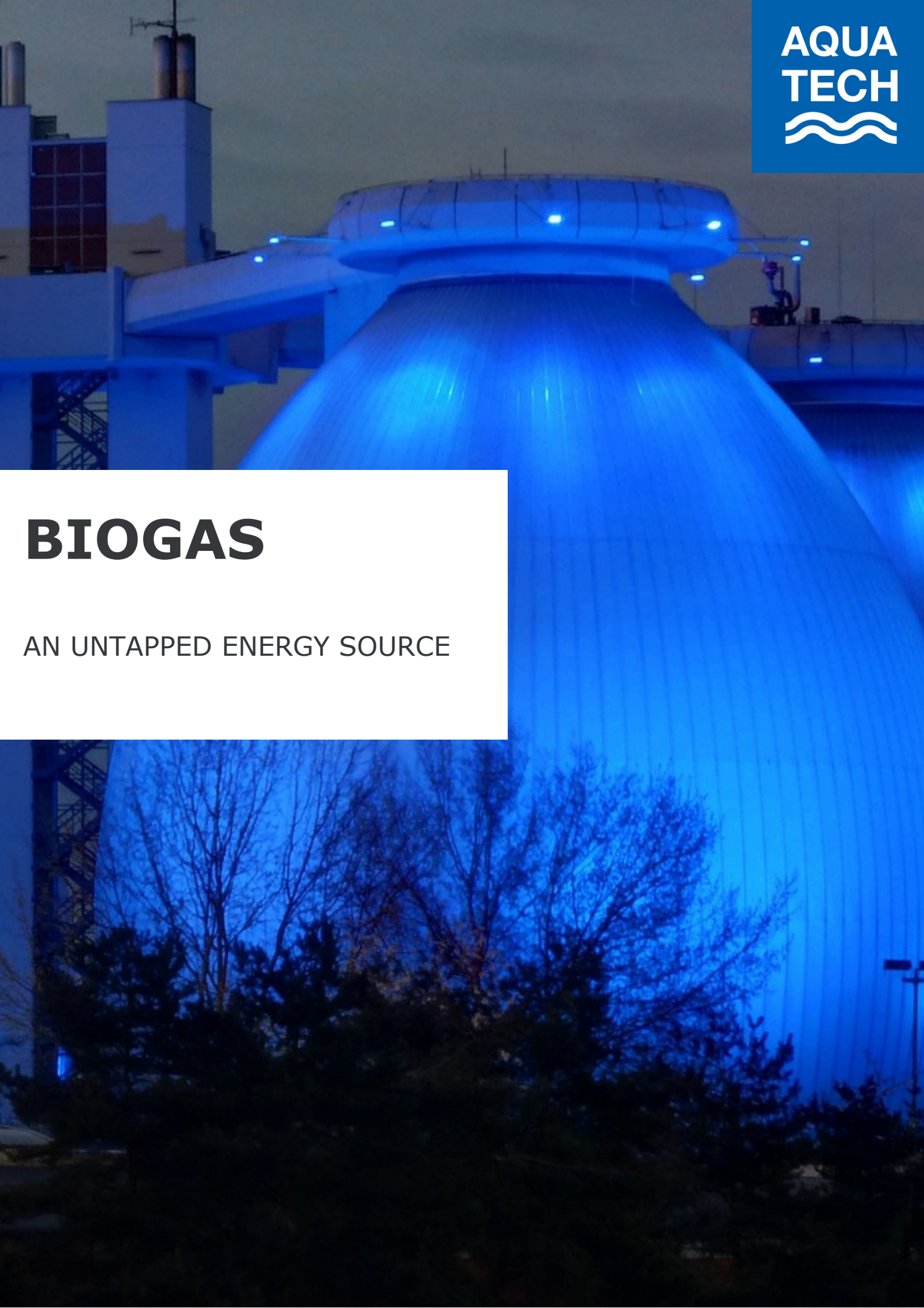


AQUA TECH

BIOGAS

AN UNTAPPED ENERGY SOURCE

How can biogas be further harnessed to be part the renewable energy mix to help with decarbonisation? Aquatech Online explores the topic further as part of the latest 'Essential Guide'.

