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Biomethane

Biomass for Energy

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Biomethan

Energetische Biomassenutzung

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Biomethane

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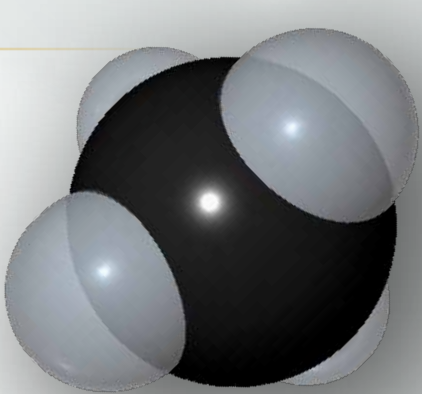
Biomethane

Biomethane is defined as methane, which is produced from biogenic resources by technical processes. Biomethane can be generated by bio-chemical conversion (via biogas) or thermo-chemical conversion (via Bio-SNG). By certain upgrading measures the gas composition and especially the methane content is upgraded to natural gas quality. Alternatively bio natural gas is used as term for biomethane.



Editorial

Dear Readers,

Renewable energy is one of the mainstays of a sustainable energy supply in Germany. Through a targeted subsidies policy and accompanying growth, many positive effects have already been achieved. Apart from a significant reduction in greenhouse gas emissions, numerous of investments have been made in plants and production capacities and therefore a large number of jobs have been created. The bioenergy industry has already achieved considerable economic success. The transfer of innovative technologies has also resulted in the starting up of numerous international cooperations.

To make the environmental and energy policy a success story in the 21st century too, it is not only necessary to achieve progress in energy efficiency and lowering power consumption but also to match the individual renewable energy sources to each other in line with demand. In particular, bioenergy must be used when and where other alternatives are not available. Biomethane, which is fed into the natural gas network, offers enormous potential for use here, not only for combined heat and power production (CHP) but also in the fuel sector. The first plants for biomethane production and injection have now been in operation in Germany for six years.

Apart from sustainable development of domestic sources, particular attention should also be paid to cross-border trading with biomethane. Although very good potential for Europe-wide trading already exists due to the available pipe network, there are considerable hurdles in the way of transnational injection and output of biomethane: Gas network access and rights of use, gas qualities, traceability from the producer through to the end user and establishing sustainable markets are only a few of the obstacles to be overcome. While trading with solid and liquid biogenic fuels is currently being established, biomethane trading is still in the initial stage; nonetheless, a reliable base of scientific studies, the first promising examples and transferable experience already exist.

The articles in this brochure are exemplary focused on these issues and describe country profiles, innovative approaches and the expectations of the producers and purchasers of trading with biomethane. Only through interdisciplinary and international exchange and by highlighting functioning examples is it possible to examine their transferability and to develop biomethane trading.

Enjoy reading!

Prof Daniela Thrän
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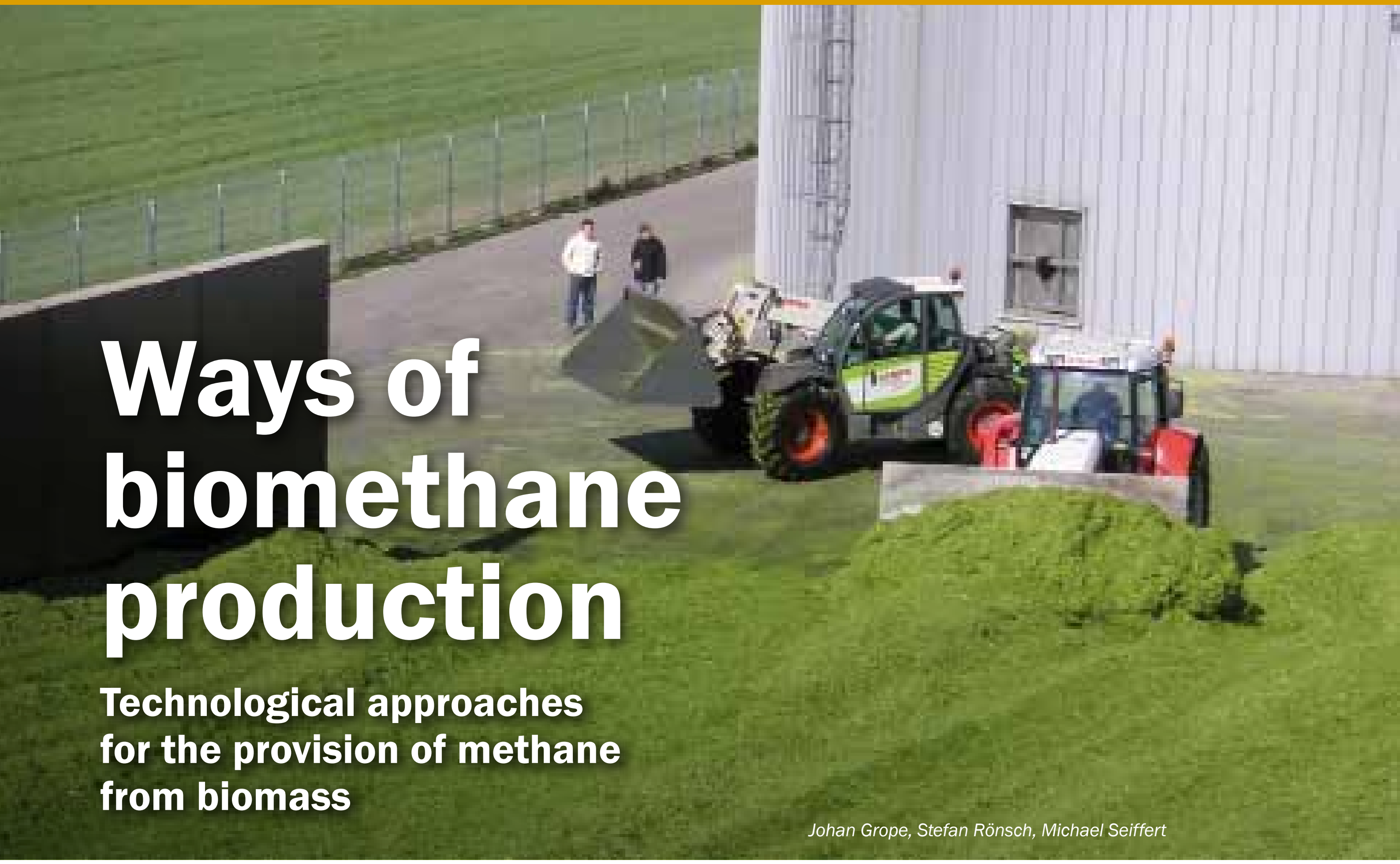


Ways of biomethane production

Technological approaches for the provision of methane from biomass

Johan Grope, Stefan Rönsch, Michael Seiffert

The utilisation of natural gas within the European energy system is of high importance. Intensive activities concerning the substitution of natural gas with so called biomethane or synthetic natural gas (Bio-SNG) are currently ongoing, in order to meet the governments objectives in the context of climate protection and diversification of energy sources. A number of concepts are available such as, the production of biomethane from the bio-chemical conversion of biomass (biogas) and via thermo-chemical conversion of solid biomass, so called Bio-SNG. Technologies for the feed-in, distribution, as well as utilisation of biomethane are mature and have already been used in commercial projects in many European countries. Methane, or in this context biomethane, has a high market potential as a well-known energy carrier (transport sector, stationary applications (heat and power)) and for material utilisation too. Within the existing and well developed natural gas grid in Europe biomethane can easily be fed in and distributed to the final consumer in industry and households.

Beside the above mentioned advantages, the combustion properties of methane are already well known and characterised through comparably low emissions.

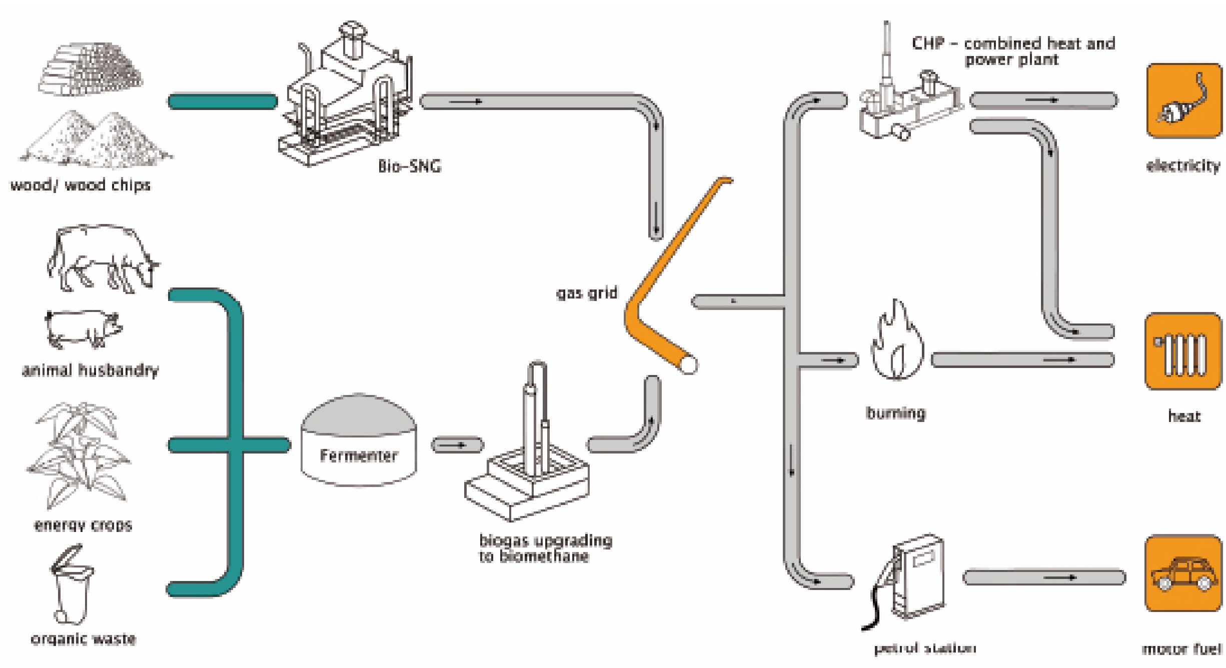


Figure 1: Value chain of biomethane production and use

Basics of biomethane provision

Due to the aspects of climate protection and availability numerous political decisions like the EU implementation of the Kyoto-protocol, the EU wide CO_2-control for passenger cars and light duty vehicles, the exhaust standards for passenger cars and duty vehicles (reduction of particles and NOx-emissions) or the diversification of fuel mix – the energy carrier natural gas and therefore biomethane gained importance. Biomethane can be added to natural gas and allows therefore an increase of domestic resources as well as an improvement of confidence in terms of a secure gas provision.

