Lechner P. (Hrsg.): Waste matters. Integrating views. 2nd BOKU Waste Conference 2007, 16. - 19. April 2007, Wien. Proceedings; Facultas Verlags- und Buchhandels AG, ISBN 978-3-7089-0060-5

Operation of a Pilot Plant for the Biogas Injection in Austria

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Introduction

Anaerobic digestion of agricultural waste as well as other organic wastes is a wide spread technology for producing biogas in Austria and Germany. Besides the usual conversion to heat and power (CHP) the upgrading to natural gas quality and injection to the gas grid opens new promising fields of biogas usage. The first biogas injection plant in Austria was started in June 2005 in Pucking / Upper Austria. The biogas of the already existing agricultural biogas plant is purified to natural gas quality and fed into the natural gas grid as exchange gas.

With a capacity of 10 m³ biogas per hour the biogas plant produces after the purifying process 6 m³ upgraded biogas with natural gas quality which is injected into the local gas grid. The operator of the plant, Erdgas OÖ GmbH, is able to provide up to 400,000 kWh per year on renewable energy. This corresponds to the average annual need of about 40 flats.

In December 2006 a similar project in large scale was put into operation in Pliening next to Munich. Reaching a capacity of approx. 4 million m3 per year of upgraded biogas the plant is the first injection plant to the natural gas grid in Germany. In this case the "biomethane" is used in 2 CHP units situated in locations with a district heating networks reaching an optimal heat and power usage throughout the year. A similar plant will start operation in the near future next to Aachen. These German full scale plants benefited from the experiences gained from the pilot plant in Austria, that a reliable operation is possible.

Upgrading of biogas and feeding into the natural gas grid

Advantages

The upgrading and feeding of Biogas into the local grid is arising to an interesting alternative for biogas utilisation. The following advantages can be attained:

Higher electrical efficiency: Biogas plants usually serve as decentralised energy supply. Caused by the relatively low energy density of the substrate, the plant capacity is limited to keep the efforts for transport in an intelligent way. The feeding of biogas into the local grid allows an easy transport of the energy. This enables a central transformation of the biogas produced in several biogas

plants. So it is, for example, possible to run gas turbines which reach a higher electrical efficiency than usual small-scale CHP units.

Higher overall efficiency: The local separation of biogas plants and heat customers is possible. At a central cogeneration unit also the produced heat can be used totally. The outcome of this is a particularhigher overall efficiency of the plant.

Utilization as fuel possible: The produced biogas can be used as fuel for gas driven vehicles. The transportation sector is responsible for 30 % of the end-energy-efforts in the EU and is expanding. The application of biogas in the transport sector contributes to the EU-directive 2003/30/EG "Biofuels" (EU-directive Biofuels, 2003). The herein required share of 5.75% for biogenous fuels up to 2010 accords e.g. for Austria 17.7 PJ or 800 bio Nm^3 biogas per year, assumed that the share is covered only by biogas.

Flexible application possible: The upgrading and feeding of biogas creates a flexible and easy grid-bound transportable energy source which is independent from the place of production. It can be used in other places for a variety of purposes (generation of electricity, supply of heat, process energy, fuels). So the potential of demand for the renewable energy source biogas increases enormous.

In particular the efficiency using biogas to generate electricity in a CHP unit depends on the ability to utilize heat energy. Heating demands are quite inhomogeneous throughout the year in comparison to electricity demand. Additionally the heat demand at the biogas plant, which is normally located in rural areas, is potentially too low to take all produced heat, even in wintertime. The CHP unit can therefore not always be operated economically.

The injection of biogas into an existing infrastructure enables a higher overall efficiency. When using biogas (100 % energy) in a CHP unit, the overall efficiency ranges between 30 % at no heat utilization and 68.5 % with 100 % heat utilization.

In comparison, the biogas upgrading results in a loss of about 5 % (refinement consumption and energy required). In addition, the energy requirement including the heating of the biogas- plant requires about 15 % of production. The overall efficiency therefore reaches a remarkable value of 80 %.

Requirements

The requirements of the gas quality and the possible biogas-feeding into the Austrian natural gas grid are shown in the following table. Basically there is no official directive for the biogas-feeding until now. The criteria for gas quality will be similar to the natural gas guideline ÖVGW G31 "Gas condition – gas quality". So the maximum concentration of trace components as well as the heating value and the Wobbe index are obligatory (ÖVGW G31, 2001).

