IV Present state and perspectives of the treatment of biogas to the quality of natural gas

F. Scholwin

1 INTRODUCTION

Treatment of biogas is being increasingly regarded as an option for using renewable energy in the future. Biogas from fermentation or thermochemical transformation is the only regenerative alternative towards obtaining the fossil energy source natural gas. In treating biogas to the quality of natural gas, it is basically possible to cover all the natural gas applications with biogas. Comparable to electricity, even gas can in principle, then enter the market as a „green" source of energy. At the same time however, the purpose of this development is questioned. Is the treatment of biogas energetically and ecologically worthwhile? For what applications does it make the most sense to substitue fossil energy sources with treated biogas? Therefore, apart from technical problems, questions concerning ecology and energy efficiency should also be discussed in this article.

2 PRESENT STATE OF TREATMENT OF BIOGAS TO THE QUALITY OF NATURAL GAS

In the meantime there are six locations in Germany for biogas input, another 20-30 plants are under construction and approval, and a large number of plants are in the project planning phase (fig. 1).

In spite of the existing ambiguity concerning marginal conditions, some of the projects have already been implemented and can now serve as examples for other projects. The projects were carried out according to foreign models (Sweden, Switzerland, France, The Netherlands) that show that the treatment and supply are the state of technology even though related to an optimization potential.

From the point of view of availability of biomass there is still considerable potential for generating biogas and makes the implementation of plants that are interesting for feeding in biogas fundamentally possible. The largest potential can be found in the agricultural area and the expected increase in potential mainly in renewable raw materials (fig.2). Even though the present, very high costs for renewable raw materials is an obstacle and the reason for which a number of projects have been put on hold, the promising ones are being promoted further. If nothing else, the negotiated agreement of the German gas industry to provide 10% of natural gas being sold as fuel, from biogas by 2010 and 20% by 2020, is responsible for this.

In the area of development of a company, the interest in biogas imput appears to be clear. Interesse an der Biogaseinspeisung zeigt sich dabei klar im Bereich der Unternehmensentwicklung. In the last few years, large gas suppliers in Germany have established their own companies for implementation, participation and operation of plants for supplying biogas in the natural gas network. Moreover, some companies are intensely engaged in the development of trade platforms for biomethane and one gas supplier is already the first one to offer a „green" gas mixture with 5% biomethane, in the market.

