BIOGAS - AN IMPORTANT RENEWABLE ENERGY SOURCE

WBA Factsheet

Summary

Biogas is a gas produced through the anaerobic digestion (AD) of various organic materials and consists mainly of methane (CH_4) and carbon dioxide (CO_2). Common feedstocks for biogas production include manure, animal by-products, crop residues, the organic fraction of household and industrial waste, and sewage sludge.

The methane content of biogas has a variety of applications, spanning electricity and heat generation, material use, transportation fuels, and natural gas substitutes in cooking, among others. The global potential of biogas is substantial enough to meet a significant proportion of future gas demand. Estimates suggest that the world could sustainably produce close to 1 trillion m^3 of biogas annually, based on the organic waste already available. This amount could replace around one-quarter of the current global demand for natural gas. Most of this potential, about 80%, lies in emerging and developing countries, with Brazil, China, and India leading the way.

To facilitate the increased production of biogas, each country should develop and implement an integrated biogas concept. This strategy would offer several advantages, including accelerated progress in mitigating climate change by reducing greenhouse gas (GHG) emissions, enhanced national energy security, and the creation of new jobs, particularly in rural areas.

1. Introduction

The transformation of the energy system from fossil to renewable sources is driven primarily by enhanced energy security and climate change mitigation. Biomass must play a pivotal role in this transition to a low-carbon economy. Worldwide, biomass (including putrescible waste and bio-waste) accounts for over two-thirds of all renewable energy supplies. Biogas, in particular, is an interesting option with significant potential to reduce the dependence on natural gas and other fossil fuels. Currently, the biogas production industry is experiencing rapid growth. Although a significant number of biogas plants are already in operation in some countries, there is still huge potential for development worldwide.

A specific advantage of biogas technology is the utilization of organic waste and other organic by-products for energy production[1], as opposed to disposal via landfills, which inevitably leads to further greenhouse gas emissions through methane emissions. Additionally, the by-product of biogas plants, called digestate, can be used as fertilizer on agricultural land, replacing synthetic fertilizer and enhancing crop yields[2].

From an economic viewpoint, national biogas development is effectively stimulated when significant costs are incurred for the disposal of putrescible waste or the emission of greenhouse gases, and when financial incentives for biogas production roughly match previous levels of incentives for natural gas sourcing or reticulation. The latter may be achieved through a carbon tax on fossil fuels, the proceeds of which are used to subsidize biogas production and processing facilities.

The purpose of this WBA factsheet is to provide readers with basic information about biogas as a renewable energy source, including details about the process, feedstock, versatility, worldwide potential, and current global significance, as well as the necessary policy measures for further development.

2. Basics

In this factsheet, the term 'biogas' refers to a gas produced by anaerobic digestion (AD) from various forms of organic matter. Biogas is also produced under anaerobic conditions in nature, for example, in swamps. This anaerobic process is driven by various types of microorganisms. In anaerobic digestion tanks, this usually occurs at temperatures above 35ºC. During this biological process, most of the carbon compounds[3] are converted into methane (CH_4) and carbon dioxide (CO_2). Biogas is saturated with water and contains some minor components (like hydrogen sulfide and ammonia), as well.

The fermentation process also produces digestate, which is the outflow of the biogas system and can be used as fertilizer. Digestate can be used directly on agricultural land or processed into a concentrated fertilizer.

The process itself occurs in airtight biogas digesters in the absence of oxygen. The biogas yield depends on the feedstock and several operational parameters. Digestion times vary from several hours for sugars and alcohol to several weeks for hemicelluloses, fats, and proteins. Typical retention times in the digester are between 20 and 100 days.

These digesters can vary greatly in size. Millions of small digesters (only some m^3 digester volume) are used in connection with family homes or small farms in tropical regions, e.g., several Asian countries, to produce gas for cooking and/or lighting. Medium-sized digesters can be found on farms around the world, mainly producing electricity and heat. Larger digesters are used to digest all kinds of feedstocks, such as animal and vegetable by-products, food industry waste, household organic waste, and energy crops.

A biogas plant on a farm, for example, comprises various components, including a liquid manure store, a receiving area, one or more digesters, gas storage, and, in the case of combined heat and power (CHP) applications, a gas engine combined with a generator, a grid connection for electricity, and a connection to the heat utilization.

The costs typically amount to around 2-2.5 million USD for a 1 MW installation and 5-6 million for a 1 MWe installation including gas engine; the capacity-specific investment cost is higher for smaller plants and lower for larger ones.