Besides numerous technical benefits, like the possibility to store biomethane and provide demand oriented and flexible energy, biomethane can contribute significantly as a „green" and environmentally sound energy carrier to fulfill the greenhouse gas reduction goals. Biomethane can be a market opener for increasing gas sales within the transportation sector, because of its low environmental impact in comparison to other fuels. Additionally, biomethane can also be used with high conversion efficiency within the heat and the electricity market.

The bio- and thermo-chemical conversion routes allow both the provision of biomethane for the subsequent feed-in or application within the mobile and stationary sector. Nevertheless, numerous aspects distinguish the pathways significantly.

For the production of biogas mainly substrates like excrements from animal husbandry, energy crops or organic residues (e. g. household; industry) are used. Against this background the raw material supply chain can be based from a local up to a regional logistic concept. This has a significant impact on the plant capacity which is in a typical range of a few MW_{CH4} for agricultural plants to several 10 MW_{CH4} for conversion plants using industrial residues.

In comparison, the production of biomethane via gasification is based on lignocellulose like woody biomass. Thus, logistical concepts can be applied that are already in use for the pulp and paper, as well as wood processing industry, which are typically regional up to transnational. Expected conversion plant capacities are in the range of several 10 MW_{CH4} up to a few 100 MW_{CH4} [1]. Thus, both concepts complete each other in terms of biomass assortments and logistical concepts.

In the following sections the main technical steps of the single biomethane provision concepts based on biomass will be described briefly.

Biogas pathway

The bio-chemical conversion pathway of biomass to biomethane can be subdivided into two main process steps: (i) the biogas production based on anaerobic digestion or rather wet fermentation of biomass residues (and organic wastes) as well as energy crops (e.g. maize silage) and (ii) the upgrading of biogas or rather raw-biogas to biomethane.

The production of biogas has a long history and has become a market mature technology for the provision of electrical and/or thermal energy in conversion units with capacities ranging from a few kW_{CH4} up to 10 MW_{CH4}. For a long time it was common practice to provide energy only directly from biogas without any or just a crude purification. For making the advantages of biomethane, which were mentioned above, more accessible, the upgrading of raw-biogas to biomethane has become a more prominent alternative to the utilization of the biogas on-site. In many European countries projects using biogas-upgrading plants have been established and these upgrading technologies have been shown to be suitable for daily use, even though there is still a high potential for optimizing the existing biogas upgrading plants and developing new biogas upgrading technologies. In the following sections, the two main process steps involved in the bio-chemical conversion of biomethane production will be described with a focus on the second step, the upgrading of biogas to biomethane:

Raw-biogas production

Biogas can be produced out of any organic material under anaerobic conditions. Microorganisms convert the biomass to biogas in several sub-steps. Many settings, besides the anaerobic conditions, like e. g. temperature between 37 and 42 °C (mesophilic conditions) or 50 to 60 °C (thermophilic conditions), the adequate biomass mix or the provision of the microorganisms with nutrient matter influence the efficiency and the stability of the biogas production process. There are many different processes within the digester which can influence the efficiency and stability of the biogas production process, for examplethe anaerobic conditions, like e. g. temperatures between 37 and 42 °C (mesophilic conditions) or 50 to 60 °C (thermophilic conditions), the adequate mixing of the biomass or the provision of adequate nutrients to the microorganisms. Primarily, depending on the feedstock, the composition of the biogas varies from 50 to 75 % methane (CH_4) and 25 to 45 % carbon dioxide (CO_2). Besides these main components, raw-biogas is saturated with water and contains different micronutrients; the most important is hydrogen-sulphide (H_2S). [2]

Upgrading of raw-biogas to biomethane

Before biogas can be injected into the gas distribution system, it must be upgraded to gas with equivalent quality characteristics to natural gas, or so called "biomethane" gas. To achieve this, the CH_4 content of the biogas must be increased, which is being done by removing most of the CO_2 from the biogas. Furthermore the gas has to be dried to a certain water dew point, depending on the pressure of the gas grid, where the biomethane is supposed to be injected. Last but not least, different micronutrients – essentially the H_2S – have to be removed from the rawbiogas. An exemplary illustration of the process steps of biogas upgrading to biomethane is shown in figure 2.

The technologies for the removal of CO_2 differ in the principle means of separation between CH_4 and CO_2, important operational parameters include, the necessity of a pre-purification (mainly removal of H_2S), the required operation pressure, the heat demand or rather the temperature for the regeneration process, the methane loss and the methane content of the product gas at normal process design (cf. tab. 1). Most technologies for upgrading biogas are based on well-established processes for upgrading natural gas or process gases of different origin [3]. Upgrading technologies, which are mainly used for the treatment of biogas, will be shortly described in the following.

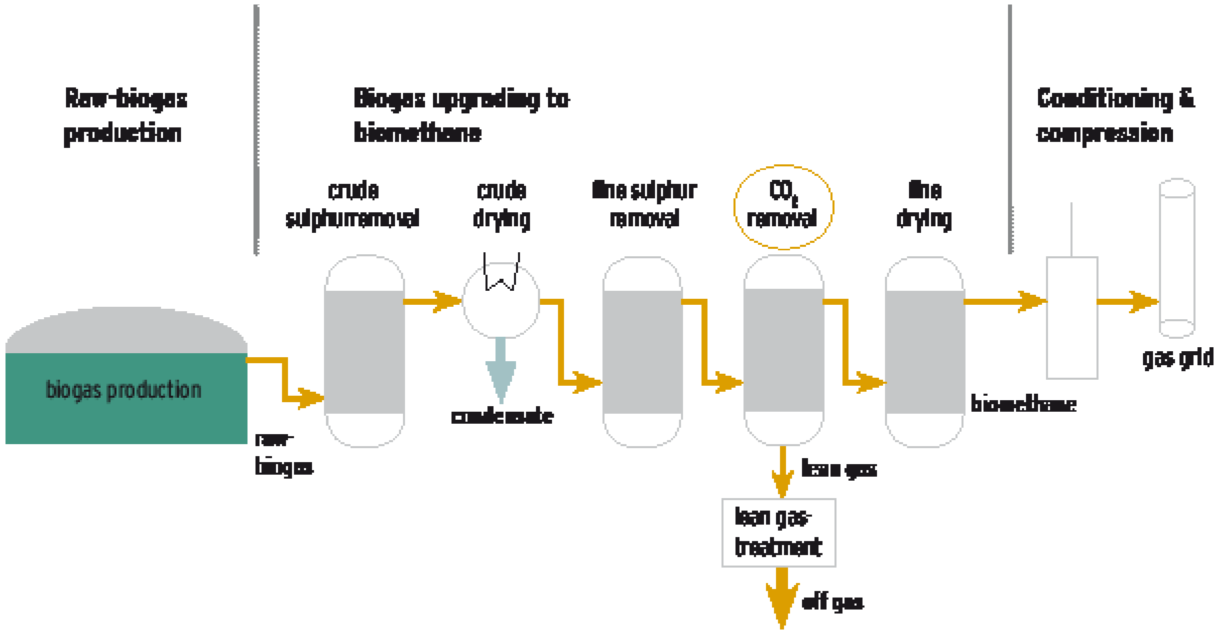


Figure 2: Process steps for upgrading biogas to biomethane (see [3] Graf, Bajohr, et al.)

Pressure Swing Adsorption (PSA)

The PSA refers to the fact that gas molecules' adsorption ability differs and highly depends on the partial pressure. In PSA CO_2 and remaining traces of other gases from raw biogas are removed through adsorption onto an adsorbent (e. g. active carbon) at high pressure (4 to 10 bars). The adsorbent is being regenerated at low pressure.
H_2S and water vapour must be removed from the raw biogas before coming in contact with the adsorbent, since these substances can damage the active carbon required in the process.

Pressurized water scrubbing (PWS)

PWS is a physical absorption process and is based on the principle of different solubility of gases in washing solutions, depending on pressure and temperature. In common technologies, the biogas is separated into CH_4 and CO_2 in water-filled pressure columns (mostly at around 7 bars), where CO_2 and other components like H_2S are being absorbed by the water. By lowering the pressure and with the help of stripping air jet of air to remove, the CO_2 is desorbed afterwards which allows the water to be used in a closed loop. A drying of the biomethane afterwards is necessary.

Genosorb

Like PWS, this biogas upgrading process is based on a physical absorption.
Unlike to the PWS a washing solution that is highly absorptive of CO_2 and H_2S is involved. The washing solution Genosorb is regenerate at high-temperatures up to 80 °C.

Amine washing

The cleaning of biogas using amines (e. g. monoethanolamine) is based on a chemical reaction between the CO_2 and the amine washing solution. The process can be implemented with atmospheric pressure or only minimal pressure above, though it requires a standard temperature for the regeneration of the loaded washing solution between 100 and 180 °C.

Seperation by membranes

The separation of CO_2 and CH_4 by membranes is based on a selective permeation of the membrane. The process only works with a pressure difference between the up- and the downstream of the membranes. Operational pressures in common technologies vary between 6 and 10 bars. As high permeation results in low selectivity between CO_2 and CH_4, a compromise between high methane losses and high methane content in the product gas has to be found. The cleaning of the raw biogas before entering the membranes is of high importance, as H_2S, water and particles can cause damage of the membranes.
All upgrading-technologies cannot achieve a complete separation of the CH_4 and the CO_2. This causes a loss of methane, leaving the process with the lean gas or rather the CO_2-stream. To avoid high methane emissions, a treatment of the lean gas, e. g. by a catalytic or regenerative oxidation, can be necessary.

Bio-SNG Pathway

The conversion of biomass into Bio-SNG is not as far developed as the biomethane production via biogas. Current biomass gasification based on water vapour (as gasification medium) for the production of heat and electricity is successfully demonstrated and mature. The required subsequent methanation was realised in a demonstration stage with a MW thermal capacity so far [4]. The Bio-SNG production is characterised by the possibility of using relatively small conversion units with capacities in a range of 10 up to

	PSA	PWS	Gensorb	Amine	Membrane
pre-purification	yes	roughly	roughly	yes	yes
methane loss	2 – 10%	1 – 2%	1 – 4%	< 0,1%	3 – 5%
methane content in product gas	> 96%	> 97%	> 97%	> 99%	96 – 98%
operating pressure [bar]	4 – 10	4 – 10	4 – 8	–	6 – 8
heat demand [°C]	–	–	55 – 80	100 – 180	–

Table 1: Process parameters of different biogas upgrading technologies, source: DBFZ

100 MW_{bf}. Hence, the conversion of regionally available lignocellulosic biomass is feasible.
The production of synthetic biofuel, electricity and heat (so called tri-generation) allows high overall efficiencies (e. g. high CO_2 mitigation potential) within the entire production process. As distinguished from the production of BtL fuels (like Fischer-Tropsch-fuels), the Bio-SNG production system is characterized by lower technical and financial risks due to a technology that is less complex (e. g. raw product upgrading). Based on these circumstances a rapid and easy market entrance could be possible.
The thermo chemical production pathway of synthetic natural gas aims to convert solid biofuels into gas with relatively high methane content (approx. 95 %). The conversions pathway from biomass to Bio-SNG can be subdivided into five process steps: (i) biomass pretreatment, (ii) biomass gasification, (iii) raw gas cleaning, (iv) methanation and (v) raw-SNG upgrading.

