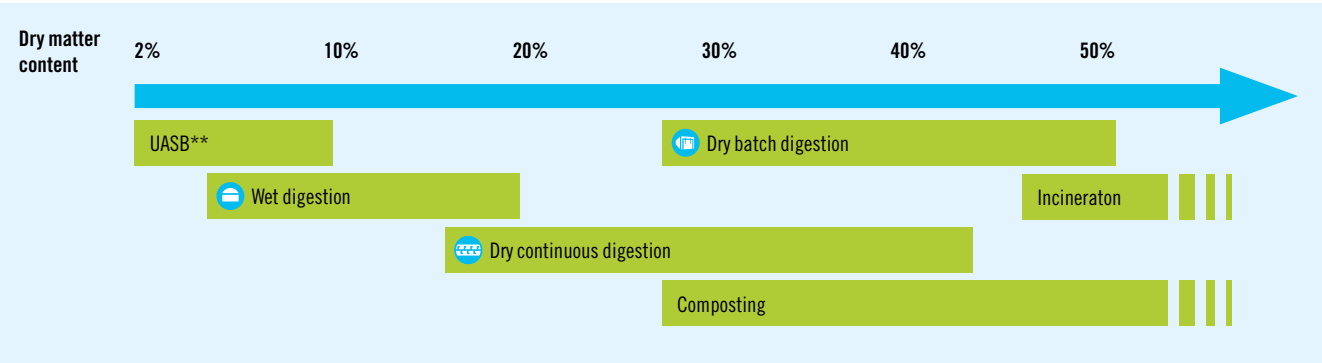
tions and availability of spare parts inevitably result in high maintenance costs. Operator know-how, training courses, and good cooperation among all those involved in the biogas project (e.g. the project planners, manufacturers, construction companies and operators) are therefore important factors for delivering a successful biogas project.

The digester is the main component of a biogas system. For this reason, biogas systems tend to be categorised according to the type of digestion process they use:

-  Wet continuous digestion (continuously stirred tank and hydraulic reactors)
-  Dry continuous digestion (horizontal or vertical plug flow reactors)
-  Dry batch digestion (garage and percolation systems)

These three categories are briefly described below.

Overview of technologies depending on dry matter content for the possible operating mode*



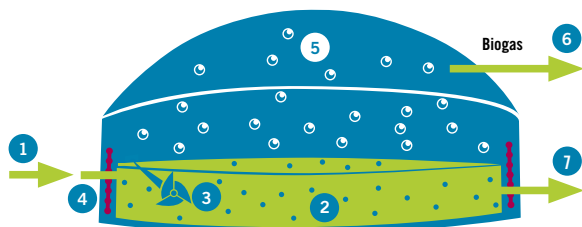
* Mostly every feedstock can be diluted to the needed dry matter content of each digester technology.
** UASB: Upflow anaerobic sludge blanket technology is a form of anaerobic digestion designed for materials with high water content (e.g. sewage sludge). UASB reactors are installed for waste or process water treatment.

Wet continuous digestion

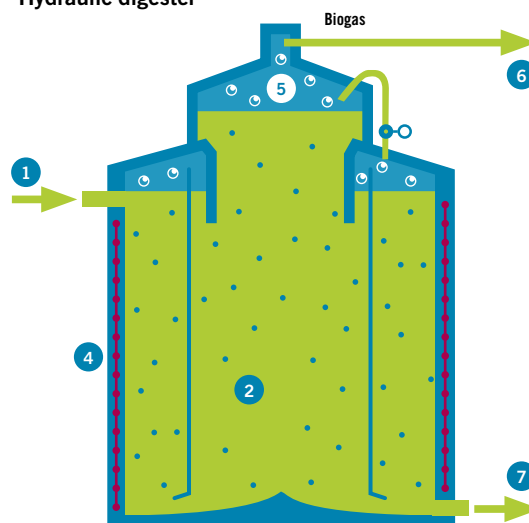
Solid biomass is converted into slurry using process water or liquid biomass to provide a diluted feedstock for the digester. Liquid biowaste or manure, on the other hand, can be used directly without dilution. As the di-

gestate is wet after the digestion, it can also be used to dilute solid feedstock. If a post-composting step is required, the digestate will need to undergo separation. Liquid digestate can be spread directly as fertiliser.

Continuously stirred tank reactor (CSTR)



Hydraulic digester



1 Input 2 Biomass 3 Agitator 4 Heating system 5 Biogas storage 6 Biogas utilisation 7 Output

For this kind of reactor:

- ▶ the material is fed in continuously;
- ▶ suitable feedstocks are






- ▶ the dry matter content of the feedstock ranges from below 6% up to 15%;
- ▶ feedstock has to be pumpable;
- ▶ agitators are necessary;
- ▶ the process temperature is mesophilic or thermophilic;
- ▶ the process can be single or multi stage (i.e. with a separate hydrolysis tank);
- ▶ one or more main digesters, a post-digester and digestate storage usually need to be installed.

For this kind of reactor:

- ▶ the material is fed in continuously;
- ▶ suitable feedstocks are






- ▶ the dry matter content of feedstock ranges from 6% up to 16%;
- ▶ no agitators are required and there are no moving parts in the reactor;
- ▶ mixing and feedstock discharge is driven by biogas produced by the digester;
- ▶ the process temperature is mesophilic or thermophilic;
- ▶ a minimum amount of around 20,000 tonnes of feedstock are required per year.

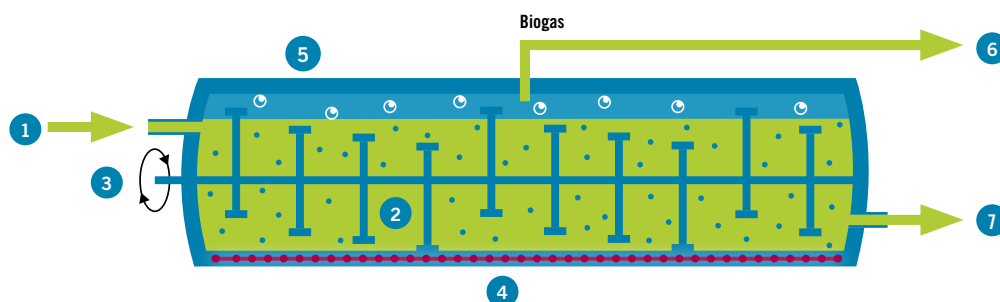
CSTR is the most commonly used digester technology. It is a simple but robust technology that accepts a wide range of possible feedstocks. Almost any size of plant is possible.

Dry continuous digestion

The concept that underpins the plug flow reactor is that the biomass is slowly transported (horizontally or vertically) from the inlet to the outlet. Ideally all particles are processed with the same retention time as they pass through the reactor, although some shortcuts are possible depending on the nature of the feedstock. To ensure optimal processing conditions, plug flow reactors are equipped with very robust stirring technology.

- 1 Input
- 2 Biomass
- 3 Agitator
- 4 Heating system
- 5 Biogas storage
- 6 Biogas utilisation
- 7 Output

Plug flow reactor



For this kind of reactor:

- ▶ the material is fed in continuously;
- ▶ suitable feedstocks are





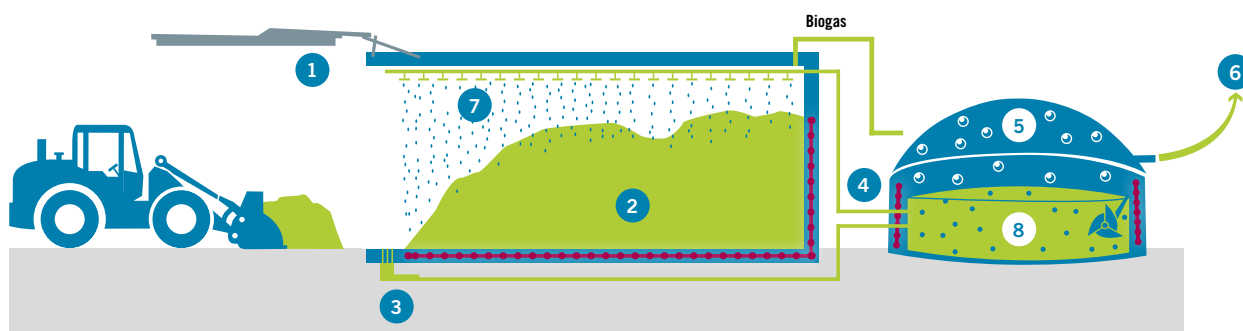

- ▶ the dry matter content of feedstock ranges from 15% up to 45%;
- ▶ the digester can operate either horizontally or vertically;
- ▶ agitators operate along or across the flow of material (although vertical flow systems operate without agitators);
- ▶ a high reactor load is possible;
- ▶ reactor volume is usually limited to between 1,000 and 2,000 cubic metres because of the strong radial forces involved that affect stirring ability; however, a number of reactors can be operated side by side;
- ▶ the process temperature is mainly thermophilic;
- ▶ a minimum amount of around 20,000 tonnes of feedstock are required per year.

Dry batch digestion

Biomass is processed in batches that remain in the digester for a defined retention time. Afterwards, the digester is emptied and refilled with the next batch. The digestate is post-composted without a separation step. New incoming feedstock is inoculated with digestate from the previous process or from another reactor and is left to digest inside the digester. Leachate from the drainage system is recirculated as percolation liquid to improve contact between the degrading biomass, locally formed organic acids and methane-forming bacteria. Dry batch digesters are mainly developed as garage systems.

- 1 Gastight door
- 2 Biomass
- 3 Drainage system for percolation liquid
- 4 Heating system
- 5 Biogas storage
- 6 Biogas utilisation
- 7 Percolation liquid distribution
- 8 Percolation liquid storage tank

Garage systems



For this kind of reactor:

- ▶ the material flow is discontinuous;
- ▶ biomass usually needs to be moved in and out of the unit using a wheel loader;
- ▶ suitable feedstocks, which need to be stackable and thus to contain a large amount of structural material, are






- ▶ the dry matter content of feedstock must be higher than 30%;
- ▶ there are no moving components in the reactor, which means the reactor is robust, operations are reliable and maintenance costs are low;
- ▶ a percolation liquid distribution ensures optimal water content;
- ▶ the process temperature is mesophilic or thermophilic;
- ▶ min. three digesters are required to equalise the gas production level.

7 Safety first!

Safety considerations play a very important role in biogas plants. The main areas of biogas safety are emission control, product safety, water protection, and safety at work, but many other issues and safeguards must be taken into account. Only when all the required measures are taken a safe biogas production can be ensured.

To ensure that biogas plant operations do not lead to health or environmental hazards, manufacturers, planning consultants and operators must work together closely from the outset to avoid problems arising in the plant planning phase. Decades of experience building and running thousands of biogas plants show how safe biogas facilities can be. Today, reliable technologies, standards and training are available to ensure safe biogas operations.

Declaration of "Ex-zone" where an explosive atmosphere may occur



Gas detector

In general, this technology presents two main types of risk: environmental hazards and health hazards. Environmental hazards may, for example, be greenhouse gas emissions or digestate leakages into bodies of water due to structural or operational failures. Health hazards may involve people who work in biogas plants or third parties (e.g. communities local to the plant) and are categorised as: gas hazards (e.g. explosions), fire hazards, mechanical hazards and electrical hazards as well as noise pollution and the emission of hazardous substances.

The most common risks on biogas plants are not specifically caused by biogas but by falling, cutting, physical impacts and so on (i.e. they are mechanical in nature). Some of the toxic, harmful and/or sensitising chemicals used in the process – the processing aids (essential nutrients), biological agents or compounds to desulphurise the biogas – can also present a risk to operators and staff.

Given that biogas is a flammable gas containing a high amount of methane, it also presents a number of risks. In general, the occurrence of a dangerous explosive atmosphere is unusual, but it may arise in situations where biogas reaches from 6% to 22% of the volume of the ambient atmosphere in areas of the biogas plant. To avoid explosions resulting from these conditions, plant operators must install explosion protection zones. These 'ex-zones' must be easily identifiable with appropriate signage. Among other requirements, only special and officially approved tools and devices that carry no danger of sparking (ATEX) should be permitted in sensitive areas.

Biogas is not only dangerous because it is explosive. Its component gases, such as carbon dioxide, ammonia and hydrogen sulphide, can also be harmful for people if inhaled. Biogas plants must therefore put in place relevant technologies (e.g. air ventilation in closed spaces or containers), organisational specifications (e.g. working instructions or risk assessments) and systems for personal protection (e.g. gas detectors to warn about the presence of toxic gases).

Furthermore, defective electrical equipment or wiring poses the risk of electrocution. The most effective way to reduce electric shock hazards is to ensure a specialised electrician who carries out or oversees all electrical installation work and the regular checks.

To address these kinds of hazards, it is essential to perform a risk assessment and take all necessary precautions. For the risk assessment, the plant operator must determine, evaluate and minimise any hazards arising (a) from the design of selected work equipment and spaces and (b) in production processes and work procedures. In addition, all explosion threats and possible counter-measures must be documented in an explosion protection document.

The German Biogas Association organises safety training programmes. Interested parties who need support on safety matters are encouraged to get in contact with the Association.

8 Digestate application

Digestate is a high-quality biofertiliser, rich in humus and nutrients. It can be used directly in liquid form (but may also be separated, composted or dried) on farms, landscaping and on market or domestic gardens.

All the nutrients and micronutrients contained in the feedstock for the biogas plant will remain in the digestate. Only some of the carbon, hydrogen and oxygen (as part of CH_4 and CO_2) and marginal quantities of nitrogen, sulphur and oxygen will be removed from the material as gas. As such, the feedstock fed into the digester directly determines the composition of the resulting digestate. Essential nutrients for plant growth are predominantly nitrogen, phosphorus and potassium. When nitrogen is bound in organic molecules (like proteins), it cannot usually be assimilated by growing plants except in form of ammonia. Nitrogen availability and, hence, plant nutrition is improved after digestion due to a higher ammonium concentration. Additionally, the digestate's valuable organic carbon content is a key component of humus.

In general, the use of biofertiliser should be promoted to close nutrient and carbon cycles and to reduce the use of inorganic fertilisers, which often have to be transported over long distances. Furthermore, the production of inorganic fertilisers requires vast amounts of energy, which is mainly generated using fossil fuels and thus results in high greenhouse gas emissions. Shortages of phosphorus, a finite resource, look set to affect our society soon and are already leading to critical levels of uranium and cadmium in inorganic phosphorus fertilisers. With the prices of inorganic fertilisers rising, the production of organic alternatives is timely and potentially lucrative.

The use of digestate as a fertiliser is not only beneficial for the environment but also economically essential. For example, it avoids the high waste disposal costs that can result from treating liquid digestate in a water treatment plant. The output quality always depends on the input quality of the feedstock used. As such, the choice of feedstock must be considered when planning the plant in order to guarantee the production of high-quality fertiliser that, ideally, earns increased revenue due to its nutrient and humus content.