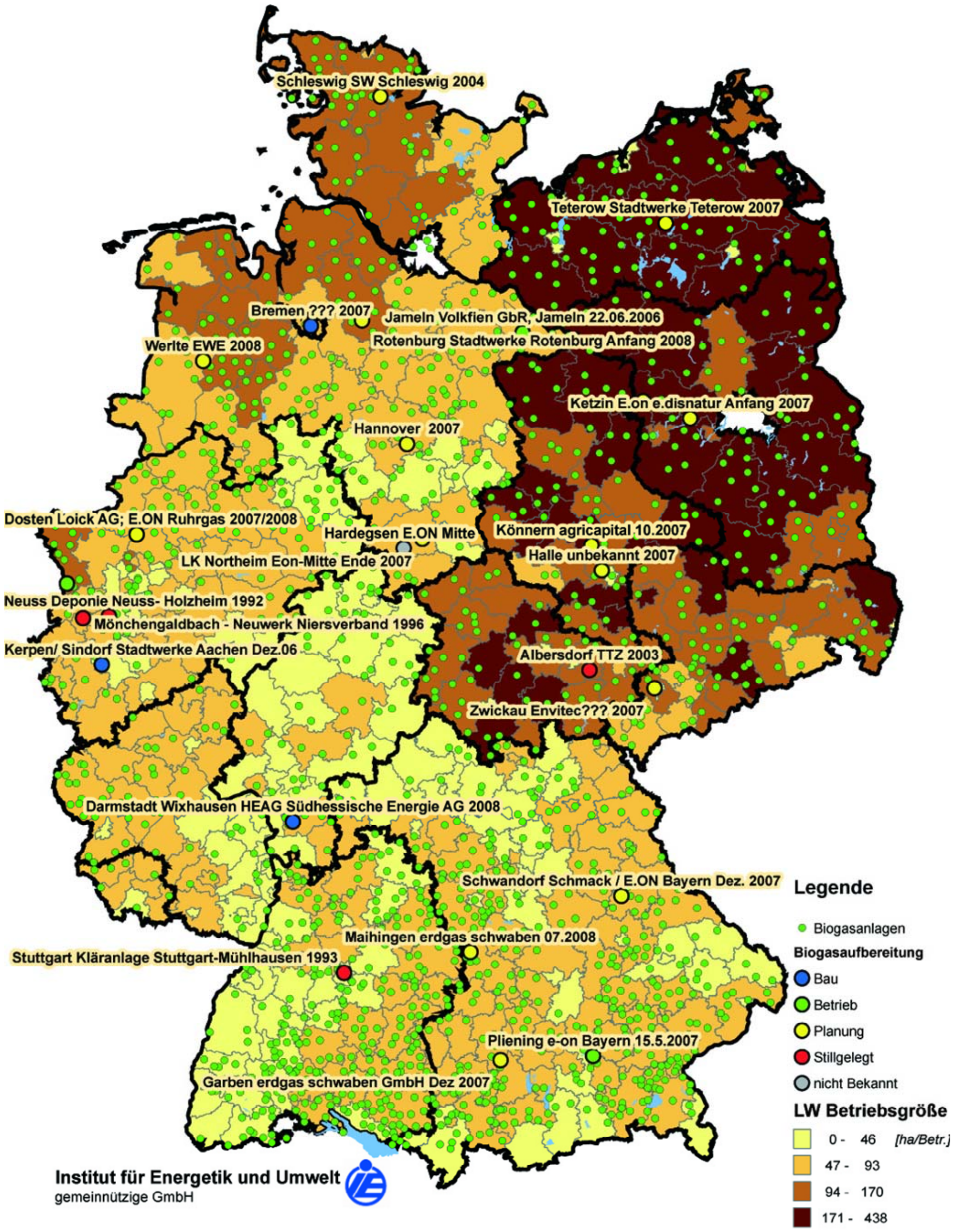

Fig. 1: Projects known for biogas supply in the German natural gas network in operation, construction and approval