A two-stage process to remove pharmaceuticals

Biogas, an untapped energy source that has the potential to help the water sector decarbonise and tackle the climate crisis. Continuing to be explored and scaled, biogas is a viable, sustainable and environmentally-friendly alternative way of generating energy to natural gas.

With more and more companies committing to decarbonisation in the next few years, biogas could play a key role in achieving this target. But how revolutionary could it be? How is it produced? How can existing wastewater treatment plants be upgraded into "resource" generating facilities, including biogas?

How is biogas produced?

Biogas is produced through the process of anaerobic digestion, which is a type of decomposition that occurs in the absence of oxygen, according to the National Grid

Biogas can be produced from agricultural waste, food waste, animal manure and more importantly, sewage sludge. Organic matter is then combined with water and transferred into a digester, where it is broken down by microorganisms that release methane and carbon dioxide as by-products.

It can also include small amounts of hydrogen sulphide, siloxanes and moisture. The quantities of these vary depending on the type of waste involved in the production. Microbes play a big role in the production process, feeding on the biomass. This follows a several stage process:

1. Biowaste is crushed into smaller pieces and turned into slurry to prepare it for the anaerobic digestion process
2. Biowaste is heated to around 37°C, as microbes need warm conditions
3. The anaerobic digestion process takes place in large tanks for about three weeks
4. In the final stage, gas is purified by removing impurities and carbon dioxide.

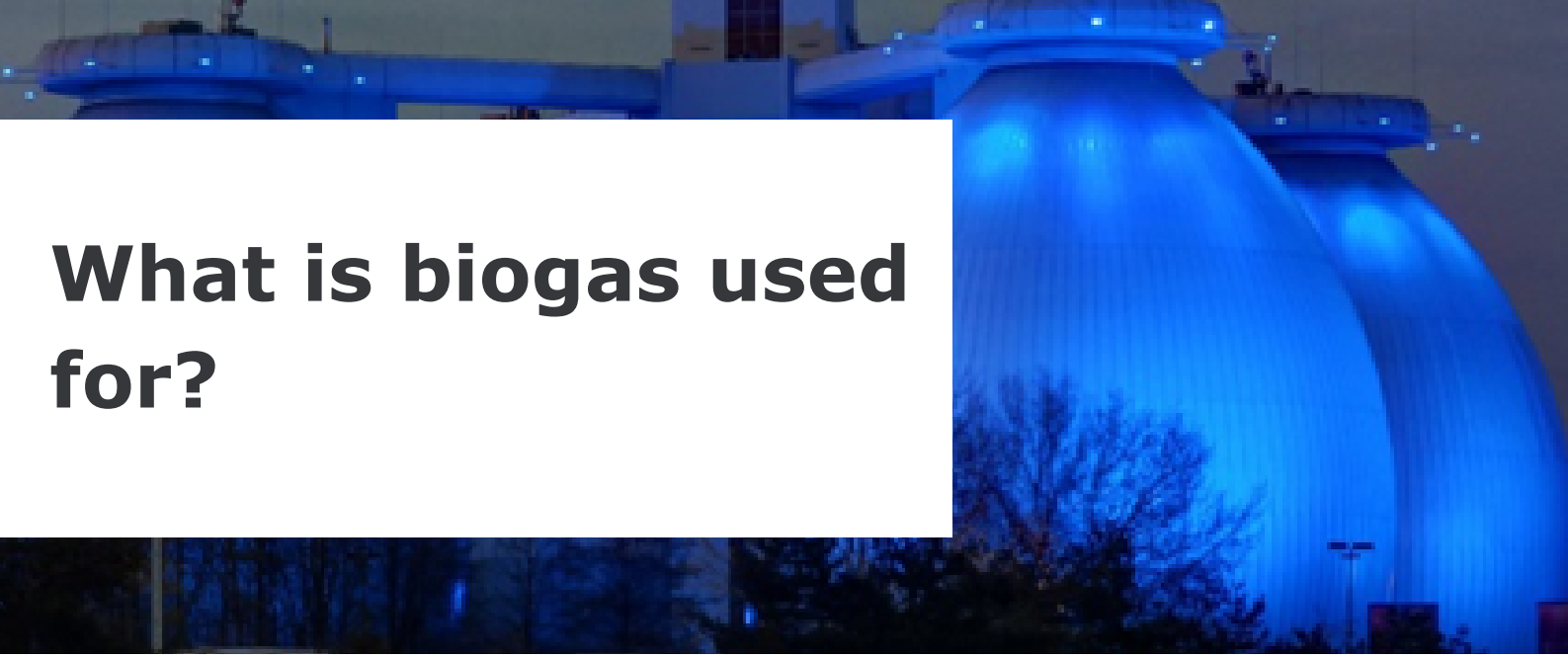
According to the Anaerobic Digestion and Bioresource Association (ADBA), biomethane can directly displace fossil gas, providing a low-carbon fuel for domestic and commercial heat.