Digestate can be applied directly in liquid form (containing 5% to 15% of dry matter) like slurry or in a semi-solid form (containing 10% to 30% of dry matter) like peat or compost. To establish new markets and reduce costs (storage, transportation and application), a number of techniques can be applied to upgrade the liquid digestate such as dewatering, composting, drying, pelletising, granulating, nutrient stripping or

precipitation, steam evaporation, filtration (e.g. ultra-filtration or reverse osmosis), etc.

Dried or composted digestate is physically stabilised and will have reduced emissions to air when kept in open storage, transported or applied. Conditioned products like this can be stored more easily, which is necessary during the continental European winter, for example, when no nutrient demand exists in agriculture and spreading is forbidden by law (e.g. in Germany from November to February). Another possible opportunity for selling processed digestate is new market sectors like garden centres, home improvement stores and retail markets.

The choice of upgrading technology largely depends on market demand and the location of the plant. However, if a market has been established for non-upgraded digestate and suitable storage facilities have been installed, these kinds of technology are not always necessary.

If digestate cannot be used as fertiliser due to high levels of impurities and other contaminants (like heavy metals) resulting from unclean feedstock, it may be worth considering incinerating the solid digestate to recover its energy. Using digestate as a fertiliser is, however, preferable from an economic as well as environmental perspective. Its use (liquid, solid, composted, upgraded) as organic fertiliser or soil improver should therefore be supported by national legislation as well as voluntary product specifications.

Liquid digestate application with drag hose spreader



The use of biogas technology as part of integrated waste and resource management

Viewpoints and contributions of
German international cooperation

giz Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

The high organic content of municipal solid waste in low- and middle-income countries (up to 60%) causes numerous problems in the handling and disposal of the waste. Banning the dumping or landfilling of organic waste is therefore of great benefit: it reduces the generation of landfill gas, relieves the pressure on scarce landfill capacities and mitigates all of the conflicts, costs and social burdens involved.

By reintroducing recyclables ('secondary raw materials') into value chains, the use of biogas technology that uses waste as feedstock promotes a circular economy. The advantages are twofold: (1) energy is recovered and (2) the nutrient cycle is closed.

The situation of low- and middle income countries is also in the waste sector not comparable with high-income countries



Energy recovery: Biogas is an excellent alternative source of energy that helps to meet rising energy demands and contributes to local energy access and security.

The nutrient cycle: If derived exclusively from clean, source-separated waste streams, the spent and sanitised digestates left over from the process are subsequently further processed into organic fertilisers and soil amendments that can, at least in part, replace mineral fertilisers. In this way the nutrients are recirculated, which contributes to closing the cycle between food-consuming urban spaces and food-producing rural areas.

When anaerobic digestion projects focus on waste, they are more likely to be sustainable and far less likely to threaten food supplies.

Employment (job creation) and health: The provision of energy services from biomass waste tends to be labour-intensive due to the amount of personnel needed to collect and process the feedstock. Also, the reductions in odour, disease, soil pollution, and surface and ground-water pollution that the system engenders all serve to improve health conditions.

Achieving environmental benefits through **climate change mitigation** and **pollution reduction:** Anaerobic biowaste digestion and the energetic use of biogas is helping to reduce greenhouse gas (GHG) emissions directly, by reducing uncontrolled methane emissions from open waste storage, and indirectly, by replacing the use of fossil fuels. Methane is a powerful short-lived climate pollutant (SLCP). Methane emissions caused by human activities are the second largest driver of climate



Biowaste collection for biological treatment

change after carbon dioxide. Reducing SLCPs through well-managed waste systems contributes to overall efforts to mitigate climate change and secure significant health, environmental and economic co-benefits, which include an improved quality of life for local communities. Anaerobic biowaste digestion helps to prevent contamination of both surface and ground water.

The waste sector is uniquely positioned to help achieve mitigation targets across sectors. On a global scale, around 3% to 5% of GHG emissions come from the waste sector. The potential impact of improved waste management (which includes the manufacture of waste-derived biogas for energy generation) on reductions in GHG emissions across the whole economy amounts to between 15% and 20%.

By diverting organic waste from landfill sites to composting units, anaerobic digestion or energy recovery, Germany has transformed its waste sector from being a net polluter to a contributor of net savings of GHGs.

GIZ's approach for biogas and waste management

In the area of municipal solid waste management (SWM) GIZ is currently executing some 25 projects around the world, some of which specifically focus on biogas from waste.

In the area of renewable energy, GIZ is currently executing more than 150 projects in over 40 countries, and more than 20 of these focus on biogas or have a

biogas component. Some examples of these cooperation projects include the Energetic Utilisation of Urban Waste in Mexico project; the German Climate Technology Initiative – Promoting Climate-Friendly Biogas Technology in Brazil; the Renewable Energy Project Development Programme; and the Promotion of Least-Cost Renewables in Indonesia project. These projects' activities include the support of legal framework conditions for biogas, the analysis of different substrates for use in biogas production, capacity development at the local level, and the support of biogas pilot projects.

Usually on the basis of bilateral or multilateral agreements, GIZ cooperates and partners with a wide range of stakeholders: national ministries, local authorities, businesses, financial institutions, academia, civil society, industry, and waste management companies. Cooperation with German

and local companies is essential for these projects. GIZ has been formally cooperating with the German Biogas Association for many years.

German development cooperation aims to establish integrated, closed-cycle waste management systems. These can also create positive impacts in other sectors, such as health, climate change, poverty reduction, or food and resource security. As outlined in the citation below, low- and middle-income countries still often struggle with their waste management systems. Therefore, biogas projects in these countries need to pay special attention to holistic SWM approaches.

Low- and middle-income countries still face major challenges in ensuring universal access to waste collection services, eliminating uncontrolled disposal and burning and moving towards environmentally sound management for all waste. Achieving this challenge is made even more difficult by forecasts that major cities in the lowest income countries are likely to double in population over the next 20 or so years, which is also likely to increase the local political priority given to waste issues. Low- and middle-income countries need to devise and implement innovative and effective policies and practices to promote waste prevention and stem the relentless increase in waste per capita as economies develop.

Global Waste Management Outlook,
United Nations Environment

Programme and International Solid Waste Association, 2015¹

¹ See: www.unep.org/ietc/InformationResources/Events/GlobalWasteManagementOutlookGWMO/tabid/106373/Default.aspx



Waste pickers looking for useful things on landfills

The following approaches are of particular importance:

- ▶ Promoting the overall objective of sound waste management and, in particular, anaerobic digestion and the composting of organic waste.
- ▶ Switching from a linear economy – i.e. one that loses resources and carries the burden of improper waste management – to intelligent resource management within the circular economy.
- ▶ Sound waste and resource management should take into account the **three dimensions of sustainable development: society, environment and economy**. Measures should contribute to the recently adopted United Nations Sustainable Development Goals (SDGs) and their associated targets that implicitly and/or explicitly address waste management.
- ▶ The principles of the **waste management hierarchy** (emphasising waste prevention over minimisation; reuse; recycling; energy recovery; and final disposal) help in setting priorities and offer guidance with regard to the whole range of material flow and waste management options. The best way to manage waste is to consider it as a potential resource and to prevent materials from becoming 'waste' in the first place. A greater number of upstream preventative actions need to be incorporated in waste management.
- ▶ **Capacity development** involves building and strengthening individual, institutional, technological and professional capacities at different levels and focusing on different target groups.
- ▶ **A multi-stakeholder approach** involves stakeholder participation through enabling and participatory processes, making sure that all relevant actors are on board.

GIZ works to achieve these objectives in biogas-related projects by supporting our partners in

- ▶ identifying and creating the conditions that make biogas from waste a viable option, and
- ▶ developing cost-covering projects and mobilising additional funding.

Framework conditions for successfully establishing biowaste-to-biogas projects

A few 'simple truths' about integrated waste management need to be clearly stated and acknowledged: Waste management as a whole, including anaerobic biowaste digestion, incurs costs. This fact can run counter to what some eloquent but perhaps less-than-honest salespersons may try to make us believe.

There is an erroneous and widely held belief that the final disposal of waste in sanitary landfills and, even worse, in uncontrolled, sub-standard dumps costs less than any other waste treatment method. However, this only applies if the major environmental and social burdens these approaches engender are not taken into account but are, instead, passed on to future generations. In technical terms, this is described as the failure to internalise the external environmental costs of inadequate waste management.

Biogas facilities require considerably more capital expenditure than 'simple' windrow composting or landfill approaches. Many biowaste digestion plant projects are not viable under current economic and organisational conditions unless sufficient guarantees, incentives, feed-in tariffs and/or carbon credits are provided. To overcome the barriers to the development of biogas projects, investors and operators therefore need sufficient revenues and price certainties as a basis for their commitment.

Some extra efforts therefore appear necessary and, since waste management is a cross-cutting task, a set of political, institutional, social, financial and technical conditions must be met if biowaste-to-biogas projects are to be successfully implemented. Countries or local and regional authorities that successfully provide such favourable framework conditions – e.g. by implementing (national) strategies, providing renewable energy incentives, offering long-term contracts and ensuring price certainty for the energy generated – experience substantial increases in investments in biogas production from source-separated biowaste.

Digging a little deeper and in more detail

I. Policy and legislation

A legal framework for the source-separation of different solid waste fractions (including biowaste) and the enforcement of this framework are mandatory prerequisites for the implementation of biogas projects. The national and regional/local legal framework should clearly designate the roles and responsibilities of the institutions involved in solid waste management. It should include provisions on solid waste collection, financing mechanisms, standards for waste treatment and disposal facilities, and standards for the use of biogas plant outputs (e.g. the digestate). Institutions need to have the competencies and capacities to enforce proper waste management and control the appropriate operation of waste treatment plants.

II. Market mechanisms and economic instruments

Authorities institute these mechanisms and instruments to ensure financial sustainability and to quantify and generate market value for the environmental benefits of biogas production. At the outset it is essential to ascertain whether a local market for biogas-plant products exists and whether there is sufficient ability and willingness to pay the sums likely to be charged for these products (namely, the biogas itself and the digestates for

use in agriculture). The most appropriate mode of biogas use must also be ascertained (i.e. whether it is converted to electricity and heat, used directly, upgraded to biomethane, etc.). Acceptable, country-specific remuneration arrangements (e.g. feed-in tariffs) need to be put in place.

Feed-in tariffs (FiTs) are the policy instruments most commonly deployed for the promotion of biogas projects, including projects to generate electricity from biogas. Energy producers receive a guaranteed price for the energy they supply to the grid over a fixed period of time. It is important to set the tariff level and time period in a way that provides income security and thus serves to motivate investors. For this reason, the tariffs are normally guaranteed for a set number of years. Specific financial benefits associated with FiTs may include the following:

- a. A generation tariff where the electricity supplier is paid for each KWh of energy it produces.
- b. An export tariff for energy that is not used on site but is instead exported to the national grid.
- c. Savings on energy bills resulting from the use of the energy that is generated on site.

The existing solid waste management system should offer a secured financing mechanism for operating the system. The sale of biogas provides additional revenue but generally does not cover all costs related to anaerobic waste digestion. Therefore, sufficient waste management fees (tipping fees, gate fees) should be imposed, or other public funds should be made available to cover the costs of separate collection and to contribute to covering part of the operating costs of biogas plants. Without incentives it is very difficult to run a biogas plant in an economically feasible way using the feedstock mentioned in this booklet.

III. Financing options, in particular with regard to climate finance, and related information sources for bioenergy projects and programmes

The Global Bioenergy Partnership (GBEP), an initiative and platform for international cooperation on bioenergy with its secretariat hosted by the UN Food and Agriculture Organization (FAO), brings together committed public, private and civil society stakeholders to jointly promote and finance bioenergy for sustainable development. GBEP's website holds a database of financing options for bioenergy for sustainable development at the project, programme and sector levels in developing countries (www.globalbioenergy.org/toolkit/financing-options-for-bioenergy/results-financial/en/). National governments and project developers can use this resource to assess different financing opportunities for bioenergy projects and programmes and get a clear picture of the selection criteria and bioenergy project characteristics required for them to be eligible for financing. The database contains relevant information on, among others, international and German financial institutions and various German financial instruments and climate-finance instruments, including the following:

- **KfW Group** – KfW Development Bank, DEG (Deutsche Investitions- und Entwicklungsgesellschaft) and KfW IPEX-Bank are together responsible for KfW's international business activities. The KfW Development Bank is Germany's leading development bank and one of the biggest money-lenders worldwide in the field of climate and environmental protection. While KfW IPEX-Bank is active in international project and export finance, DEG as a subsidiary of KfW Group provides financing and consultancy to private companies investing in developing and emerging countries. In





Produced biogas is directly used for cooking

order to boost climate-friendly technology, DEG is running the programme „**Climate partnerships with the private sector**“ on behalf of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). The initiative aims at mobilising additional actors from the private sector for climate protection in developing and emerging-market countries. The focus is on the promotion of technology and knowledge transfer to support the development of a climate-friendly economy.

