Biomethane Production
– Input Material, Technology and Energetic Utilization –

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1. Introduction

The production of biogas from organic waste material and energy crops has been realized successfully around Europe for many years in numerous biogas plants. The plants treat a broad range of organic waste material as well as energy crops and many different processes are therefore implemented. With the production of biogas many important environmentally relevant goals are pursued, as the production of biogas generates a valuable, storable renewable energy source. The production of renewable energy sources has globally become very important from an environmental point of view in order to use the fossil energy sources which contribute to a great degree to the reduction of the greenhouse effect. Also, fossil energy sources are only available for a limited time period and therefore alternative, renewable energy sources must be produced in the future.

Biogas plants also treat large-scale organic municipal waste, organic agricultural waste and organic industrial waste. Thus, an important and necessary eco-political goal is reached: the re-structuring of the waste landfilling – which unfortunately is still very much practiced – into waste recycling and energy production from waste. With the controlled recycling of organic waste in biogas plants, the emission of climate damaging gases such as carbon dioxide and methane on landfills as well as from heavily contaminated seepage water from landfills can be reduced considerably.

Biogas is utilized energetically at numerous decentral locations in co-generation units. The electricity which is produced is fed into the power grid and is financially remunerated according to the country-specific legal framework. Additionally to electricity, the co-generation units also produce considerable heat. However, biogas plants only require very low specific heat so the main part of the produced heat unfortunately cannot be utilized energetically at the decentral locations. This being the situation, it is very important to also realize the most ideal energetic concept in the future, depending on the location. An interesting possibility for a more efficient energetic utilization of biogas is the upgrading into biomethane with natural gas quality. Biomethane offers interesting alternative utilization possibilities such as its feed into the existing natural gas grids or its utilization as biofuel.

This presentation explains which input material is used for the biomethane production, how biomethane is produced and which different areas of utilizations are possible.

2. Input material for the biomethane production

For the production of biomethane a number of input materials can be used. Either organic waste from the municipal, agricultural or industrial sector is used or energy crops such as whole crop silage, grass silage and sorghum which is especially cultivated for the production of biomethane.

The municipal authorities are responsible for the recycling/disposal of waste and sewage sludge. Their energetic recycling is reasonable in anaerobic treatment plants in which biogas or biomethane respectively is generated. In the sector of municipal waste treatment, biomethane can be produced by mechanical-biological waste treatment from residual waste by means of an integrated fermentation step. Furthermore, separately collected biowaste can be used as input material for the biomethane production in appropriate digestion plants. The technical effort for the construction of the digestion and biogas upgrading plant can be reduced by using biowaste as input material. Numerous municipal sewage plants are already equipped with a so-called digestion tower in which the sewage sludge is treated anaerobically and biogas is produced which can be utilized for biomethane production by integrating a biogas upgrading plant.

Biomethane is also produced from biogas that is generated in agricultural plants. These plants use input material such as pig manure, cow manure and poultry manure for the biogas/biomethane production. Unfortunately this input material only has little biogas potential and therefore other substrates are used if possible in order to increase the biogas yield of the plants. Generally, for the increase of yield, energy crops are used. Amongst others, these crops include crop, cereals, whole wheat silage, grass, sugar beet and sorghum. Partially, agricultural biogas plants also utilize food waste from restaurants and hotel kitchens or other organic residue from food and beverage productions such as fats, distiller's wash and bakery products. The inclusion of such organic residue into the process is a highly interesting option for the plant operator because this waste is very energy-rich and generally a yield can be reached for the treatment, i.e. the profitability of the plant can be optimized. However, corresponding installations have to be provided in the biogas plant for the upgrading of the residue (separation of foreign objects, homogenization) and pasteurization.

For the production of biomethane also industrial waste can be used such as too long stored and packaged food which must be pre-treated accordingly before it can be fed into the digesters for biogas production.

Depending on the used input material biogas is produced with a different composition concerning the methane content as well as trace substances. The knowledge of the biogas quality is vital for the correct dimensioning of the biogas upgrading plant.

Figure 1:

Biomethane plant Kielen, Luxemburg

Figure 1 shows an exemplary biomethane plant which was installed in Kielen, Luxemburg by Ros Roca envirotec. The plant treats cow dung, cow manure, energy crops as well as organic waste which are then used for biogas production. The generated biogas is treated and is then fed into an existing natural gas grid that is located next to the plant.