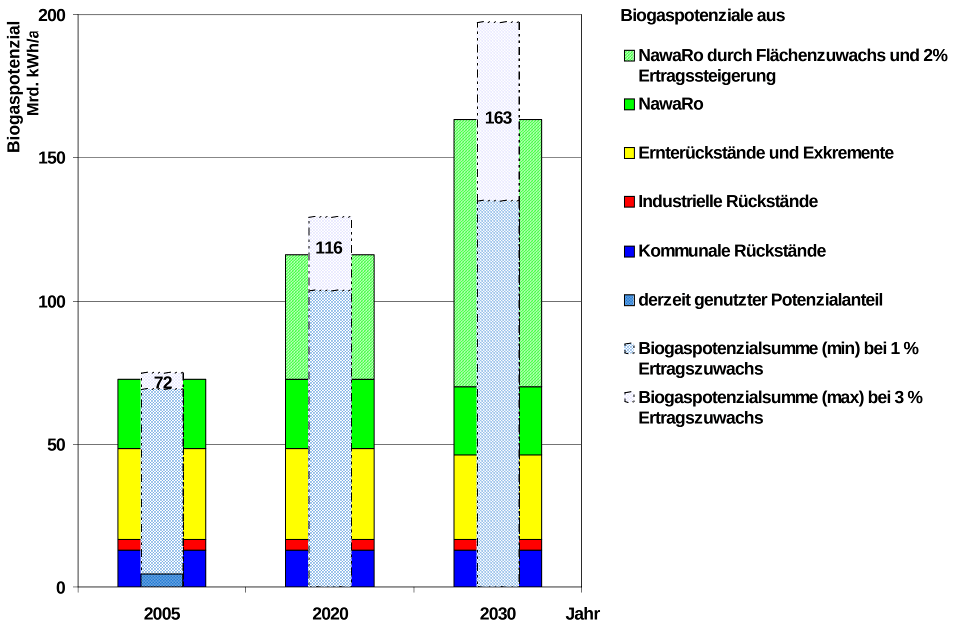

Fig. 2: Potential development towards biogas generation in Germany

Most of the implemented projects were a result of strong cooperation with the gas and power industry. This has certainly helped to simplify negotiations concerning any open questions related to biogas supply and remuneration, considerably. The projects are usually linked to the generation of electricity from the biogas supply, in order to be able to claim the innovation bonus of the Renewable Energy Law for the treatment of biogas to the quality of natural gas. In connection with the sale of waste heat from power generation and availment of the CHP bonus as specified by EEC, treating and supplying biogas as well as transmitting bio methane through the natural gas network can become economically efficient. In fact climbing substrate prices will considerably complicate the profitability but simultaneously increasing energy costs offer the possibility of compensating a part of the increased substrate costs with higher sales proceeds. For this reason, biogas charging offers the possibility of developing the locally existing biomass potential especially for biogas plants in which energy recovery is not possible. Finally, this enables an efficient gas utilization also for those biogas plants that use residual materials and waste as substrate and are even peripherally located away from residential areas.

3 Technology for the treatment of biogas to the quality of domestic gas

The motor driven utilization of biogas for electric supply and the direct (co) firing of biogas for generating heat both belong to the state of technology and will not be further discussed here [Hofmann et. al.].
Since the electrical efficiency factor of utilizing biogas for conventional applications (viz. engines) cannot in all probability, be considerably improved, the present focus is on running developments on the application of coupled electricity and heat generation with the possibility of utilizing heat all the year round. Both these are not usually not possible if the biogas is generated at peripheral locations. Therefore, added possibilities are being investigated for transporting biogas as energy source to the location of requirement. The biogas can either be transported by special gas pipes (which is mostly very expensive over long distances and logistically complicated owing to the area-holding ratio) or by (the already existing) domestic gas network which will require treatment of the gas to the quality of domestic gas.
There are at present three different processes for treatment of biogas to the quality of domestic gas. In the first place it is the **pressure swing adsorption**, in which mainly the carbondioxide is adsorbed on the active carbon through a strong, quick swing of pressure in order to generate a clean gas having the quality of domestic gas [Hofmann et. al.]. The process is depicted in the following diagramme.

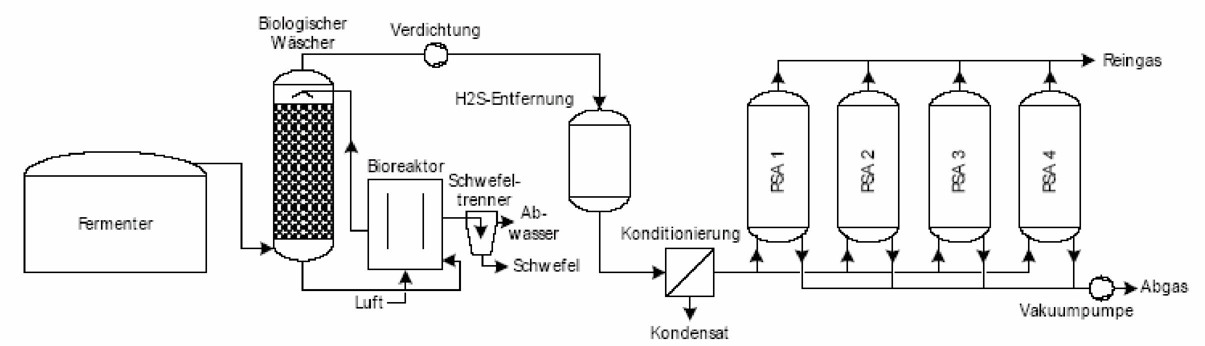

fig. 3: Schematic depiction of pressure swing adsorption [Ramesohl et. al.]