Biomass pre-treatment

Due to its heterogeneous characteristics biomass has to be pretreated before gasification to ensure a reliable feeding into the gasification reactor on the one hand and to allow optimal gasification conditions inside the gasification reactor on the other hand. Thereby, in general, the pre-treatment focuses on an adaption of the biomass size to meet the demands of the feeding system and of the drying of the biomass to reduce the energetic losses of the gasification process.
As entrained-flow gasifiers require a pumpable or dispersible fuel, their application demands a special biomass pre-treatment (e. g. pyrolysis, torrefaction). The biomass pre-treatment can be distinguished between mechanical, thermal and thermo-chemical pretreatment.

Biomass gasification

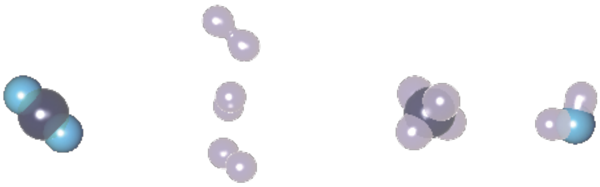
Gasification is a thermo-chemical conversion process, where the gasification media (pretreated fuel) is converted into gaseous fuel (called raw gas) with the main components CO_2, CO, H_2O, H_2 and depending on the gasification parameters certain amounts of CH_4. [5]
As the process is basically endothermic, heat is needed for the process. Beside the main gas components the raw gas contains different impurities, such as particles, tars, sulphur compounds, nitrogen compounds, halogens and alkali compounds. The amount of impurities depends on multiple process conditions and can be influenced by gasification technology and conditions.
Gasification processes can be distinguished according to the (i) gasification agent, (ii) gasification pressure level, (iii) heat supply and (iv) the reactor design.

Gas cleaning

Depending on the gasification parameters (e. g. reactor design, gasification pressure, gasification temperature and gasification agent) the raw gas contains different impurities as particles (e.g. char, dust, ash, bed material), tars (e. g. C_7H_8, $C_{10}H_8$), sulphur compounds (e.g. H_2S, COS, thiophenes), nitrogen compounds (e.g. NH_3, HCN), Halogens (e. g. HCl) and alkali compounds (e. g. Na- and K-compounds).
To avoid catalyst poisoning in the subsequent synthesis (e. g. caused by organic sulphur) and damage of other plant components (e. g. corrosion of heat-exchanger surfaces) the raw gas has to be cleaned after leaving the gasifier. To remove the impurities mentioned above, various cleaning methods are available at the market.

Methanation

The process step methanation comprises of a catalyst-based synthesis with the aim to increase the methane content of the cleaned gas.
Thereby, the gas components hydrogen and carbon monoxide are converted to methane and water-steam (see equ. 1).



$$CO + 3\,H_2 \longrightarrow CH_4 + H_2O$$

Equ. 1

In principle, all metals of the 8th group catalyse the methane synthesis. However, due to their availability and price stability the use of nickel catalyst is of particular interest. The catalysts work in a wide pressure (1 – 80 bar) and temperature range (250 – 650 °C), but, the desired formation of methane is enhanced at low temperatures and high pressures. To ensure a high carbon monoxide conversion, a H_2/CO-ratio of at least 3/1 is advisable. However, as raw gases from biomass gasification processes are typically characterised by H_2/CO-ratios of 0.3 – 2.0, an adjustment of this ratio is generally foreseen either by adding additional hydrogen or by converting carbon monoxide and water-steam into hydrogen and carbon dioxide according to the water gas shift reaction. As nickel catalysts catalyse the water gas shift reaction well at elevated temperatures and pressures, the water gas shift reaction can be integrated in the methanation reactor instead of an upstream shift-reactor before the methanation.
Basically, methanation reactors can be distinguished according to the fluid-dynamic behaviour of their catalysts in fixed-bed reactors and fluidised-bed reactors. [6]

CHP Güssing, photo: DBFZ

Raw-SNG upgrading

To feed Bio-SNG into the natural gas grid, it has to fulfill the quality requirements of the grid. Therefore, a final raw-SNG upgrading step after the methanation is necessary. The raw-SNG upgrading includes the separation of carbon dioxide, water and – depending on the raw-SNG quality, other gas components (e. g. hydrogen). Therefore, beside the Bio-SNG composition and purity, the Wobbe index is of particular interest. For all raw-SNG upgrading steps several technologies are currently available at the market and in operation for coal gas treatment processes, natural gas treatment processes and biogas upgrading processes. However, due to their different technical and operational effort, selected technologies are advisable for small scale and others for large scale applications.

The production of SNG can occur so far within a very promising concept via the steam gasification of woody biomass with water as gasification agent, gas cleaning, subsequent methanation and upgrading.

The steam gasification and the gas cleaning have been demonstrated successfully in a full technical scale for instance at the biomass combined heat and power (CHP) gasification plant in Güssing/Austria.

In the following numerous gasification plants were established (Austria: Oberwart, Villach; Germany: Ulm) or are currently within its planning phase (Austria: Klagenfurt; Sweden: Gothenburg).

Generally, steam gasification leads to a producer gas with a relatively high content of hydrogen and methane as well as a low content of nitrogen. These properties are necessary for an efficient SNG production. Within figure 3 an overview to the Bio-SNG production process is given.

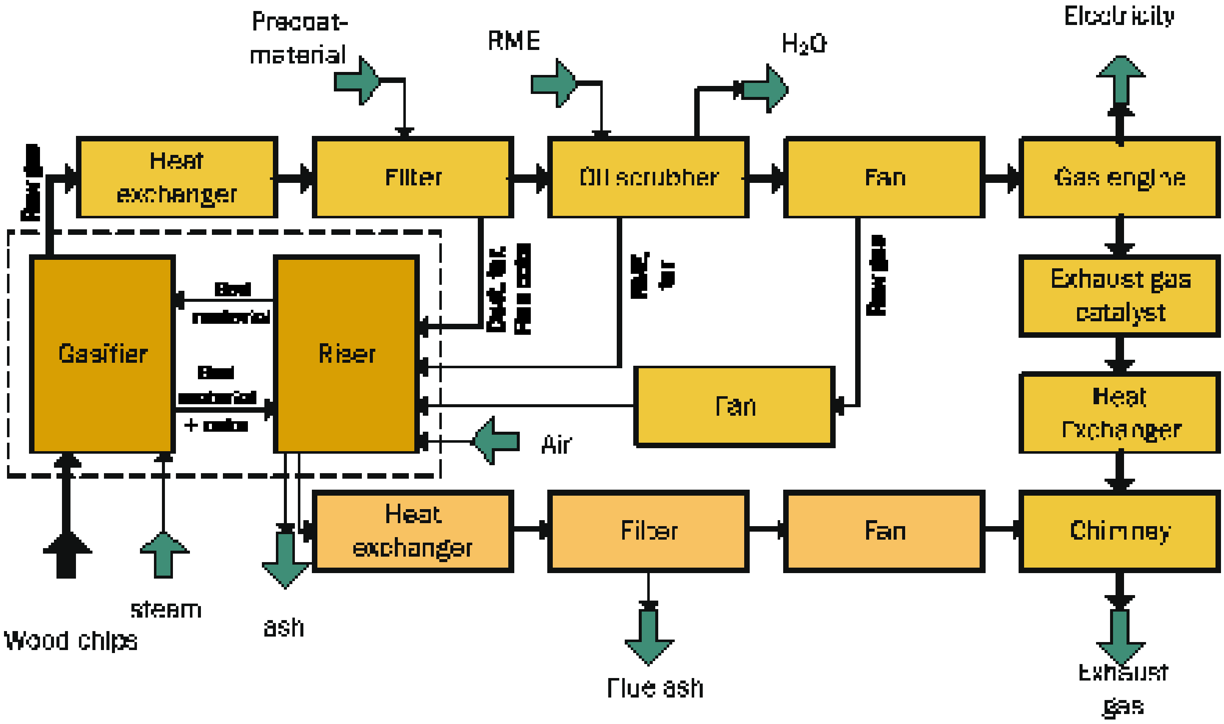


Figure 4: Process flow diagram (Bio-SNG)

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Biomethane derived from agriculture

Upgrading of biomethane in Grabsleben/Thuringia

Heike Gröber, photos: DBFZ

In the middle of Thuringia, in the Erfurt Basin, lies the picturesque village of Grabsleben. In August 2010, a biomethane plant started up operation, which since then has produced 50 million kWh energy a year. We follow the path from the raw material through to the "natural gas fine" biomethane...

Approx. 10 million euro has been invested in the Grabsleben site, to build the biogas, the methane upgrading plant and the CHP. The entire plant produces approx. 50 million kWh energy a year. The main customer for the green biomethane is the Frankfurt airport. The heat produced on site during power generation is almost completely used in the gas cleaning.

The six biogas towers on the edge of Grabsleben can be seen from far away. They belong to GraNottGas GmbH and are in the immediate vicinity of the agricultural holding of the 450 resident community. This supplies part of the raw materials, from which biomethane is produced at the end of a long process chain.

Even the operator model keeps a firm eye on the stable raw material supply. Apart from Landwirtschaftlichen Betrieb Grabsleben GmbH & Co. KG., BBW Nottleben GbR is also a shareholder of GraNottGas GmbH, and has operated the biogas site since 2010. Both farms use around one quarter of their land for the cultivation of energy crops, which are located at a maximum distance of twelve kilometres from the biogas plant. The fermenters are filled daily with 90 t maize and 10 t rye-whole crop silage. Slurry from the pig-fattening facility in Alkersleben is also added, and is delivered at regular intervals.

Materials used and feeding the biogas plant

Slurry delivery

Solids input by means of containers

Slurry is regularly delivered for operation of the biogas plant. It contains 80 % pig slurry and 20 % cattle slurry. The renewable raw materials used consists of 90 t maize silage and 10 t rye-whole plant silage per day (which are delivered by the farms involved).

Thomas Balling, managing director of the biogas plant in Grabsleben

"We achieve an energy yield of 85 % with biogas", explained Thomas Balling, one of the managing directors of the plant in Grabsleben and at the same time, shareholder of the Nottlebener farm. "Three quarters of the materials used is output again at the end of the biogas processes as fermentation residue and contain all the constituents of high-quality fertiliser", he says, describing the idealised material cycle. The Franconian biogas pioneer Balling coolly waved aside the complaint of the rampant maize cultivation: "Here in Thuringia we mainly have a cereal monoculture. Therefore, the maize we grow tends to facilitate crop rotation rather than dominate it."

