Biomethane from Biogas

Lab Scale | Bench Scale | Pilot Plant | Demonstration | Production

SNG

Biogas/Biomethane/SNG CH_4

Biomethane is a gaseous fuel which consists of mainly methane. Biomethane is normally produced by upgrading (purifying) biogas. Biogas is the raw gas formed by anaerobic digestion of sewage sludge, food waste, manure etc. Before use in vehicles, biogas is always upgraded to bio-methane. Biomethane can also be produced synthetically, e.g. by gasification of biomass followed by methanation; it is then called SNG (Synthetic Natural Gas or Substitute Natural Gas).

Primary area of use

Biomethane can be used as a transport fuel, often as a mixture of biomethane and natural gas with fossil origin. Other areas of use are heat and power production, and as raw material for chemical products. The dominating use of biogas in many countries is for electricity production without prior upgrading to biomethane.

Methane is an ideal fuel for the Otto engine, but it can achieve an even higher energy efficiency if used in an engine that uses the Diesel cycle combustion process. However, the high ignition temperature of methane is a challenge in the Diesel combustion cycle and requires additional ignition assistance, usually in the form of a small pilot injection of diesel fuel. This type of engine is called a dual fuel engine. Although it has the potential of achieving higher efficiencies than the Otto engine, it comes with higher complexity and cost.

There are two ways in which biomethane (or natural gas of fossil origin) can be stored in the vehicle fuel tanks: as compressed natural gas (CNG) at approx. 200 bar and ambient temperature, or as liquefied natural gas (LNG) at approx. 10 bar and -125°C. Today CNG is much more common than LNG. LNG is suitable for heavy trucks that need to carry large amounts of fuel due to their long driving distances. Sometimes, fuel made of 100% biomethane is called compressed biogas (CBG) and liquefied biogas (LBG), but the terms CNG and LNG are generally used irrespective of the biomethane content.

Properties of methane

Chemical formula:	CH_4
Molecular mass:	16.04 g/mol
C (%wt)	74.9
H (%wt)	25.1
Density at 20°C 1,013 bar:	0,668 kg/m³
Boiling point (°C):	-162°C
Lower heating value:	50.01 MJ/kg, 13.9kWh/kg

Biomethane consists of methane, small amounts of carbon dioxide and impurities. It has a slightly lower heating value than pure methane since the energy density is proportional to the methane content. Methane is odourless and colourless and it is a powerful greenhouse gas, 25 times more potent than carbon dioxide based on the global warming potential over 100 years (IPCC 2012).

Feedstock and production

Biogas typically contains 60% methane and 40% carbon dioxide. It is produced through anaerobic digestion of easily degraded biomass (e.g. sugars, fatty acids, proteins). It is a naturally occurring process where microbial communities degrade biomass into hydrogen, carbon dioxide and acetic acid, synthesizing methane from these intermediates. Also, slow anaerobic digestion naturally takes place in landfills containing organic waste and the collected biogas of this type is denoted landfill gas. Several types of biomass can be used to produce biogas: the organic fraction of municipal solid waste and industrial waste, wastewater treatment sludge, agricultural residues, manure and energy crops. Before injection into a natural gas grid and/or use in vehicles, biogas needs to be upgraded to approximately 97% methane and purified from contaminants such as siloxanes and sulfur.

SNG can be produced by thermochemical gasification, achieved by heating biomass to high temperatures (>700°C) without combustion. The intermediate product is a synthesis gas consisting of methane, hydrogen, carbon monoxide and carbon dioxide. Depending on the type of gasification process, the composition of the synthesis gas differs and thus its suitability for methanation (the final process step where methane is formed from hydrogen and carbon monoxide). Alternatively, other fuels than methane can be produced from the synthesis gas, e.g. diesel, methanol or petrol. The raw material for thermochemical gasification is lignocellulosic biomass including energy crops and residues from forestry and agriculture; coal can also be used as raw material, though in that case the result is of course not a biofuel.

SNG can also be produced from carbon dioxide and hydrogen. For a low carbon footprint, the hydrogen is produced by electrolysis using renewable electricity. Carbon dioxide can e.g. be supplied from a conventional biogas upgrading plant. Other hydrocarbon fuels such as diesel, methanol and petrol can be synthesized in a similar way; all such fuels are usually denoted electrofuels.

Current production volumes

The use of biomethane as a vehicle fuel, which is small compared to bioethanol and biodiesel, is concentrated to Europe, more specifically to Sweden, Germany, Switzerland, the Netherlands, and Austria. European statistics for biomethane used as vehicle fuel are difficult to find, probably because the volumes are still very small and the final use is difficult to trace when biomethane is co-distributed with natural gas in a gas grid. According to the Swedish Energy Agency, production volumes for upgraded biogas in Sweden amounted to 1 TWh during 2014, of which almost all was used in the transport sector. This is equivalent to 9% of the biofuel use, and 1.1% of total use of fuels for domestic transport in Sweden. Even though the production of biomethane for use in vehicles is limited in Europe today, there is a large production of raw biogas that potentially could be upgraded to biomethane. The biogas production in Europe amounted to 156 TWh (primary energy) during 2013 (EurObserv'ER 2014).

System of distribution

Biomethane may be distributed from production site to fuel station by road transport either under high pressure (CNG) or in a liquefied state (LNG). Compressed biomethane may also be injected in the natural gas grid which in turn supplies many fuel stations (although that is not common in Sweden).

SNG projects in Europe

GoBiGas (Göteborg Energi) in Gothenburg, Sweden. A demonstration plant producing biomethane by gasification of forest residues with 20 MW SNG output is in operation since 2014.

Audi/ETOGAS plant in Werlte, Germany. The plant uses hydrogen from intermittent wind power and carbon dioxide from biogas upgrading to produce biomethane which is injected into the natural gas grid. The corresponding amount of methane is sold to Audi car owners.