After production, the raw biogas can be cleaned and upgraded to separate methane from carbon dioxide, in which case it is called biomethane. In this pure form (methane content above 90% up to above 99%), it can be compressed and injected into gas grids or used as a transport fuel. The energy content of raw biogas varies between 5 and 7 kWh/m^3 depending on its composition. On average, 5.5 kWh/m^3 can be assumed (i.e., assuming a methane content of 55%). The energy content of pure biomethane is nearly 10 kWh/m^3.

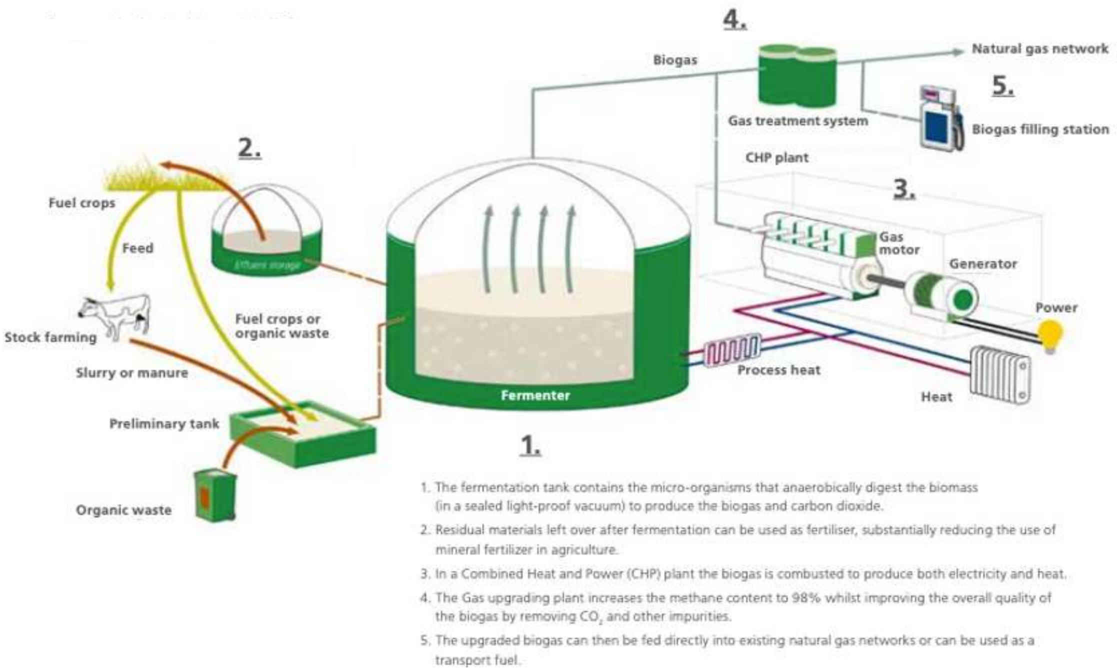

Figure 1. Energy production in a biogas plant

Table 1. Typical chemical composition of biogas

	Biogas	Biomethane (natural gas quality)
Methane (CH_4)	50-70%	> 97%
Carbon dioxide (CO_2)	30-45%	< 3%
Water	saturated	dried
Hydrogen sulphide (H_2S)	some ppm[4] - above 10,000 ppm	< 5 ppm

3. Feedstocks

Almost any organic material, except for material with a high cellulose or lignin content, e.g., wood, can be used to produce biogas. The water content and degradability of the feedstock are particularly important factors. The moisture content can range from a few percent to around 50 percent. As biogas is only produced from the organic fraction of the input material, and water does not contribute to the biogas yield, a high moisture content will result in a low yield.

Woody biomass is not suitable for anaerobic biogas production due to its high lignin content, which shields it from enzymatic degradation. Although a broad variety of materials can be used, even slight changes in the type or quality of feedstock can have a significant impact on the digestion process and final yields of biogas.

3.1. Animal by-products

Manure is probably the most common feedstock in biogas plants because its composition stabilizes the biological process and balances deviations. Residues originating from livestock include pig, sheep, goat, and cattle droppings, as well as poultry droppings. Other examples of animal by-products include slaughterhouse waste, fats, oils, and greases.

Animal by-products usually require sanitization to prevent the presence of pathogenic bacteria. However, manure can be used without sanitization if pathogens can be safely excluded.

3.2. Vegetable by-products

Vegetable by-products are residues resulting from harvesting or from products that are not fit for market or animal fodder (e.g., due to low quality). Common examples are wheat straw, corn residues, rejected potatoes, crop residues, rice husk flour, grass silage, and cactus. Materials from landscape maintenance, such as tree, bush, and grass trimmings, can also be used in biogas plants.