Up to 56,000 t of silage can be stored in GraNottGas GmbH's four large silos, which in total would secure plant operation for one and a half years.

Two fermenters in use

Once a day, Daniel Zapfe climbs into his multi-handler, in fact a construction vehicle, whose driver's cab can be extended to 4 m height and whose bucket reaches deep into the silage. When he tips out his load, 2.5 t of fresh nutrients are emptied into an open container, from which the bacteria in the warm fermenter obtain their fresh supplies.

The biogas plant has two fermenters, which are connected in parallel. In front of these are so-called solid feed containers with pusher

To ensure that the maximum concentration of hydrogen sulphide used for the combustion of biogas in the CHP biological desulphurisation takes place in the secondary fermenter. In the process an atmospheric oxygen is added and the hydrogen sulphide is converted into elemental sulphur and water.

plates, by means of which the ferment is automatically loaded. The integrated scale exactly records the quantities added. Before they are added to the fermenter, solid (NawaRo) and liquid substrate are mixed together. This process, called liquid feeding, reduces the stirring required in the fermenter and ensures a homogeneous distribution of the substrates to be fed in.

In the fermenter, in an atmosphere without air, bacteria process the starting material, such as proteins, carbohydrates and greases, in several steps to produce biogas, which mainly consists of methane and carbon dioxide. The fermentation takes place within the mesophile range at a constant temperature of 40-42 °C and a pH value within the neutral range (6.7- 7.5 pH). The biogas is collected by means of a gastight sheeting and is temporarily stored. The conically shaped weatherproofing sheeting is kept in shape by a fan.

After the appropriate dwell time in the fermenter, the fermentation substrate is moved to the gas-tight secondary fermenter for further outgassing. The end station for the fermentation products until they are applied to the farmland is one of the three fermentation residue stores.

The heart of the CHP plant, a room with a twelve-cylinder internal-combustion engine, can only be entered with ear protectors, because of the deafeningly loud noise of the 1.000 HP machine.

Plant manager Daniel Zapfe in one of the 14.000 t silos

An ultrasonic meter determines the officially accepted quantity of gas

Part of the amine scrubbing facility

Combined heat and power

Of the 50 million kWh produced in the biogas plant, around 20 million kWh are generated through the heat and power of a CHP and condensing boiler.
The CHP used is a Jenbacher (gas-fired combustion engine) with an output of 650 kWhel. The exhaust gas is passed through an after-burning process to satisfy the requirements for the formaldehyde bonus.
The heat simultaneously produced by CHP is required to heat the fermenter and for regeneration of the scrubbing solution from the gas upgrading. The residual heat is currently removed, but in future it is planned to use it to heat the office building still under construction and the rooms of the Grabsleben farm.
A conventional biogas plant ends at the CHP, not so in Grabsleben, where the gas's path is continued, up to the injection point of the gas grid.

Washed, dried & compressed

The raw biogas leaves the plant with approx 52 percent methane. The rest is mainly CO_2 and is separated out in the subsequent cleaning process.
The gas is upgraded using the pressureless amine scrubbing process of MT-Biomethan GmbH. Before the actual scrubbing process, interferents such as water and hydrogen sulphide must be removed from the raw biogas. Apart from removing the condensate, fine desulphurisation takes place with the help of an activated carbon filter, before the dried and cooled gas in the scrubbing plant. 700 Nm3 raw biogas is upgraded to 350 Nm^3 biomethane in an hour in Grabsleben and it is fed into the network of the natural gas supply company Thüringen-Sachsen mbH (utility company).

The black giant

The highest structure of the methanation unit is a black cylinder. It is where the pressureless amine scrubbing takes place. With the help of this process it is possible to separate out the unwanted carbon dioxide from the welcome methane and therefore to increase the calorific value of the biogas so far that it is hardly any different from its fossil brother natural gas.
The dehumidified and desulphurised biogas flows from below into the scrubbing column. An aqueous amine solution is injected into the contraflow to the biogas. Packing in the scrubbing column increases the surface area of the scrubbing solution, so that intensive substance exchange can take place between the gas and liquid phase. Due to their chemical properties, the amine solution can readily absorb the carbon dioxide contained in the biogas. The methane, on the other hand, does not react with the scrubbing liquid and is drawn off as highly pure biomethane at the top of the column. The selectivity of the scrubbing solution leads to minimum methane losses of < 0.1 %, also called methane slip.

Screw compressor

Reciprocating compressor

If the biomethane in the start-up process still does not have the required quality, it is burned off as "bad gas" via the emergency gas flare.

After it has been cleaned the biomethane must be cooled and dried again. To do this, it is passed through a heat exchanger. There the water and amine vapour still contained in the gas condenses on the cooling surfaces before it is returned to the scrubbing cycle. To regenerate the scrubbing solution, the carbon dioxide is driven out by adding heat and is discharged in the atmosphere. The scrubbing solution can then be used again.

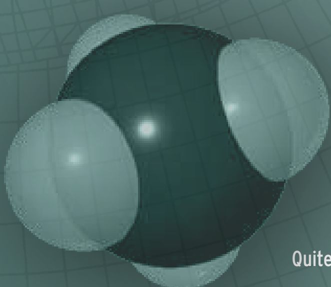
"With the use of heat exchangers to cool the biomethane and the use of the waste heat from the biogas CHP to regenerate the scrubbing solution, the energy is efficiently used in the pressureless amine scrubbing process", explains Volkmar Braune, who as a plant technician of Erdgasversorgungsgesellschaft Thüringen-Sachsen mbH (EVG), is responsible for proper operation of the feed-in plant.

Compressor container

Measured & injected

Before it is fed into the natural gas network, the quality and quantity of the biomethane produced is determined. The gas flows through complicated pipes with different sensors which, among other things, monitor the moisture or dust content. A gas chromatograph provides information about the gas quality. The official measurement to determine the quantity of biomethane, used as the basis of the gas billing, is carried out using an ultrasonic gas meter. Further, the biomethane must be compressed from 300 mbar to 25 bar for injection into the long-distance transport pipeline network of the utility company. Either a screw compressor or as a substitute a reciprocating compressor is used.

It arrives relatively unspectacularly - the point at which the biomethane leaves the biogas plant including upgrading and flows into the natural gas network. It is only a single pipe between the building wall and floor and yet means that the environment is spared 5,000 tonnes CO_2.



Quite unspectacular: The entry point of the methane upgrading plant into the gas grid of the natural gas supply company „Erdgasversorgungsgesellschaft Thüringen-Sachsen" (EVG)

Get the sulphur out!

Regenerable filters made of metal alloy foam facilitate biogas desulphurization

René Poss, photos: Alantum GmbH, Fraunhofer IKTS

Desulphurisation of biogas is prerequisite for its efficient use. Alantum Europe GmbH together with its partners develops new solutions, which offer economic and ecological advantages for the upgrading of the renewable energy source and for the after-treatment of exhaust gases containing sulphur. This is based on porous metal foam, which is tailored to the applications.

Desulphurisation with metal foam

Apart from the actual energy source methane, biogas produced during the microbiological degradation of organic matter also contains, among other things, hydrogen sulphide. As this fraction has corrosive properties and is environmentally harmful, it is usually filtered out before the biogas is used to generate electrical power, for running vehicles or is fed into gas supply networks. If biogas is used in combined heat and power stations without fine desulphurisation of the biogas beforehand, a robust, sulphur-resistant oxidation catalyst is required for the aftertreatment of the exhaust gases. The porous metal alloy foam of Alantum Europe GmbH can be used to implement innovative systems for both applications.

Environmentally friendly fine desulphurisation with up to 50 % cost savings

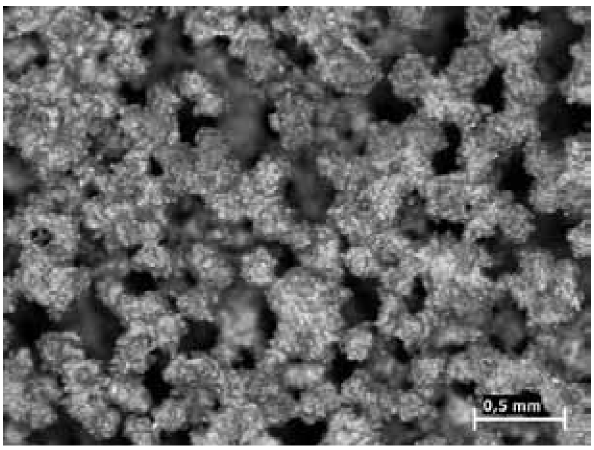
Fine desulphurisation is used to upgrade biogas to natural gas quality. At present, this is primarily done using activated carbon with potassium iodide. However, it is then necessary to dispose of the sulphur-saturated substrates. On the one hand, this has a negative effect on the environmental friendliness of the process and on the other, it is expensive.

In a project sponsored by the German Federal Ministry of the Environment, Alantum Europe GmbH together with the Fraunhofer Institutes for Ceramic Technologies and Systems (Institut für Keramische Technologien und Systeme – IKTS) and Manufacturing Technology and Advanced Materials ("Institut für Fertigungstechnik und Angewandte Materialforschung" – IFAM), and Lehmann Maschinenbau GmbH, is working on a regenerable filter system. The substrate used is porous metal alloy foam, which – like the

Biogas can be desulfurized with the help of metal foam not only environmentally friendly but also up to 50 % cheaper.

The laboratory test bench for the process of testing the coated metal-foam-substrate for desulfurization of biogas at the Fraunhofer-Institute IKTS.

previous used wood chippings and pellets – is coated with iron oxide. Due to the higher loads with the sorbent, the metal foam based filters can be designed to be smaller and yet have the same cleaning efficiency. In addition, due to the larger surface area compared to wood pellets, the operating period before regeneration is expected to be up to 4 times longer, as the loading with elementary sulphur takes a longer time. The elementary sulphur left on the foam surface by the regeneration reduces the active surface area. The required purity is no longer guaranteed above a critical sulphur load and the filter element must be replaced. In this case, the technologies used to date (activated carbon, zinc oxide and wood pellets) only provide for disposal of the filter elements on land fill sites. The aim is to remove this disadvantage using technology with which the sulphur is removed from the foam surface, either thermally or chemically, without having a negative effect on the filter system (in particular, causing deactivation of the sorbent or permanent damage to the foam). The removed sulphur is collected and, for example, is returned to the economic cycle as fertiliser. After use, the filter does not have to be disposed of on a landfill site, but instead its components are returned to the material cycle using existing recycling concepts (e.g. melting them down). These advantages reduce the costs per kilogram of sulphur removed from 16 to 20 euros to date to around 10 euros. This definitely contributes to reducing the price of biogas, until now relatively high compared to natural gas.