With the **Up-Scaling Program**, DEG finances investments of small and medium enterprises (SMEs) that intend to scale up innovative business models with high developmental impact. The program addresses companies whose financing needs lie somewhere between microfinancing and the traditional financing by commercial banks.

www.kfw.de/kfw.de-2.html | www.deginvest.de

- **International Climate Initiative** – Since 2008 the International Climate Initiative (IKI) of the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) has been financing climate and biodiversity projects in developing and newly industrialising countries, as well as in countries in transition. The IKI is a key element of Germany's climate financing and funding commitments in the framework of the Convention on Biological Diversity. The Initiative places a clear emphasis on climate change mitigation, adaption to the impacts of climate change and the protection of biological diversity. These efforts provide various co-benefits, particularly the improvement of living conditions in partner countries. Find out more at:

www.international-climate-initiative.com/en/about-the-iki/

- **develoPPP.de** – Through the develoPPP.de programme, the German Federal Ministry for Economic Cooperation and Development (BMZ) provides companies investing in developing and emerging countries with financial and, if required, professional support. Investing companies are responsible for covering at least half of the overall costs involved, and the ceiling for BMZ contributions is set at EUR 200,000. These development partnerships with the private sector

can last up to a maximum of three years and cover diverse areas and topics. Companies are invited to register their interest with DEG, GIZ or Sequa by participating in one of the calls for expressions of interest that are put out four times a year. These calls are open to all German and European companies and their subsidiaries in developing countries and emerging economies. Development partnerships with the private sector that have the potential to achieve outstanding development benefits and involve several countries may receive more generous funding beyond the scope of the idea competitions as Strategic Development Partnerships. Find out more at: www.developppp.de/en

Further potential financing and funding sources are as follows:

- **The Green Climate Fund (GCF)** – The GCF was adopted as a financial mechanism of the UN Framework Convention on Climate Change (UNFCCC). It aims to make an ambitious contribution to attaining the mitigation and adaptation goals of the international community. Over time, it is expected to become the main multilateral financing mechanism for supporting climate action in developing countries. The GCF became fully operational in 2015 and is committed to supporting projects, programmes, policies and other activities in all developing-country parties to the UNFCCC. Countries will also be supported in the pursuit of project-based and programmatic approaches in accordance with strategies and plans (such as low-emission development strategies, Nationally Appropriate Mitigation Actions, National Adaptation Programmes of Action, National Adaptation Plans, and others). Recipient countries can submit funding proposals through National Designated Authorities (NDAs), and they will be able to access the fund directly through the accredited regional, national and sub-national implementing entities that they propose and set up, as long as these implementing entities meet certain fiduciary standards. GCF funds can also be accessed through multilateral implementing entities such as accredited multilateral development banks and UN agencies. Find out more at www.greenclimate.fund

A private sector facility will also be established to make it possible for the GCF to provide direct and indirect financing for private sector activities. The National Designated Authorities, which can object to private sector activities, are tasked with ensuring that private sector interests are aligned with national climate policies. For a more detailed description visit www.climatefundsupdate.org/listing/green-climate-fund

- ▶ **Pilot Auction Facility for Methane and Climate Change Mitigation (PAF)** – The PAF is an innovative climate finance model developed by the World Bank Group to stimulate investment in projects that reduce greenhouse gas emissions while maximising the impact of public funds and leveraging private sector financing. The PAF is backed by Germany, Sweden, Switzerland and the United States, and has a capitalisation target of USD 100 million. In a first phase, it will support projects that cut methane emissions at landfill, animal waste and wastewater sites that are facing low carbon prices and thus reduced revenues from emission trading mechanisms. The key objective of the PAF is to demonstrate a new, cost-effective climate finance mechanism that incentivises private sector investment in and action on climate change in developing countries by providing a guaranteed floor price on carbon reduction credits. Find out more at www.pilotauctionfacility.org/
- ▶ **Carbon Markets of the Future** – Hosted on the BMUB Carbon Mechanisms website, this web resource provides an overview of the carbon markets of the future: www.carbon-mechanisms.de/en/introduction/carbon-markets-of-the-future/
- ▶ **Climate Funds Update** – This website (www.climatefundsupdate.org) contains the latest information on climate funds. Particularly useful is the list of tracked funds that indicates their typology (multilateral or bilateral) and provides links to access their respective profile pages where you can find key information on each of the funds in question. See the list at www.climatefundsupdate.org/data/the-funds-v2
- ▶ **The Global Landscape of Climate Finance** – This web resource claims to be the most comprehensive inventory of climate change investments currently available: www.climatefinancelandscape.org/

IV. Waste composition and collection systems

Regarding access to resources, basic data should show that a sufficient amount of organic waste is constantly available and of adequate quality. Securing a guaranteed and regular feedstock supply for biogas plants should not be taken for granted. In practice, this means that all elements of the waste management value chain must contribute to the smooth functioning of the entire system – i.e. the collection, transport, handling and storage of the biowaste feedstock.

When the digestate is intended for use in agriculture, it is important for the collection system to ensure separation at source. However, many countries do not yet have separate collection systems (fully) in place. In such cases complementary measures are necessary such as government-issued economic incentives for the source separation of ‘clean’ organic fractions and their subsequent treatment.

Where source-separated collection systems for municipal solid waste are deemed to be impossible or limited, alternative or additional sources for separated organic waste collection should be considered (e.g. waste from food wholesalers, restaurants and catering, food processing industries, or similar). The collection system might also need to be optimised to avoid the loss or premature degradation of organic matter (feedstock), especially in hot climates.

V. Operator models and stakeholder inclusivity

Private sector participation is often an important factor in any project to install sophisticated waste treatment technologies. Managed properly, the private sector can achieve improved service efficiency and thereby reduce unit costs. Private sector participation is valuable in mobilising investment and bringing in the operational experience needed to provide efficient services. A necessary condition when involving the private sector is to guarantee that private companies can recover all the legitimate costs they incur (and profits they make) when financing, setting up and operating services. Contracting with the private sector therefore depends on having a reliable understanding of the full costs involved in privately delivered services as well as the capacity to cover these costs from recurrent revenue streams. Setting clear mandates for the public and private sectors and having the appropriate skills in place on both sides are key.

When redesigning the solid waste management sector, it is important to include not only the formal private sector but also the informal sector. In many low- and middle-income countries, informal actors are a key part of the waste management system, working mostly in the small-scale recovery of recyclables. By involving the informal sector, the livelihoods of people in poor and vulnerable communities can be improved and recycling rates boosted.

Finally, community participation is very important, especially when setting up separate collection schemes, but also when seeking to promote the acceptance and use of biogas plant outputs.

Separate green waste collection is very easy and convenient to realise



Reference plants



Cattalini Bio Energia S.A.



Digesters and buffer tanks

The first AAT-biogas plant in Brazil and the first foodwaste treatment plant in Brazil

The plant treats about 170 tonnes of market and grocery store waste as well as the sludge of the neighbouring waste water treatment plant and produces 2.8 MW of electrical energy. It's the first biogas plant of this kind in Brazil.

Other facts about the plant:

- input materials: Market and grocery store waste and sludge
- gas production: up to 23,000m³ a day
- power: 2.8 MW electrical
- volume of the 2 digesters: 10,000m³

The plant is currently under construction now and the finishing of the plant is expected in June 2016.

Operator

Cattalini Bio Energia S.A.

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URL: www.cattalinibioenergia.com.br

Manufacturer:

Cattalini Bioenergia S/A & AAT GmbH

Commissioning: 2016

Types of fermentation:

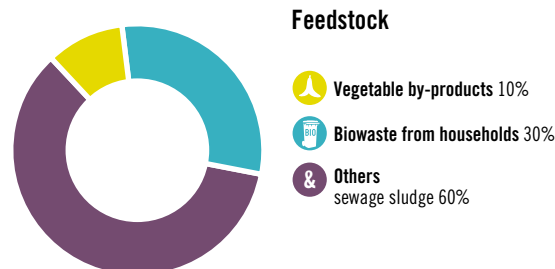
mesophilic,
wet digestion,
separate hydrolysis



Waste treatment capacity: 200,000 t/a

Installed electrical capacity: 2 x 1.426 MW_{el}

Gas treatment capacity: 958 Nm³/h



Feedstock preparation: liquid (Belt press), solid (Hammer mill)

Energetic usage: electricity, heat (pre-treatment and conditioning of digestate)

Products: liquid, solid & dried digestate, granules/pellets

Application of the digestate: thermal utilisation, treatment in a public sewage plant

Harvest Energy Garden



Biogas plant „Harvest Energy Garden“ with a two-stage dry-wet fermentation process (GICON®-Biogas-process)

The Harvest Energy Garden uses anaerobic digestion technology to produce power from the region's food scraps and yard debris. This project is the first commercial-scale high solids anaerobic digester (HSAD) facility in Canada.

The Energy Garden consists of 10 air tight tunnels where the pre-treated waste material is percolated for about two weeks. In this hydrolysis stage, organic macromolecules are biologically broken down into soluble organic substances and discharged as an aqueous solution, the hydrolysate. The collection of the hydrolysate from all percolators takes place in a buffer tank from which the second stage, digesters for methanization, are continuously fed.

Inside the digesters, biogas production takes place by biological degradation of organic compounds. The resulting liquid, which is neutralized by the biogas process, is then fed to a second buffer tank, and recirculated back to percolation in the hydrolysis stage.

Operator

Richmond Energy Garden

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Phone +1 604 315 2150
Fax: +1 604 207 8720
E-Mail skerr@harvestpower.com
URL www.harvestpower.com/bc

Manufacturer:

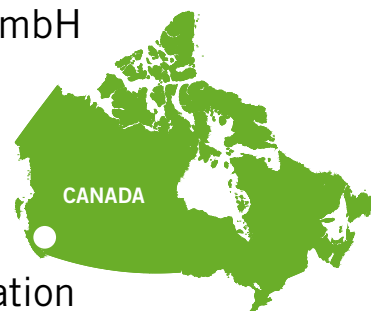
Maple Reinders

Technology provider: GICON Engineering
North America GmbH

Commissioning: 2013

Types of fermentation:

mesophilic,
dry batch percolation
plus continuous digestion

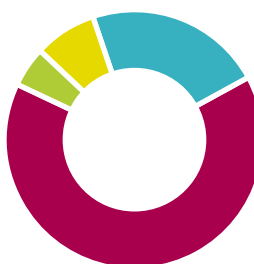


Waste treatment capacity: 40,000 t/a

Installed electrical capacity: 1.058 MW_{el}

The biogas contains a high amount of methane – up to 78% – and is combusted in a combined heat and power module, CHP. The produced electricity is fed to the grid. The remaining solids from the percolator tunnels are converted into valuable compost in a CASP process (Covered Aerated Static Pile). The Energy Garden has low energy requirements, for example, because no mixing technology is required. At the same time, batch operation leads to high availability and the two step process provides distinguished controllability of the biogas formation.

Feedstock



-  Animal by-products 5%
-  Vegetable by-products 8%
-  Biowaste from households 22%
-  Industrial and commercial wastes 65%

Feedstock preparation: solid (dual-shaft shredder)

Energetic usage: electricity, heat (heat supply for the plant and Green Energy Center)

Generated products: compost

Application of the digestate: spreading as fertiliser, treatment in a public sewage plant

Lethbridge Biogas LP



Lethbridge AD plant processes 110,000 tonnes of biowaste per year

The idea for Lethbridge Biogas LP was sparked by Thane Hurlburt of ECB Enviro North America Inc. Hurlburt researched biogas designers-builders, ultimately choosing PlanET – the only biogas company in Canada with a number of successfully realized projects. ECB developed the project and prepared the land, readying the site for PlanET's construction team. PlanET built six concrete tanks: two pre-storage tanks, three digester tanks and one digestate storage tank. Most of the tanks' equipment was provided by PlanET Germany, including the dry feeding technology system: PlanET Vario eco flow and the PlanET eco cover plus for desulphurization. Two 1.425 MW Jenbacher CHPs were installed to process the huge amount of biogas and cover the AD plant's parasitic load of 5–10%, feeding the balance into the Alberta power grid.

As Alberta was the first North American jurisdiction to pass climate change legislation requiring large emitters to reduce greenhouse gas (GHG) emissions in 2007, the Lethbridge project was eligible to register carbon offsets under the Alberta Offset System. This system

Manufacturer:

PlanET Biogas Solutions

Commissioning: 2013

Types of fermentation:
mesophilic,
wet digestion

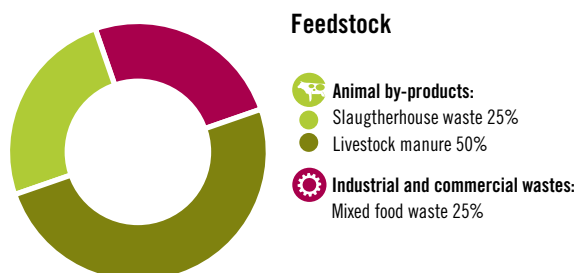


Waste treatment capacity:

110,000 t/a

Installed electrical capacity: 2.85 MW_{el}

allows projects that actually reduce GHG to actively market their carbon offsets to large emitters as a means to be in compliance with the climate change legislation. Lethbridge Biogas LP has the potential to reduce GHG emissions up to 225,000t of CO₂ by 2021, which is a remarkable value for the whole area. The project received non-repayable grants from the Climate Change and Emissions Management Corporation (CC EMC) and the Government of Alberta, Department of Energy, covering half of the total project costs.



Operator

Lethbridge Biogas LP

4456 8th Ave North

T1 H 6W5 / Lethbridge · Canada (Alberta)

Contact: Ed Mulder

Phone: +1 403-328-1429

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E-Mail: ed@ecbna.com

URL: www.lethbridgebiogas.ca

Feedstock preparation: solid, thermal hydrolysis (12 bar, 180°C)

Energetic usage: electricity

Generated products: liquid digestate

Application of the digestate: spreading as fertiliser

Investment volume: 30 million CAD

W2W - Waste to Wealth - Biomethanation Plant



The W2W biomethanation plant can produce up to 20 m³ biogas per day out of waste generated by an university canteen.

W2W - Waste to Wealth is a Biomethanation Plant designed, engineered and manufactured by Transparent Energy Systems Pvt. Ltd. (TESPL) under the technical know-how collaboration with BioenergieBeratungBornim (B³), GmbH.

W2W is a compact and skid-based plant which is easily transportable on a regular container. The entire plant is built in Carbon steel for better durability. Vital components of the plant include wet waste crusher, hydrolysis unit, sanitation unit, insulated and FRP coated biodigester, biogas storage balloon, biogas booster pump, and a single slurry pump to circulate feed through the entire system. The biodigester is equipped with vertical stirrer and hot water coil arrangement to maintain optimum digester environment. The safety features of the plant include automatic flaring system coupled with pressure indicator and transmitter. Besides, the plant is fully automated and instrumented to document biogas quality and quantity with the help of biogas analyzer and flow meter linked to online data monitoring system (ODMS). The ODMS also measures other vital parameters such as digester temperature, agitation frequency and electricity consumption.

Operator

W2W - Waste to Wealth - Biomethanation Plant

College of Engineering Pune, Hostel Campus, Shivajinagar

Pune 411005 - India

Contact: Anand Atre

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Fax +91 20 4212533

E-Mail anand.atre@tespl.com

URL www.bmethanation.com

Manufacturer:

Transparent Energy Systems Pvt. Ltd.

Commissioning: 2015

Types of fermentation:

mesophilic,
wet digestion

Waste treatment capacity: 90 t/a

Gas treatment capacity:

20 m³ biogas/day



quency and electricity consumption. W2W is operated on canteen waste generated by University hostel canteen. The waste is segregated for organic content, weighed and then mixed with known amount of water. The waste is then crushed and the resulting slurry is pumped to the digester. Sanitation and hydrolysis are deployed whenever necessary. The digestate which acts as an excellent bio-fertiliser is collected by overflow mechanism. Being easy to operate, the plant is operated and maintained by the client with remote supervision from TESPL.

