Use in natural gas vehicles

In comparison to liquid fuels, biogas as a gaseous fuel has a lower energy density (0.036 MJ/l) and therefore requires more space for storage. For natural gas vehicles, it is stored compressed in special pressure tanks at a pressure of 200 bar. With a tankful of gas, the vehicle can cover a distance between 300 - 500 km, depending on the type of vehicle.

On the other hand, there are very positive combustion qualities and a very good energy balance. The emission of pollutants such as nitrous oxides (NOx), particulates and hydrocarbons can be reduced by up to 80% in comparison to petrol and diesel fuels. As a fuel, biogas has the highest energy content and the greatest area efficiency.

Energy crops cultivated on a single hectare can deliver an amount of biogas which would power a natural gas car almost 70,000 kilometres.

An important advantage to the consumer is the favourable price level. Biogas/natural gas is free from mineral oil tax until 2015 in Germany, making the purchase of a natural gas car worthwhile because of the much lower fuel costs compared to petrol and diesel vehicles. Also, commercial gas suppliers have undertaken to expand the existing network of natural gas filling stations.

In particular, new filling pumps are planned to supply motorway traffic in the coming years and these will dispense more and more biogas as a result of the increase in processing and supply to the natural gas pipelines.

In the meantime, the number of natural gas vehicles is also increasing. Sweden has taken a leading role in this respect.

Around the world, about 1 million new natural gas vehicles are registered each year (cars, commercial vehicles, buses and special vehicles).

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What means CNG and LNG?

Because natural gas has a very low energy density at normal atmospheric pressure compared to diesel fuel and has a lower volumetric calorific value than diesel with 34.7 MJ/litre, it is compressed to about 200 bar pressure (CNG = compressed natural gas), or it is liquefied by reducing the temperature to –162 degrees Celsius (LNG = Liquefied Natural Gas), so that sufficient energy can be carried taking up an acceptable space in the vehicle.

Natural gas from the existing network, today an important energy source for households, is compressed and also made available to motorised traffic.

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Bio Fuels in Motion

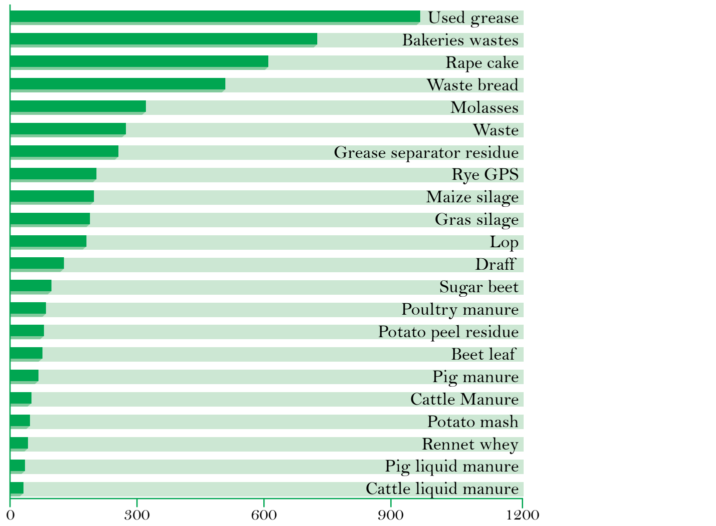
Biogas

Biogas

Biofuels need not always be in a liquid state. This can be seen in the case of biogas, a fuel which offers a further step towards independence from fossil fuels. Processed biogas is completely identical to natural gas with the highest quality level 'H'. Therefore, natural gas vehicles can fill up with biogas without the need for additional modifications. However, compared to natural gas, biogas has the advantage that it is a climate-neutral fuel because it is produced from sustainable energy crops.

Across Europe, there is an increasing number of biogas installations in which specially cultivated energy crops, manure, slurry and other organic byproducts can be fermented to produce electricity, heat and fuels.

Biogas production from various substrates in m³ per tonne fresh mass



Source: FNR; 2008

What is biogas?

