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FEEDING BIOGAS INTO THE GRID – DEMONSTRATION FACILITY IN BRUCK AN DER LEITHA

Developing innovative technologies to produce and treat biogas, feed it into the grid and charge for it within the subprograms “Energy systems of Tomorrow” and “Factory of Tomorrow”

bmvit
Austrian Federal Ministry of Transport, Innovation and Technology

DEVELOPING INNOVATIVE TECHNOLOGIES TO PRODUCE AND TREAT BIOGAS, FEED IT INTO THE GRID AND CHARGE FOR IT

Today the usual way of utilizing the energy content of biogas is to generate electricity by burning biogas in gas engines, at 35 to 40 % efficiency. As energy and raw materials go up in price, it becomes increasingly important to make use of the waste heat given off, from the point of view of running a biogas facility efficiently as regards both ecology and economics, which is why numerous regional district heating schemes are tied in here.

An alternative approach is to treat the biogas stream. Treated biogas can make a perfectly satisfactory substitute for natural gas as a fuel both for households / industry and for vehicle engines designed to run on CNG. Existing infrastructure – pipelines, storage vessels, filling stations etc. – can be used to supply the gas produced to the consumers.

In contrast to other biogenous sources of energy, biogas could conceivably cover up to 25 % of natural gas consumption in Austria. Biogas' share of primary energy sources in Austria could go up dramatically if it can be purified and fed into the natural-gas grid. This way treated biogas could be transported without further losses to the customer, where its primary energy content can be exploited efficiently.

As part of the subprogram "Energy Systems of Tomorrow" feeding biogas into the natural-gas grid was implemented in a comprehensive project for the first time in Austria. Since 2007 a demonstration facility in Bruck an der Leitha has been purifying biogas to natural-gas standard at a rate of 180 m^3/h and feeding up to 800,000 m^3 per year into the grid. The project reveals that purifying biogas to natural-gas standard is technically feasible, energy-efficient and economically profitable.

As part of the demonstration project located in the ***Bruck an der Leitha Energy Park***, a consortium of eleven project partners is engaged in analysing and optimizing the value creation chain, from producing raw material via producing and treating biogas all the way to using it as an engine fuel.

In separate supplementary workpackages the project team are concerned with overall process management, i.e. coordinating and controlling feeding biogas into the grid, and with the key aspect of charging for the "virtual" biomethane fed in.

Within the "Factory of Tomorrow" subprogram, MABA Fertigteilindustrie GmbH is heading an innovative project to develop a radically new type of prefabricated biogas vessel, first installed as part of the biogas facility in Bruck an der Leitha. Standardized industrial fabrication of a vessel with a completely new sealing system and design principle has successfully eliminated a number of engineering problems connected with designing, installing and operating such vessels.

As long ago as 1999 the Austrian Federal Ministry of Transport, Innovation and Technology (bmvit) launched the "Sustainable Development" research and technology program, aimed at effectively supporting the process of restructuring towards sustainability. Since then both R & D projects and demonstration and diffusion activities that lend new impetus to innovation in Austria's economy have received support within the scope of a number of subprograms.
The "Energy Systems of Tomorrow" subprogram is aimed at developing technologies and concepts for a flexible, energy-efficient energy system based on using renewable energy sources and capable of safeguarding our energy requirements long-term. System issues, approaches and technologies are researched and developed within the subprogram, as are implementation strategies.
In the „Factory of Tomorrow" subprogram, pioneering pilot projects in the field of developing sustainable technologies are promoted. Model cases may include sustainable technologies and innovations in production processes, the use of renewable raw materials or products and services consistently oriented toward product utility.

Bruck an der Leitha Energy Park
The association "Bruck an der Leitha Energy Park" is involved in projects concerned with renewable sources of energy, climate protection, environmental protection and regional development. It acts as a centre of innovation and a motor of development. The Energy Park includes several firms – Windpark Bruck/Leitha, Windpark Petronell-Carnuntum, Biomasse-Fernwärme Bruck/Leitha – and the facility BIOGAS Bruck/Leitha.