Feedstock



 Industrial and commercial wastes
Leftover canteen food waste 100%

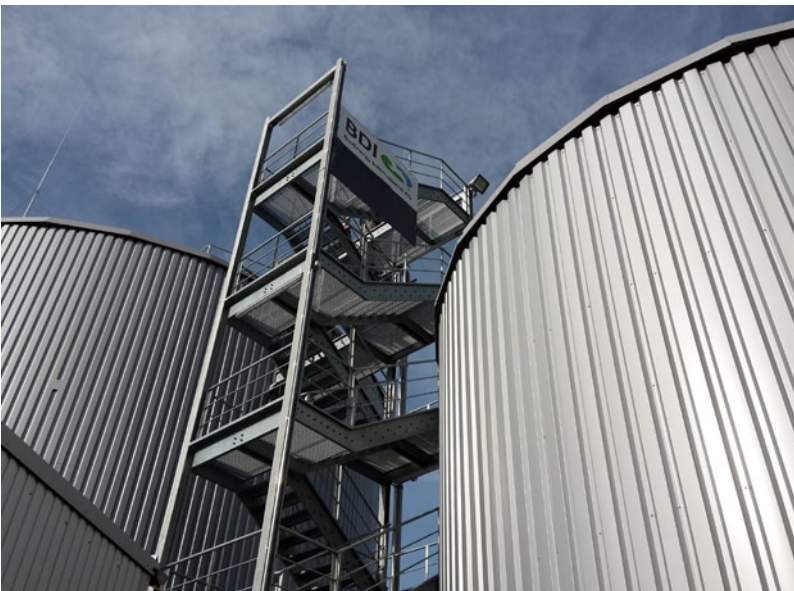
Feedstock preparation: solid (crushing and mixing with water)

Energetic usage: fuel (biogas is used as a cooking fuel in the kitchen of hostel canteen where it directly replaces the LPG.)

Generated products: liquid digestate

Application of the digestate: treatment in a public sewage plant, drained to public sewage canal

BDI spent-grain-fermentation Plant



BDI spent-grain-fermentation plant in Göss (AT)

“Brewing a better Future” is the name of Heineken’s sustainability initiative. The Brewery Göss, one of the most important breweries of Brau Union Österreich and part of the Heineken family, is opting for a “green” beer production.

The main objective for the brewery was to design the biogas plant in a way that the brewery is able to be a 100% CO₂-neutral brewery. Due to the fact that the brewery is covering its electrical energy demand completely by hydro power, the main design criteria for the biogas plant was the substitution of natural gas in combination with a suitable profitability.

The outcome of the pre-engineering phase was a biogas plant with a capacity to treat about 20,000 tonnes of brewery residues per year. With this feedstock amount, approximately 15 GWh of biogas energy can be produced. One half is used for steam production in the existing boiler of the brewery and the other half can be utilized in a CHP to produce electricity, which is sold to the grid, and heat energy, which is used for the parasitic demand of the biogas plant and in the brewery for heating.

Operator

BDI spent-grain-fermentation Plant

Hans-Kudlich-Straße 15

8700 Leoben · Austria

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Phone +43 316 4009 117

Mobil +43 664 966 1036

E-Mail sales@bdi-bioenergy.com

URL www.bdi-bioenergy.com

Manufacturer:

BDI – BioEnergy International AG

Commissioning: 2015

Types of fermentation:

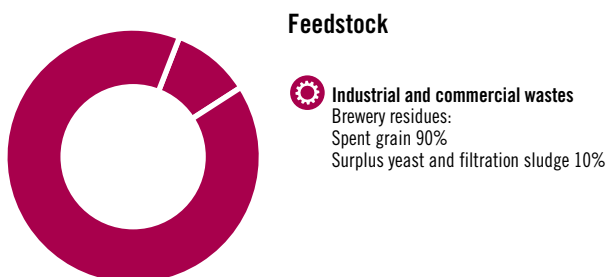
mesophilic,
wet digestion, separate hydrolysis

Waste treatment capacity: 20,000 t/a

Installed capacity:

0.7 MW thermal power
(direct burning of biogas in a steam boiler)

CHP: 0.45 MW_{el} & 0.47 MW_{th}



Feedstock preparation: Solid (dilution and mixing)

Energetic usage: electricity, heat (heating of AD plant (hot water), utilization in the brewery process (steam and hot water))

Generated products: liquid digestate

Application of the digestate: spreading as fertiliser

Investment volume: middle-single-digit-million range

BGP Rapotin



Biogas Plant Rapotin, Czech Republic

The biogas project „Rapotin“ was developed by the Czech company „IS Environment SE“ which is active in the field of waste treatment. The plant has been built in cooperation with BioConstruct who was chosen for the delivery of fermentation technology and the Czech company Moravostav Brno a.s. The project has been built in Rapotin (CZ) close to the city Sumperk and was commissioned in March 2016. The input substrates will be delivered from supermarkets, restaurants, agriculture or any other different kind of industry. The total input amount of 30,000 t/a represents an electrical capacity of 905 kW_{el}. The produced electricity will be fed into the local grid and the heat will be used for internal processes plus heating of local buildings.

All input substrates will be unloaded in a receiver hall which is equipped with a biofilter. The hall is divided into two sections: section 1 will be designed for the reception of material without pre-treatment (green line) and section 2 is designed for the reception of waste which needs to be pretreated (waste line). The waste line is equipped with a depackaging unit where all packaged material will be shredded and the organics will be separated from plastic

Operator

BGP Rapotin

Jesenická 311

78814 Rapotin · Czech Republic

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E-Mail sterba@isenvironment.cz

URL www.isenvironment.cz

Manufacturer:

Moravostav a.s.,
BioConstruct GmbH

Commissioning: 2016



Types of fermentation:

mesophilic,
wet digestion, separate hydrolysis

Waste treatment capacity: 30,000 t/a

Installed electrical capacity:

0.905 MW_{el}

etc. These organics will be mixed up with other liquids and afterwards be pumped to the hygienisation unit. After this process, the stuff is pumped into another mixing tank which is acting as a hydrolysis and whereas the green line inputs are fed in directly before pumping into the fermenters. After the fermentation process the digestate is separated into a liquid and solid phase for the usage of agricultural fertiliser.

Feedstock



Vegetable by-products 16%

Biowaste from households
Kitchen waste 30%
Other biowaste 5%

Industrial and commercial wastes 33%

Others
Food production wastes 16%

Feedstock preparation: liquid & solid (unpacking, hygienisation)

Energetic usage: electricity, heat (internal process energy, heating of local buildings)

Generated products: liquid and solid digestate

Application of the digestate: spreading as fertiliser

Investment volume: 6.7 million EUR

Bioabfallvergärungsanlage Hochfranken



BVA Hochfranken - overview - gas buffer, Helix-Hydrolysis, digester

Manufacturer:

Rehau Energy Solutions

Commissioning: 2014

Types of fermentation:

mesophilic, thermophilic
wet digestion,
separate hydrolysis



Waste treatment capacity: 30,000 t/a

Installed electrical capacity:

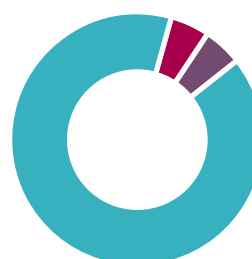
1.2 MW_{el} (500 Nm³/h)

BVA Hochfranken is designed to accept and process all kind of municipal, commercial and industrial organic waste: solid and liquid, loose and with packaging. The underlying WastERGY® wet digestion process with a separate “Helix Hydrolysis” (patented) enables the plant to utilize nearly the complete biogas production potential of the substrates. Simultaneously, the wet process allows to separate the impurities easily and very efficiently, leading to an odourless, fully degraded compost („Rottegrad V“) with less than 0.05% of impurities, the flat fraction of which is less than 10 cm²/l. The upstream Helix-Hydrolysis enables the operator to accept and immediately process all sorts of (spot) waste without running the risk of acidification, impairing the biogas production, when processing waste with fluctuating caloric values.

WastERGY® allows to operate thermophilic and mesophilic; the mesophilic operation in cooperation with the special Helix-Hydrolysis already fulfils the hygienisation requirements. The water balance of the process depends on the TDS content of the incoming waste. At the BVA Hochfranken, the water surplus is appr. 10–15 m³/d.

The key features at glance:

- high biogas production due to the complete exploitation of the biogas production potential
- compost with less than 0.05% of impurities and a flat fraction with less than 10 cm²/l
- acceptance of loose and packed, dry and solid organic waste
- all waste can be processed immediately, no waste storage outside the waste pre-treatment hall necessary
- nearly odour emission due to ventilation of the waste pre-treatment hall via bio-filters and literally odourless compost
- no unplanned power production interruption yet



Feedstock

- Biowaste from households 90%
- Industrial and commercial wastes 5%
- Others 5%

Operator

Bioabfallvergärungsanlage Hochfranken

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Fax: +49 3741 55 05 20

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URL: www.rehau-es.com

Feedstock preparation: solid & liquid

Energetic usage: electricity, heat, biomethane

Generated products: liquid digestate, granules/pellets, refuse-derived fuel (RDF), compost

Application of the digestate: spreading as fertiliser, thermal utilisation

Investment volume: 9.9 million EUR

Bioabfallverwertungsanlage Schwerin



Dry Fermentation Plant SAS Schwerin

As scheduled, the new organic waste utilization plant of the Schweriner Abfallentsorgungs- und Straßenreinigungsgesellschaft mbH (SAS) was officially opened on 1st January 2015. As a Private Public Partnership, with SAS holding a 49% share, REMONDIS was responsible for the overall planning of the plant.

The organic waste is prepared for anaerobic digestion in the 2,000 square meter collection and treatment hall of the new plant. A rotary drum screen separates the coarse extraneous materials. A concrete walking floor and conveyor belts transport the material to the Eisenmann plug-flow digester, where microorganisms anaerobically digest the organics. Methane and carbon dioxide, the main components of biogas, are released in this process. Finally, SAS converts the biogas generated into electricity and heat in a combined heat and power plant.

Each year, the organic waste recycling plant can generate up to 2.6 million kilowatt hours of climate-friendly electricity. A reciprocating pump conveys the digested substrate to a dewatering plant. The

Operator

Bioabfallverwertungsanlage der Schweriner Abfallentsorgungs- und Straßenreinigungsgesellschaft mbH

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URL: www.sas-schwerin.de

Manufacturer:

EISENMANN Anlagenbau GmbH & Co. KG

Commissioning: 2015

Types of fermentation:

thermophilic,
dry continuous digestion



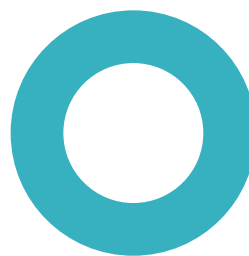
Waste treatment capacity: 18,000 t/a

Installed electrical capacity: 370 kW

plant in Schwerin (Mecklenburg-Vorpommern) is characterized by a gas-carrying press water tank for sand settling. Some of the liquid digestate is recirculated or sent directly to the digestate storage tank, where it is stored until it is spread on fields for use in agriculture. The solid digestion residue is composted in two composters, where it is made into quality compost.

For Schwerin, the operation of this plant is a key contribution to more climate protection. "The climate-friendly city is our declared goal. By 2050 we should have made the state capital carbon neutral."

Feedstock



 **Biowaste from households 100%**

Feedstock preparation: solid (drum screen)

Energetic usage: electricity, heat (in preparation)

Generated products: liquid & solid digestate, compost

Application of the digestate: spreading as fertiliser

Investment volume: 6.5 million EUR

Biomassezentrum Stausebach



Biogas plant Stausebach

Biowaste can be very heterogeneous. Thus, the processing in a dry fermentation plant is only possible for certain substrates or requires additional bulking material if the substrate is very humid. Another challenge are the seasonal peak periods of material streams. Starting from this initial situation the best solution for the biogas project in Stausebach was to create a hybrid-type AD facility. This combination of dry and wet fermentation technology allows the most efficient fermentation method for all kinds of biowaste and its completion with renewable energy crops. Pumpable substrates are processed to the wet reception pit while dry stackable material is passed to the dry AD plant. This high level of flexibility leads to a process- and energy-optimised fermentation system.

The hybrid AD in Stausebach consists of 8 dry fermentation digesters (1,000 m³) and 2 wet fermentation digesters (4,000 m³, post fermenter 5,500 m³). A PASCO dosing station (80 m³) feeds the substrate into the wet fermentation line. The dry fermentation is equipped with a mixing area, a composting box and a composting system. The plant is in operation since August 2014. With the cur-

Manufacturer:

Schmack Biogas GmbH

Commissioning: 2014

Types of fermentation:

thermophilic,
wet digestion,
dry batch digestion



Waste treatment capacity: 35,000 t/a

Installed electrical capacity:

4 MW_{el} Gas

rent installed capacity, it processes 45,000 tonnes of biomass per year: biowaste from households and businesses as well as energy crops from local farmers. The plant produces six million m³ of raw biogas, which provides heat to 2,000 households.

Schmack Biogas provided the turnkey dry and wet fermentation technology for this project. It proved that the combination of dry and wet fermentation is evidently beneficial. The biggest advantages are the wide range of possible input material and the compensation of seasonal peaks.

Feedstock



- Vegetable by-products 10%
- Energy crops 30%
- Biowaste from households 60%

Operator

Biomassezentrum Stausebach

Kesselwiese 11

35274 Kirchhain-Stausebach · Germany

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URL: www.eam.de

Feedstock preparation: liquid (pasteurization) & solid (compost by ASP tunnel and gore cover treatment)

Energetic usage: heat, biomethane

Generated products: liquid digestate, compost

Application of the digestate: spreading as fertiliser

Investment volume: AD only 12 million EUR

TTV dry AD plant, AVA Augsburg GmbH



TTV digester AVA Augsburg

The facility is using three Thöni TTV digesters. The process operates in the thermophilic range, maximising process rate, hygiene and biogas yield in a system that is low-rise and easy to fit into a built-environment.

Incoming biowaste is shredded, followed by separation into fine and coarse fractions. The oversize fraction is delivered to the neighbouring waste incineration plant for combustion (in turn the incinerator provides heat for the AD and compost site).

The feeders dose the digestible material into a pre-mixer where it is blended with press water which is then force-fed into the digesters using hydraulic pumps. The digesters are large static vessels, made as a steel base within an insulated concrete cradle. The internal area of the digester incorporates floor- and cross-heating zones linked to the computer-controlled heating system. This controls the thermophilic process, accelerating bioconversion on the one hand while hygienically treating the biological waste within the digesters on the other.

Operator

TTV dry AD plant, AVA Augsburg GmbH

Am Mittleren Moos 60

86167 Augsburg - Germany

Contact: DI Wolfgang Veszely

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Fax: +49 821 7409-120

E-Mail: wolfgang.veszely@ava-augsburg.de

URL: www.ava-augsburg.de

Manufacturer:

THÖNI INDUSTRIEBETRIEBE
GMBH

Commissioning: 2013/2016

Types of fermentation:

thermophilic,
dry continuous digestion



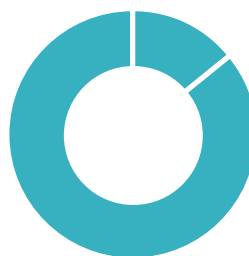
Waste treatment capacity:

75,000 t/a

Gas treatment capacity: 1,000 m³/h

At the end of the digestion process the residue is dewatered by means of Thöni screw presses. Part of the liquids is recirculated in the digestions process and used for inoculation of the fresh input material. The remaining part of the liquids is stored in tanks and used as fertiliser in agriculture. The solid part undergoes a further aerobic composting process in special Thöni composting units. Compost is sold as finished high-quality compost for agriculture and amenity horticulture. The biogas produced by the AD facility is being upgraded to natural gas standard and fed into the gas grid of Stadtwerke Augsburg.

