Website address:
https://www.biooekonomie-bw.de/en/articles/dossiers/biogas-a-promising-source-of-renewable-energy

Biogas – a promising source of renewable energy?

In addition to sunlight, water and wind, biogas is a regenerative source of energy that contributes to saving fossil resources. Germany is home to around 7,100 biogas plants, including 796 (as of 2011) in Baden-Württemberg. In 2010, these facilities produced 11 per cent of the electricity generated from renewables in Germany. Energy-rich methane is the major constituent of biogas and is produced when organic compounds are broken down by bacteria in the absence of oxygen. The methane thus produced is used to drive electricity and heat generation plants. However, optimal methane production methods are not yet available. Current research is focusing, amongst other things, on prokaryotes that carry out metabolic processes with quantities of energy that are so small that the organisms are barely able to subsist.

Biogas is an environmentally friendly renewable for the production of electricity and heat.

Biogas is naturally produced by bacteria when they degrade organic compounds. It can be produced in waste recovery processes or from plants. A broad range of different biodegradable materials can be used for the production of biogas, including green waste, meat offal, sewage sludge, liquid and solid manure and energy plants. Biogas contains on average 60 per cent methane, around 35 per cent carbon dioxide and up to 10 per cent water vapour. However, only the methane can be used for energy production. Depending on the source material used to produce biogas, the methane content can differ considerably. The fact that it contains a high percentage of methane makes biogas a very energy-rich fuel.

Over the last few years, 25 bioenergy regions have been created in Germany, including two in Baden-Württemberg. Germany is the market leader in biogas technology. The objective of the bioenergy regions is to produce as much electricity and heat as possible from renewables. Some of these regions are home to so-called bioenergy villages. The 32 bioenergy villages in Baden-Württemberg, which account for more than one third of all bioenergy villages in Germany, get most of their energy from environmentally friendly bioreactors, including solar and wind power. In contrast to biogas, the energy produced by solar and wind power stations depends on the weather and can thus vary considerably. Biogas is available at all times; it can be stored and used to compensate bottlenecks. In addition, biomass plants can be flexibly regulated and adapted to the energy required and the availability of sun and wind energy. After the fermentation of biomass, fermentation residues can be used as fertilizers by farmers.

Bacteria as small helpers

Bacteria in the reactors ferment maize and waste, a process that produces biogas.

The microbial production of biogas has huge unexploited potential. The fermentation process is still associated with the risk that acidification will bring the process to a standstill. Current research and development is directed towards increasing production efficiency. Bacteria provide major assistance in the production of biogas. They can be grown in oxygen-free tanks where they break down organic components into their individual constituents in a multi-step process that leads to the production of acids and gases such as acetic acid, hydrogen, carbon dioxide and finally methane. Bioreactors that are used to produce methane need to be oxygen-free because this is the environment in which metanogens typically thrive. If oxygen is present, bacteria use aerobic metabolic processes, which are more effective than anaerobic processes, but which use up most of the energy. Methane is not then produced. In order to exploit bacteria's ability to produce methane, research is concentrating mainly on metanogens, i.e. methane-producing bacteria, in order to optimize methane production methods.

For example, a research project at the University of Konstanz is looking into the ability of certain prokaryotes to survive in deep sediment layers where there is no oxygen. These anaerobic bacteria need to live on quantities of energy that are barely sufficient to ensure survival and too low to enable them to produce adenosine triphosphate (ATP), which is the universal energy currency. However, anaerobic microorganisms too require ATP for their metabolism, which is why they typically live in

association with other microorganisms with which they share available energy. Research projects at Universität Heidelberg are concentrating on intestinal bacteria of termites that are able to degrade lignocellulose. These bacteria produce around 17 per cent of worldwide methane, accounting for around 100 billion tons. The research projects are specifically focused on the difficulties of breaking down cellulose in biogas reactors. Although microbial communities are able to break down almost all compounds, this is the one remaining problem that needs to be tackled. Over the last two years, bioreactor technology has progressed further, which means that biomass plants can now also use harvest waste and grass, something that has made them considerably more attractive in terms of energy production.

Coupling power and heat production

As the simultaneous production of electricity and heat is the most productive way to use energy, biogas-driven combined block heat and power plants (BHPP) are the most common types of energy production plants in Germany. In contrast to the usual way of producing electricity and heat separately, the heat that is produced by the motors and by the exhaust gases of the BHPPs is transferred through heat exchange (usually with water) and used for heating public swimming pools, houses and greenhouses. Electricity is produced by a generator that is powered by a combustion engine, and can be fed directly into the plant's own or a publicly owned electrical grid.

Optimizing the use of resources

Maize is not only rich in energy, but can also be broken down into methane.

Biogas can do more than just operate specific power stations, it can also be fed directly into the natural gas grid, which is a particularly attractive option when excess energy is being produced. In order for the gas to be produced as fuel gas, for example, it must be upgraded or purified. These processes create more methane per unit volume of gas than without purification. However, it is expected that further progress in effective biogas production technologies will at some time in the future make purification and upgrading unnecessary. Researchers at the University of Hohenheim are currently developing a new biogas production method that has the potential to reduce current costs by around 40 per cent. The method makes use of the pressure resilience of the bacteria, which does away with the rather complex and time-consuming purification steps. The high pressure keeps the biogas clean during the production step, so that it can be fed directly into the natural gas grid.

However, at present, biogas still needs to be purified/upgraded before it can be used as car fuel, be fed in natural gas grids or used for the operation of combined block heat and power plants. Biogas is highly corrosive and quickly embrittles the iron and steel used for many engine components. Water vapour and hydrogen sulphide therefore need to be removed. Biogas quality can be further improved by removing carbon dioxide. All these processes can deliver around 100 per cent methane content of biogas. Different gas grids throughout Germany use different qualities of gas; depending on the purpose for which it is intended, the biogas produced may need to be mixed with air or liquid gas.

Extensive maize fields instead of biological diversity – new law is likely to limit potential damage

Biogas production has numerous advantages as well as a number of negative points. For example, state subsidies have been counterproductive in that they have led to monocultures. The demand for land that is used to grow energy crops, especially maize, has been on the increase. This has in turn led to a huge increase in the cost of renting agricultural land. The increased cultivation of energy crops in the place of food crops is a somewhat controversial issue. The reduced availability of food crops has already led to higher food prices and the increasing importation of organically grown food from abroad generates higher CO_2 emissions due to the long-distance transport of food. Furthermore, monocultures have a negative effect on biological diversity.

In order to counteract the large-scale cultivation of crops for the production of biogas and the problems associated with this, the German government recently amended the Renewable Energy Sources Act (EEG), in which it also gives greater priority to the support of biomass research and use. The new version of EEG, which came into effect in early 2012, stipulates that the use of maize is to be capped, the use of liquid manure will increase and more support will be given to smaller agricultural biogas plants. Although huge efforts have been made, many experts are nevertheless of the opinion that the implementation of the latest version of the EEG has so far failed. They believe that too many errors in the quickly pushed through amendment to the Renewable Energy Sources Act has reduced the attractiveness of biogas. A big problem is the obligation for small agricultural plants to produce at least 60 per cent heat while coal-fired power plants are not subject to the same requirement. The Biogasrat e.V., the German association of leading market players in the biogas economy, is calling for sensible remuneration of biogas production in order to counteract customers' inclination to return to more attractively funded fossil fuels.

Dossier

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