The treatment in which the biogas will have to be desulfurized in the biological gas washer prior to being processed, is usually carried out by the pressure swing adsorption process in four steps:

1. Adsorption of carbondioxide on active carbon or molecular sieve in a column from biogas at high pressure (approx. 10 bar).
2. Slackening the pressure after diverting the biogas to a second column (in which the first step then takes place), by rinsing with ambient air,
3. Desorption of carbondioxide from the active carbon or molecular sieve in cocurrent or counter current in the ambient air,
4. Increase in pressure in the column and feeding in biogas to begin with step 1 again.

Depending on the quality of gas, the four steps are usually repeated two or three times in a row in order to maintain the purity of gas above 97% methane.

Weiterhin werden The process of **hydropneumatic washing** still being used in which the difference in solubility of methane and carbondioxide in water at variable pressure is taken advantage of in order to generate a pure gas containing more than 96% methane. This procedure is depicted in the given diagramme.

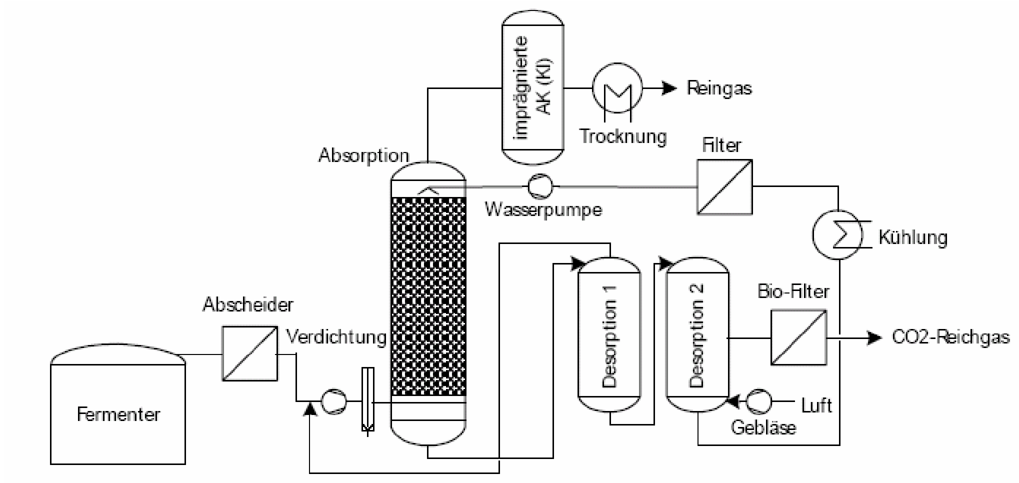

fig. 4: Diagram showing hydropneumatic washing for treatment of biogas [Ramesohl et. al.]

In the case of hydropneumaticc washing, the biogas is compressed to about 10 bar without prior desulferization and then lead to an absorption column and flows through it from the bottom to the top. The column is usually designed as a trickle bed reactor in which water having a temperature of 25 or 5° flows in counterflow to the gas from the top to the bottom. The alkaline and acidic components dissolve in water in the adsorption column. Possibly dust and micro-organisms contained in the raw gas are also absorbed by the wash water to a large extent. Above all the carbondioxide and hydrogen sulfide get dissolved in the water. The purified gas leaves the column with a methane content of upto 98%. The water vapour contained in the gas conditional to the process will have to be condensed out. The carbondioxide contained in the wash water is liberated by multi-stage devolatilization by which small amounts of methane is again introduced to the raw gas after the first devolatilization stage in order to minimize loss.