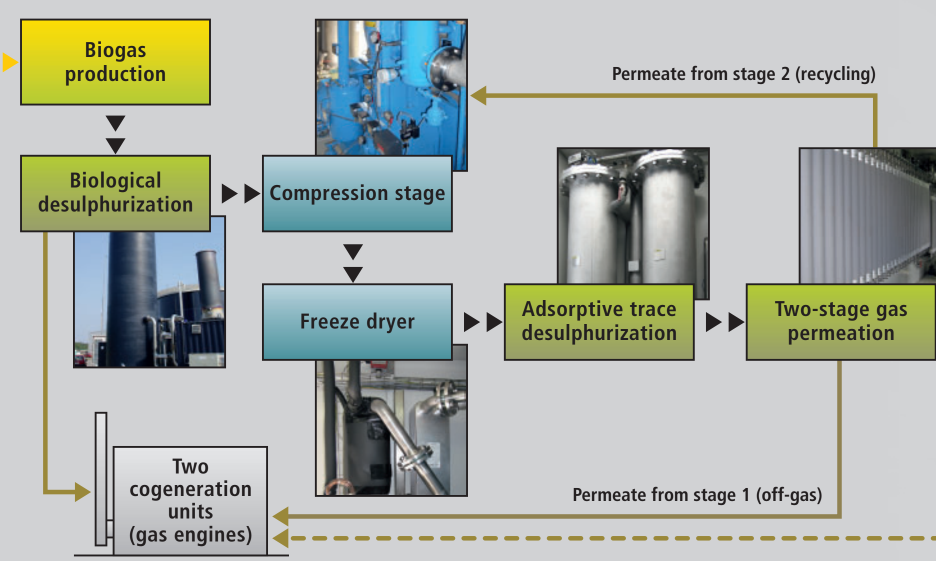
FEEDING BIOGAS INTO THE GRID IN BRUCK AN DER LEITHA

The biogas facility in Bruck/Leitha started operation in May 2004. It involves co-fermentation, i.e. it handles both agricultural substrates (grass, beet and maize silage, liquid manure etc.) and products/residues from food processors. The biogas produced is used to generate electricity and heat in a cogeneration facility. Electricity is fed into the grid (some is used in the facility itself). The heat produced is used to heat vessels and for space heating; some is fed into the Bruck/Leitha district heating grid. The residue cake left over from fermentation is returned to the agricultural production areas as fertilizer.

Within the **pilot project "Virtual Biogas"** crude gas from the biogas facility in Bruck an der Leitha has been treated and fed into the EVN grid since 2007. The gas is passed through to the CNG filling stations operated by the project partners EVN, Wien Energie and OMV. It can thus be sold "virtually" (i.e. for invoicing purposes) to consumers far from the feed-in point. Since 2007 treated biogas has been fed into the grid at rates up to 100 m^3/h (800,000 m^3 per year) – enough to supply more than half the CNG in Austria. In Bruck an der Leitha a new treatment process developed at Vienna University of Technology, using membrane technology to purify the gas stream to natural-gas standard, is employed. Following extensive tests in the laboratory and a pilot plant, the principle of gas permeation was put to work on an industrial scale on this site for the first time in Austria. In spring 2007 Axiom Angewandte Prozesstechnik assembled the equipment in a standardized 30-foot container on its premises and transferred it to the final destination, the co-fermentation facility in Bruck an der Leitha, where it was officially started up in June 2007. Routine feeding-in at varying rates began in January 2008. Since then the treatment unit has been in continuous operation, and serves as a demonstration unit for the technology in question. A range of inspection appointments, excursions and presentations are on offer on site.

Using this new technology, the treatment unit purifies 100 m^3/h of crude biogas to the required natural-gas quality standard. Eliminating sulphur and ammonia, and drying the gas stream, involves several steps. Finally the carbon dioxide present is removed. The key technology here is gas permeation, using selectively permable membranes to separate carbon dioxide from methane.