Biogas is produced when organic material is fermented in the absence of air (anaerobic conditions), similar to processes in the stomachs of ruminants.

Plants, slurry, byproducts and non-agricultural biogenic wastes (such as food waste or bio-waste) are fed into a fermenter and converted there by microorganisms to a combustible, methanic gas. The residual substrate is a valuable fertiliser which can be spread on the land and so close the biogas cycle.

Normally, the biogas is then fed into a combined heat and power plant in order to produce electricity and heat energy. A fraction of the resulting heat is needed to raise the temperature of the fermenter. Biogas which undergoes suitable processing can be fed into the natural gas pipeline grid or can be used as a fuel for motor vehicles.

Raw materials

The various substrates yield different energy outputs. Energy crops such as maize, whole-plant cereal, sunflower, beet, sorghum and grasses differ with respect to their potential energy yields per hectare. The energy yield is a result of the hectare yield of the particular variety and its methane content (see overview). The higher the energy content, therefore, the lower the area of land needed. Through the inclusion of plant materials which have a low utilisation value (late grassland cuts, growth on municipal land etc.), the land requirement can be reduced further. A precondition for this is, however, the use of technical processes adapted to the particular raw material.

Biogas processing

In the biogas fermenter the substrate is converted to biogas in a multi-stage process in the absence of atmospheric oxygen (anaerobic process).

In the first phase - hydrolysis - the solid substances (fats, proteins, carbohydrates) are broken down by enzymes into water-soluble substances.

In the second phase - acidification - the smaller components are split by bacteria into various organic acids, which are then converted to acetic acid, hydrogen and CO_2 in the third (acetogenic) phase. In the final phase, methanogenic bacteria produce the desired methane through the splitting of acetic acid (or through a reaction of carbon dioxide and hydrogen).

Methods and technology used for biogas production

The selection of the equipment and production method is based mainly on the type of substrate and the amount which will be used.

As a rule, agricultural biogas installations are wet fermentation processes which are operated as through-flow or through-flow and storage units.

In this type of installation, the fermenter is continuously fed with fresh substrate while the same amount of fermentation residue is removed.

In the biogas reactor, the substrate (dry substance content up to a maximum of 20%) is regularly mechanically stirred to ensure a homogenised mix which avoids the formation of settlement or floating layers and facilitates the escape of gases. In through-flow installations, the fermented residues are delivered directly to a final storage unit after the fermentation process. In the case of through-flow with storage the final storage unit has a gas-tight cover and serves as a second-stage fermenter.

In dry fermentation units materials can also be fermented which have a very high dry substance content (above 20%) and may be very difficult to pump.

The fermenter is completely loaded and the substrate remains there until ready for removal (batch procedure).

For most installations the four stages of the biogas process operate parallel in the fermenter both spatially and temporally.

In multi-stage installations, the phases of biogas production are spatially separate.

Biogas processing refers to the treatment of the gas in which biogas is cleaned and processed so that it can then be used directly pumped into a motor vehicle as a pure biogas ('green gas') or can be fed into an existing natural gas network and used as an admixture to compressed natural gas.

Properties

Biogas consists of methane (CH_4), carbon dioxide (CO_2) as well as oxygen, nitrogen and trace gases (including hydrogen sulphide). Methane, the chief combustible component, mainly determines the properties of biogas. A cubic metre of biogas has on average a methane content of about 55% and therefore a calorific value of about 5.5 kWh.

		Biogas	Natural Gas
Gas composition (vol. %)	Methane	50-75	96
	Ethane	-	2
	Carbon dioxide	25-50	0,3
Calorific value (MJ/Nm³)		24.5-27.6	35.8-39.9
Density (kg/Nm³)		1,15	0,73
Flammability limit (vol. % gas in air)		7,7-23	5-15

As a fuel, only the methane proportion is usable.
1 kg methane replaces about 1.4 l of petrol/motor fuel

Source: Fachagentur Nachwachsende Rohstoffe e.V. (FNR), Basisdaten Deutschland, 2009-10