NACHHALTIG*wirtschaften*
konkret

FORSCHUNGSFORUM
2/2006

FEEDING BIOGAS INTO THE AUSTRIAN NATURAL GAS GRID

ANALYSES OF TECHNOLOGICAL, ECONOMIC, AND LEGAL PREREQUISITES AS WELL AS PILOT PROJECTS WITHIN THE "ENERGY SYSTEMS OF TOMORROW" SUBPROGRAM

Biological H_2S removal in a Laboratory-Scale Biogas Plant by PROFACTOR

bmvit
Austrian Federal Ministry for Transport,
Innovation and Technology

T O P I C

APPROACHES TO AN EFFICIENT USE OF THE BIOGAS POTENTIAL IN AUSTRIA

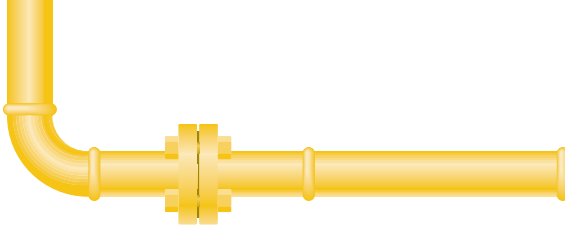


Photo: erdgas oö

In 1999, the Austrian Federal Ministry of Transport, Innovation and Technology (bmvit) launched the "Austrian Program on Technologies for Sustainable Development", which aimed to effectively stimulate the restructuring of the economy towards sustainability. Various research and development projects as well as demonstration and diffusion measures, which give new impetus to innovation in Austria's economy have since been supported within the scope of a number of subprograms.
The "Energy Systems of Tomorrow" subprogram aims to encourage innovative and trend-setting technologies and concepts in the field of renewable energy sources that are capable of safeguarding energy supply on a long-term basis.

■ The production of biogas is a pioneering sustainable technology towards the use of renewable energy. Biogas is generated in a biological process through the decomposition of organic matter such as plants, food leftovers, fat, oil, and animal dung (liquid and solid manure). In contrast to composting this fermentation process takes place without oxygen (anaerobic). In addition, biogas also occurs in sewage plants and landfills. Biogas is a flammable gas mixture consisting of a large proportion of methane, which can be used as an energy source. The technically usable biogas potential in Austria amounts to approx. 1,000 million m^3, which equals an energy content of 24 PJ per year. Until now, biogas has been used in Austria almost exclusively for power generation in combined heat and power plants (CHP). In this process, (decentralized cogeneration of heat and electricity) a large proportion of the energy contained in biogas cannot be used, because in most cases there is no demand for the waste heat, which is produced in addition to the electric energy.

Another efficient use of biogas consists in feeding it into the public natural gas grid. In this case the existing grid is used to transport biogas to the consumer where it can be used for power generation, space heating, or as fuel. By feeding biogas into the grid, use of this energy source is not restricted to the site of biogas generation anymore. Separating generation and utilization offers more flexible applications and thus a higher overall efficiency compared with mere power generation from biogas. At the same time, feeding biogas into the public grid can replace a certain amount of fossil natural gas.

If all of the biogas potential existing in Austria were used, natural gas consumption could be reduced by 6.7 %. This corresponds to a reduction of CO_2 by 1.18 million tons, which, in turn, equals 1.6 % of annual CO_2 emissions in Austria. In contrast to fossil natural gas, biogas is "CO_2 neutral". While the combustion process also discharges produces CO_2, as is the case with natural gas, the CO_2 here comes from regenerative processes. This means that the carbon, which is released into the atmosphere in the form of CO_2 during combustion, was previously withdrawn from the atmosphere by the growing plant. Consequently, CO_2 concentration in the earth's atmosphere is not increased.

Four research projects within the **"Energy Systems of Tomorrow"** subprogram focused on the technological, economic, and legal aspects of feeding biogas into the grid.

Researchers developed concrete solutions concerning the issues of prime cost / feedstock, types of process, treatment costs as well as prerequisites for feeding biogas into the public grid and implemented the research results in demonstration projects and pilot plants.