3.3. Industrial and commercial wastes

Organic residues from the production of food, beverages, or feed can be designated as industrial and commercial waste. Examples include residues from fruit processing (e.g. orange pulp, pomace, and potato pulp), the sugar industry (e.g. sugar cane distillery vinasse, sugar cane press cake, and bagasse), the dairy industry (e.g. casein, whey, milk sugar, unskimmed milk and waste milk) and the beverage industry (e.g. spent grain or apple and grape pomace). One advantage of this type of feedstock is its proximity to energy-intensive industrial processes, as a large amount of residue is usually produced and much energy is required to process organic material. Wastes require sanitization to prevent the spread of pathogenic bacteria.

3.4. Biowaste from households

Household biowaste refers to the organic fraction of waste produced at home. Although separating biowaste from households is advantageous because the organic material can be degraded anaerobically to a high-purity product, source separation of waste is not common practice in many countries and is challenging to establish among the population. Moreover, biowaste from hotels or restaurants could also be valuable for separation. Another challenge is that wastes require sanitisation to prevent the spread of pathogenic bacteria.

3.5. Energy crops

In the context of biogas production, energy crops are agricultural plants grown specifically for energy production. Examples of typical energy crops include maize, sweet sorghum, grasses, and sugar beet. The production of energy crops is costly and competes with food production. This is why this feedstock is rarely used in developing countries.

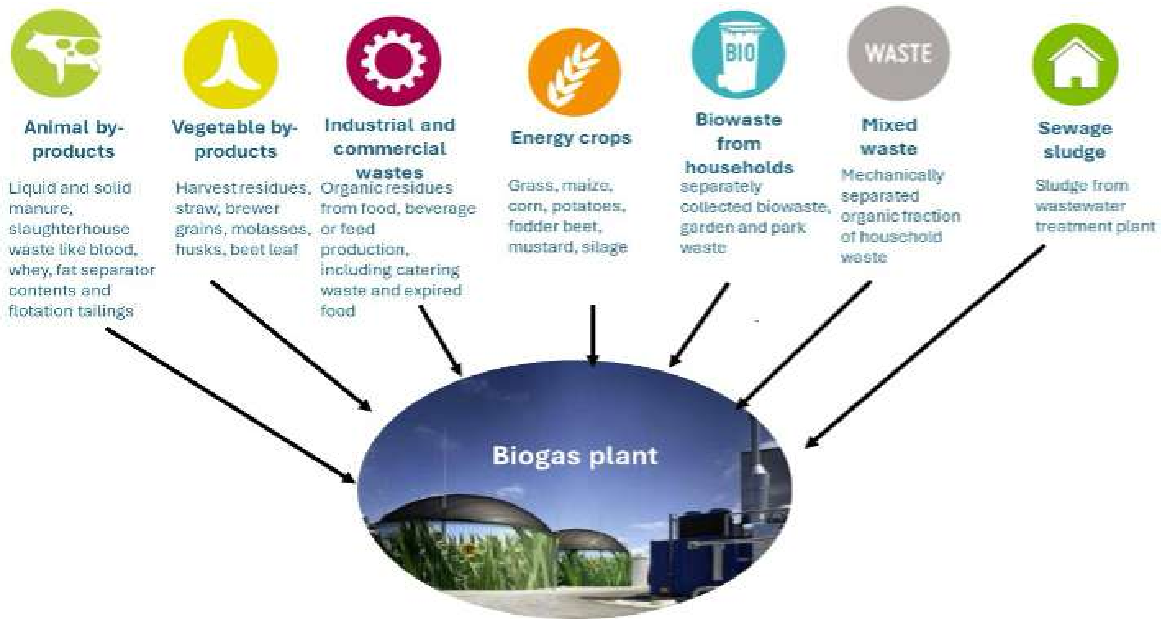

Figure 2. Feedstock used in biogas plants.
Source: German Biogas Association / Fachverband Biogas