The recently launched guidline ÖVGW G33 contains further specific criteria

Tab. 1: comparison of gas content and important firing properties of raw-biogas, natural gas and the requirements of ÖVGW G31.

		raw-biogas[a)] (dry)	natural gas[b)]	ÖVGW G 31
composition:				
C_xH_y	vol%(dry)	---	0.4	n/a
CH_4	vol%(dry)	50...66	99	n/a
CO_2	vol%(dry)	29...43	0.1	≤ 2
H_2	vol%(dry)	---	---	≤ 4
N_2	vol%(dry)	0.3...20	0.4	≤ 5
O_2	vol%(dry)	0.1...6.3	---	≤ 0.5
H_2S	mg/m³$_N$(dry)	17...2470	---	≤ 5
R-SH	mg S/m³$_N$(dry)	0...90	---	≤ 6
NH_3	mg/m³$_N$(dry)	0.6...50	---	0
Siloxane	mg/m³$_N$(dry)	0...0.9	---	0
firing properties:				
Wobbe-Index	MJ/m³$_N$(dry)	22.7...33.3	52.9	47.7...56.5
	kWh/m³$_N$(dry)	6.3...9.3	14.7	13.3...15.7
heat value	MJ/m³$_N$(dry)	22...28	39.6	38.5...46.0
	kWh/m³$_N$(dry)	6.1...7.8	11.0	10.7...12.8
rel. density	---	0.84...0.97	0.56	0.55...0.65

a) Profactor Produktionsforschungs GmbH, biogas analyses of agricultural co-fermentation plants and sewage gas plants in Upper Austria and in Slovakia 2002

b) Analyses Salzburg AG, Austria, January 2003

for renewable gases for injection to the gas grid concerning gas quality control (www.biogas-netzeinspeisung, 2006; ÖVGW G 33, 2006). A further ÖGVW standard for security and delivery quality of natural gas is the directive for thermal gas accounting (ÖVGW G 177, 2002). It contains data for thermal accounting by end customers. In the standard G 177 a limit of deviation for the accounting heat value of +/- 3 % is set.

Similar requirements have to be achieved in Germany (DVGW G260, 1983; DVGW G262, 2004). The actual legal situation there allows to deal with the virtual "bio-methane" taking out of the gas grid achieving the green electricity price after conversion.

In several European countries biogas is used as fuel. In comparison for example, in Switzerland biogas is fed into the gas grid for several years. For bigger amounts of biogas a minimal CH_4-concentration of 96 vol% is claimed (SVGW

G13/d, 2004). The requirements to the gas quality are different. In Sweden for example a Wobbe-Index of 45.5 – 48.3 MJ/m³(dry) and a H_2S concentration of 23 mg/m³N(dry) is claimed. (IEA Bioenergy, 2001).

The alternative possibility to upgrade biogas without CO2 removal and mix it with natural gas or propane gas is considered in several studies, e.g. (Hornbachner, 2005)

Biogas upgrading technique

Based on the requirements of the directives and the natural gas operators, the corresponding purification methods have to be chosen. Following components have to be purified by the claimed limit values: hydrogen sulphide (H_2S), ammonia (NH_3), water (H_2O), siloxanes, carbon dioxide (CO_2).

The common commercial H_2S purifying methods are

- Biotrickling filter or bio-scrubber (biological oxidation)
- Addition of ferric chloride to the fermentation substrate (sulphide precipitation)
- Impregnated activated carbon (catalytic oxidation)
- Iron oxide on steel wool (chemical sorption)
- Iron oxide pellets (chemical sorption)
- Scrubber with water, organic solvent or caustic soda (absorption)

The most common methods for the removal of H_2O are

- Cooling (condensation)
- Molecular sieve (adsorption)
- Polar solvent – glycol (absorption)

The most common methods for the removal of siloxanes are

- Gas drying system and adsorption on activated carbon
- Adsorption on polymorphic porous graphite
- Absorption in Selexol®
- CO_2 - scrubber
- Lab studies (biological removal)

The most common methods for the removal of CO_2 are

- Scrubber (absorption)
- Pressure-swing-adsorption (adsorption)
- Membrane process (permeation)

The costs for the supply of upgraded biogas into the natural gas grid consist of biogas production, biogas conditioning, compression and feeding. In Germany the network access fees are approximately the same as the costs for upgrading (Tentscher, 2005).

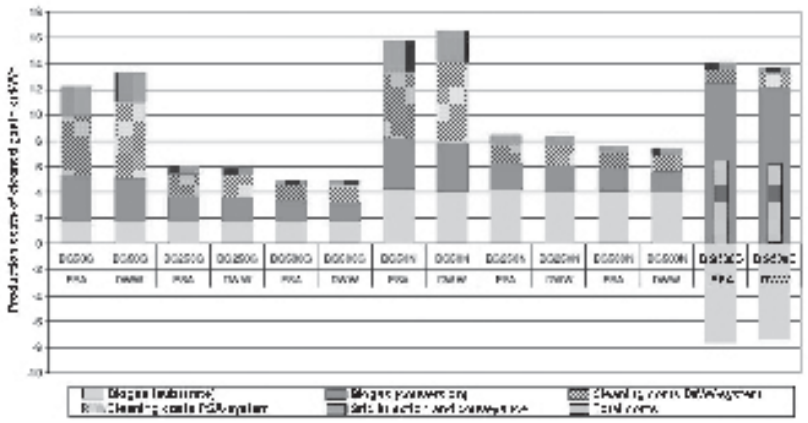


Fig. 1: Production costs (€ct/kWh) of injected biogas (FNR, 2006)