PROJECT 1
Biogas-Netzeinspeisung
Rechtliche, wirtschaftliche und technische Voraussetzungen in Österreich,
D. Hornbachner, G. Hutter, D. Moor,
Vienna 2005

PROJECT 2
Biogas – Einspeisung und Systemintegration in bestehende Gasnetze
Matthias Theißing, FH Joanneum Gesellschaft mbH / Infrastrukturwirtschaft,
Kapfenberg 2005

PROJECT 3
Aufbereitung von Biogas zur Einspeisung in das Salzburger Erdgasnetz
Johann Bergmair, PROFACTOR Produktionsforschungs GmbH,
Steyr 2005

PROJECT 4
Effiziente Biogasaufbereitung mit Membrantechnik
Michael Harasek, TU Wien,
Institut für Verfahrenstechnik,
Vienna 2005

Photo: erdgas oö

Photos:
First grid-coupled biogas plant in Austria erdgas oö, Plant at Pucking operated by erdgas oö and OÖ Ferngas AG

Photo: erdgas oö

PROJECTS

FEEDING BIOGAS INTO THE AUSTRIAN PUBLIC GRID

This project investigated the legal, economic, and technological prerequisites for feeding biogas into the public grid in Austria. Researchers analyzed various methods for each stage of the process and prepared a cost analysis.

A crucial cost factor in feeding biogas into the grid is **prime cost**, which may vary considerably depending on the source of the biogas. While the cost of sewage or landfill gas – a waste product from wastewater treatment and solid waste disposal – is almost negligible, the economic feasibility of raw biogas production strongly depends on feedstock prices. The most expensive method is **producing biogas from renewable raw materials** because, in this case, the feedstock has to be produced first.

Nevertheless, biogas from specially grown energy crops, e.g. silage corn (maize) shows a substantial potential, as the available quantities from other raw material sources (waste from animal husbandry, food leftovers, etc.) are limited. Using renewable raw materials has the advantage that the resulting biogas varies only slightly in composition as the feedstock used is more or less consistent.

The study calculated the prime cost for a medium-sized biogas plant (capacity: 300 m^3/h) to range from 2.3 to 3.2 Eurocent/kWh). Plant size too, has a significant influence on costs; the bigger the facility, the lower the prime cost.

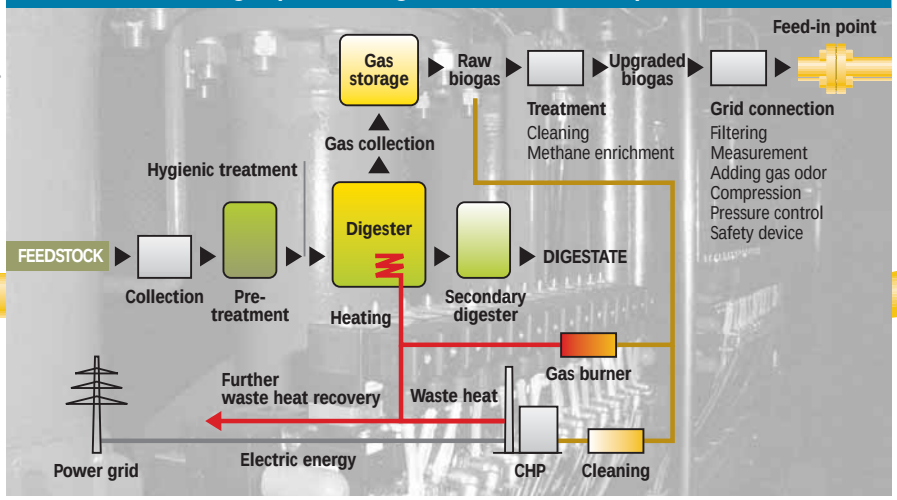
Biogas for the public grid has to meet certain quality requirements; this is to ensure safe operation of the gas grid and of the appliances used by consumers. The requisite chemical composition follows the guidelines for natural gas specifications (ÖVGW, guideline G31 "Erdgas in Österreich"). Biogas is a mixture comprised of methane, hydrogen, carbon dioxide, and nitrogen as main components. In addition, biogas also contains harmful trace gases such as hydrogen sulfide. The methane content of biogas is approx. 60%, its CO_2 content approx. 40%. Natural gas contains 97% methane. Methane is the most important component for use as an energy source. On account of its lower methane content raw biogas also has a lower calorific value than natural gas (6.6 kWh/m^3 as compared to 11 kWh/m^3).