Treating Biogas and feeding it into the Grid in Bruck an der Lei



For the facility in Bruck/Leitha a two-stage membrane configuration was chosen. Crude biogas is mixed with the permeate recycled from the second membrane stage, compressed and then cooled to a temperature below 7°C, which dries it. Next the gas is heated to the ideal temperature for the stages beyond, using some of the waste heat from the compressor. Trace desulphurization is followed by treatment in the two-stage membrane configuration, which was chosen in order to minimize overall methane wastage. Here "wastage" refers to the share of methane in the crude biogas that is vented with the off-gas, rather than being fed into the natural-gas grid. In this configuration the permeate from membrane stage 2, which contains significantly more methane than that from membrane stage 1, is returned and recompressed. The permeate from membrane stage 1 functions as a sink for the carbon dioxide involved, and leaves the treatment unit as off-gas. Like all other separation methods, gas permeation is unable to transfer 100 % of the methane contained in the crude biogas to the product stream: some of this methane is separated out, which is why the off-gas contains a small proportion of methane (typically 2 to 3 % of the biomethane produced). For this reason, in order to avoid emitting any methane at all,

Factbox
Biogas facility in Bruck an der Leitha

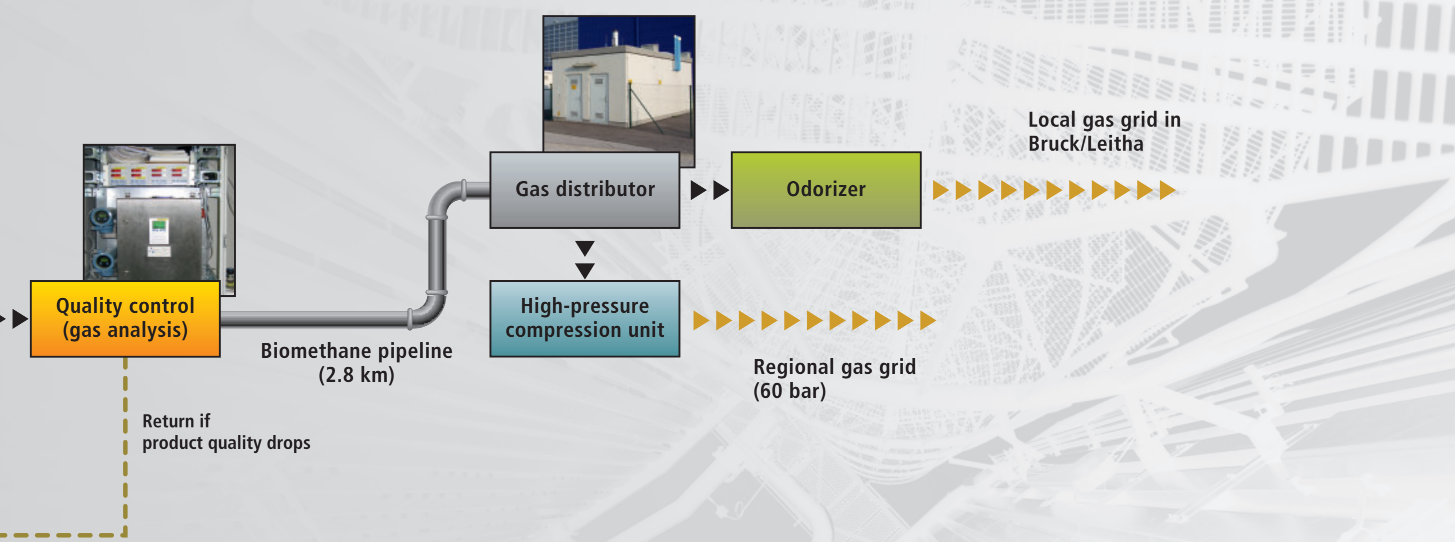
- *Annual electricity production 12,000,000 kWh*
- *Annual heat production 15,000,000 kWh*
- *2 digesters (3,000 m^3 each)*
- *2 secondary digesters (5,000 m^3 each)*
- *2 cogeneration facilities (826 kW_{el} each)*
- *Biogas fed into grid: 800,000 m^3/year*

This process, which achieves a methane content of more than 99 %, is attracting international attention (cf. FF 1/2009). The product gas (biomethane) complies in all respects with the relevant Austrian guidelines laid down in ÖVGW G31/G33, and thus qualifies for feeding into the grid as a perfectly adequate substitute for natural gas.