Due to its porous structure the metal sulfide binds more foam than other conventional solutions. Here's the foam loaded to its half. photos: Alantum

Who is Alantum?

Founded in 2006, Alantum Europe GmbH is a subsidiary of the Korean Alantum Corporation, which in turn is a subsidiary belonging to the Korea Zinc and Korea Nickel Corporation.

Alantum's key expertise includes the research and development and manufacture and sale of iron and nickel-based metal and metal alloy foams.

Alantum's metal alloy foams are used in applications such as the after-treatment of car and truck exhausts, as well as rail and off-road vehicles and stationary diesel engines. An SCR system (selective catalytic reduction) is currently being developed. Catalytically coated, alloyed metal foam is used as the primary product for this. Due to its properties, the metal alloy foam is also particularly interesting for use chemical plant construction for heterogeneous catalysis processes. On the one hand, this is because of its large reactive surface area and on the other hand its uniform and completely porous structure. Possible uses include reformer technologies such as hydrogen production. Other areas in which the alloy foams are used include filter systems, silencers, heat exchangers, spark separation and flame distribution as well as biogas desulphurisation.

Large-volume production and research laboratory

Alantum currently produces around four million square metres of nickel foam per year in China. It also produces 500.000 m^3 of metal alloy foam in Korea. The Munich-based company is working closely with the Fraunhofer IFAM in Dresden to further optimise the material for biogas desulphurisation applications. The IFAM has its own research laboratory in which tests can be performed and samples produced.

A project the BMU-funding-programme

Biomass energy use

Partners: Alantum Europe GmbH
Fraunhofer IKTS
Fraunhofer IFAM

The allotherm gasifier called HPR®500 operates on the principle of a heat pipe reformer.

Biomethane directly out of the gasifier?

Demonstration of decentralised production of Bio-SNG in the heat pipe reformer

Sebastian Fendt

Use of biomass as an energy source frequently reaches its limits based on the conversion chains used to date. The causes are manifold and diverse. On the one hand the resources are limited and on the other hand in many cases the energy yield leaves much to be desired. Rising biomass prices and inadequate energy recovery frequently lead to economic difficulties for the plant operators. In new plants, for example combined heat and power or district heating plants, the focus is not only on economic aspects but also the sustainability of the use change and local emissions.

Producing a gaseous energy source is an additional option to conventional use chains via the direct burning of biomass and conversion into heat and electricity. Here the biomass is first converted into a gas mixture consisting of CO, H_2, CH_4, CO_2 and H_2O by means of thermo-chemical gasification. The gas mixture also contains contaminants and interferents such as dust particles, tar, sulphur and chlorine compounds. These are largely removed in the gas cleaning, consisting of particle filter, tar reduction and sulphur adsorption.

Methanation

Any carbon monoxide (CO) and carbon dioxide (CO_2) can be exothermally converted to methane (CH_4) using a catalytic process. This reaction stage is called methanation or methanation. The most reaction equation for this is:

$$CO + 3\,H_2 \longrightarrow CH_4 + H_2O$$

By separating out CO_2 and water vapour, a synthetic energy source can be provided, equivalent to natural gas (figure 1). This gaseous energy source produced from biomass can be fed into existing natural gas pipes at the appropriate pressures. Relevant framework conditions for injection into the grid are defined in the DVGW standards G 260, 262 and 280-1. In general, this gas is called synthetic natural gas (Bio-SNG).

Use decoupled from the production

The main advantages of Bio-SNG are its low-emissions production, the ability to store energy in the large gas stores available and its use, decoupled from the production and its locations, in efficient CHPs, fuel cells and gas and steam plants. A decisive factor for its use in cogeneration (combined heat and power) plants is that this takes place in locations with a high heat requirement. However, the exothermic reaction during the methanation also produces heat for heating purposes at the production site.

Biomass-based gasification and methanation plants can be built within the output range up to around 100 MW power. Limiting factors are the availability of the biomasses, the transport logistics and ability of the natural gas grid to accept the gas during low-consumption periods (summer). Decentralised (local) production of SNG within the small output range of around 500 kW up to several MW has several advantages: In particular, these include good availability of the biomass, the chance of building a plant (permit, acceptance) and efficient heat use.

However, the pressure of costs is increasing substantially, especially for decentralised plants. Therefore, the most simple processes possible and cost-effective biomasses are required.

With good framework conditions, around 65 % of the energy contained in the biomass can be converted into SNG and 25 to 30 % into heat. In this way, in total, 80 to 90 % of the biomass can be used for energy purposes and the greenhouse emissions are reduced by more than 85 % compared to fossil natural gas. An important factor is the substantially lower emissions (e. g. fine dust

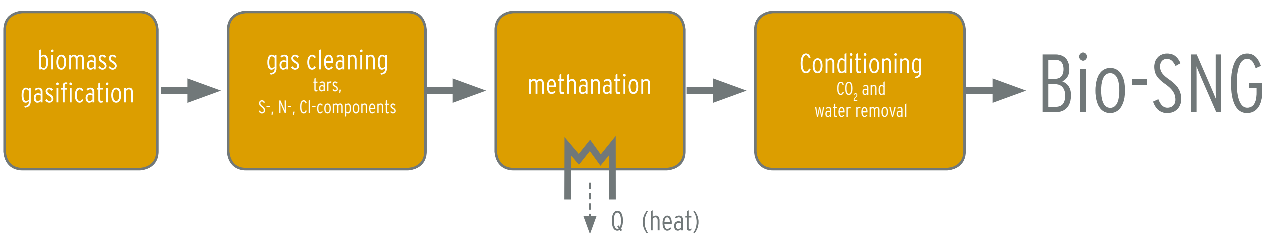


Figure 1: Process chain for the supply of synthetic natural gas (Bio-SNG), source: TUM.

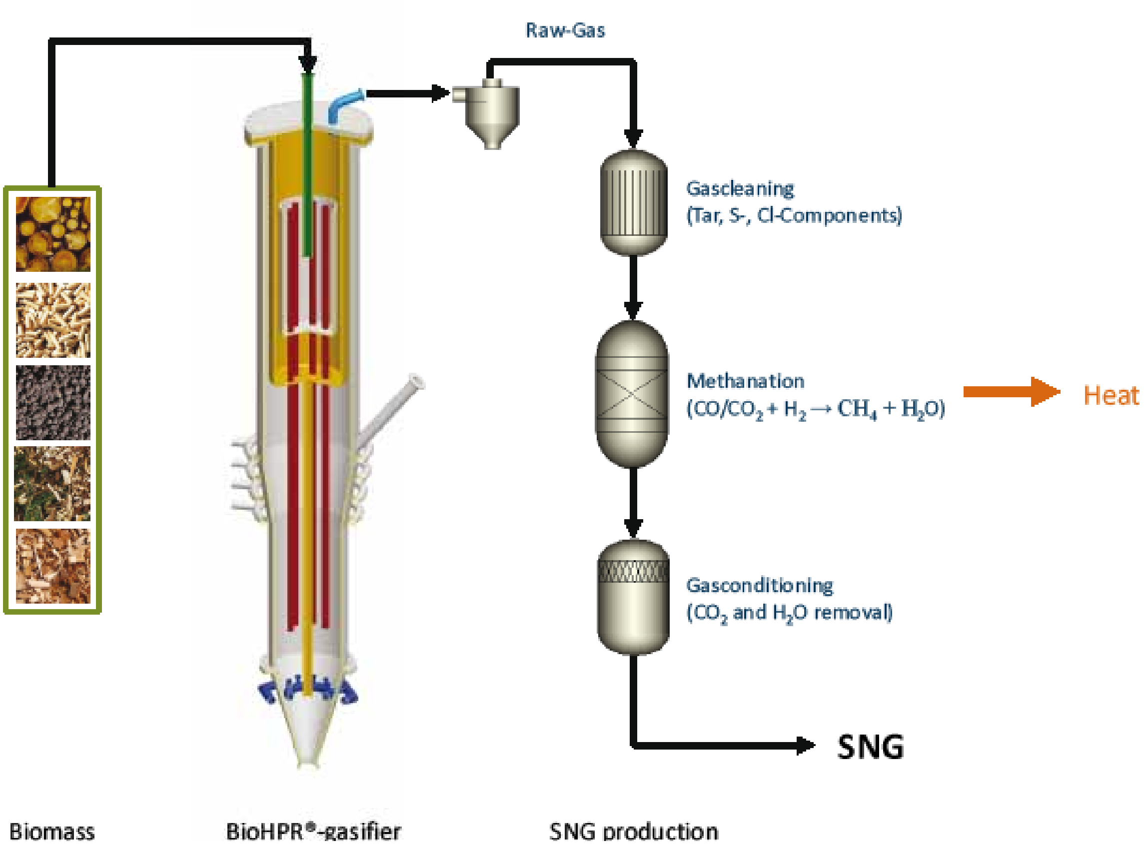


Figure 2: The HPR®500 heat pipe reformer coupled with the SNG process. photos: Sebastian Fendt

produced during combustion of the gas) compared to e.g. chippings or pellets.
The objective of the "Local production of Synthetic Natural Gas (Bio-SNG) from the product gas of an allothermal biomass gasifier" project (ID: 03KB042) is to develop a decentralised Bio-SNG process and to demonstrate the process in conjunction with the so-called heat pipe reformer HPR®500 (figure 2). This is an allothermal gasifier made by h s energieanlagen gmbh with an output of 500 kW. The gasifier is commercially available and is currently used for combined heat and power generation with microgas turbines.

Cleaning

As methanation is a highly exothermic and catalytic process, trace elements such as tars, alkalis, chlorine and sulphur as well as the heat management in the reactor are particularly important. The trace substances can influence the function and activity of the catalysts. An important part of the investigations is therefore cleaning the gas mixture to remove contaminants. The subsequent exothermic methanation takes place in a fixed-bed reactor.

Figure 3: Laboratory system for gas cleaning and methanation.

Figure 4: In-situ filter with integrated catalyst.

Laboratory facilities for examining the gas cleaning and methanation are set up on the basis of simulations. This is done using a test plant in which the various reactors and the different catalysts and adsorbents are tested (figure 3). The aim is to reduce the tars produced during gasification – as far as possible – in the gasifier with the help of catalytic in-situ tar conversion (figure 4).

Test of the adsorbents

In this way, within the scope of the project, the necessary basic principles are drawn up for the development of a competitive process. The plan is to use a larger number of SNG plants, which are comparatively small compared to other developments, in conjunction with the HPR®500.