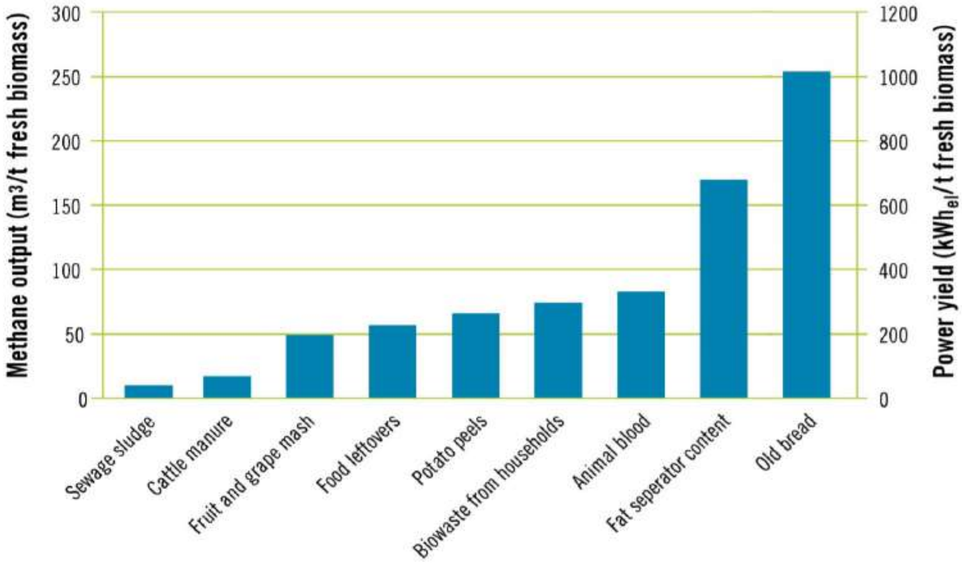

Figure 3. Biogas yields from different feedstocks.
Source: German Biogas Association / Fachverband Biogas

3.6. Sewage sludge

Sewage sludge is a residue left over from wastewater treatment. This can be used as a feedstock for biogas production. This is already common practice in many wastewater treatment plants.

However, due to the possible presence of contaminants such as heavy metals, siloxanes, antibiotics and hormones, using the digestate as fertiliser is not always possible. Sewage sludge typically has a low solids content and low biogas yields. To decrease digester volume, dewatering may be necessary prior to the anaerobic digestion (AD) process.

3.7. Biogas yields

The used feedstock has a wide range of biogas yields. The main components contributing to the biogas yield are carbohydrates, fats, and proteins.

An initial impression of the biogas yield can be gained from the organic dry matter content, which usually varies from a few percent (e.g., manure or sewage sludge) to over 80 percent for concentrated, energy-rich materials (e.g., bread and other materials with low water content). The table below displays typical biogas yields from various waste sources.

4. Use and applications

As stated before, biogas is a multi-purpose renewable energy that can be used for cooking, producing electricity, heating, cooling, or as transport fuel.

4.1. Combined heat and power production

Biogas can be used to fuel gas engines, which are a type of internal combustion engine designed to operate using gaseous fuel. While like engines operated with natural gas, they are adapted to burn biogas, which has a lower heating value due to the CO_2 it contains.
A gas engine can be connected to a generator to convert mechanical energy into electricity. This combination is often called a 'genset' and is used exclusively to produce electricity. In Combined Heat and Power (CHP) systems, both the produced electricity and heat are used.

This heat can be used to heat digesters and for other applications outside the biogas plant, such as heating buildings, providing process heat in industry, and drying processes.

4.2. Upgrading to biomethane

An alternative to the other uses is biogas upgrading to natural gas quality. Upgraded biogas, known as biomethane, can be fed directly into the existing natural gas grid (when there is one available), or be stored in gas reservoirs or compressed in pressure-bottles, or be used as transportation fuel in Compressed Natural Gas (CNG) or Liquefied Natural Gas (LNG) vehicles. 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 92 - 98%.

However, the additional process step of biogas upgrading to grid quality involves investment and operational costs.

After undergoing a cleaning and upgrading process, biogas can be used in the form of biomethane as a renewable substitute for natural gas.

The main process involved in the upgrading of biogas to biomethane quality is the separation of CH_4 and CO_2. There are several upgrading technologies available on the market that have been used and improved for many years. Biogas upgrading methods can be categorised as follows:

- Membrane separation
- Scrubbing technologies (absorption methods)
    - » Water scrubbing
    - » Physical scrubbing
    - » Chemical scrubbing
- Pressure swing adsorption (PSA)
- Cryogenic treatment.

All upgrading technologies aim to achieve high methane purity and low losses with minimal energy consumption. The purity of methane is typically between 92% and 99%. Methane losses should be below 0.5%. The electricity demand for these processes is typically between 0.15 and 0.4 kW per cubic metre of biogas.

Biomethane can be used for all applications where natural gas or LPG is typically used. To store and/or transport the gas, it can be fed into the natural gas grid or filled into pressure tanks.

After the separation of biomethane and CO_2, the latter can be used for many purposes. These include use in greenhouses, cleaning processes, the food and beverage industry, such as brewing, as well as many other purposes. As mentioned above, biogenic CO_2 is a product that is in increasingly high demand from the industry.

There are approximately 2,000 biomethane plants worldwide[5].