Using the product as virtual biogas for gas-fuelled vehicles makes the overall process cost-effective. The biomethane fed in is routed to the neighbouring community Bruck an der Leitha at a pressure of around 3 bar. In the winter months all the gas produced is consumed here; in addition, fossil natural gas is bought in to avoid shortfalls in supplying the community. In the summer months local gas consumption is much lower; excess biomethane is then compressed to 60 bar and fed into the regional grid. This arrangement ensures that the biogas treatment unit can run at a constant level all year round – the facility can be used to the full, with a satisfactory cost structure. The demonstration project has aroused considerable interrnational interest; by now it is seen as a reference facility. Several thousand visitors have inspected the facility to date. In benchmark comparison with technologies employed in other countries (Germany, Sweden) the facility scores well, so there are good chances of the treatment technology in question catching on – initially in neighbouring European countries.

na: Process sequence

Source: Vienna University of Technology/Institute of Chemical Engineering



the new treatment unit has been fully integrated in the existing biogas facility in Bruck an der Leitha: the residual methane is not vented, but passed to the gas engines in the existing cogeneration units. This way the chemical energy in the off-gas is used to produce electricity and heat. The way in which the biomethane stream is then handled is also interesting. Gas composition is analysed on line (to monitor all relevant components: methane, carbon dioxide, oxygen, hydrogen suphide, water vapour), before the gas is passed via a pipeline 2.8 km long to a gas distributor. If gas composition strays outside the limits laid down in Austrian regulations, the supply line to the outside world is shut off immediately, and the product gas is passed to the gas engines in the biogas facility instead. In such cases the automatic control system returns gas composition to the setpoint values; once quality is satisfactory again, gas is fed into the grid once more.

PREFABRICATED BIOGAS DIGESTER

In a pilot project supported within the framework of the "Factory of Tomorrow" subprogram, a digester with a capacity of 3000 m^3 to produce biogas was assembled from prefabricated concrete elements: an industry first. The collaboration partners in this research project were MABA Fertigteilindustrie, responsible for fabrication technology, overall project management and erection, and Wopfinger, who contributed a special concrete technology.

As a rule, biogas digesters are fabricated in in-situ concrete, stainless steel or enamelled steel plates. In practice each of these choices has various disadvantages as regards fabrication cost, time required for erection, seal reliability, ensuring processing quality throughout, resistance to corrosion , and maintenance costs. The high price of the material makes stainless steel vessels extremely expensive; enamelled steel plates are less expensive, but there is a risk of the enamel being damaged during erection. The most common version involves in-situ concrete, which requires elaborate formwork. The quality of the pre-mixed concrete supplied necessarily varies with fluctuations in weather, journey time and temperature; as a result, it is not always possible to fill the formwork completely, and cavities and/or cracks can develop in the concrete, frequently making repair work necessary at an early stage.

The requirements applying to a biogas vessel that can also operate as a digester include:

- resistance to acids (in extreme cases, where gas is desulphurized with air oxygen, up to a pH value of 2 in the gas space)
- efficient liquid seal under a hydrostatic pressure of as much as 1.2 to 1.8 bar on the vessel floor
- efficient gas seal in relation to the gauge pressure in the gas space within the vessel (15 mbar)
- satisfactory blending of substrate during digestion

As regards the prefabricated concrete elements, the specific design of the new biogas vessel takes its cue from tunnel construction. With prefabrication all elements are produced under industrial conditions, which makes exact process and quality control feasible. The quality of the concrete and the processing are consistently high – very different from conditions on site. As prefabrication is extensive and the prefabricated elements are large, erection on site goes quickly. Prefabrication lowers life-cycle costs a second time when dismantling the elements turns out to be extremely straightforward.