Further information is available under:
http://www.energetische-biomassenutzung.de/de/vorhaben/liste-aller-vorhaben/details/projects/85.html

A project the BMU-funding-programme
Biomass
energy use
Partners: Technical University of Munich (TUM), Institute of Energy Systems, h s energieanlagen gmbh

From chip oil to fuel

The Greasoline process shows a way to multiple biomass use

Dr Thomas Isenburg

The market place for innovation and trends in the automobile industry, the international motor show ("Internationale Automobile Ausstellung" - IAA), took place in Frankfurt am Main at the beginning of September 2011. Leading representatives of the vehicle manufacturers and energy industry, as well as automobile customers agreed to increase the use of natural gas and biomethane as transport fuels and therefore to contribute to the reduction of CO_2 emissions in road traffic. Stephan Kohler, chairman of the managing board of Deutsche Energie-Agentur GmbH (dena) said: "Together, we want to tap the large potential of natural gas and biomethane as climate-friendly fuels.

Within the scope of the Kyoto protocol, the EU has pledged that by 2012 it will reduce greenhouse gas (GHG) emissions by 8 % of the 1990 GHG reference value and to make traffic in Europe more sustainable. At the EU conference in 2007 it was proposed that by 2020, 10 % of the fuels used in the transport sector in each member state must be covered by bio fuels.

High quality hydrocarbons

Under the aspect of raw material shortages, the use of waste fats to produce biogenic fuels is also a much-discussed topic. After deacidification, high-quality waste fats (used frying oils, UFO) from system catering companies could be used to produce biodiesel. In this field of research, the Fraunhofer Institute for Environmental, Safety and Energy Technology (UMSICHT) in Oberhausen has been supplying promising research results for a significantly long time. In the "greasoline" process, grease is used to produce diesel fuel and petrol ("gasoline"). A further planned approach is to convert the "used or spent" biogenic greases in high-quality gaseous hydrocarbons for natural gas substitution.

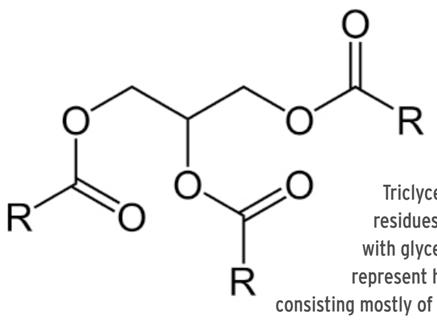
The process is intended to produce the hydrocarbons methane, ethane, propane and butane from waste greases of biogenic origin. The biomethane, called 'bio-natural gas' exclusively consists of the hydrocarbon methane. Until now it has been produced from farm manure (slurry) and biowastes. One vision is to blend this biomethane, which is solely made up of methane, with the higher-quality hydrocarbons ethane, propane and butane from the greasoline process, so that it can be injected into the gas grid as a natural gas substitute (Bio-SNG). The propane and butane fractions can be used as car gas (LPG) to drive motor vehicles. Another alternative is to produce ethylene and propylene as chemical raw materials. The market potential lies in the same application areas as the comparable fossil products. The hydrocarbon mixture should have the same hydrocarbon fractions, consisting of methane, ethane, propane and butane, as in natural gas. This new biogas is then directly suitable for use as a fuel in the commercially available combustion engines.

Catalytic cracking

One research subject is therefore the catalytic cracking of vegetable oil and grease residues to produce high-quality, linear and oxygen-free hydrocarbons with C_1 to C_4 carbon chains. The basic processing principle has been known of since the start of the 20th century, but is only now being technical implemented.

To this end, the biogenic greases and oils are converted into hydrocarbons on catalysts at temperatures between 400 °C and 500 °C. In most cases processes involve the use zeolithic silicon/aluminium based catalysts and vegetable oils such as rapeseed or palm oil or also waste cooking fats.

As part of the "Energetic biomass use" programme funded by the BMU, the researchers of the Fraunhofer UMSICHT are developing the process further in the project: "Screening of bio-based wastes concerning their applicability to conversion into petrol and diesel fuel fractions by catalytic cracking" (ID: 03KB007). Biofuel researcher Dr Volker Heil of the research institute presented the laboratory and pilot plant for the gasoline process during a visit and explained the patented inventions: "Biogenic oils and greases are evaporated and together with a carrier gas, and if applicable steam at 350 to 500 °C are passed without pressure through an acti-



Triclycerides are acyl-acid residues that are esterified with glycerol. The residues R represent hydrocarbon-chains consisting mostly of various fatty acids.

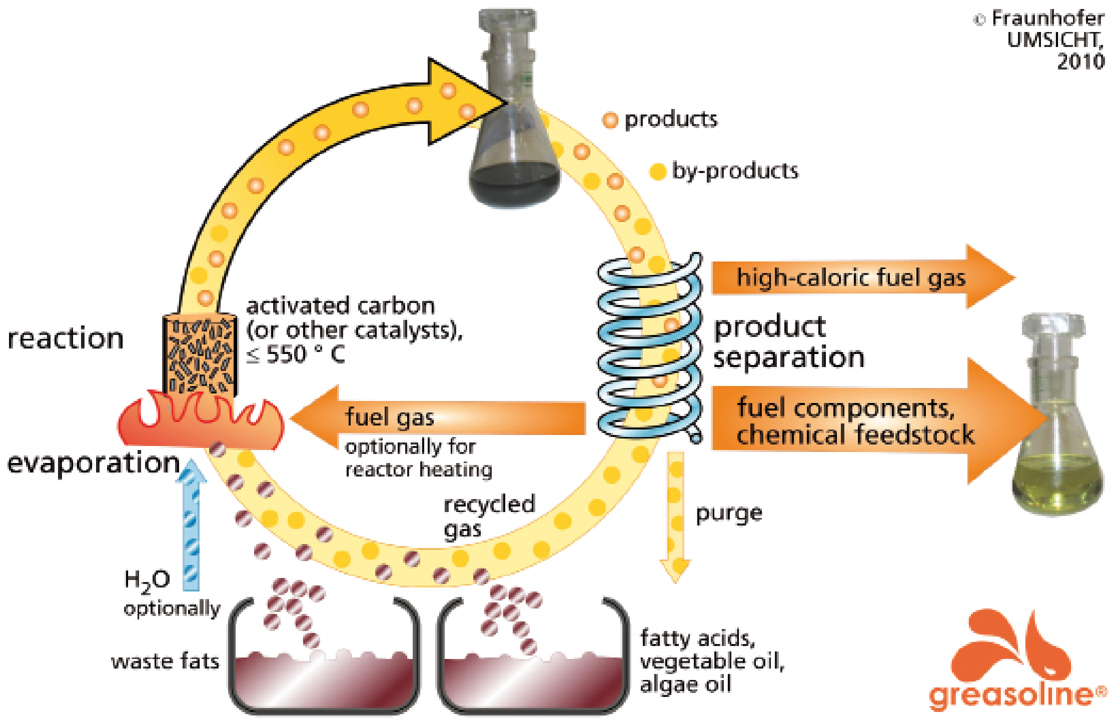
vated carbon catalyst”. The starting material used in the tests was waste cooking oil, which was primarily made up of rapeseed oil and palm oil. Vegetable oils such as rapeseed, soya, palm or sunflower oil belong to the group of substances called lipids. These are made up of a mixture of different triglycerides. These primarily consist of a glycerine molecule whose OH groups have been esterified with aliphatic carboxylic acids (fatty acids).
The product at the end of the process is made up of pure hydrocarbons. The oxygen from the acid and ester groups is discharged as CO and CO_2. The hydrocarbons produced in this way are therefore oxygen free, this is a large advantage compared to the methods known to date for the production of biodiesel, in which fatty acids containing oxygen are produced by base-catalysed ester hydrolysis (saponification). The oxygen can then cause corrosion processes in the engine. One objective of the tests is also to determine the optimum process parameters for the production of short-chain hydrocarbon blends as natural gas substitutes for running combustion engines.

The greasoline process

In its basic form, the greasoline process is a three-stage process chain consisting of feedstock evaporation, catalytic reaction and cooling.
First, following mechanical precleaning, the grease is liquefied at temperature of around 70 °C, to make it pumpable and to pump it into a second preheating stage where the hydrocarbon mixture is heated to at least 180 °C. It is then passed into an evaporator.
There it is converted into the gas phase at 450 °C and is combined with water vapour and nitrogen preheated to approx. 300 °C. The mixture of substances then flows into a fixed-bed reactor filled with activated carbon. Various reactions take place in which, at 400 °C – 500 °C, the triglycerides are catalytically converted on the activated carbon into a mixture of different hydrocarbons. The resulting products are then cooled in the next process step and, if possible, are condensed. The liquid product is then collected and is analysed by means of gas chromatography in combination with mass spectrometry. Higher catalyst temperatures and longer grease dwell times on the activate carbon surface result in short-chain hydrocarbons that are gaseous at room temperature.
These can be used to produce high-calorie fuel gases as the main components. By adjusting the process parameters, up to 53 % of the energy yield can be achieved from gas. Alkenes are increasingly produced on inorganic catalysts and alkanes are primarily produced by carbon-based catalysts.In determining the suitable test parameters, the mixture of product gases with a carbon number of C_1 – C_4 can be adjusted so that it can be optimally used for further use as a natural gas substitute or liquid gas fuel.
The scientists in Oberhausen have a laboratory and pilot plant that can be used for this. Until now, 60 g hydrocarbon per hour can be converted in the laboratory plant. The pilot plant processes 3 kg waste grease per hour.

Capture the market

In 2003/2004, world production of biogenic greases and oils was approximately 126 million tonnes. Around 20 % of these greases and oils are used as feed and as raw material for the oleochemical industry. Around 80 % of the greases and oils are used as food, where a large proportion of the greases are used in catering and privately for frying, especially deep-fat frying. These greases are merged by so-called waste grease collectors and are re-processed. In Germany, approximately 300.000 tonnes per year are collected from the catering industry. The Oberhausen scientists have started up a company, in which the researchers are shareholders, to market and industrially implement their biorefinery concept. The patented concept uses the biomass twice. The spent greases are also to be used as a natural gas substitute. The process will now be placed on the market with the help of economic experts. Mineral oil companies are possible addressees.



Schemata of the greasoline process
(source: Fraunhofer UMSICHT)

A project the BMU-funding-programme

Biomass
energy use

Partner: Fraunhofer UMSICHT

Faster and cleaner

Pilot plant should produce the purest methane possible using faster method

Franziska Schories

A new test plant at the University of Hohenheim should make it possible to upgrade biogas to natural gas quality with less energy input, and to then inject it into the natural gas grid. The objective of the joint research project of the University of Hohenheim and the DVGW research unit of the Karlsruhe Institute of Technology (Karlsruher Institut für Technologie - KIT) is to develop a new type of plant, which combines the advantages of flexible substrate use, a shorter process time and a methane content of over 85 percent in the end product.