Within biogas, methane content typically ranges from 45 per cent to 75 per cent by volume, with the remainder being carbon dioxide, added the International Energy Agency.

As a result, biogas energy content can vary. For example, the lower heating value (LHV) is between 16 megajoules per cubic metre (MJ/m3) and 28 MJ/m3.

Biomethane is a near-pure source of methane produced either by "upgrading" biogas - a process that removes any carbon dioxide and other contaminants present in the biogas through the gasification of solid biomass followed by methanation.

Biogas production reduces the amount of organic matter that would otherwise end up in landfills. It reduces greenhouse gas emissions by capturing methane, a potent greenhouse gas, and using it as a source of energy.



What is biogas used for?

Biogas has many different applications, from generating heat to powering vehicles.
One common use for biogas is as a source of electricity. When burned in a generator, biogas can produce electricity, which can then be distributed to power homes and businesses.

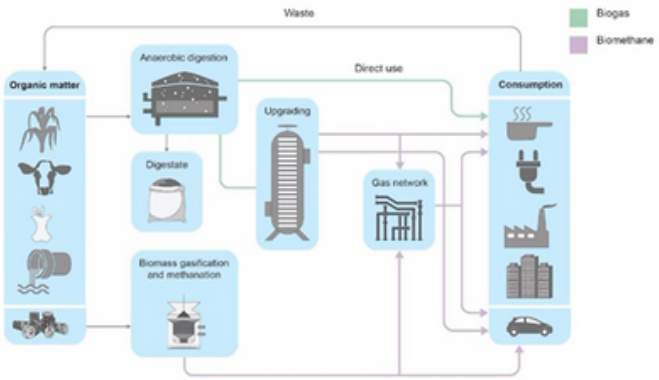
Buses, trucks, and cars, can also be powered by biogas. For example, in 2017, Queensland Urban Utilities revealed the world's first "poo-powered car" which ran off of biogas produced from sewage at the Oxley Creek Sewage Treatment Plant in Brisbane's west.
One of the first biogas plants in the UK came online in 2011, as part of the government's Renewable Heat Incentive scheme. Fast forward five years and in 2016, the UK built 33 new plants, according to the ADBA.

The country's food waste could be a huge resource from which to generate biogas. It's estimated that around 10 million tonnes of food waste is produced annually by UK households, the food service, manufacturing and whole sectors, according to the Waste & Resources Action Programme (WRAP).

A total of 11 terawatt hours (TWh) of biogas could be generated if this amount of organic waste was treated through AD. This would be enough to heat 830,000 homes and cut emissions by 8.8 million tonnes of CO2 equivalent, or 2 per cent of the UK's annual emissions.

In comparison, across 50 US states, there's over 2,200 sites operating that are producing biogas. This includes 1269 water resource recovery facilities using anaerobic digestion (AD); 652 landfill gas projects; 250 farm-based anaerobic digesters and 66 stand-alone systems digesting food waste, according to the American Biogas Council.

Biogas can also be used in industrial processes, for example chemical and plastic production. Its production helps to reduce waste and greenhouse gas emissions, making it an important part of the transition to a more sustainable and environmentally-friendly energy system.



How does biogas production work?

In 2019 there was a total of 132,000 small, medium or large-scale digesters were operating globally, according to the World Biogas Association.

Biogas plants typically have three major components: a reception area, a digester (or fermentation tank) and a gas holder.

There are several different types of digesters that can be used to produce biogas, including continuous flow digesters, batch digesters, and plug flow digesters. The type of digester used will depend on the specific needs of the biogas production facility and the type of organic matter being used.