Legend:	
PSA	Pressure swing adsorption
DWW	Water scrubber
BG	Biogas plant
50 – 500	Nm³/h raw biogas production
G	Substrate: Manure + 10 % energy plants
N	Substrate: Energy plants + 10% manure
B	Substrate: Separate collected organic waste

Colors of specific costs:	
Light blue	Substrates
Red	Biogas conversion
Green	Upgrading costs (water scrubber)
Grey	Upgrading costs (PSA)
Dark blue	Injection and network access fee
Orange	Total costs (case organic waste)

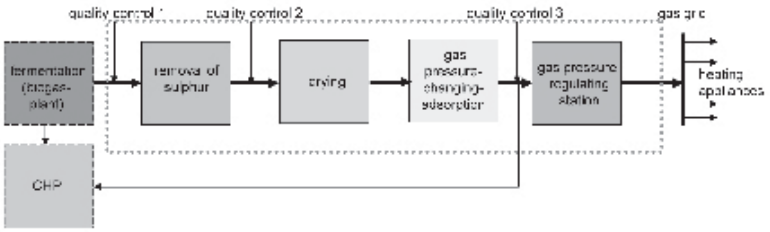


Fig. 2: Block diagram of pilot plant Pucking - biogas injection into the natural gas grid, biogas upgrading to natural gas quality

Pilot plant in Pucking

The first biogas feeding plant in Austria was started in June 2005 in Pucking / Upper Austria. The biogas of the already existing agricultural biogas plant is purified to natural gas quality and fed into the natural gas grid as exchange gas.

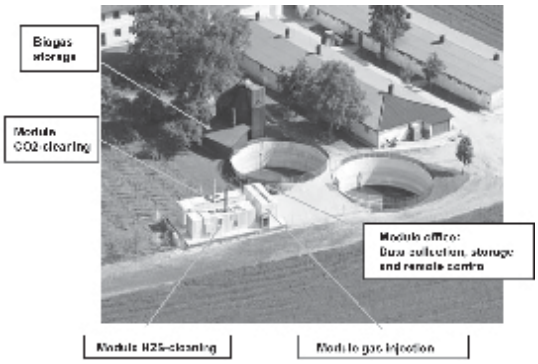
With a performance of 10 m³ biogas per hour the biogas plant produces, after the purifying process, 6 m³ of upgraded biogas with natural gas quality which is injected into the local gas grid. In the test run 5,800 m³ were injected until end of 2005. Furthermore a CO_2-reduction of 180,000 kg per year (compared to conven-

tional oil heating systems) is achievable.

The process cycle is shown in Figure 2. The sulphur removal of the biogas is a specific challenge. In comparison to conventional methods, the sulphur in the biogas in Pucking is purified with a biological trickling filter without direct air injection. There are no waste products produced. The separated sulphur is added to the fermented substrate of the biogas plant as valuable fertilizer.

The CO_2-removal fulfils the very high quality requirements. It is based on a reversible adsorption process, in which the carbon-molecular sieve is cyclic regenerated in the compression change, the so called pressure swing adsorption (PSA). Generally the change of the adsorption material is not necessary over a period of several years. (Schulte-Schulze, 2003).

The location of the pilot plant is the existing biogas plant of a farmer in Pucking (Figure 3). Up to now the biogas was used for the transformation in a CHP station. There heat accrues which cannot be used completely especially in summer. With the new system the produced energy is utilized totally, which means an increase in efficiency. Furthermore a CO_2-reduction of 180,000 kg CO_2 per year (compared to conventional oil heating systems) is achievable. The new system delivers a contribution to reach the Kyoto-aim.