4.3. Other uses of Biogas, like heat and material use

Biogas cooker/burner/boiler

Biogas can be used directly in standard household cookers. This is mainly used in domestic installations. It is a simple and cost-effective way of using biogas. Often, a hose is laid directly from the fermenter to a small cooker, e.g., in the kitchen. This type of biogas use is typical in millions of installations worldwide.

There are three types of heating systems: a) atmospheric burners (up to 35 kW) work without blower support, the air is brought to the combustion chamber by means of the suction force of the gas flow, air and biogas mix and are ignited electrically, b) force draft burner (up to 10 MW) use a blower to compress air and blow it together with the biogas into the combustion chamber, which allows a higher combustion efficiency, and c) lance burners with or without pressure atomisation (up to 150 MW) are suitable for short combustion fireplaces.

Material use

Until now, biogas has rarely been used for its molecules, mainly because natural gas was cheaper. However, several projects combine biogas in biorefineries for the production of hydrogen, carbon dioxide, and biofuels. Methane, the smallest carbohydrate molecule, can be converted in refineries into molecules of any desired chain length, which are then used to produce organic materials.
However, digestate is widely used, and sometimes upgraded for use as a material. See Chapter 9.1 for more information.

5. Biogas concept for infrastructure and supply

Different uses of biogas, such as heat generation or upgrading for injection into a gas grid, require different configurations of biogas plant locations and sizes. Initially, when biogas first began to be used for energy production, CHP units were often located in the same place as the biogas production plant. More recently, new concepts have emerged involving the production of biogas in one place and its subsequent transportation to a central CHP plant or an upgrading station located near a gas pipeline for injection into the regional gas grid.

Other concepts include shared biogas or biomethane plants, which are used by many farmers. There is also decentralised biogas production and biogas pipelines to a central biogas upgrading plant. Many more concepts demonstrate the variety of biogas solutions available.

6. Support Policies

The use of biogas often competes with fossil fuels (e.g., natural gas). Those fossil fuels have been heavily subsidized in recent decades, and some structures date back to this period. In addition, many of the costs of environmental pollution are not passed on via the costs of fossil fuels.

This often makes it difficult for biogas to compete with (subsidised) fossil fuels. Industrial biogas production can often only develop rapidly in regions with consistent and effective government support policies. The most important elements of a typically successful support policy are: guaranteed access to the electricity and gas grid, reasonable feed-in tariffs for electricity and biomethane, investment subsidies, training and further education for workers, support measures for the integration of heat utilisation, a kind of carbon tax on fossil fuels, and promotion of methane-powered vehicles.

Like natural gas, biogas or biomethane are high-quality energy sources. It should therefore be used primarily for energy services that require high-quality energy, such as combined heat and power or transport.

Table 2 lists some examples of policy instruments. This table only shows a small selection of policies.

7. The Global Potential

Biogas and biomethane represent a massive and mostly untapped opportunity for clean energy production worldwide. The International Energy Agency (IEA) states that the global sustainable potential of biogas could potentially touch nearly 1 trillion cubic meters of natural gas equivalent per year, meeting about 25% of today's global natural gas demand. Yet only around 5% of this potential is being realized globally[11]. Most countries other than the major biogas producers - China, and Germany- are only beginning to harness their biogas resources. However, significant growth opportunities exist across emerging economies like India, Brazil, and regions of Africa. These countries collectively generate massive amounts of organic waste, representing a vast resource not yet fully exploited for energy generation.

Table 2. Policy instruments accelerating biogas uptake globally

Regions in Focus	Key Policy Actions	Global Effect/ Actions and results
FR, DK, DE, IT[6]	Feed-in-Tariffs/ Premiums	• France offers Fixed, long-term prices (FiTs) or premium payments (FiPs) above market rates for renewable gas supplied to the grid or used for power - up to 109€/MWh, updated annually. • Denmark's mixed premium scheme made biomethane competitive with fossil gas, leading to the world's highest per-capita grid injection
SE, FI, DE[7]	Tax Exemptions and Carbon Highlight	• SE had a full tax exemption (carbon and energy tax) on biomethane from 2011 to 2023, resulting in 95% of its gaseous transport fuels being biomethane. • FI Promotes Biomethane with lower excise duty • DE combines heat tax reductions with incentives for CHP units to support biomethane use.
IN, BR, EU[8]	Blending Mandates	• India's SATAT scheme mandates 5% compressed bio gas (CBG) blending in natural gas to scale biomethane use in transport and energy. • Brazil's 2026 regulatory framework enforces biomethane blending quotas, backed by CGOB certificates and infrastructure plans under its "Fuel of the Future" strategy. • The EU's Fit-for-55 mandates renewable gas integration via binding targets and incentives like FiTs/FIPs, tax reliefs, and grid blending obligations.
EU[9]	Guarantees of Origin and LCA	• EU's cross-border Guarantees of Origin system; the Netherlands' implementation of mandatory biomethane mandates alongside Guarantees of Origin certification enabling better transparent cross-country trade, harmonized sustainability criteria. • Aligned with financial incentives with emissions reduction, allowing biomethane to be credibly counted towards net zero commitments.
CH, USA, FR, DE[10]	Capital & R&D Support	• DE lead Europe with about 10,000 biogas plants supplying energy to ~8 million households, supported by FiTs. • FR has ENGIE partnership aiming to produce 500 GWh/year of biomethane. • Switzerland operates ~632 AD plants, with public funding prioritizing methane leakage reduction and R&D