During the process selection it is important to consider the best possible flexibility concerning the different substrate qualities. Due to the long operating times of biogas plants it also has to be considered that due to changing legal framework the conditions for an profitable plant operation can change significantly and the plant operator has to have a flexible technology which enables him to realize according measures e.g. by using alternative substrates.

3. Technology for the biomethane production

Biomethane is produced via an according upgrading of biogas. During the upgrading carbon dioxide and other trace components such as hydrogen sulphide (H_2S) are removed from the biogas. At the moment various processes are used for the upgrading of biogas and the production of biomethane. The pressurized water scrubbing technology (PWS), pressure swing adsorption (PSA) as well as the de-pressurized amine scrubbing are the most field-proven and at the moment the most used technologies.

During the pressurized water scrubbing the CO_2 is removed under pressure by the use of water within a scrubber equipped with filling material. Low temperatures favor the efficiency of the upgrading. A desulphurization of the biogas is not necessary because the hydrogen sulphide is also removed in the scrubber and then can easily be removed after the upgrading. No chemicals are necessary for the scrubber process.

Figure 2 shows the main process of the pressurized water scrubber technology.

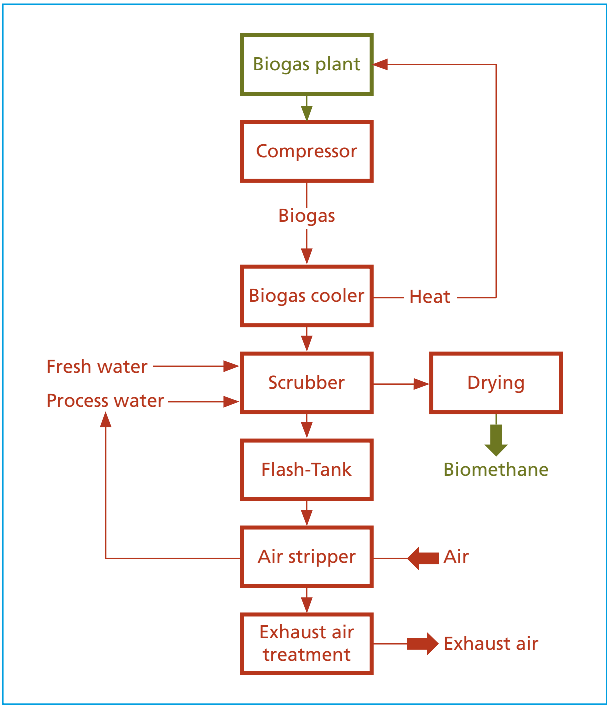

Figure 2:

Process principle of the pressurized water scrubbing technology for the biomethane production

At first, the biogas is compressed to a pressure of 6 – 7 bar and then passes the scrubber which is filled with special filling material in a counter current. At the same time process water passes the scrubber in a counter current. The filling material guarantees an intensive material exchange between the biogas and the water and thus an efficient separation of CO_2. Afterwards, the biomethane generated in the scrubber is dried, has now reached natural gas quality and can be – after conditioning and pressure increase, if necessary – fed into the natural gas grid. The process water in which CO_2 and small amounts of methane are dissolved is then relieved and the gas released in this process step passes the scrubber again. Thus methane losses can be minimized. The process water is then regenerated in an air stripper where CO_2, small amounts of residual methane and hydrogen sulphide are removed. The process water is cooled and used again in the scrubber. Cyclically also small amounts of process water are exchanged and replaced by fresh water. The amount of fresh water is small and the actual requirement depends on the quality of the biogas that is to be treated.

The feeding of the biomethane is realized by the gas grid operator. Via the process gas chromatograph the biomethane quality is tested before the feeding into the natural gas grid and it is secured that only biomethane is fed which fulfills the qualities required by the German DVWG directives or the qualities listed in the shut-down matrix of the gas grid operator. In case of any non-conformances concerning the biomethane quality the biomethane is redirected into the biogas upgrading plant and is purified again. Depending on the location, the required grid pressure is set in the feeding station and, if necessary, the heat value is adjusted by addition of propane.