For this reason, raw biogas has to be **upgraded** before it can be fed into the grid. The upgrading process includes purification and methane enrichment. Transfer into the grid also requires an increase in pressure. **Purification** refers to the removal of contaminants that might damage the gas grid or consumers' appliances. H_2S and moisture removal from the raw biogas are important steps in this process. In the case of sewage and landfill gas the removal of siloxanes is necessary as well. The study analyzed various cleaning methods such as H_2S removal directly in the digester (conventional method, which is currently being used in biogas-fueled power plants) as well as new processes such as external desulphurization in a special biological drip filter, which affords improved control of the pH-value, temperature, and oxygen concentration. Researchers also investigated other methods such as H_2S removal by adsorption using an iron sponge or activated carbon filters and various moisture removal processes.

Methane enrichment is realized by reducing carbon dioxide content. Researchers analyzed different methods for this process stage, too. Biogas upgraded in such a process may be used as **"exchange gas"** and thus replace natural gas. The costs, especially for methane enrichment, are very high. The specific total costs of biogas fed into the public grid range from 3.1 to 5.7 Eurocent/kWh for a medium-sized plant. Given market prices ranging from 1.21 to 2.5 Eurocent/kWh, this type of biogas is, therefore, not competitive. In order to avoid expensive methane enrichment, purified biogas may be fed into the grid as **"substitute gas"**. In this approach, biogas and natural gas are mixed in the grid; the calorific (heating) value then will depend on the ratio of the gas mixture. Current legislation for gas being fed into the grid is based on natural gas as a reference. If the minimum admissible calorific value is to be attained, a ma-

Source: Study 2 D. Hornbachner

Schematic of a biogas plant / Stages of the treatment process



ximum 5.6%$_{vol}$ biogas may be added to natural gas. If we want to use all of the available biogas potential, the proportion of biogas would have to be increased to 25%$_{vol}$. This would yield a gas mixture with a calorific value of 10 kWh/m^3, which is 8% below the currently admissible value. The adaptation of appliances to this calorific value would not be a technical problem. Consequently, the study also recommends working out new guidelines for gas specifications with a lower admissible calorific value. In addition, quality measurements should be made at the point of use instead of the feed-in point.

Another barrier for the marketing of biogas refers to high **charges for using the gas grid**, which also had been calculated on the basis of natural gas supply. Present regulations provide that even for short distances, suppliers must pay the full "toll". Here, a new system, which takes into account distances actually used by biogas, should be created. The study has shown that, in Austria, feeding biogas into the grid at competitive costs largely depends on the legal framework. For this reason, the project participants are working out recommendations aiming to create the prerequisites for a positive market development of this new technology. However, even with an optimized legal framework, there will remain a **need for subsidizing** the use of biogas from renewable raw materials and coenzymes (cf. Oekostromgesetz / "Green Power Act"). The recommended measures would contribute to considerably reduce the need for subsidies, though.

PROJECT 2

BIOGAS: GRID-COUPLING AND SYSTEM INTEGRATION INTO EXISTING GRIDS

Photo: FH Joanneum GmbH

This project proposes to analyze issues concerning feeding biogas into the public grid with a view to system integration. In keeping with the task of promoting a sustainable energy supply project participants also take into account site-specific factors. In addition to local / regional availability of feedstock, the load characteristics of the gas grid, the yield characteristics of the biogas plant and the quality requirements for gas fed into the grid have a decisive influence on the design and mode of operation of a biogas plant.

Project goals:

- Developing a method for a technological and economic evaluation of feeding biogas into the grid
- Balancing the load profile of the gas grid, the yield profile of the biogas plant, and quality requirements
- Development of indicators

The local / regional environment is considered a closed system; the supply of feedstuff, energy, and auxiliary materials as well as the utilization or disposal of the digestate occur within the bounds of this system. All components, including biogas plant, treatment facility, feed-in unit, and the gas grid are seen as elements that interact with each other. In addition to site-specific indicators, the researchers also introduced general technical and economic indicators concerning the individual plant components and process stages. Indicators are used to evaluate the technical end economic feasibility of feeding biogas into the grid. Researchers analyzed the load profiles of two typical level 3 gas grids (operating pressure < 6 bar). Both, the gas grid of a small rural village and the grid of a small town showed a dramatic drop in gas consumption during the summer months: It was only about one tenth of the average consumption in winter. The survey has also shown that load forecasts based on normal load profiles are very inaccurate for these periods of low consumption.