The third relevant method is chemical washing. In this method, biogas is conveyed to a wash column with a counter flow of a wash solution comprising of a mixture of mostly monoethanolamine or diethanolamine (MEA or DEA) and water. The carbondioxide (together with other minor components) dissolves in the wash solution. The methane remains mainly in the gas phase. The adsorption takes place almost without pressure owing to the suitable properties of the wash solution. A higher amount of heat is required for the regeneration of the CO_2 charged wash solution.

In addition to these very reliable procedures from the point of view of the operator, other methods for gas separation with the help of membranes also exist as also cryogenic gas separation method [Ramesohl et. al.].

An overview of the different methods for treating biogas to natural gas quality is shown in table 1.

Tab. 1: Procedural advantages and disadvantages of biogas treatment procedures in comparison

	PSA	Hydropneumatic wash	Amine wash	Membrane-separation	Kryogenic separation
Industrial experience	high	high	little	little	none
Methane slip	high	high	Very little	high	Very little
Ability to regenerate	Without heat	Heat needed	Much heat required	-	-
Precipitation of air components	partial	Very limited	no	yes	yes
Technical effort	high	high	low	low	Very high
wastage	high	medium	low		
Prior desulfurization	Necessary	no	no		

4 ECOLOGICAL EVALUATION

Im While comparing the utilization paths of natural gas quality biogas it can be stated that the supply of biogas of natural gas quality fulfills the target of being able to reduce the climate gas emissions connected with the use of fossil energy sources (fig. 5). The assumed substitution of different fossil energy sources (natural gas i.e. german powerplant mixture for electric supply) results in various but positive degrees of reduction.

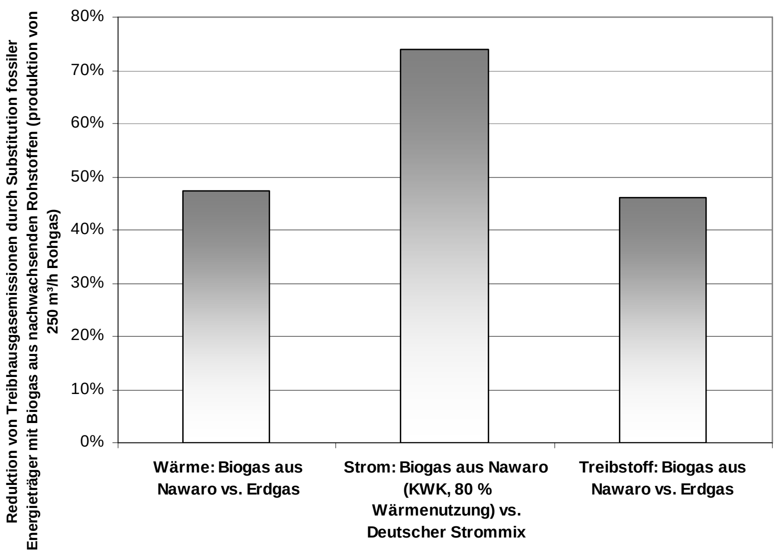

Fig. 5: Effect of the use of biomethane on the climate balance of different options for supplying end energy.

Yet, in addition to this the utilization of biomethane after treatment and supply is also supposed to lead to considerable ecological advangtages compared to local CHP utilization without treatment. Here five basic variables can be drawn in comparison of extreme values: Local biogas plants with a high percentage of heat utilization, 30% waste heat (german average), 72% waste heat (high realistic value) as well as central plants having biogas treatment, supply and conveyance und coupled electricity and heat supply with high waste heat utilization and average heat utilization (fig. 5). Both the options give a degree of utilization of about 65% of the energy contained in biogas, which however is strongly dependent on the regionaly possible heat recycling. As a rule it is about 35% with local plants as compared to about 55% for central plants.