Project partner
Erdgas Oberösterreich GmbH & Co KG
OÖ. Ferngas AG
Landwirtschaftskamm
Franz Linsbod: operat

Supported by:
Land Oberösterreich
Lebensministerium

The most important su
Profactor Produktions
Schmack Biogas AG
Rütgers CarboTech En
Johann Hochreiter Gm
AWITE Bioenergie Rb

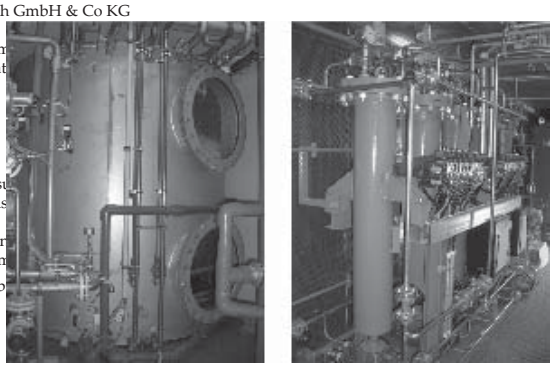


Fig. 3: Pilot plant Pucking biogas injection into the natural gas grid: biogas upgrading to natural gas quality [Source: Erdgas OÖ]

Fig. 4: Pilot plant Pucking: biogas upgrading to natural gas quality, left: H_2S removal (biological filter), right: CO_2 removal (PSA) [Source: Profactor GmbH]

Highlights

- May 2005: construction of the biogas upgrading in Pucking
- June 2005: official initiation of the first biogas injection plant in Austria
- April 2005: The operator Erdgas OÖ reached the Austrian EPCON AWARD 2005
- November 2005: The operator Erdgas OÖ reached the international Energy Globe Awards 2005 – category "air" (handed over in March 2006)
- December 2005 100 % of availability at the pilot plant
- 2006 several optimisation tests and evaluation

Outcomes

- Realisation of the first pilot plant in Austria which feeds biogas in the gas grid
- Technical specification of the biogas upgrading to reach the directive ÖVGW-G31
- First combination of biological external desulphurization (Biotrickling method Profactor) and adsorptive CO_2-separation (pressure swing adsorption CarboTech)
- Reaching the feeding criteria and injecting since midyear 2005

Tab. 2: Pilot plant Pucking: Produced and injected upgraded biogas amount (= Reingas 2) June-December 2005 [Source: Erdgas OÖ]

	Produced quantity Reingas 2	**Injected quantity Reingas 2**	**Percentage of injection**
from 15.6.05 to 31.12.05	**10,321.00 Nm³/h**	**5,815.00 Nm³/h**	**56.34%**
Dec-05	3,006.00 Nm³/h	3,006.00 Nm³/h	100.00%



Nov-05	2,746.00 Nm³/h	2,491.00 Nm³/h	90.71%
Oct-05	570.00 Nm³/h	173.00 Nm³/h	30.35%
Sep-05	1,967.00 Nm³/h	134.00 Nm³/h	6.81%
Aug-05	1,483.00 Nm³/h	0.00 Nm³/h	0.00%
Jul-05	446.00 Nm³/h	11.00 Nm³/h	2.47%
Jun-05	103.00 Nm³/h	0.00 Nm³/h	0.00%

Awards

Already in April 2005 the project was honoured with the Austrian EPCON Award 2005. At the international Energy Globe Awards 2005 the project won the 1st place in the category air. The presentation of the award took place in March in Vancuver (Canada) – Figure 5. For the first time since existing of the Energy Globe Award, an Austrian project won the first price.

Fig. 5: Presentation of the Energy Globe Awards 2005, Category air to Erdgas OÖ. and OÖ. Ferngas, Vancuver March 2006 [Source: Erdgas OÖ]

References

DVGW G260 (1983): DVGW Deutscher Verein des Gas- und Wasserfaches e.V. (Hrsg.), Arbeitsblatt G260 / Teil 1 Gasbeschaffenheit, Wirtschafts- und Verlagsgesellschaft Gas und Wasser mbH Bonn.

DVGW G262 (2004): DVGW Deutscher Verein des Gas- und Wasserfaches e.V. (Hrsg.), Arbeitsblatt G262 / Nutzung von Gasen aus regenerativen Quellen in der öffentlichen Gasversorgung, Wirtschafts- und Verlagsgesellschaft Gas und Wasser mbH Bonn.

(EU-Richtlinie Biokraftstoffe (2003): EU-Richtlinie 2003/30/EG zur "Förderung der Verwendung von Biokraftstoffen oder anderen erneuerbaren Kraftstoffen im Verkehrssektor", Europäischen Parlaments und des Rates, 17. Mai 2003.

FNR (2006): Fachargentur Nachwachsende Rohstoffe e.V. (FNR), „Einspeisung von Biogas ins Erdgasnetz", Leipzig.

Hornbachner (2005): Hornbachner D., Hutter G., Moor D., Rechtliche, wirtschaftliche und technische Voraussetzungen für die Biogas-Netzeinspeisung in Österreich, 2005, Online im WWW unter URL: http://energiesystemederzukunft.at/nw_pdf/ 0519_biogasnetzeinspeisung.pdf [28.06.2005].

IEA Bioenergy (2001): Asger Myken, Jan Jensen (DGC), Martin Hagen, Erik Polman