As of 2020, there are approximately 50 new policies that are implemented across many parts of the world with the intent of supporting biogas development. Countries such as India, China, Brazil, and others have initiated large joint ventures and expansion initiatives targeting greater sector maturity and market penetration. The global biogas market was valued at $65.53 billion in 2024 and is expected to continue to grow at a rate of about 4.2% per year until 2032[12]. Notably, biomethane is gaining traction for injection into existing natural gas grids, with its demand growing at around 15% annually since 2020[13].

8. Biogas Around the World

8.1. Worldwide, Household biogas systems

There are millions of installed household biogas systems, particularly in China, India, Nepal, and other Southeast Asian regions. However, there has also been substantial growth in other tropical regions, e.g., Latin America and Africa. Decades of experience exist with domestic biogas. Essentially, there are three types of installation: Plastic bag or tubular digesters, fixed dome digesters, and floating drum digesters.

The advantage of household biogas systems is that the investment is typically very low, ranging from a few hundred to a few thousand USD. They are also very simple to operate.

The negative aspects are the low amount of energy produced and the danger of methane losses, e.g., due to cracks, holes, or unused biogas.

Europe

Germany: Industrial scale

Biogas plants have been in operation in Germany for decades. Their development was driven by committed farmers (often from the organic farming sector) and, in particular, the introduction of feed-in tariffs for electricity (since 2000). There are currently around 10,000 plants in operation. Most of them produce electricity that is fed into the grid according to energy demand. The background to this is that approximately 60% of the electricity grid in Germany is made up of renewable energies, of which wind and solar energy are fluctuating. Biogas plants are switched off (and store the energy) or switched on as required to balance the demand for electricity with production. The installed electrical capacity is above 6,000 MWe.

Additionally, there are about 270 biomethane plants in operation. Most of these enterprises are injecting biomethane into the gas grid.

Sweden: Focus on the use of biogas for transport

Sweden is home to 225 biogas plants, producing a total of 712 GWh of biogas in 2023. Of these, 71 were biomethane plants, producing 1,542 GWh of biomethane. Most of the biomethane produced in Sweden is used in the transport sector. A long-term production support scheme for biomethane and liquefied biogas (LBG) aims to help produce 10 TWh by 2023. There is also production support for biogas from manure[14].

The United States

The US biogas industry has experienced unprecedented growth, with 2024 being the record-breaking year. The sector brought 125 new projects online, representing a 17% increase compared to 2023, with total investments reaching $3 billion (about 40% increase from the previous year). This growth trajectory positions biogas as one of the fastest-expanding renewable energy sectors in the country[15].

Biogas currently contributes approximately 1.5% of US electricity consumption, generating around 60-70 terawatt-hours (TWhe) annually[16]. While the numbers remain modest, at their full potential, biogas could generate 255 billion kilowatt-hours of renewable electricity annually, enough to power 23.7 million homes, equivalent to nearly all households in Texas and California combined[17].

The Landfill Gas (LFG) Sector dominates biogas production, accounting for 72% of total biogas output despite having fewer facilities than other sectors[18]. These projects capture methane from decomposing organic waste in landfills, preventing atmospheric release while generating renewable energy. The US biogas sector is primarily driven by two key federal policies. The Renewable Fuel Standard (RFS) and California's Low Carbon Fuel Standard (LCFS). These policies have proven highly effective, with 91% of new biogas projects in 2023 designed to produce Renewable Natural Gas (RNG) rather than electricity, demonstrating the strong policy-driven market pull.

China: Leader in household biogas plants

China's biogas sector represents a significant component of the nation's renewable energy portfolio, though it still comprises a relatively modest share of total electricity consumption. As of 2024, biomass power (including biogas) generated 193 TWh of electricity, contributing approximately 2% of China's total electricity output. The installed capacity of biomass power reached 46 million kilowatts (46 GW) by the end of 2024, with the sector adding 1.85 GW of new capacity during the year, representing a 4% year-on-year growth rate[19].