Combine seperate processes

To date, biomethane has mainly been produced in large plants, in which the biogas produced is cleaned to remove water, hydrogen sulphide and carbon dioxide and is then compressed in a separate process requiring high energy input. In most of the treatment processes raw biogas is compressed to 10 bar. In the small pilot plant in Hohenheim, this process is now to be carried out by special methane gas bacteria during the fermentation process. In the Hohenheim plant, the gas production of the bacterial builds up and maintains a controlled overpressure. The emerging biogas is therefore already pressurised with an increased process pressure. At the same time, the gas is cleaned during its production: "This means that the pressure and purity are ensured during the fermentation of the biomass and do not have to be produced in technically elaborate downstream processes", explained the agronomist Dr Andreas Lemmer, who is leading the research project at the University of Hohenheim.

Two-phase anaerobic digestion

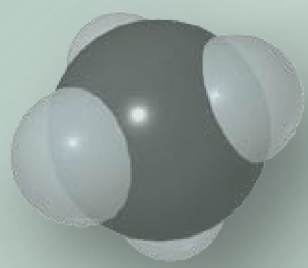
The innovative approach of the Hohenheim project lies in the two-phase fermentation, in which the fermenting and the methanogenesis processes are separated. This accelerates the overall process: For example, while it takes at least 70 to 100 days to decompose grass in a single-phase plant, it will only require around 18 to 25 days in the new plant. The low pH values and high temperatures in the first phase means that difficult to decompose substrates can also be broken down and therefore the range of materials used can be extended.

As this process technically simplifies the gas upgrading considerably and increases energy efficiency, a significant cost reduction could be achieved. The hope is that in future it will be possible to make biomethane production economically feasible even in small plants.

Constant pressure

The particular challenge for the scientists at present is to keep the pressure in the fermenter constant, because a sudden pressure drop, e.g. when the gas is removed, would cause the bacteria to break up. For this reason, the control engineering must be perfected before the plant is put into service, so that the fermentation can take place fully automatically, and without pressure changes. The project is being sponsored by the German Federal Ministry of Research until April 2013.

Further information:
www.uni-hohenheim.de
State Institute of Agricultural Engineering and Bioenergy



Biomethane trading

Germany, Sweden, the Netherlands, Switzerland and Austria lead the way in Europe

Sabine Nollmann

There has hardly been any free trading of biomethane to date, but in Europe it will not take much longer before it can develop across borders, as many important basic conditions for this have now been established. Among others, Germany, the Netherlands, Switzerland and Austria are already on the right way. At least, here it is already possible to fuel vehicles with natural gas, and therefore biomethane also, almost nationwide in all these countries, but noteworthy quantities are not yet being sold here either.

Under the pressure to reduce carbon dioxide emissions, to spare resources and to protect the environment, during the past two decades, focus has increasingly shifted onto regenerative (renewable) energy and renewable raw materials (NaWaRo). For around 10 years the use of biomass and in particular the production of biomethane, has been stepped up enormously and has repeatedly been promoted – above all in Germany.

The biogas produced by the fermentation of organic matter can be refined in gas processing plants to form biomethane. It can be easily fed into the public natural gas networks (gas grid injection) and is considered to be the most versatile among the renewable energy sources because of its base load capability it can be used to meet demands for electricity and heat production (dispatchability). It can also be used for pure electricity or heat generation and as fuel in natural gas vehicles.

The most comprehensive overview of the European biomethane market is currently provided by the www.biogaspartner.de portal, operated by the German energy agency ("Deutsche Energie Agentur" – dena). According to biogas partner information, the Netherlands, Sweden and Switzerland have the longest and greatest experience in upgrading (cleaning) biogas. The most processing plants are found in Sweden, however Germany has the largest feed-in capacity which, due mainly to the structure of the existing gas network.

Most of the new projects are currently taking place in Germany and it has become the leader in Europe with regard to statutory remuneration, closely followed by Austria." In other European countries such as Sweden, the utilisation of biomethane focuses on direct fuel use without the interim step of feed-in.

Already available: the basis for free biomethane trading

The particular possibilities of biomethane as part of a largely renewable energy supply lie in the ability to transport and store it using the natural gas network. The production and use of the energy source can take place temporally and spatially decoupled from each other, which enables targeted use – for example, in combined heat and power plants (CHPs) of municipal housing associations, in filling stations or in industrial companies. However, use of this potential requires an extensive natural gas network and clear rules are required for the feed-in, as well as for the purchase ofbiomethane, as it cannot physically pass from the producer to the consumer, only in arithmetical or accounting terms.

Many steps and very complex processes have to be completed before biomethane can be truly freely handled on the market: from the biogas production, to the upgrading of the gas, to form biomethane and the feed-in into the public natural gas network (gas grid injection), to its transport and balancing and through to

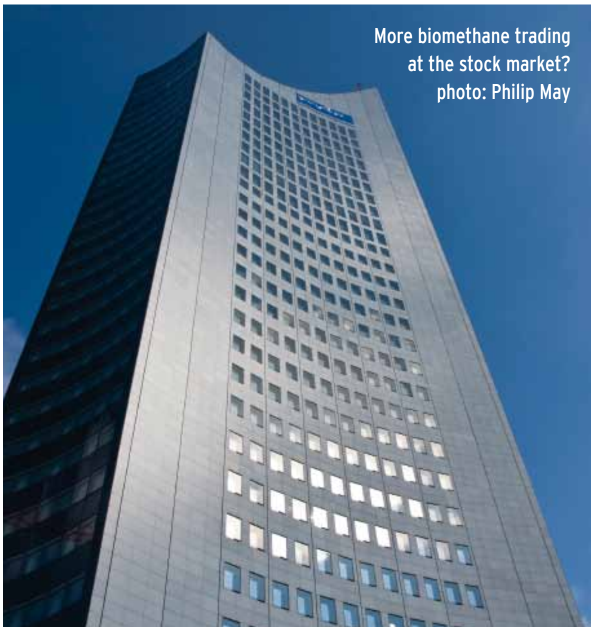
its sale and output, making it quite a long path. Free biomethane trading is developing sluggishly, although the production capacities are growing and the trading portals and verification systems are slowly being established.

The first free independent traders are ensuring movement on the emerging, yet still small market. The industry describes it in moderate terms: “Biomethane trading in Germany is still on a very low level”, reports the German biogas association (“Fachverband Biogas e.V.”). The same information is reported from Austria, Switzerland and the Netherlands. A small but growing offer is faced with too little demand. Until now trading has mainly been limited to bilateral agreements, and there is not yet any free trading through an exchange.

New biogas processing plants have steadily been connected to the natural gas network for a good five years now. In August 2011, the International Energy Agency (IEA) and dena counted a good 135 biogas processing plants operated throughout Europe, of which, according to dena’s searches, 99 plants fed processed biogas into public gas networks. According to this study, the average plant size in Europe is around 500 normal cubic metres per hour (Nm^3/h). The plants with the largest feed-in capacity of up to 5000 Nm^3/h operate in Germany and in the Netherlands, for numerous reasons, including the population density of the countries, their infrastructure, gas networks, the offer of fermentable material and natural gas consumption. In the Netherlands, plants with a capacity of up to 3,000 Nm^3/h are currently being planned.

According to a survey commissioned by the Deutsche Biomasse-ForschungsZentrum gGmbH (DBFZ), in the autumn of 2011, the number of plants feeding biomethane into the public gas networks numbered 6 in Austria, 10 in the Netherlands, 17 in Switzerland, 39 in Sweden and 60 in Germany. This is only a transitional inventory, because new plants are continuously being added, with approximately 132 feeding in plants counted in October 2011, these four countries form a clear majority in Europe and they are also among the technology leaders in the field of upgrading biogas. For example, according to dena, until recently membrane processes have only been used for large, industrial scale application in the Netherlands, Austria and Germany.

The upgrading of biogas to produce biomethane, feeding or injecting it into the natural gas networks (national gas grids), transport and output are no longer a problem. However, trading is made difficult by the large number of players involved, their different interests, transport routes and arrangements that are difficult to clearly understand, as well as the legal and organisationally very complex procedures. A decisive basic requirement for trading is therefore binding regulations which define, among other things, quality, quantity, feed-in, transport, proof of origin, balancing and use. Much has been done in this area in the past two years.



More biomethane trading at the stock market? photo: Philip May

Switzerland, Germany, the Netherlands and Austria have developed certification systems or rather a biogas register and in part, have also created rules for cross-border trading. They ensure the quality and safety requirements are met as well as verifying documentation for electricity production, the heat market and fuel mixture, and they are the basis for calculating tax relief and bonuses. They have therefore created the first reliable framework conditions for producers, traders and consumers, howeverbalancing the verifications still remains a major challenge (see also article on the climate balance of biomethane, p. 32).

“Still at the beginning”: cross-border trade

The first biomethane trader in Germany was bmp greengas GmbH in Munich. “Biomethane will play a decisive role in the future new energy mix, not only due to its base load capability, but also because of its dispatchability (ability to provide energy in line with demand”, says Lothar Gottschalk of bmp greengas. The expert is counting on the large potential of this multi-talented resource and is convinced that “the domestic biomethane markets and the European market will develop in the not too distant future”. There are now an increasing number of traders and service providers on the complex market, to assist producers, users (utility companies) and consumers with the difficult biomethane trading. This unclear, confusing business needs experience and expertise, but also simplification of the systems.

The large energy concerns as well as the regional and municipal energy suppliers still operate the largest and most biogas processing plants, and therefore turn over the largest quantities, and they primarily still base this on intercompany use and local solutions or solutions within their market area. They do not buy and sell the biomethane through the exchange and free trading, but through direct contracts with individuals. Sound collected, informative and reliable figures about the available and traded biomethane quantities are therefore not yet available from either Austria and Switzerland, or from the Netherlands and Germany. All players report that the market is just beginning to develop.

“When it comes to cross-border trading, we are still at the very beginning”, said Reinhard Schultz, managing director of Biogasrat e. V., a German association of the biogas industry during a trade conference on “biogas and biomethane in the European internal market” held at the beginning of November 2011 in Berlin. The potential is considerable, he says. Around 24 % of the European primary energy consumption was accounted for by gas, which in the future could be increasingly substituted with biogas. On the one hand it is necessary to identify and removing obstacles to investment, but on the other hand, systems must be developed, which ensure the comparability and therefore the tradability of biogas products across borders too.

Schultz calls for the replacement of six percent of the natural gas consumption in Germany with biogas by 2020 and ten percent by 2030, in line with the targets defined by the federal government. However, this would require around 2,000 to 5,000 biogas feed-in plants, and by the end of 2011 only 60 plants had been installed, he complained. “The speed is far too slow to achieve the climate protection goals and to provide a sustainable renewable alternative for electricity generation as well as the heat and fuel market, which continuously flows and is also storable. The problem is not the generation and feed-in, but consistent further development of the customer market”, he added.