Feedstock



 **Biowaste from households**
Biowaste 86%
Green waste 14%

Feedstock preparation: shredder, separator, mixer

Energetic usage: biomethane

Generated products: liquid & solid digestate, compost

Application of the digestate: spreading as fertiliser

Investment volume: 23 million EUR

BIO ENERGIA TRENTINO SRL



The Kompogas® plant in Faedo implements a presswater-free organic waste treatment technology that respects regional requirements

In light of the regional, geological and topographic features of Trentino-South Tirol, the authorities have prohibited the use of liquid digestate from the fermentation of organic waste as a fertiliser. The above-average organic fraction means this substrate is particularly moist and lacking in structure, but at the same time extremely rich in energy. The Kompogas® fermenter uses this to generate more than 170 Nm³/t fresh mass of biogas. HZI responded to these circumstances with presswater-free organic waste treatment technology based on the energy-efficient Kompogas® continuous dry fermentation process.

Unlike standard methods in this process the digestate (which cannot be stacked) is mixed with shredded green waste and coarsely structured sieved fraction from the composting process. The mixture then undergoes an intense two-week closed tunnel composting process, named IL GIRASOLE® by Cesaro MAC Import. This aerobic treatment substantially increases the dry material content by evaporating water due to self heating of the biological activity.

Operator

BIO ENERGIA TRENTINO SRL

Zona Industriale SS12

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Fax: +41 44 277 13 13 / +39 334 60 68 008

E-Mail: info@hz-inova.com / cesaro@cesaromacimport.com

URL: www.hz-inova.com / www.cesaromacimport.com

Manufacturer:

Hitachi Zosen Inova AG
& CESARO MAC. IMPORT srl

Commissioning: 2012

Types of fermentation:

thermophilic,
dry continuous digestion

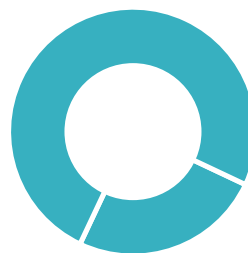
Waste treatment capacity: 44,000 t/a

Installed electrical capacity: 1 MW_{el}



After a further three weeks of stabilisation on windrows, the material has matured into an excellent, top-quality compost. This is then sieved into two categories. The coarse fraction of the compost with particles exceeding a certain diameter is mixed back into the fresh digestate from the digester. By contrast the fine fraction leaving the continuous dry fermentation process is sanitized and stable to be used as a rich source of nutrients and humus. Local producers pick it up from the plant for use on farms and fruit orchards and the steep, sunny slopes of the Trentino and South Tirol.

Feedstock



Biowaste from households
Biowaste 75%
Green waste 25%

Feedstock preparation: solid (shredder and sieve <60mm)

Energetic usage: electricity, heat (in-vessel composting)

Generated products: solid digestate, dried digestate, compost

Application of the digestate: spreading as fertiliser

C.E.A. Consorzio Energie Alternative S.p.A.



Dry fermentation plant Naples

Manufacturer:
BEKON Energy Technologies
GmbH & Co. KG

Commissioning: 2010

Types of fermentation:
mesophilic,
dry batch digestion

Waste treatment capacity: 35,000 t/a

Installed electrical capacity:
1 MW_{el} (500 Nm³/h)



The anaerobic digestion plant of C.E.A. Alternative energy consortium S.p.A. processes exclusively selected organic materials and in particular:

- organic fraction of municipal waste coming from separate collection;
- vegetable waste from agribusiness;
- green-lignocellulosic material from maintenance of public and private areas.

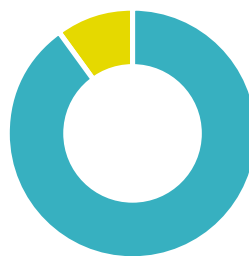
Delivered organic waste is recovered through an integrated anaerobic-aerobic treatment based on the following processes:

- anaerobic digestion (in the absence of oxygen) of organic waste and production of biogas with a high methane concentration (about 55-60%) with a system of modular dry digester (Dry Batch Fermentation);
- aerobic composting (in the presence of oxygen) of the digestate product from the anaerobic digestion phase through a first step oxidation in intensive aeration lanes and a second step of aerobic stabilization.

Obtained at the end of the process are:

- production of electricity and heat by internal combustion engines (cogenerators) fed with the biogas (which has a 55% methane) produced by anaerobic digestion;
- production of mixed composted soil amendment (with characteristics that conform to the provisions of Decree 217 of April 29, 2006) for use in agriculture.

Feedstock



- Vegetable by-products 10%
- Biowaste from households 90%

Operator

C.E.A. Consorzio Energie Alternative S.p.A.

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Caivano (Naples) - Italy

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E-Mail: giovanni.mauriello@cea.na.it

URL: www.cea.na.it

Feedstock preparation: bag opening

Energetic usage: electricity, heat

Generated products: compost, liquid digestate (small amounts)

Application of the digestate: spreading as fertiliser (compost), treatment in a public sewage plant (liquid digestate)

West London AD Facility



West London AD 2.4 MW- the best waste treatment project in the UK in 2014

The biogas plant in West London uses approximately 140 t/day of household food waste and is operated and owned by Agrivert Ltd, English waste management company. Food from supermarkets, restaurants, breweries and dairies is mixed with the household food waste in a closed reception tank in order to contain the odours. The waste is then processed to remove any contamination, such as plastic bags and metals, creating the waste soup ready for digestion. The plant has a retention time of more than 80 days, which guarantees high gas production, stable biology and low odour digestate.

The substrate needs to be treated before digestion to remove potential hazards. This process takes place in the pasteurisers, where the waste soup is heated up to 70°C for one hour using the heat from the gas engines. This stage allows the nutritious end product being used as a valuable fertiliser according to PAS 110 (biofertiliser certification). The surplus heat can be subsequently recovered in a heat exchanger before utilisation in fermentation and digestion phases. Environmentally sound produced energy is enough to

Manufacturer:

bwe Energiesysteme GmbH & Co. KG

Commissioning: 2014

Types of fermentation:

mesophilic,
wet digestion

Waste treatment capacity:

50,000 t/a

Installed electrical capacity:

2.4 MW_{el} (1,000 Nm³/h)



power 4,200 homes. In addition to generation of ultra low carbon energy and nutrient-rich fertilizer, the plant enables diversion of 50,000 tonnes of biodegradable waste from the landfill.

In 2015 West London AD plant received award by ADBA as the “Best merchant waste AD project” in the UK. The panel was impressed by the high average load factor of 95.5%, fast achievement of PAS 110 and short construction time of 6 months. The plant was nominated by its operator and owner Agrivert Ltd.

Feedstock



Biowaste from households 70%



Industrial and commercial wastes
food leftovers from
breweries, dairies, supermarkets
and restaurants 30%

Operator

Agrivert Ltd.

The Stables · Radford · Chipping Norton
Oxfordshire UK · OX7 4EB

Phone: +44 01608 677 700

Fax: +44 01608 677 711

E-Mail: mail@agrivert.co.uk

URL: www.agrivert.co.uk

Feedstock preparation: solid (hammermill and flexible depackaging system)

Energetic usage: electricity, heat (digestion, pasteurization)

Generated products: liquid digestate

Application of the digestate: spreading as fertiliser (PAS 110)

Investment volume: 11 million GBP

Company directory

SYMBOL DESCRIPTION:

Animal by-products



Vegetable by-products



Biowaste from households



Industrial and commercial wastes



Liquid feedstock preparation



Dry feedstock preparation



Wet continuous digestion



Dry continuous digestion



Dry batch digestion



Matrix overview of the company directory

Company										Page
Turnkey system provider										
AAT Abwasser- und Abfalltechnik	X	X	X	X	X	X	X			42
BEKON Energy Technologies	X	X	X	X		X			X	43
BDI - BioEnergy International	X	X	X	X			X			44
BioConstruct	X	X	X	X	X	X	X			45
BTA International			X	X	X		X			46
Greenline	X	X	X	X	X		X	X		46
bwe Energiesysteme	X	X	X	X		X	X			47
EISENMANN Anlagenbau	X	X	X	X		X	X	X		48
GICON Großmann Ingenieur Consult	X	X	X	X	X	X	X	X	X	49
Hitachi Zosen Inova		X	X	X	X	X		X		50
NQ-Anlagentechnik	X	X	X	X	X	X	X			51
PlanET Biogas Group	X	X	X	X	X	X	X			51
Rehau Energy Solutions	X	X	X	X	X		X			52
Schmack Biogas	X	X	X	X	X	X	X		X	53
Thöni Industriebetriebe	X	X	X	X	X	X	X	X		54
Engineering offices										
ARCANUM Energy	X	X	X	X	X	X	X	X	X	55
BioenergieBeratungBornim	X	X	X	X			X			55
EREPA SA	X	X	X	X	X	X	X	X	X	56
Finsterwalder Umwelttechnik	X	X	X	X	X		X			56
L.E.E. s.à r.l.	X	X	X	X			X			57
Schaumann BioEnergy	X	X	X	X						57
Feedstock preparation										
HUBER SE		X	X	X	X					58
Konrad Pumpe	X	X	X	X		X				58
LMEngineering	X	X	X		X	X				59
Tietjen Verfahrenstechnik	X	X	X		X	X				59
Wackerbauer Maschinenbau	X	X	X	X		X				60
Machinery manufacturer										
Werner Doppstadt Umwelttechnik	X	X	X	X	X	X				61
Manufacturer of pumps and mixers										
Franz Eisele u. Söhne			X	X	X					62
NETZSCH Pumpen & Systeme	X	X	X	X	X	X				62
SUMA Rührtechnik	X	X	X	X	X					63



Biogas plant Recycling Energie AG, Switzerland



Biogas plant Stahlbush Island Farm, USA



Reliable solutions for commercial success.

Whatever the motivation in building a biogas plant may be, the first priority is a satisfactory return on investment. The basic principles behind the production of biogas are fairly simple; the technology required, however, is complex. Last-but-not-least biogas production processes also demand a background of highly-specialized knowledge.

AAT is not only well known for its state-of-the-art biogas plants but also for successful operation of these during their entire lifespan. More than 1,000 biogas plants built and operating in more than 30 countries verify AAT's success; the result of 30 years of experience and ongoing in-house research and development by highly motivated staff.

Low operating, service and maintenance costs coupled with high availability are the main design targets for each individual AAT biogas plant, achieved by focusing on the customer's specific demands and input material require-

ments and supported by reliable in-house developed components and hands-on technology together with profound know-how and efficient service. An excellent example of the application of such expertise is to be found in the AAT-designed maintenance-free digester.

AAT's cumulative philosophy offers the customer the assurance of attaining not only benchmark technology but also complete functional reliability and cost-effectiveness resulting in a high return on investment within a short time span.



- ▶ Biogas plants
- ▶ Pulper
- ▶ Hygienisation
- ▶ Agitators
- ▶ Gas Cleaning

Year of foundation **1993**
Number of employees **13**

AAT Abwasser- und Abfalltechnik GmbH

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Dry fermentation plant Iffezheim (DE)



Dry fermentation plant Saerbeck (DE)



tion material. The principle is quite simple: in the absence of air and following inoculation by previously fermented material, the biological waste begins to digest, immediately resulting in the production of biogas. The BEKON process is a single-step fermentation process that employs batch operation. 'Single step', in this sense means that the various degradation reactions (hydrolysis, acidification and methanisation) constitute one process step.

Filling the digesters using batch operation

The organic waste is collected in a tipping building and taken to the garage-shaped fermenter by wheel loader. Inoculation takes place by mixing the fresh material with material that already has been in a fermenter. Once it has been filled, the fermenter is closed off by a hydraulic hatch and the process of organic waste fermentation initiated. Excess cell fluid (percolation liquid) discharged during the fermentation process is collected by a drainage system and returned to the fermenting material in a cycle to keep it moist. Wall and floor heating is used to keep the temperature of the microorganisms constant. In this way, the conditions in the fermenter are maintained at an optimum level for the bacteria used in biogas production.



- ▶ Dry batch digestion
- ▶ Dry fermentation
- ▶ Anaerobic digestion
- ▶ Hygienisation
- ▶ Composting

Year of foundation **1992**
Number of employees **50**

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ENERGY FOR THE FUTURE DRY FERMENTATION

Innovative Solutions for Municipalities, Waste Management Companies and Agribusiness

Company Profile

BEKON was founded in 1992 in Germany and currently employs approximately 50 people. The company is a worldwide technological leader (> 20 reference plants) in the construction of batch biogas plants for generating energy (electricity or biomethane) from waste. The first BEKON system went online in 2003 and has been operating successfully ever since. The BEKON dry fermentation process presently features approx. 30 patents which are constantly being amended as a result of the ongoing findings of research and development.

THE BEKON TECHNOLOGY

Production of biogas by dry fermentation

The superiority of BEKON technology is already apparent from the wide diversity of suitable substrates. Bulk materials with a high dry-substance content can be digested without need for any complex pre-treatment of the fermenta-



BDI's solution Generating green energy from brewery residues



World's first „major green brewery“ in Göss (AT)



BDI - BioEnergy International AG is market and technology leader in the construction of customized BioDiesel plants using the Multi-Feedstock Technology the company has developed itself, which can manufacture BioDiesel from different raw materials, such as Vegetable Oils, Used Cooking Oils and Animal Fats. In the “From Waste to Value” field BDI supplies efficient plant concepts that are designed to produce BioGas from industrial and municipal waste. BDI develops technologies for producing energy from waste and by-products while ensuring maximum preservation of resources at the same time!

From R&D, engineering and construction all the way to after-sales services, we operate as a true one-stop-shop. The progressive BDI technology is specially designed for the production of BioGas from a wide range of industrial and municipal waste products. The many years' experience in the planning and construction of industrial facilities enables, to provide customers with tailor-made plants that fulfil in-

dividual requests. All BioGas plants realised by BDI provide a high level of process safety and feature highest profitability and innovative power.

BDI has specialised in the development of technologies that make optimum use of resources in the industrial processing of by- and waste products ever since it was established in 1996 and owns an extensive patent portfolio that has resulted from its in-house research and development activities. Together with our subsidiary UIC GmbH we also offer plants and components for the gentle distillation of liquid mixtures in both rough and fine vacuum. Our range of services includes public authority, basic and detailed engineering, installation and start-up as well as After-Sales support.