On account of these findings the study participants suggest to focus considerations on feeding biogas into the level 2 high-pressure grid. In order to better respond to seasonal load fluctuations a next step should investigate the possibilities of a targeted feedstock selection for biogas plants. This approach would permit to control biogas yield and adapt it to varying demand patterns.

Photo: FH Joanneum GmbH

Biogas facility St. Veit / Glan

P R O J E C T

BIO-METHANE – UPGRADED BIOGAS FOR THE NATURAL GAS GRID IN SALZBURG

■ This project aimed to work out the prerequisites for a demonstration plant to test biogas feeding into the high-pressure natural gas grid in Salzburg. Work also focused on the further development of a cost-efficient zero-waste cleaning unit.

Photo: PROFACTOR

H_2S removal unit / PROFACTOR Produktionsforschungs GmbH

Researchers ascertained the optimum size of the demonstration plant with a view to prime and operating costs, feedstock supply, and marketing potentials. They also analyzed what type of feedstock is available in the region, what quantities at which price, how to optimize costs and the logistics of supplying feedstock to the production site as well as possible applications for the digestate.

The site selected for the biogas and composting plant operated by Salzburg AG is located at Wals in the Flachgau region. Economic activities there include arable farming, vegetable cropping, dairy farming, and some 50% of the region is cultivated land. There would be sufficient quantities of agricultural feedstock for the proposed facility in the region. At present, farmers use commercially available fertilizer for their fields. This fertilizer could be replaced by digestate coming from the biogas plant. Other benefits of the site include proximity to the city of Salzburg and direct connection to the highway system. These factors would facilitate supplying feedstock to the plant. The concept provides for a plant with a capacity of approx. 150 m^3 biogas per hour. Criteria for feeding biogas into the grid relied on applicable legislation for natural gas.

Researchers analyzed two different scenarios:

- Pre-cleaning and blending biogas with natural gas in a mixing station to meet the requisite specifications
- Complete purification and upgrading to meet natural gas specifications

Present planning provides for partial upgrading and for feeding a 1:25 biogas/natural gas mixture into the grid. A countrywide working group is currently revising the ÖVGW G33 guideline on "Regenerative Gase", which defines relevant quality and testing criteria. In developing a suitable upgrading technology, it will be important to aim at energy-efficiency and minimum input of additional process materials. Researchers of the bio-methane project developed a new method to optimize ***biological H_2S removal*** and analyzed an alternative method of CO_2 separation.

If biogas is used to replace part of the natural gas in the grid, it is necessary, after removal of H_2S, moisture, and other trace elements, to separate CO_2 as well. The methane content has to be increased to > 97%$_{vol}$ in order to reach the requisite calorific value. Testing of a new adsorbent (amine) for CO_2 separation has shown promising approaches to improving efficiency in pressure change adsorption; technical feasibility of the process has yet to be ascertained.

Photo: PROFACTOR

In order to be able to compare different technologies under consistent conditions, researchers realized a simulation using a simple modeling approach developed at the Vienna University of Technology. The model incorporates indicators that are needed for the comparison of different types of plant. Researchers recommended a technically and economically viable overall concept for the generation of biogas meeting natural gas specifications: a combination of a newly developed externally ventilated biological trickling filter for H_2S removal and methane enrichment using pressure change adsorption with molecular carbon filters.

The novel biological H_2S cleaning has the following benefits:

- *The system features a patented process of adding oxygen in the liquid phase. In contrast to conventional methods that introduce air into the biogas stream, contamination with nitrogen from the air is considerably reduced here.*
- *In addition, the occurrence of residual oxygen in the purified biogas can be avoided. This prevents the formation of explosive mixtures, thus affording improved operating safety.*
- *Oxygen-free biogas may be used for high-tech applications such as fuel in fuel cells.*

P R O J E C T

PROJECT 4

MEMBRANE TECHNOLOGY FOR EFFICIENT BIOGAS TREATMENT

The main goal of this project consists in the generation of a substitute for natural gas using a novel process for biogas treatment. For this purpose, researchers designed a **mobile testing facility** in a container with a two-stage gas separation unit using membranes. Researchers tested the practicability of this innovative and highly efficient method of extracting methane from biogas generated in an energy crop digester. Investigations also addressed issues relating to analysis and safety.