The broader context reveals that China currently produces approximately 15 billion cubic meters of biogas annually, equivalent to 25 million tonnes of coal and representing 11.4% of the country's total natural gas consumption[20]. This substantial production capacity demonstrates biogas's growing role in China's energy security strategy, particularly as the country seeks to reduce its dependence on natural gas imports.

China's comprehensive policy framework for biogas development is anchored in its ambitious carbon neutrality goals and renewable energy mandates. The newly enacted Energy Law 2025, which came into effect on January 1, 2025, establishes long-term renewable energy development goals and requires annual monitoring of non-fossil energy utilization. Under this framework, non-fossil energy sources must account for 25% of total energy consumption by 2030[21].

China possesses abundant feedstock resources for biogas production, with the country generating approximately 3.5 billion tonnes of agricultural, forestry, and household biomass resources annually[22] The feedstock base includes multiple waste streams: agricultural residues (primarily straw), livestock manure, food waste, and industrial wastewater.

The Harbin WABIO facility is the world's largest commercial straw-based biogas plant, with an annual energy output of more than 260 GWh. The facility was commissioned in April 2022, spanning 13 hectares with 30 MW electrical capacity, and processing 58,000 tonnes annually of corn straw and rice straw feedstock. Utilizing proprietary WABIO dry fermentation technology, the plant achieves 0.6 Nm biogas production per kg of corn straw at 65% methane concentration- currently the industry's highest yield- while producing Bio-CNG and preventing approximately 12,000 tonnes of CO_2 equivalent emissions annually.

The Chongming Island facility operated by Renergon International processes 65,000 tonnes annually of mixed organic waste comprising 19,000 tonnes of wheat straw and 46,000 tonnes of liquid pig manure through innovative zero-water concept dry anaerobic digestion technology with 40-meter fermenter boxes, generating 570 kWel and 625 kWth capacity with annual emissions savings of 15,900 tonnes CO_2 equivalent.

The Hefei Xiaomiao Organic Waste Treatment Center spans 67,000 square meters, processing 800 tonnes daily of catering and kitchen waste through anaerobic digestion, featuring two Jenbacher J420 engines with 3 MWe total electrical capacity at 85% efficiency, generating 24 GWh annually while preventing 7,900 tonnes of CO_2 emissions equivalent to 2,950 tonnes of standard coal.

9. The Benefits of Biogas Technology

9.1. Fertiliser / Digestate production

Digestate is a high-quality, sustainable fertilizer, rich in humus and nutrients. All the nutrients and micronutrients contained in the feedstock for the biogas production 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 (N), phosphorus (P), and potassium (K).

9.2. Storable and flexible energy for power grid stabilisation

Biogas can be stored and used flexibly. For example, when there is an increasing amount of electricity from variable sources, such as wind and solar energy, it is important to balance the production and consumption of electricity. Biogas can be stored. In Germany, for example, around 10,000 biogas plants are in operation. Around half of these operate flexibly, i.e., they produce electricity when it is needed and store biogas when there is a high level of electricity in the grid.

The greater the proportion of renewable energy in the electricity grid, the more important energy storage capacity becomes.

9.3. Environmental benefits

Biogas is a renewable energy source. Biogas production can help to reduce greenhouse gas (GHG) emissions in several ways:

- Due to energy generation with biogas plants, fossil energy carriers can be substituted, and CO_2 emissions can be avoided.
- During the storage of organic material (like manure or palm oil mill effluents), methane emissions occur. Methane has a GHG potential that is about a factor 25 times higher compared to carbon dioxide. Due to material treatment in the biogas plant, a closed system, and gas utilization (e.g., in a gas engine or boiler), those methane emissions are avoided as the methane is combusted into carbon dioxide. In summary, biogas offers energy production with negative greenhouse gas emissions due to the avoidance of methane emissions.
- Biogas offers nearly carbon-neutral energy generation since during the growth of plants, carbon dioxide from the atmosphere is stored in the plant in the form of carbon-containing molecules (CO_2 reduction). After combustion, approximately the same amount of carbon dioxide is emitted, which was originally extracted from the atmosphere (sustainable CO_2-neutral process).
- Digestate (the effluent of a biogas plant) is a good-quality fertilizer. Its use helps to substitute synthetic fertilizers. To produce synthetic fertilizers, high amounts of fossil fuels are used. Their CO_2 emissions can be avoided.