In the following several plants realized by Ros Roca are explained in detail.

Figure 3 shows a biogas upgrading plant which is in operation in the city of Altenstadt, Germany since 2009. The plant upgrades biogas from a biogas plant which utilizes organic waste. This biogas upgrading plant has a maximum biogas flow-rate performance of 1,250 Nm^3/h

Figure 3:

Biogas upgrading plant in Altenstadt, Germany

Figure 4 shows a biogas upgrading plant that was installed in Quesitz. The biogas to be treated is produced in an agricultural biogas plant which utilizes energy crops as substrate. This biogas upgrading plant has a maximum biogas flow-rate performance of 1,400 Nm^3/h

Biogas upgrading plants with grid injection are also sold already into other European countries. In Kielen, Luxemburg, a biomethane plant was constructed turnkey-ready in which

Figure 4:

Biogas upgrading plant in Quesitz

biogas is produced from agricultural substrates such as cow dung, cow manure, renewable primary products as well as municipal biogas, is upgraded and is fed into the natural gas grid. This biogas upgrading plant has a biogas flow-rate performance of 600 Nm^3/h.

Figure 5:

Biogas upgrading plant Kielen, Luxemburg

Luxemburg has a different remuneration system for renewable energies as Germany and therefore substances from the agricultural and municipal sector can be used as input material for the biomethane production.

Numerous other biogas upgrading plants are being realized in Germany at the moment or are already in their start-up phase, amongst others in Dorsten, Eggolsheim, Wölfersheim, Biburg, Marktoffingen and Mammendorf.

4. Utilization possibilities of biomethane

Figure 6 lists the general utilization possibilities of biomethane.

Biomethane is the most flexible renewable energy source with numerous application possibilities. Because of the possibility of the feeding into existing natural gas grids, utilization

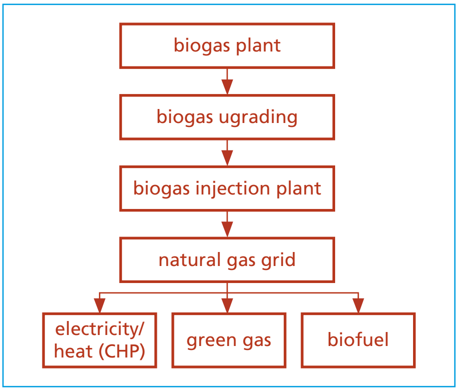

Figure 6: General utilization possibilities of biomethane

is possible at all locations which have a connection to the gas supply. As a result to the numerous application possibilities enabled by the feeding into the gas grids, a broad range of clients can be reached.

As you can see in Figure 6, biomethane can be utilized for heat and electricity production in central or de-central CHP units. Thus a complete utilization of the heat resulting from the combustion process is possible. In the meantime biomethane is also offered directly by energy suppliers to private consumers as so-called green gas or bio-natural gas.

Another interesting application is the utilization of biomethane as fuel. In this case a feeding into the natural gas grid is not necessary but other local solutions can be realized directly on the production site. After appropriate compression or liquefaction, biomethane can be utilized directly as biofuel in natural gas vehicles. Due to the higher biological substrate conversion compared to the production of the conventional fuels (bioethanol, biodiesel and rape oil), biomethane reaches the highest yields in relation to the necessary cultivation area.

5. Summary

The production of biomethane and its feeding into the existing natural gas grids is an interesting alternative compared to the conventional electricity and heat production from biogas in co-generation units directly on the location of the biogas plant. Thus the biogas can be better utilized energetically either by central cogeneration of heat and power, utilization as fuel for vehicles or by direct utilization by the end-consumer. Also, by the substitution of natural gas we reduce our dependency on imports from foreign natural gas deliveries. Germany has the lead role in Europe in the production of biomethane and biomethane is already fed into the natural gas grid at numerous locations. Most other European countries do have remuneration systems for electricity, but unfortunately there are not yet any precise legal regulations for the biomethane feeding into existing gas grids. Germany can be pioneer and can offer support based on their long experience during the establishment of appropriate legal basic parameters in other European countries. However, political commitment must also be shown in order to realize this way of utilization of biogas. Biomethane is the most flexible regenerative energy source which can be utilized in different variations and especially with the highest efficiency.