To maximise the efficiency of the anaerobic digestion process, it is important to maintain the proper temperature and pH levels inside the digester. Microorganisms that produce biogas are sensitive to changes in these conditions, and fluctuations can impact the rate at which biogas is produced.

Once the anaerobic digestion process is complete, the remaining material, called digestate, can be used as a fertilizer for crops. This makes biogas production not only a source of renewable energy but also a way to reduce waste and improve soil health.

According to a report from the Global Biogas Association (GBA), adding anaerobic digestion treatment to centralised wastewater treatment facilities to generate biogas could help reduce global greenhouse gas (GHG) emissions by over 10 per cent.

Furthermore, the generated electricity could meet the needs of almost 40 million people globally.

Biogas vs natural gas

Biogas and natural gas are both sources of energy that can be used for heating, cooking, and generating electricity. However, there are some significant differences between the two.

One of the main differences between biogas and natural gas is the way in which they are produced. As a fossil fuel, natural gas is formed over millions of years from the decomposition of organic matter.

When compared to natural gas obtained by drilling into the earth, biogas is clearly a more sustainable option, said the World Wildlife Fund (WWF).

On the other hand, biogas is produced through the process of anaerobic digestion, which is a type of decomposition that occurs in the absence of oxygen.

Another difference between the two is the composition. Natural gas is primarily composed of methane, while biogas can be composed of a variety of gases, including methane, carbon dioxide, and hydrogen sulphide.

The exact composition of biogas can vary depending on the specific feedstocks used in the anaerobic digestion process.

In terms of environmental impact, biogas is often considered to be a more sustainable energy source compared to natural gas. Additional benefits include removing food waste and animal manure from the environment, in the process preventing nitrogen pollution and runoff into water resources.

Furthermore, biogas also helps to mitigate methane emissions from landfill sites or manure lagoons. By using methane, which is up to 34 times less potent as a greenhouse gas, as a fuel it can help to reduce its climate impact, the WWF said.

However, while biogas is known as renewable natural gas, the definition of "renewable" should be used carefully when discussing waste streams. According to the WWF, it is "renewable" in the sense that animals and humans will continue to produce this waste stream. Simply put: generating more waste to create more biogas shouldn't be encouraged.

However, biogas is a more sustainable solution than traditional natural gas and it can be used to help with the fuel transition to help decarbonize existing energy supplies.

How is biogas formed?

Biogas is formed through the process of anaerobic digestion, which is a type of decomposition that occurs in the absence of oxygen.

This process is carried out by microorganisms, which break down organic matter and convert it into biogas.

A variety of organic matter can be used to produce biogas, according to the IEA:

- Crop remains: maize, wheat, rice and other course grain residues, as well as soybean, sugar beet and other oilseeds.
- Animal waste: From livestock such as cattle, pigs, poultry and sheep
- Organic compounds: Food and green waste such as grass and leaves, wood, paper and cardboard otherwise not used

Wastewater sludge: Semi-solid organic matter recovered in the form of sewage gas from wastewater treatment plants.

To maximise the efficiency of the anaerobic digestion process, it is important to maintain the proper temperature and pH levels inside the digester.

The microorganisms that produce biogas are sensitive to changes in these conditions, and fluctuations can impact the rate at which biogas is produced.

What is biogas plant?

A biogas plant is a facility that converts organic matter, such as animal waste or agricultural waste, into biogas. The facility provides oxygen-free conditions where anaerobic digestion can occur.

In essence, it's an artificial system where you can turn waste into sustainable energy and fertilisers, with positive effects on the environment.

The production of biogas in a plant can be broken down into five steps:

1. Pre-treatment and filling of the digester
2. Fermentation process
3. Production of the biogas
4. Pulling out the residues
5. Removing any impurities.

Energy produced from biogas can be stored or injected into the electricity grid to reduce dependence on fossil-fuel energy, which can in turn help reduce our carbon footprint.

Another advantage of biogas plants is that they eliminate the need for synthetic fertilisers, as they get replaced by digestate.

In terms of regions, Europe is the largest producer of biogas, with Germany being by far the largest market, and home to two-thirds of Europe's biogas plant capacity, said the IEA.