However, methane is a very harmful GHG, and leaks from biogas plants must be limited (e.g., by covering the storage of digestate and installing a flare that burns the produced methane during times when the biogas utilization is not in operation).

10. Economic and social benefits

10.1. Increased employment

Biogas plants affect the creation of jobs positively. Several research studies and experience in biogas practice show that with each MWe installed capacity, about 10 full-time jobs are created (some studies calculate figures up to 16.4 full-time employees per MWe).

These figures do not suggest that 10 persons are employed at a biogas plant, but it is the sum of all kinds of (mostly part time) work that has to be done through the biogas supply chain: biogas plant operator (between 1 to 3 full time employees needed), feedstock supply, maintenance, management/administration; planer, engineers; research; governmental bodies dedicated to biogas; and several other kinds of jobs. Furthermore, most of these jobs are created in rural areas, where biogas plants are usually located.

10.2. Sustainable energy resource

Energy independence is a key aspect of energy policy in many countries. One aim of this publication is to raise awareness among biogas stakeholders of the role biogas (and renewable energies in general) can play in this regard, as it is energy produced by its own sources.

Fossil fuels have to be imported from other countries; therefore, economic benefits also stay abroad. Even if renewable energy might be more expensive compared to fossil energy, the money spent on renewable energy circulates within the country, supporting local businesses and employment as well as rural development. This is an argument to convince a government to establish a renewable energy support system rather than letting large amounts of money go abroad for fossil fuels.

10.3. Decentralized energy generation

One of the advantages of biogas technology is that it can be established locally, without the need for long-distance transportation or import of raw materials. Small or medium-sized companies and local authorities can establish biogas plants anywhere (i.e., they need not be sited in any location; for example, in or close to large cities).

One benefit of local production is that: Fossil fuels are often supplied from central locations. Diesel, for instance, is delivered to harbours, but then must be transported hundreds of kilometres into the country to reach its destination. In contrast, biogas can be supplied locally.

10.4. Sustainable waste management

Traditional landfills have many disadvantages. These include the emission of methane and other gases, sanitation issues, and fires. Furthermore, all the nutrients in the waste material are lost.

However, if the organic waste is used in biogas plants, these problems can be avoided. Additional energy is produced, and the nutrients can be recycled in the form of digestate.

10.5. Clean fuel for industry

Methane is in high demand in industry because it is a gas that provides high-quality, precisely controllable combustion. Methane burns with a clean, pure flame, meaning boilers and other equipment do not become clogged with soot and cinders. This creates a cleaner workplace environment and potentially reduces maintenance costs for the plant.

WBA Position

The WBA advocates that biogas production should be an important part of the strategy to reduce GHG emissions and improve energy security everywhere, because biogas production uses feedstock that otherwise is not used at all, but would emit greenhouse gases through decay and cause several environmental issues. Biogas also replaces fossil fuels, reducing emissions of greenhouse gases even further.

The deployment of biogas technology requires a decentralized approach involving many new entrepreneurs. The construction and successful operation of biogas plants need an integrated support policy by the governments comprising the following elements:

- Training and education of the labour force
- Monitoring and continuous improvements in the plant's operation
- Access to the electricity and the gas grid
- Reliable and long term financial support for electricity generated and biomethane produced

WBA strongly encourages every country to set up a biogas development plan. Such a plan should not only contain quantitative targets but also an array of measures and a system of monitoring to reach the targets. This should be valid for countries in the developing world as well as the developed world.

The global institutions such as UN and its affiliates (e.g. World Bank), Green Climate Fund etc. should offere support in terms of knowledge, technology transfer, fianancing mechanims, that support small, medium and large scale applications.

WBA is convinced that such an integrated approach to the development of biogas would enhance the national energy security, generate employment (especially in rural areas), and contribute positively to climate change mitigation.

Acknowlegments

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Disclaimer

The findings, interpretations and conclusions expressed in this document are a result of a collaborative process facilitated and endorsed by the WBA but whose results do not necessarily represent the views of the WBA, nor the entirety of its Members, Partners or other stakeholders.

Endnotes

1. For more information, please see: “Biowaste to Biogas”, https://www.biogas.org/en/media/publications/biogas-know-how
2. For more information, please refer to the following source: "Digestate as fertilizer”, https://www.biogas.org/en/media/publications/biogas-know-how
3. The degradation rate for organic substances is typically between 50% and over 90%, depending on the input material and the technology used.
4. ppm = parts per million
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18. When comparing biogas data in different countries, please bear in mind that in the European Union, the landfilling of untreated, biodegradable municipal waste has been prohibited since 1 June 2005. As a result, landfill gas is becoming increasingly insignificant.
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