Pre-studies conducted by the project team have shown that membranes technology permits to simultaneously remove harmful biogas components such as CO_2 and water vapor and that methane enrichment can reach levels slightly above 96% at relatively low pressures. One still unsolved problem consisted in unacceptably high methane losses in conventional one- or two-stage operation. Therefore, researchers developed a new approach relying on a two-stage gas permeation process; this method uses modified membrane modules for the individual separation stages and a system that requires only one compressor. This concept was put into practice in cooperation with partners in the industry within the scope of the "Energy Systems of Tomorrow" subprogram.

Photo: TU Wien

Container assembly, production of membrane modules from polyamide hollow fibers, Vienna University of Technology/ Department of Process Engineering

At the end of 2004, the first **pilot plant for biogas upgrading to natural gas specifications** started trial service at St. Martin in the province of Burgenland. The plant uses a process where, after compression, H_2S is removed in a pre-treatment stage. The membrane separation unit then reduces CO_2 concentration in the gas to less than 2%. At the same time, moisture is completely removed from the gas, which then reaches a dew point below –50°C. These values comply with the required specifications.

Researchers participating in the project also developed and tested a **photo-acoustic measuring method** for analysis of the upgraded biogas. This online method permits real time monitoring of important quality parameters of the generated gas.

FORSCHUNGSFORUM in the Internet:

www.NachhaltigWirtschaften.at

in German and English

You will find a complete list of all publications of the series ***"Reports on Energy and Environment Research"*** by the bmvit with order form on the HOMEPAGE: www.NachhaltigWirtschaften.at

PROJECT PARTNERS

Project 1
Biogas-Netzeinspeisung
Rechtliche, wirtschaftliche und technische Voraussetzungen in Österreich
D. Hornbachner, G. Hutter, D. Moor
Vienna 2005

Project 2
Biogas – Einspeisung und Systemintegration in bestehende Gasnetze
Matthias Theißing
FH Joanneum Gesellschaft mbH / Infrastrukturwirtschaft
Kapfenberg 2005

Project 3
Aufbereitung von Biogas zur Einspeisung in das Salzburger Erdgasnetz
Johann Bergmair
PROFACTOR Produktionsforschungs GmbH
Steyr 2005

Project 4
Effiziente Biogasaufbereitung mit Membrantechnik
Michael Harasek
Vienna University of Technology, Department of Process Engineering
Vienna 2005

INFORMATION PUBLICATIONS

The final reports on the abovementioned projects have been published in the bmvit series "Reports on Energy and Environment Research" and are available in from: www.NachhaltigWirtschaften.at

Project 1: Biogas-Netzeinspeisung
19/2005
Project 2: Biogas – Einspeisung und Systemintegration in bestehende Gasnetze
1/2006
Project 3: Aufbereitung von Biogas zur Einspeisung in das Salzburger Erdgasnetz
8/2006
Project 4: Effiziente Biogasaufbereitung mit Membrantechnik
9/2006

PROJEKTFABRIK
A-1180 Vienna, Währinger Straße 121/3
versand@projektfabrik.at

Further informations you will find on the website:
www.energytech.at/biogas

F I G U R E S / D A T A / F A C T S

FORSCHUNGSFORUM *provides information on selected projects within a bmvit program focusing on "Sustainable Economy". Published by the Austrian Federal Ministry for Transport, Innovation and Technology (bmvit), Division for Energy and Environment Technologies; Director: Dipl. Ing. M. Paula; Renngasse 5, A-1010 Vienna, Austria. Coverphoto and diagrams: erdgas oö, PROFACTOR Produktionsforschungs GmbH, Vienna University of Technology, Department of Process Engineering, FH Joanneum GmbH, Projektfabrik. Editors: Projektfabrik, Währingerstrasse 121/3, A-1180 Vienna. Layout: Wolfgang Bledl; Printed by: AV+Astoria Druckzentrum GmbH, Faradaygasse 6, A-1030 Vienna.*

FORSCHUNGSFORUM is published four times a year and is available for free from: Projektfabrik, A-1190 Vienna, Währinger Straße 121/3, versand@projektfabrik.at

P.b.b. Erscheinungsort Wien, Verlagspostamt A-1010 Wien.