A specially ground slag sand was used as binder in making the prefabricated elements. In comparison with ordinary CEMI cement, this binder has real environmental advantages: 90 % less CO_2 is released during production. The resulting concrete is more resistant to acid and resists chemical attack much better than the material previously employed. It is no longer necessary to apply a coating to the inside of the digester; here again, material and expense are saved.

The roof structure also consists of prefabricated concrete elements, so it was feasible to install a central agitator (not possible in conventional designs with a foil roof). This arrangement has advantages over placing agitators on the side walls, since the substrate is blended more efficiently and digestion goes better. The biogas vessel is 12 metres high and 19 metres in diameter. The walls are made up of 22 elements 11.6 metres high, 18 centimetres thick and weighing 16 tonnes each. The roof was put together from 15 prefabricated elements. The entire wall and roof were erected in only five days.
To accommodate the hydrostatic pressure inside the digester, tendons supplied by VORSPANN-TECHNIK VT, Salzburg, were fitted around the outside of the vessel.
On completion of work, the digester was tested for gas and liquid leaks. The MABA vessel is leak-free up to 2 bar (liquids) and 15 mbar (gases). The first prefabricated concrete biogas vessel has been operating in Bruck an der Leitha since January 2009.

Advantages of prefabrication

- ***Maximum endurance due to high-grade starting materials***
- ***Resistance to acids without additional coating***
- ***Cost savings due to shorter erection times***
- ***Highly efficient central agitator***
- ***Operating reliability and ease of maintenance are improved***

PROCESS CONTROL AND CHARGING FOR BIOGAS

Process management plays a key role in ensuring that the biogas treatment unit operates as flexibly and transparently as possible. The aim is a facility that can be maintained and controlled remotely with an absolute minimum of hazard. In biogas treatment and grid supply in Bruck an der Leitha process control is handled by systems developed at the Vienna University of Technology (in the research area of thermal process engineering and simulation). These systems couple all the available inputs (instrument data, sensor responses) intelligently with the outputs (controller actions, adjustment signals). Customized software capable of presenting the "visage" of the facility in question is used for process visualization, i.e. the human/machine interface.

For electricity from renewable sources a recognized **charging procedure** already exists; for biogas in grids (biomethane) such a procedure is yet to be established. How to coordinate gas

supply to the grid from a biogas facility, and how to charge for the quantities of gas supplied, was also worked out in a separate project. Charging for biomethane "virtually" is set up very much like charging for electricity from renewable sources, using the concept of defined accounting periods: in the period in question the amounts of electricity from renewable sources generated and consumed must be equal. The arrangement is the same for biomethane: the gas suppliers can sell (e.g. at CNG filling stations) only the amount actually fed into the grid within the accounting period defined. Invoicing is verified during the obligatory annual audit of the firms concerned.

In addition, EVN are one of the first energy suppliers to document technically the ecological credentials of biomethane production and use. TÜV Austria have certified the process of invoicing and documentation, which encompasses all production facilities and raw materials involved, all metering equipment and connections, the various utilization paths (district heating, CNG filling stations, electricity from renewable sources, feeding points to other grids), and all contracts and invoices. Provided that the findings are satisfactory, a certificate of "verified biomethane origin" is issued; any discrepancies in quantity must be evened out in the following financial year.

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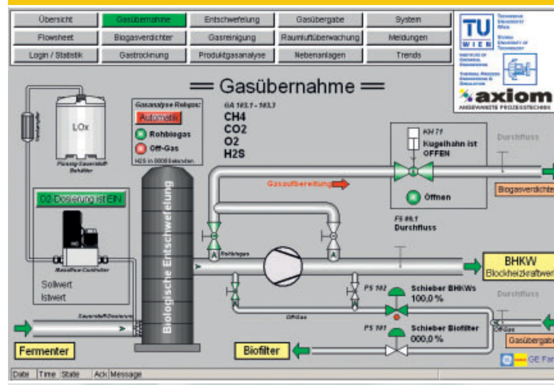

FIGURES / DATA / FACTS

PROJECT PARTNERS

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www.virtuellesbiogas.at
www.energiepark.at

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Vienna University, Department of Risk Research

INFORMATION PUBLICATIONS

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