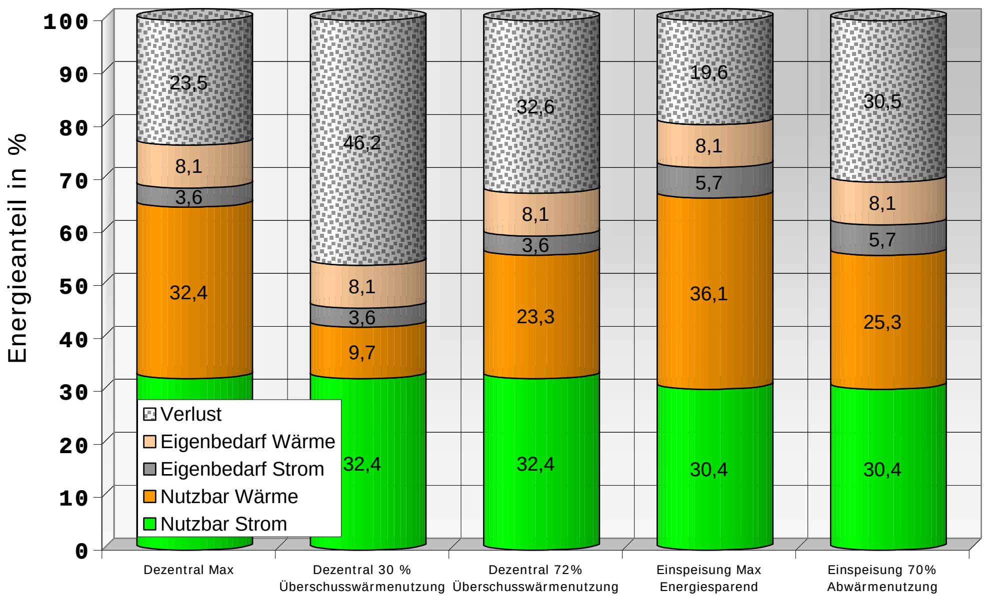

fig. 5: Comparison of energy utilization with local and centralized congeneration of heat and power

In comparison it is necessary to reasonably use the same percentage of heat with local CHP as with centralized gas utilization in order to obtain the same efficiency factor of the energy contained in biogas. This will not be possible with many locations especially for large biogas plants that only enable a marginal local heat utilization and are economically suitable for the treatment and supply of biogas, as well as show ecological and energetic advantages regarding biogas utilization.

4 CONCLUSIONS

Based on the developments shown and the positive ecological effects of biogas supply and the utilization of biomethane, an extraordinarily flexible energy source is being offered for substituting fossil energy applications. It can be basically used for supplying electricity, heat and fuel. Inspite of lacking competitive capacity at present when compared to natural gas, a future convergency of biomethane and natural gas prices can be expected if further increase in oil prices is taken into consideration. In the case of fuel, the basic economic threshhold has already been overstepped. This has been widely demonstrated and exemplified in Sweden.

The development of biogas supply will be mainly dependant on the costs for providing biomass in the future, since precisely energy crops show the largest service capacity. Inspite of this, the potential given by residual matter and waste should also be taken into consideration.

What is important for the development is the improvement of legal marginal conditions for biogas treatment and supply. Since the appropriate rules and regulations are at present being revised, one can hope that open questions will be answerd quickly. In any case it can be additionally expected that, owing to the substitution capability, treated biogas will play an increasingly important role in the gas market as compared to natural gas.

5 LITERATURE

Hofmann, F.; Plättner, A.; Lulies, S.; Scholwin, F.; Urban, W.; Burmeister, F.: Evaluierung der Möglich¬keiten zur Einspeisung von Biogas in das Erdgasnetz; Forschungsvorhaben im Auftrag der Fachagentur für Nachwachsende Rohstoffe; 2005.

Ramesohl, S; Arnold, K.; Kaltschmitt, M.; Hofmann, F.; Plättner, A.; Lulies, S.; Scholwin, F.; Urban, W.; Burmeister, F., Althaus, W.: Analyse und Bewertung der Nutzungsmöglichkeiten von Biomasse; Forschungsvorhaben im Auftrag von BGW und DVGW; 2005.