- ▶ Energy concepts/marketing
- ▶ Substrate management
- ▶ BioGas technology
- ▶ Energy conversion
- ▶ Industrial Waste

Year of foundation **1996**

Number of employees **126**

BDI - BioEnergy International AG

Parking 18

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A view on BioConstruct's Headquarter and own operated anaerobic digestion plant



Biogas plant Teesside 5.1 MW based on the fermentation of waste



- ▶ Feeding technology
- ▶ CHPs
- ▶ Unpacking
- ▶ Hygienisation
- ▶ Fermentation technology

Year of foundation **2001**
Number of employees **70**

BioConstruct GmbH

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Since its incorporation, **BioConstruct GmbH** has successfully commissioned more than 250 plants with an installed capacity of more than 130 MW. Our portfolio of realised projects ranges from:

- agricultural plants processing energy crops or co-fermentation plants with liquid or solid manure
- plants with difficult/more complex input materials such as > 90% grass silage, dung, slaughterhouse waste and food waste
- biogas plants with biomethane upgrading and gas-to-grid technology
- high-end industrial biogas plants up to 5.1 MW
- high-efficiency plants with heat usages for industry, local heating distribution companies and greenhouses as well as for electricity providers
- industrial waste fermentation systems

BioConstruct has international experience in the realisation of projects in Italy, France, Czech Republic, the Netherlands, Turkey, Estonia,

Latvia, Greece and the UK. Only materials able to withstand the strain of continuous operation are used in our plants. BioConstruct technology meets the most rigorous standards and is permanently monitored by a fault management system that is continuously improving due to our broad experience in the operation of 20 biogas plants, most of which are majority-owned by BioConstruct. The plants are meticulously planned, exceedingly low-maintenance and furnish the highest yields as a result. For BioConstruct, turnkey plant construction means performing – profitability forecasts, individual plant designing, obtaining necessary approvals, service and maintenance and even operation of the plants.

In a nutshell, BioConstruct's involvement does not end with the handover of a plant. BioConstruct sees itself as a partner, not only during the construction phase but rather throughout the whole lifetime of a biogas plant, and supports clients in matters pertaining to the biological process, technology and financial ways of optimising the plants.



BTA International GmbH is the leading specialist for the wet mechanical pre-treatment and subsequent anaerobic digestion of different kinds of organic residue. The BTA® Process allows to convert the cleaned organic suspension to biogas and quality compost. The high substrate flexibility combined with an above average efficiency and selectivity in the removal of impurities from the organic suspension are unique in the BTA® Hydromechanical pre-treatment. This leads to a high operational safety and minimizes the disposal costs from rejects while maximizing the biogas production



The biogas plant at Zell am See (Austria)

and securing the quality of the digestate. On the basis of 30 years of experience, we offer:

- highly efficient wet pre-treatment systems
- turnkey anaerobic digestion facilities for biowaste, food waste and commercial waste
- co-digestion plants with agricultural residues or sewage sludge
- refurbishment of existing facilities

Since 2007 BTA International GmbH is part of the Agraferm Group with more than 100 reference projects in roughly 20 countries worldwide.



- ▶ Composting
- ▶ Pulper
- ▶ Grit separation
- ▶ Wet pre-treatment
- ▶ Wet digestion

Year of foundation **1984**
Number of employees **30**

BTA International GmbH

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As an independent planning office **Greenline GmbH & Co KG** advises and supports comprising investors, farmers and municipalities. We plan and supervise construction projects holistically in the fields of process engineering fermentation plants, combined heat and power couplings, heating networks and gas supply. Whether it is new construction or re-powering existing plants: our focus is on the design of a tailored, efficient and economical system solution. Here, all factors such as location, substrate, permit situation, infrastructure and economy are taken into account and are interwoven in terms of current technological



Biogas plants in Wolfshagen, Nessa, Lenzen and Vettin

possibilities to a notion of individual concept. We attach much importance to punctuality, cost-effective and quality- assured handling. Let us convince you of our expertise and extensive range of services from technical advice, feasibility studies, direct planning services according, due diligence, project management or general planning. All planning and implementation processes take place independently of any influence by interests of company or product suppliers. The special procedural requirements of the planning task and their economic goals are our main focus in the project implementation.



- ▶ Energy concepts/marketing
- ▶ Hygienisation
- ▶ Pumping technology
- ▶ Heating technology
- ▶ Heat distribution

Year of foundation **2006**
Number of employees **5**

Greenline GmbH & Co KG

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Our plants hold the first three positions among the top 30 food waste AD facilities.



bwe plants have the highest load factor among other food waste AD facilities in the UK in 2014



Wallingford AD Plant 2.4 MW



- ▶ Unpacking
- ▶ Hygienisation
- ▶ Energy concepts/marketing
- ▶ Grit separation
- ▶ Heating technology

Year of foundation **2000**
Number of employees **108**

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bwe Energiesysteme GmbH & Co. KG was founded in 2000 in Friesoythe, Germany. Since then BWE has grown into one of the leading biogas technology providers in the EU.

With more than 360 operating plants, we have gained extensive experience in biogas technology both in Germany and abroad, e.g. Spain, Italy, Czech Republic, the UK, Hungary and Turkey. BWE organic waste treatment plants are characterised by the high level of profitability and efficiency. The plants in Cassington, Wallingford and West London have the highest load factor (>95%) among the top 30 food waste AD facilities in the UK in 2014.

In the last years the company offers wider range of services in energy sector including heating concepts, electrical installations and maintenance of combined heat and power (CHP) units. In order to reflect the expansion of the service package, starting from 2016 BWE is going to be known under the name bwe Energiesysteme GmbH & Co. KG. Our service package includes inter alia:



Heat recovery systems: We design and optimise the heat recovery system to achieve a high annual utilisation level of the biogas plant. Moreover, we develop projects for industrial heat processes and drying systems.

Micro gas network: We offer micro gas network option installing the CHP units close to the consumers. A gas drying unit and compressor system at the biogas plant feed the gas into the micro grid.

Electrical installation and automation: We design the automation and electrical systems in order to guarantee continuous operation. Moreover, retrofitting existing electrical installations, programming and interfaces are also part of our scope.

Biological supervision: We offer biological process supervision including sampling and digestate analysis.

Repair and maintenance: In order to avoid the reduction of the availability of the plant, bwe offers a range of maintenance contracts following health and safety standards.

Emergency service 24/7: Should you have an unexpected situation, you can upgrade your service package to 24/7 assistance and personal contact number.

Project management and planning: Before starting the construction, our development team tailors the concept to your needs and if necessary leaves the possibility for future expansion of the facility.

Repowering, expansion and retrofitting: We are also happy to take over an existing biogas plant and maximise its production, retrofit it or repower its capacity.

EISENMANN



Eisenmann is a leading global industrial solutions provider for surface finishing, material flow automation, environmental engineering and thermal process technology. The company develops and builds custom manufacturing, assembly and logistics plants that are highly flexible, energy- and resource-efficient. The family-run enterprise is headquartered in southern Germany and has been advising customers across the globe for around 65 years. Today, Eisenmann has a workforce of approximately 3,600 worldwide, with subsidiaries in Europe, the Americas and the BRIC countries. In 2014, Eisenmann generated annual revenues of 753 million euros.

Eisenmann is your specialist partner for the planning, design and construction of turnkey biogas and biowaste fermentation plants as well as for the inspection, maintenance and service of the plants. We offer horizontal plug-flow digesters, which are especially designed for processing waste materials from agriculture and biowaste. The digester with its robust, slowly and continuously turning agitator shaft can be adjusted to very high dry substance fractions. This means that the addition of fluids for dilution purposes is not necessary in almost all applications. Minimization of the digester volume and of fermentation waste accumulation serves to increase efficiency and cost effectiveness.

Eisenmann plants can be found in a wide variety of applications. The range of products/services extends from the complete planning of new plants and extensions of existing composting plants to the extension of existing fermentation plants. Eisenmann also offers a wide variety of combination options with the use of steel or concrete digesters in accordance with specific requirements. The plants can process a wide range of substrate and waste volumes

starting from annual throughputs as low as 5,000 metric tons.

The Eisenmann process has significant advantages in comparison to other processes with respect to the climate balance. Yet another reason to go beyond simply composting by also using your waste to generate renewable energy. Our strengths at a glance:

- experience: Eisenmann has now completed more than 90 such facilities
- short delivery and construction times due to pre-assembled components
- main digester capacities from 270 m³ to 1,500 m³
- plug-flow process to manage high dry substance fractions of up to 32% with high, constant gas yield and maximum process stability
- agitator system suppresses floating layers
- modular extensibility
- main digester efficiently heated with wall-mounted heating jackets
- compact design



Dry Fermentation Plant Kelsag Liesberg, Switzerland



Dry Fermentation Plant Labio Oy, Finland



- ▶ Dry fermentation
- ▶ Biogas
- ▶ System provider
- ▶ Plug flow digester
- ▶ Turnkey provider

Year of foundation **1951**
Number of employees **3,600**

EISENMANN Anlagenbau GmbH & Co. KG

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Wet fermentation system in Les Herbiers, France



Wet fermentation system for agricultural residues in Hertník, Slovakia

GICON®



- ▶ Biogas technology
- ▶ Energy concepts
- ▶ Owner's engineer
- ▶ Waste management concept
- ▶ Optimization of biogas process

Year of foundation **1994**
Number of employees **170**

GICON Großmann Ingenieur Consult GmbH
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Whether you intend to process organic waste or renewable raw materials, high-solids or liquid feedstocks, municipal waste or food waste – **GICON** provides optimal biogas technology in conjunction with appropriate feedstock pre-treatment.

GICON was founded in 1994. The company develops, designs and executes biogas plants as a general contractor or technology provider. Clients will therefore be assisted during the entire project lifecycle, from initial feasibility studies to commissioning and optimization of the plant. The range of services of GICON includes:

- market analysis for biogas technologies
- concept and project development
- engineering services for all design phases
- implementation of test fermentations in our large-scale R&D facility in Cottbus for investment preparation
- construction supervision
- delivery of complete process units, single components or complete plant delivery and erection (turnkey)

- operational optimization and engineering support for existing biogas plants
- commissioning
- research towards the development and optimization of bioenergy processes

GICON can also fall back on decades of experience and comprehensive know-how for construction and operation of wet fermentation plants for wastes and energy crops. From design and permitting to turn key delivery of plants, GICON offers all services from one source. Through process adaptation, the requirements of the plant and the feedstock to be treated can be best addressed.

Hitachi Zosen INOVA



Further Kompogas® presswater-free plants are in operation in Germany and the Netherlands



The fine fraction is sanitized and stable to be used as a rich source of nutrients and humus



We are a global leader in energy from waste (EfW), acting as an engineering, procurement and construction (EPC) contractor delivering complete turnkey plants and system solutions for energy recovery from waste. Our solutions are based on efficient and environmentally sound technology, are thoroughly tested, can be flexibly adapted to user requirements, and cover the entire plant life cycle.

The company's customers range from experienced waste management companies, municipalities to up-and-coming partners in new markets worldwide. HZI's innovative and reliable thermal and biological waste treatment solutions have been part of some 600 reference projects delivered since 1933.

In 2014 HZI acquired the patented Kompogas® technology which is based on continuous dry fermentation of organic waste using a horizontal plug-flow digester. The process is both thermophilic and anaerobic. It ensures that the organic waste is fully converted to biogas and that the digestate is sanitized with regards to

undesired spores, germs and micro-organisms. Together with its own gas upgrading technology BioMethan, HZI offers integrated solutions for biological state-of-the-art waste treatment.

With their profound operational expertise and long-term maintenance experience the company's after sale services cover the whole lifespan of today's thermal and biological EfW plants.



- ▶ Composting
- ▶ Waste treatment
- ▶ Dry AD
- ▶ Dewatering
- ▶ Gas upgrading

Year of foundation **1933**
Number of employees **450**

Hitachi Zosen Inova AG
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- ▶ Feeding technology
- ▶ Service
- ▶ Biogas plants
- ▶ Heating technology
- ▶ Planning

Year of foundation **2003**
Number of employees **100**

NQ-Anlagentechnik GmbH
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NQ-Waste digestion plant (1 MW_{el}) with an input of 24,000 t per year

NQ-Anlagentechnik GmbH is one of the leading companies in the biogas sector in southern Germany. On two locations in Bavaria we provide professional staff qualified for all concerning biogas plants, components and service.

We plan and build biogas plants successfully and customer-focused, both for commercial and agricultural sector. Our portfolio shows the wide versatility of our products, for biogas plants processing wastes or agricultural products from 30 kW up to 2 MW. With our own production line, we



guarantee high quality and field-tested products, just as we are able to create individual solutions for every concern. Our services include approval planning, consulting, biological and IT services, project management, engineering, implementing, down to turn-key plants.

A comprehensive service hotline available 24/7 all through the year round out our profile. By now about 480 biogas plants are running and they show the great experience the company achieved over the last 20 years.



- ▶ Feeding technology
- ▶ Plant manufacturing
- ▶ Energy concepts/marketing
- ▶ Hygienisation
- ▶ Gas upgrading

Year of foundation **1998**
Number of employees **230**

PlanET Biogas Group GmbH
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Long-time proven biowaste processing AD plants from PlanET Biogas Group

PlanET Biogas Group GmbH is one of the leading AD manufacturers worldwide. Our portfolio covers the whole range of biogas technology and utilization incl. biowaste feeding and pasteurization technology, bio-methane upgrading or heat and electricity utilization technology, as well as digestate separation and drying. Several successfully operating waste-to-energy plants in the United Kingdom, Canada, France, Germany, and the Netherlands prove the reliability of our concepts. These plants are using slaughterhouse waste, fish process-



ing residuals, carcasses, expired groceries or vegetable waste, all in an effort to reduce CO₂ emissions, to produce electricity and to supply heat to end-consumers.

We understand ourselves as long-term partners for our customers; therefore we provide all after-sale services from one single source. This includes biological assistance, service and maintenance for all technical equipment incl. CHP unit, as well as technical support and repowering technologies for all AD plants.



BEA Süddleder - TanERGY®



BVA Hochfranken - WastERGY®



Rehau Energy Solutions GmbH is a joint venture between REHAU AG+Co and OAG mbH and exists since 2009. REHAU AG develops and manufactures innovative, polymer-based products and systems for either construction or automotive industries on all continents. OAG is an engineering office dealing with planning, designing, construction, supervision of various projects with a main focus on biogas plants and waste water treatment plants.

Thus, Rehau Energy Solutions combines the resources and structures of a large company with worldwide activities with the expertise of a specialized engineering office.

Rehau Energy Solutions has been concentrating on turn-key projects of biogas plants, CHP units and district heating systems basing on renewable energy resources and energy-efficient cogeneration of heat and power.

Our focus is on planning and designing of innovative biogas plants aimed at waste digestion. Only the wet digestion allows to utilize nearly

the full biogas production capacity, resulting in maximum biogas yield, impurity separation and compost quality.

Therefore, Rehau Energy Solutions has chosen this technology, has eliminated its shortcomings and maximized its advantages.

The results are the WastERGY® and the TanERGY® process, successfully in operation since 2012. WastERGY® has been developed to process municipal, commercial und industrial organic waste, loose and packed, solid and liquid, very effectively into biogas and highly pure compost. The compost complies with the very German compost regulations, both with the existing ones and with the even more demanding already drafted.