Data from the European Biogas Association (EBA) revealed that Europe beat its record in 2021 with an "exponential deployment of biomethane plants".

Whereas in China, policies have supported the installation of household-scale digesters in rural areas to increase access to energy and clean cooking fuels; these digesters account for around 70 per cent of its installed biogas capacity.

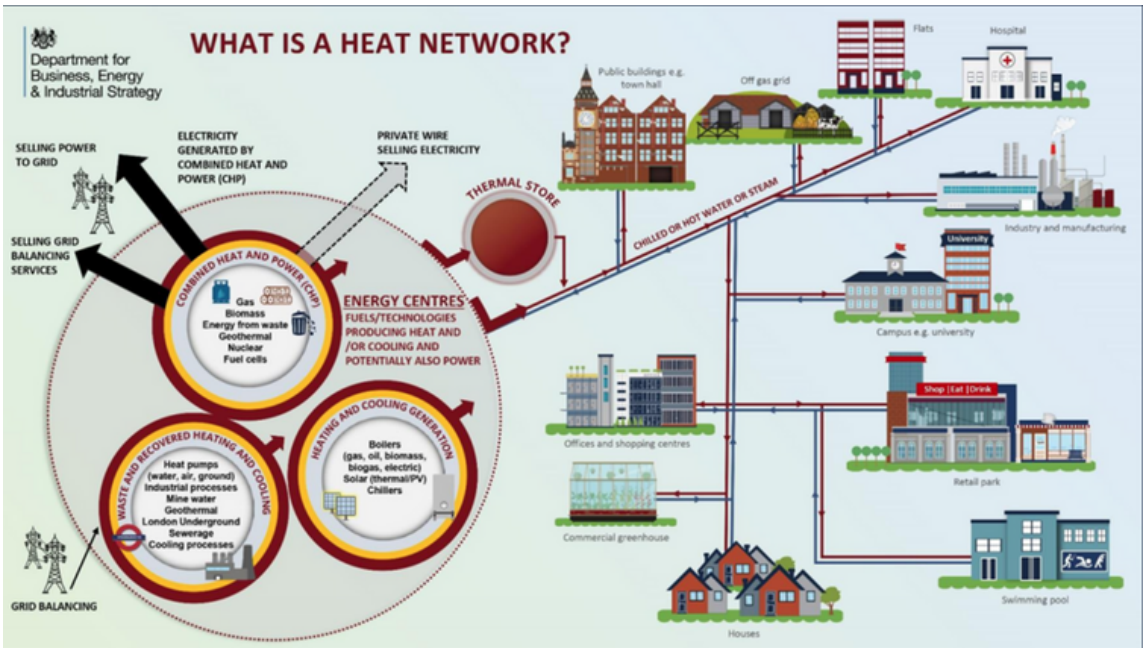
India has laid out plans to develop around 5,000 new compressed biogas plants by 2024, as part of a Global Methane Initiative commitment.

Where is biogas used?

Biogas has five main uses, according to the ADBA.

These include heat generation, transport, electricity, carbon reduction and the development of bioresources.

Heat represents one of the hardest sectors to decarbonise in the UK. The entire energy network has been built to suit fossil fuels, from gas transmission to domestic boilers. As a result, only biomethane can act as a direct substitution for fossil natural gas, according to ADBA.



Currently, biogas is most commonly used as a fuel in combined heat and power (CHP) units.

These units generate renewable electricity and primary heat, which can be exported to the national grid and piped within local heat networks, respectively, added the ADBA.

From a transport perspective, biomethane can be used as a transport fuel and can achieve significant environmental and operating cost savings compared to diesel in HGVs, buses and other vehicles, while also playing an important role in improving air quality in towns and cities.

As one commercial example, John Lewis Partnership recently adopted biomethane by investing in 43 dual-fuel trucks and 12 dedicated gas trucks, as well as a filling station near Leyland. By 2024, the organisation aims to have 700 biomethane trucks.

In terms of decarbonisation, ADBA found that if all suitable UK feedstock was used for anaerobic digestion, the produced biomethane could heat 6.4 million homes, or fuel 97 per cent of the UK's HGVs.

Sources:

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