The special TanERGY® process has been designed to turn the highly polluted waste from tanneries into biogas - turning tanneries into energy self-sufficient entities and reducing their waste disposal (and the related cost) drastically.



- ▶ Food industry waste
- ▶ Organic waste
- ▶ Compost production
- ▶ Municipal solid waste

Year of foundation **2009**
Number of employees **10**

Rehau Energy Solutions GmbH

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Digester gate with substrate barrier



Wet AD plant Tongeren (process waste & energy crops)

Schmack

VIESSMANN Group



- ▶ Biological service
- ▶ Feeding technology
- ▶ Planning & construction
- ▶ Technological service
- ▶ Gas upgrading

Year of foundation **1995**
Number of employees **370**

Schmack Biogas GmbH

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Full-Range Supplier of Highly Efficient and Economical Biogas Plants

Schmack Biogas GmbH, Schwandorf, is one of Germany's leading providers of biogas plants. Since 1995, the company has been setting standards for highly efficient and economic biogas plants. The range of products includes plant systems in the output range of 50 kW for compact plants to a 20 MW gas feed-in plant. Over 450 plants have been installed in 18 countries worldwide. Since January 2010, Schmack Biogas has been part of the Viessmann Group.

Innovative Technologies and Processes

The range of products and services covers the entire biogas value creation chain: from project development and engineering to raw materials management and plant management. Besides technical support, the focus is on comprehensive micro-biological services. An in-house R & D laboratory serves to identify and increase efficiency potentials in the area of process biology.

Specialists in Wet and Dry Fermentation

With system solutions for wet and dry fermentation, Schmack Biogas covers the entire spectrum of fermentation technologies. By using high-quality components of its own manufacture, especially in the priority areas of agitator and dosing technology, the company offers process and energy optimized system solutions. Schmack Biogas GmbH is also active in international markets and with subsidiaries in Italy, the USA and the UK the company has established a broad international presence.



THÖNI Industriebetriebe GmbH is an Austrian based provider of biogas plants for treating organic waste and agricultural by-products. With track record of more than 25 years, Thöni provides highly-efficient plant solutions offering an excellent price-performance ratio. These systems are planned and designed by Thöni's own engineering division, the key plant components are manufactured by the in-house metalworking facility. To date, THÖNI currently has more than 90 biogas plants in operation in Austria, Italy, Germany, Great-Britain and Bulgaria.

Put waste in, draw energy out – Thöni AD dry digestion TTV

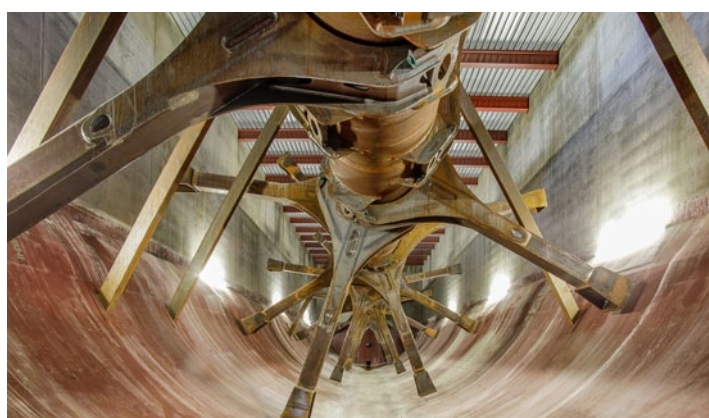
Waste has enormous potential. Thöni Environmental Energy Engineering uses it to produce clean energy and valuable resources. Thöni TTV is a dry digestion process that is especially well suited for organic waste because it has a higher insensibility against impurities than other processes. The heart of the Thöni TTV process is the plug-flow digester equipped with a slow rotating paddle agitator ensuring the optimum mixing of the substrate and thus a high biogas yield. The Thöni paddle stirrer ensures highly efficient stirring as well as optimum prevention of swim layers and sediments. The dewatering of the digestion residues is effected by Thöni screw presses which are particularly characterised by low energy consumption and durability.

Turnkey systems for the agricultural sector – Thöni NATURGAS

Thöni NATURGAS technology is based on the wet digester which is continuously filled with liquid and solid input material via a special feed hopper system. The patented Thöni paddle agitator creates the conditions for stirring input mixtures with high content of dry matter so efficiently that no floating layers arise and ensuring at the same time high gas yields.



Headquarter Thöni in Telfs



TTV paddle stirrer

Outstanding features of Thöni biogas plants

Robust system technology and the operational reliable design of critical components ensure maximum availability. Thöni delivers turnkey, ultra-efficient plants offering an excellent and trend-setting price-performance ratio:

- high system and input flexibility, robust and durable plant technology
- operational efficiency, low operating costs and maximum availability
- high biogas yields due to efficient stirring technology

The company has its headquarters in the town of Telfs in the western Austrian province of Tyrol and has further facilities in Landeck, also in Tyrol, and in Kempten in the southern German region of Allgäu and in Rovereto, Italy. Besides Environmental Energy Engineering, the Thöni Group is also active in the following business divisions: aluminum extrusion, automotive components, plant engineering, hose production and machining



- ▶ Feeding technology
- ▶ Composting
- ▶ Dry digestion technology
- ▶ Pressing
- ▶ Wet digestion technology

Year of foundation **1964**

Number of employees **500**

Thöni Industriebetriebe GmbH

Obermarkt 48

6410 Telfs · Austria

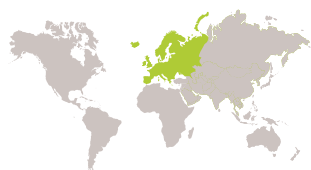
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- ▶ Biomethane production
- ▶ Energy concepts/marketing
- ▶ Fermentation technologies
- ▶ Heating technology
- ▶ Gas upgrading

Year of foundation **2001**

Number of employees **40**

ARCANUM Energy

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ARCANUM Energy is leading as an engineering, consulting and project developing company in the biogas and biomethane field

ARCANUM Energy is one of the leading engineering, consulting and project developing companies specialized on all subjects in biogas and biomethane production. Besides its engineering services ARCANUM Energy acts as an international trader of biomethane by using its own certified mass balancing system "BiMAS". Highly specialized support can be provided for:

- evaluation of local/regional potential of waste and residual materials
- planning and calculation of profitability for biogas- and biogas upgrading plants
- choosing the best suitable technology



- independent quality assurance and control during the planning, construction and implementing phase of waste based projects
- safety protection
- approval procedures for plants/gas grid connection and feed in
- initiation and realisation of investment and corporate financing projects
- maintenance and operational management of plants
- europe-wide marketing of biomethane
- balancing and online trading platform, portfolio management



- ▶ Energy concepts/marketing
- ▶ Pumping technology
- ▶ Digester technology
- ▶ Mixing technology
- ▶ Hydrolysis

Year of foundation **2003**

Number of employees **4**

BioenergieBeratungBornim GmbH

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Phone: +49 331 60 1498-12

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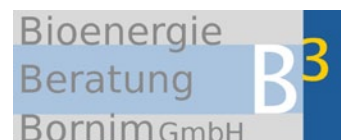
URL: www.b3-bornim.de



Since 2005 **BioenergieBeratungBornim GmbH** collaborates with companies and institutions in Vietnam, India, Cuba, South Africa, Madagascar, Kenya, Egypt, Indonesia, Philippines, Thailand, Brazil.

We provide the technical design, the basic design for the local deliveries and the following items for anaerobic digestion of wastes and other renewable resources:

- Engineering totally with
 - construction supervision and
 - starting of operation of our deliveries
- Basic design for the local deliveries
- complete stirring technology



- complete electrical technique
- complete piping and instrumental technique
- complete pump technique
- complete separation technique
- desulfurization of gas engineering
- feeding technique

In addition we offer teaching and instruction of personnel to operate and maintain the biogas plant. This may include the introduction of a laboratory and the teaching and instruction of personnel to observe and understand the biology and chemistry of the biogas plant in operation.



Traitement et valorisation
de déchets et
d'effluents organiques



Planning - design - optimisation: Take the advice of an independent biogas specialist

EREP SA is a design and consultancy office specialized in biowaste treatment and one of Switzerland's pioneering firms in the field of biogas engineering, founded in 1980. As a service provider, EREP SA is completely independent of any system supplier or manufacturer. Our company offers a wide range of engineering services from conceptual design and feasibility



Construction of the industrial biogas plant in Lavigny, Switzerland

ity studies through ongoing support during the planning, authorization, building and operation phases of a biogas project. During its 35 years of experience in the biogas sector, EREP SA has managed hundreds of projects involving biowaste from food industry, municipalities, agriculture, and wastewater treatment plants. Our large network of (inter)national partners and the day to day collaboration with universities and industry, ensures the implementation of the latest biogas knowledge available in our projects.



- ▶ Feasibility studies
- ▶ Planning and design
- ▶ Consultancy
- ▶ Project management assistance

Year of foundation **1980**
Number of employees **5**

EREP SA

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Finsterwalder Umwelttechnik GmbH & Co. KG (FITEC) is specialized in designing of wet AD plants. We have developed highly specialized components to cope with all kind of contraries that are unavoidably collected with the organic waste.

Based on over 15 years own operational experience, these components and the process are continuously optimized. The portfolio of FITEC machine technology includes technologies for pre-treatment of organic waste (separation press Biosqueeze BS200) and equipment to



Wet fermentation system operated by the "Fitec"-process of the Finsterwalder Umwelttechnik GmbH & Co. KG, Rothmühle AD Schweinfurt Germany

continuous clean digesters from sediments and from floating material. (FITEC floor scraper with sediment trap and FITEC skimmer). FITEC AD plants can process any kind of organic waste, like restaurant waste, overdated supermarket waste or green bin waste from private households. The process technology is extremely robust and long-lasting. For over 15 years we have been dealing with organic waste. Numerous reference projects verify the high efficiency of the FITEC-process and our components.



- ▶ Sink-float separation
- ▶ Hygienisation
- ▶ Pumping technology
- ▶ Grit separation
- ▶ Pressing

Year of foundation **1997**
Number of employees **11**

Finsterwalder Umwelttechnik GmbH & Co. KG

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E-Mail: info@fitec.com
URL: www.fitec.com



- ▶ Energy concepts/marketing
- ▶ Biogas plants
- ▶ Waste-to-value concepts
- ▶ Energy system design
- ▶ Integration of renewable energies

Year of foundation **2000**
Number of employees **12**

L.E.E. s.à r.l.

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6131 Junglinster · Luxemburg
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Phone: +352 2678 34-1
Fax: +352 2678 34-44
E-Mail: info@lee.lu
URL: www.lee.lu



Design of forward-looking Bio-energy concepts

L.E.E. s.à r.l. is a service-oriented company with core competences in the field of biogas and bioenergy ("waste to energy" processes). L.E.E. develops integrated technical concepts that combine in an efficient manner different biomass technologies to maximize the valorization of waste or biomass for the generation of renewable energies in the form of heat, cold and electricity, biomethane and organic fertilizers. Thus creating regional added-value and contributing to the mitigation of the environ-



mental impacts. L.E.E.'s high-quality services cover all aspects: advisory, feasibility studies, individual planning, preparation of approval applications, detailed engineering, construction and operation of the plant. L.E.E. has proven national and international references in all relevant sectors (agricultural, public and industrial), ranging from small decentralized farm-scale biogas plants up to sophisticated large scale plants with district heating or biogas upgrading.



- ▶ Process consultancy
- ▶ Additives
- ▶ Lab Services

Year of foundation **2007**
Number of employees **30**

Schaumann BioEnergy GmbH

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URL: www.schaumann-bioenergy.eu



Continuous biogas fermenters – from basic research in batch fermenters and trials in continuous fermenters through to field studies in parallel working commercial fermenters, the ISF Schaumann Research has created outstanding facilities for resolving complex issues relating to biogas production

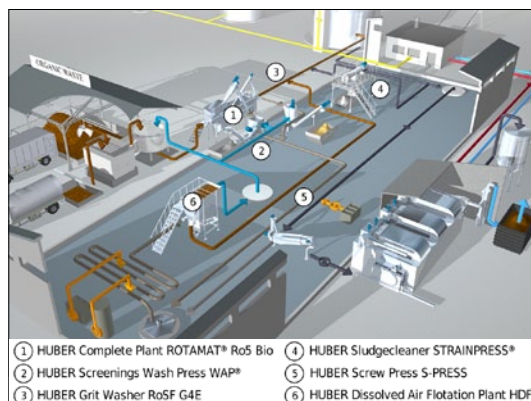
Schaumann BioEnergy – Competence in Biogas

Schaumann BioEnergy GmbH offers know-how and tailor-made additives for the increasing biogas market. Schaumann BioEnergy is the leading company concerning the optimisation of anaerobic digestion facilities and conservation of organic substrates. Next to the profound process consultancy and accredited lab services, Schaumann BioEnergy offers tailor-made additives to increase efficiency of AD processes. The portfolio of Schaumann BioEnergy



comprises trace elements mixtures, several specific additives to reduce inhibition effects, enzymes and bacterial products for conservation purposes.

With the high degree of experience Schaumann BioEnergy also supports investors during the realisation of their projects through neutral/independent project evaluation, opinion letters, market studies and training courses.



1 HUBER Complete Plant ROTAMAT® RoS Bio 4 HUBER Sludgecleaner STRAINPRESS®
2 HUBER Screenings Wash Press WAP® 5 HUBER Screw Press S-PRESS
3 HUBER Grit Washer RoSF G4E 6 HUBER Dissolved Air Flotation Plant HDF

HUBER Solutions for Organic Waste Processing. For wet anaerobic treatment (fermentation with biogas generation) good mechanical pre-treatment of the supplied bio-waste is essential for the reliability and performance of the entire treatment plant. Most important is not only the choice of effective and efficient processes, but also their implementation with most robust and dependable machines; both are also important for the quality of the generated products. We have developed solutions and products for processing organic waste and for further treatment of residues for their disposal or reuse:

- coarse material separation: Separation and treatment by screening, washing, dewatering and compaction
- mineral treatment: Removal and processing by washing and dewatering
- fermentation residue treatment: Post-treatment for reuse by screening, dewatering, compaction and eventually drying
- process/wastewater treatment: Wastewater treatment and process water recycling with a dissolved air flotation plant



- ▶ Sieving
- ▶ Grit separation
- ▶ Pressing
- ▶ Digestate treatment
- ▶ Scum removal

Year of foundation **1872**
Number of employees **1,100**

HUBER SE

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Fax: +49 8462 201-239
E-Mail: Martin.Feicht@Huber.de
URL: www.huber.de



BIG-Mix 80 m³ incl. Walkingfloor

Konrad Pumpe GmbH has over 15 years of experience in designing and developing storing, processing, and dosing equipment for biomass. More than 3,000 screw feeders and solid matter dosing units supplied provide proof of our performance capabilities. Rapid delivery of all spare parts is guaranteed because customer service is provided 7 days a week. Our solid dosing units of stainless steel are especially developed for difficult substrate materials such as 100% grass silage, solid manure, green and food waste. Our intelligent process control and

continued design and development reduce the energy consumption and system wear and tear. Capacity volumes from 8 – 210 m³ are available to suit your plant.

Direct feed to digesters or downstream equipment such as crushing and liquid feeding systems are provided by our screw technology. Flexibility, future modernization and repowering are our specialties. On site advice is gladly given.



- ▶ Feeding technology
- ▶ Solid treatment system

Year of foundation **1830**
Number of employees **50**

Konrad Pumpe GmbH

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48324 Sendenhorst · Germany
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E-Mail: info@pumpegbmh.de
URL: www.pumpegbmh.de



- ▶ Feeding technology
- ▶ Maceration
- ▶ Fertiliser technology
- ▶ Hydrolysis
- ▶ Conveyor belts

Year of foundation **2007**
Number of employees **5**

LMEngineering GmbH

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08543 Pöhl - Germany
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E-Mail: info@lmengineering.de
URL: www.lmengineering.de



Extruder

LMEngineering GmbH is known by technologies like „Bioextrusion by Lehmann“. The disintegration technique is especially suitable for the fermentation of all materials that contain cellulose and hemicellulose.

The material is decomposed up into the cell structure, the aim is the disintegration of the fermentable organic biomass is at 100%. We offer the following processes and components:

- biogas before compost
- 3A-Technique



- small plants for solid manure on the basis of containers
- separation and extraction of solid digestates for the substantial and energetic use

We accompany your projects for the complete process beginning with the planning up to the realization.

Plants in many countries prove our expertise in bioenergy. Cooperation with research institutions at home and abroad ensure the technological lead.



- ▶ Feeding technology
- ▶ Unpacking
- ▶ Separation technology
- ▶ Biowaste recycling
- ▶ Grinding

Year of foundation **1959**
Number of employees **40**

Tietjen Verfahrenstechnik GmbH

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URL: www.tietjen-original.com



Effective separation of organic and inorganic waste

We **Tietjen Verfahrenstechnik GmbH**, develop, design and manufacture disintegration systems for different biomasses in our factory in Schleswig-Holstein, Germany.

This includes advice and project support as well as machine and plant engineering. Complex biomass disintegration systems are our specialty. Our expertise includes not just the crushing technology but also the necessary infeed and conveyor systems, including dust extraction and dust explosion protection as well as biogas substrate disintegration and



separation of materials, each with the necessary pumps and separators. We know that every customer has different requirements and objectives. Hence we try to understand the requirements of our customers first. Project management is supported at all levels with a quality management system certified according to DIN ISO 9001. Our staff is the key factor for our success.

We only do what we can do very well. The focus is on customers who appreciate us as professionals to realise their ideas.



WACKERBAUER – INNOVATIVE TECHNOLOGY FOR THE PROCESSING OF BIO-WASTE

Innovations for Machines

“Innovation means for us to find new concepts on our way to achieve quite special aims and to make changes and developments with fresh ideas.”

Meanwhile, our third generation family business, which was established in 1938, is working with qualified and experienced personnel in quite different fields of production.

With our range of products and services, we offer professional advice followed by the design planning and the construction of high-quality products and plants, which meet the individual requirements of our customers.

Separation Mill TM 75 – A Story of Success

- Developed in 2009; since then, more than 55 worldwide installations
- Honoured with the Bavarian State Award 2013

Separation Mill TM 75 to Mill and Separate Sorted Bio-waste and Packaging for Further Treatment in Digestion Plants.

Operational Efficiency

- Throughput capacity: approx. 25 m³/h
- On general, the throughput capacity depends on the dry substance content, the specific weight, the size and the percentage of extraneous material, and on the (adjustable) addition of liquids.
- Depending on the bulk density of the material and the selected screen perforation, the throughput will be 10 -20 to/h.

Operation

The Separation Mill is based on a specifically developed principle which unifies different processes in one machine (mechanical unpacking, milling of the bio-waste to substrate,

separation and washing out of the extraneous materials, mechanical transport of heavy extraneous materials to the discharge chute and air separation of light fractions). The unpacked bio-waste, which was freed from the extraneous materials, is milled with hammers and screens and flows into substrate containers from which it can be pumped off directly. The extraneous materials (glass, metals, plastic material, etc.) are ejected through the discharge chute.

Which materials are suited?

- **Municipal organic waste, household organic waste:**
Kitchen waste, food residues, fruits and vegetables, bread, packaged milk products, juices, meat scraps, fats, oils, grass clippings, green waste etc.
- **Expired food, market waste:**
Old fruits and vegetables, bread, packaged milk products, juices, meat products etc.
- **Organic waste from the food production:**
Fruit pulp, distilling dregs, residues of the food production and/or off-specification batches, etc



Separation Mill



Biowaste treatment plant with 25m³ Bunker



- ▶ Shredding
- ▶ Feeding technology
- ▶ Unpacking
- ▶ Sieving
- ▶ Grit separation

Year of foundation **1938**

Number of employees **25**

Wackerbauer Maschinenbau GmbH

Wernher-von-Braun-Str. 7

84539 Ampfing · Germany

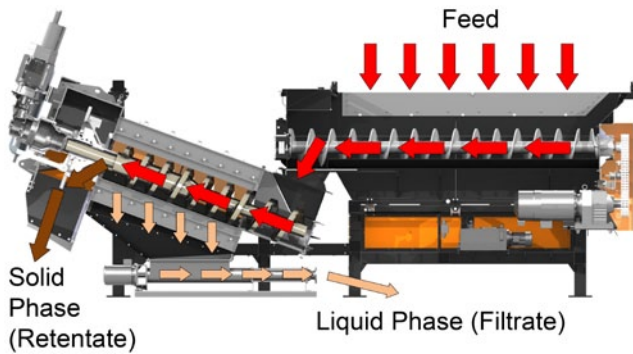
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URL: www.wackerbauer.net



Cross Section of Doppstadt Screw Press with Feeding Hopper



Doppstadt Screw Press with Feeding Hopper



Feeding Hopper with counter-conveying mixing screws



The pressing screw (outer diameter of 500mm) is surrounded by a screening basket and transports the material towards the co-rotating pressing cone. The pressing side of the screw flight is covered by highly wear-resistant cast steel elements, which can be changed by bolt connections, while the pressing screw stays in place.

The screening basket is composed of four separate parts in order to facilitate a possible basket change. Furthermore, it permits to combine different mesh sizes in longitudinal direction.

The pressing cone rotates with the pressing screw and can be shifted in axial direction by means of hydraulic cylinders. This way the pressing cone regulates the width of the circumferential annular gap through which the retentate is extruded and thus sets the process pressure. The rotation of the cone decreases the friction of the material during ejection and prevents blockages.

In case material jams, the pressing screw reverses automatically and releases large solid bodies by completely retracting the pressing cone and opening of the annular gap. This way, solid bodies with diameter of up to 80mm in the input material can be processed without failure.

Thanks to this innovative and contaminant-resistant system an optimum pressure can be set for a large range of input materials thus achieving the required degree of dewatering. Plastic parts and plastic films are transported through the machine without any risk of wrapping or jamming and are discharged as part of the retentate.



- ▶ Shredding
- ▶ Sieving
- ▶ Mixing
- ▶ Washing
- ▶ Pressing

Year of foundation **1965**
Number of employees **600**

**Werner Doppstadt Umwelttechnik
GmbH & Co. KG**

Steinbrink 13
42555 Velbert · Germany
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URL: www.doppstadt.com

The Doppstadt Group – well known for its grinders, shredders, screens, etc. – offers a range of innovative solutions for solid-liquid separation as well. The Doppstadt Screw Press DSP 205 is designed for disintegration and separation of packaged biowaste and food waste prior to biogas production.

During processing via DSP 205 the bio-available organic fraction of the input material is concentrated in the liquid phase (filtrate). According to the application the solids (retentate) can be composted or directly used as RDF. The throughput depends mainly on the input material, the feeding, and further factors. It averages between 8 and 12t/h with a maximum of up to 20t/h.

The machine consists of a feeding hopper with two counter-conveying mixing screws. Packaging is opened in the area between the mixing screws by shear stress. This way unnecessary reduction of the packaging material into too small pieces is avoided. Therefore, the filtrate extracted during the following solid-liquid-separation is particularly clean of plastic flakes.



Franz Eisele u. Söhne GmbH u. Co.KG

Founded in 1887 the family-owned company Franz Eisele u. Söhne has specialized in the development and manufacture of machinery and equipment for efficient manure management (storage, conveying, homogenizing, spreading and transport of liquid manure) and for alternative solutions such as components for biogas plants. All machines are available in a wide variety of sizes and capacities to meet the special requirement of small and large agricultural business as well as sewage treatment plants.



EISELE-submersible mixer GTWSI-Ex 204 with service cover and lift attachment



► Pumping technology

Year of foundation **1887**
Number of employees **90**

Franz Eisele u. Söhne GmbH u. Co.KG

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NETZSCH



NEMO® B-Max® enters the biomass in the digester

NETZSCH Pumpen & Systeme GmbH has manufactured positive displacement pumps worldwide for more than 60 years. Applications in the fields of environment and energy can be covered with different pump systems. NETZSCH rotary lobe and progressing cavity pumps, also in combination with our grinders and macerators, always ensure the right solution for your process. The NEMO® B.Max® sets new standards with maximum bio-strate mixing and feeding. It is a perfectly coordinated piece of feed technology for biogas applications.

With a production of over 50,000 pumps per year NETZSCH underlines the technology and market leadership, which it has gained thanks to the quality of the pumps and spare parts. It is guaranteed by the core competence and vertical manufacturing which we have built up over the many decades. NETZSCH has been supplying worldwide NEMO® progressing cavity pumps, TORNADO® rotary lobe pumps, NOTOS multi screw pumps, macerators/grinders, dosing technology and equipment for custom built and challenging solutions for every application.



► Shredding ► Maceration ► Pumping technology

Year of foundation **1952**
Number of employees **2,000**

NETZSCH Pumpen & Systeme GmbH

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URL: www.pumps.netzsch.com



- ▶ Hygienisation
- ▶ Fertiliser technology
- ▶ Gas upgrading

Year of foundation **1957**
Number of employees **70**

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URL: www.suma.de



Submersible agitator Optimix 2G



Stirring needs to be effective, efficient and sustainable. We prepare solutions for complex challenges by using our innovation and know-how. We develop, manufacture and optimize our products only for the benefits of our customers.

Throughout we are working on further developments and improved processes with our own engineering department. Our propellers are accurate tested in our own test basin for efficiency, effectiveness and performance.

Our recent design for agitating biogas substrates, Giantmix FR SP, contains all know-how we gained the last 20 years making agitators for biogas plants. I.e. the design allows changing directions up to 30° in all directions and can be installed up to 8 m below substrate level. Our Optimix 2G is our submersible motor for the best stirring outcome. With small current consumption, high thrust and a great circulation rate it is the most valuable submersible motor you can use for your own proper mixing.

Save the date!

- » Current lectures from the industry for the industry
- » Exclusive Workshops for members
- » Main Topics: security, efficiency, legal requirements for biogas plants, use of digestate as fertiliser, biomass production, repowering and future projects
- » Biogas worldwide: case studies, best practice, regulations and market drivers from all corners of the world



BIOGAS Convention

Worldwide the biggest meeting of the biogas industry

November – every even year
at Hanover
together with the Trade Fair:



December – every uneven year
at Nuremberg
BIOGAS Convention & Trade Fair:



Joint plenary session with panel discussion



Presentations in German or English
or with simultaneous translation



Current information:
www.biogas-convention.com

Organisations

Fachverband Biogas e.V.

The German Biogas Association unites operators, manufacturers and planners of biogas plants, representatives from science and research and all those interested in the industry. Since its establishment in 1992, the association, which has more than 4,900 members, has become the most powerful organisation in the field of biogas worldwide. The Association works closely with various international organisations and provides knowledge by seasoned biogas experts. This is gained by the experiences of about 9,000 biogas plants in operation in Germany over several decades.

The Association has excellent expertise and knowledge in nearly all aspects of biogas, biogas plants and biogas plant operation and is involved in almost all official German bodies where standards or regulations for biogas plants are discussed and defined. One example is its contribution within an ISO (International Organization for Standardization) working group to define terms, definitions and classifications of biogas systems.

Year of foundation **1992** | Number of employees **43**



Fachverband Biogas e.V.

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Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH is a global service provider in the field of international cooperation for sustainable development. GIZ has over 50 years of experience in a wide variety of areas, including economic development and employment, energy and the environment, and peace and security.

As a public-benefit federal enterprise, GIZ supports the German Government – in particular the Federal Ministry for Economic Cooperation and Development (BMZ) – and public and private sector clients in around 130 countries to achieve their objectives in international cooperation. With this aim, GIZ works together with its partners to develop effective solutions that offer people better prospects and sustainably improve their living conditions.

Year of foundation **2011** | Number of employees **16,400**



Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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European Biogas Association (EBA)

Founded in February 2009, EBA is the leading European association in the field of biogas and biomethane production covering the anaerobic digestion and gasification industries.

Committed to the active promotion of the deployment of sustainable biogas and biomethane production and use throughout Europe, EBA has created a perfect network of established national organisations, scientific institutes and companies.

In 2015, the association counted around 75 members from all over Europe and had established co-operation with biogas associations from outside Europe.

Year of foundation **2009** | Number of employees **6**



European Biogas Association (EBA)

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ISWA – the International Solid Waste Association

The International Solid Waste Association (ISWA) is a global, independent and non-profit making association, working in the public interest and is the only worldwide association promoting sustainable, comprehensive and professional waste management.

ISWA is open to individuals and organisations from the scientific community, public institutions and public and private companies from all over the world working in the field of or interested in waste management. ISWA is the only worldwide waste association that enables its members to network with professionals, companies and institutional representatives.

ISWA's mission is to Promote and Develop Sustainable and Professional Waste Management Worldwide. It achieves this by:

- ▶ promoting resource efficiency through sustainable production and consumption;
- ▶ supporting developing and emerging economies;
- ▶ advancing waste management through education and training;
- ▶ promoting appropriate and best available technologies and practices;
- ▶ promoting professionalism through its qualifications programme

Year of foundation **1970** | Number of employees **11**



ISWA – the International Solid Waste Association

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www.biowaste-to-biogas.com



SYMBOL DESCRIPTION:

Animal by-products	
Vegetable by-products	
Biowaste from households	
Industrial and commercial wastes	
Energy crops	
Liquid feedstock preparation	
Dry feedstock preparation	
Wet continuous digestion	
Dry continuous digestion	
Dry batch digestion	
Fuel	
Heat	
Gas	
Electricity	
Digestate	

The depicted symbols are consistently used throughout the booklet and as a classification system of the different companies in the directory.



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www.biogas.org



www.biowaste-to-biogas.com