“Cross-border biomethane trading in Europe also offers numerous options for improved use of other renewable energy sources, for example, wind and hydropower”, says Dr. Arthur Wellinger, President of the European Biogas Association (EBA) and manager of the Swiss biogas association “Biomasse Schweiz”. “Switzerland is highly interested in further opening of the markets and in international biomethane trade”, he emphasised. The capacities available in Europe could be used more effectively.

The marketplace of the Verbundnetz Gas AG in Leipzig, photo: VNG

Technically equipped: filling station networks enable free biomethane travel

In the fuel sector, biomethane has played hardly any role to date, says the biogas monitoring report of Germany's federal network agency ("Bundesnetzagentur" – BNetzA) at the end of May 2011 on the importance of the multi-talent fuel on Germany's roads. Small, indeed minimum, quantities are also only being sold through the filling stations in Austria, Switzerland and the Netherlands. Yet all four countries now have well developed and virtually nationwide natural gas filling station networks. In the summer of 2011, there were 171 natural gas filling stations in Austria, 130 in Switzerland, 110 in the Netherlands and almost 900 in Germany. If biomethane can also be fuelled there, then mostly as bio CNG mixed gas fuel (CNG: compressed natural gas). Pure biomethane (bio SNG: bio synthetic natural gas) is not yet so easy to buy. Pure biomethane filling stations are also rare.

Internationally, biomethane as a fuel is still a niche market. The spread of natural gas vehicles plays a decisive role here. The exemption from fuel oil tax and subsidies for the purchase or retrofitting of natural gas fuel systems are driving ahead development. The German biogas association has found out: in August 2011, 1.5 million natural gas vehicles were licensed worldwide, most of which are in Europe. With almost 700,000 vehicles, Italy is a lone front-runner. Natural gas cars have been used there for around 60 years. In the summer of 2011, almost 3,000 natural gas vehicles were licensed in the Netherlands, almost 6,000 in Austria, around 10,000 in Switzerland and around 92,000 in Germany.

The growth of natural gas vehicles in these countries is developing in line with the different subsidies. However, what they all have in common is their local public transport companies and companies with large vehicle fleets, switching to run their vehicles on natural gas first and specifically opting for biomethane as the fuel. In general, regional energy suppliers and local communities tend to be very actively committed. Due to the high mileages, they also make noticeable savings and the image-promoting external effect of such measures is also a motivator.

The automotive industry has now finally woken up, and has begun manufacturing more attractive models promoting the development of natural gas vehicles, this coupled with the rising petrol and diesel prices may contribute to increased future growth in the number of natural gas vehicles licensed for private use. Measured against the natural gas consumption of the countries, the proportion of biomethane traded as fuel is still infinitesimal, and Austria, the Netherlands, Switzerland and Germany are still a long way from achieving their ambitious targets. But they have set up an infrastructure, which can be very quickly further developed in line with a corresponding demand.

Requiring further discussion and promotion: incentive systems and opening eastwards

In the promotion of use of biomethane, Germany is leads the way: from the technologies through to the Renewable energy sources act ("Erneuerbare Energien-Gesetz" – EEG) with its high feed-in remuneration. Yet there are also calls for more effective incentive systems.

"High feed-in remuneration enables more projects, however, this also means that the focus is no longer solely on maximum efficiency to ensure economic operation", says Dipl.Eng. Christian Domes, energy and project developer of the Lower Austria energy supplier EVN in Maria Enzersdorf. He considers more targeted subsidies in Austrian housing, for example, for heating systems with biomethane use to be meaningful and, with a view to Europe, and he suggests that "The capacities of targeted incentive systems are not yet being optimally used." Domes share this assessment with most of his international colleagues: there is still substantial room for action and an enormous potential.

Considering international biomethane trading and providing Eastern Europe is more intensively involved, the DBFZ sees very large chances of achieving the EU climate targets. Dr.-Ing. Daniela Thrän, head of the DBFZ's bio-energy systems, says: "In the medium-term we need a common European biomethane strategy. The course must be gradually set and further impetus, innovations and cooperations are necessary, not least to develop the potential in Eastern Europe, which has not yet been activated". In her opinion, functioning international trading also requires open, cross-border collaboration during the development phase.

On the path to ecogas

The customers of Lichtblick AG are creating a large demand in the consumer segment

Brigitte Holland

The story of LichtBlick AG begins in Hamburg in the autumn of 1999 with a mere eight household customers. A supplier independent of the large energy corporations enters the market, to satisfy the demand for electricity from renewable energy. The liberalised electricity market in Germany enables the start. LichtBlick AG now supplies more than 600,000 households, companies and public facilities with power and has risen to become Germany's market leader for green electricity and gas. The most well-known customer is the German parliament, the Deutsche Bundestag.

Incidentally, in 2001, LichtBlick was the first utility company to receive the "ok-power" label for particularly environmentally friendly electricity, which is awarded by "Energievision". This independent association was started up by the WWF, the Öko-Institute and the consumer advice centre of North Rhine-Westphalia ("Verbraucher-Zentrale Nordrhein-Westfalen"). The label promotes strict environmental standards for eco power stations. The seal of quality specifies that LichtBlick must purchase at least one third of its electricity from power stations which are not more than six years old and a further one third from plants which are not more than twelve years old. "The demand for green electricity of our currently 500,000 private customers creates an incentive for the construction of new eco power stations – completely independent of government subsidies", explains the LichtBlick spokesperson.

LichtBlick currently supplies 500,000 private and 35,000 business customers with green electricity and 85,000 customers with green gas. In 2011, now with 420 employees in its headquarters in the Hamburg district of St. Pauli, the company was voted „Germany's most customer-focused energy utility company" for the third year in succession. ZuhauseKraftwerk receives the „Innovation prize for the climate and environment" from the Federal Minister of the Environment and the Federation of Germany Industry Bundesverband der Deutschen Industrie - BDI).

According to its own information, in 2010, the company sold 2.6 billion kWh of green electricity. With their demand communicated through LichtBlick, consumer's have the power to increase even further the share of green electricity in the Germany-wide grid. "Only if our customers' demand increases suddenly does LichtBlick purchase short-term small quantities of grey electricity from the power exchange. We neutralise this share by placing additional quantities of green electricity on the market", explains Katinka Königstein. Because all types of electricity are traded on the power exchange, including electricity from coal-fired and nuclear power stations. Wind farms and hydroelectric power stations also feed their green electricity into the pool of grey electricity, yet when it is mixed in this way it loses its label on the exchange.

In 2007, LichtBlick was the first power supplier to offer green gas. "It contains an annual average biogas content of at least 5 %" says Katinka Königstein, referring to the test result of TÜV Nord. The company makes sure that neither slurry from intensive livestock farming, nor genetically modified raw materials are used in the production of biogas, which is blended with the LichtBlick gas. "65 % of the biogas added is produced from renewable resources and 25 % from agricultural residues", says Katinka Königstein. Slurry from regional farms accounts for less than 10 % of the raw material. The biogas is purchased from plants in Saxony-Anhalt, Lower Saxony and Brandenburg. TÜV Nord also certifies the annual quantity bought-in and therefore also confirms the composition.

More than 85.000 customers have now opted for the LichtBlick gas, which is still a long way from being pure green gas. But LichtBlick's gas customers are at least creating the largest demand for biogas in Germany and are therefore promoting the development of climate-friendly biogas plants. Because, according to an industry survey by the specialist magazine "Energie & Management", LichtBlick has a market share of more than 75 % of the private biogas customers.

At the end of 2010, LichtBlick entered the decentralised power generation market with the installation of networked and controlled mini-combined heat and power plants. Through its "energy partnership" with Volkswagen, the first "home power plants" ("ZuhauseKraftwerk") are produced in series by VW in Hamburg. "260 are now in operation in Hamburg, Berlin and Lower Saxony, up to 10 plants are added weekly", says Katinka Königstein. The plan is for a "swarm" of 100.000 decentralised "home power plants" to be networked to form Germany's largest gas-fired power station. "With the "swarm electricity", we can compensate for fluctuating renewable energy and stabilise the power supply networks" says the LichtBlick spokesperson.

Factory complex in Zoerbig/Saxony-Anhalt
(photos: Verbio AG)

Interview with Dr Oliver Lüdtke, Chief operating officer Verbio AG

"Far and away the most climate-friendly mobility..."

VERBIO Vereinigte Bioenergie AG based in Zörbig (Saxony-Anhalt) has been in the biofuels market for ten years. Since 2010, the company has produced biomethane as a fuel in its own biorefinery. The product marketed under the brand name "verbiogas" is produced from slops, a residual material arising during bioethanol production.
The chief operating officer of VERBIO AG, Dr Oliver Lüdtke, reports on the activities of his company.

Dr Oliver Lüdtke
(Chief operating officer
bioethanol, biogas)

Eva Mahnke

Mr Lüdtke, why did VERBIO decide to opt for biomethane as a fuel?

Oliver Lüdtke: our company has been producing bioethanol from cereal starch since 2004. We initially used the residual materials produced, the so-called slop, as fertiliser, however, the price we get for it is low. Alternatively, we could have produced feed from these residual materials. The disadvantage of this technology, however, is the enormous energy consumption and the associated poor CO_2 balances. Our objective was to produce the most climate-neutral biofuels possible and we therefore decided to change tack; to convert the residues into biomethane and use it as biofuel. The biomethane produced in this way saves 90 % carbon dioxide compared to fossil fuels.

What steps were necessary before VERBIO was able to start production?

Oliver Lüdtke: As we decided to take the biomethane route in 2007, we found that there wasn't any suitable technology on the market. With investments of 30 to 50 million euro per plant, the risk would have been too large, to trust the promises of the biogas plant manufacturers although they had no experience of this new technology. We therefore decided to develop the technology ourselves. From 2007 to 2009, we set up our research department in Zörbig and developed the technology until it was ready to go into production. At present we operate a biorefinery based on this technology developed in-house not only in Schwedt/Oder but also in Zörbig; the refinery is an integrated facility incorporating a bioethanol, biogas and biofertiliser plant. There are no comparable plants worldwide. This integrated plant converts almost 90 percent of the raw materials used into energy. In both plants we inject biomethane with a methane content of over 98 percent into the natural gas grid.

What is the production process?

Oliver Lüdtke: The special feature of the plants in Schwedt and Zörbig is that we operate them with mono-fermentation, in which we only use the residues from the ethanol plant. Depending on its type, the aqueous slop (also called stillage or vinasse) is fermented for a period of 30 to 60 days to produce raw biogas with a methane content of around 50 to 55 %. The hydrogen sulphide in the raw biogas is then oxidised by bacteria and separated out in the gas phase. Due to the coupling with the ethanol plant, it has a relatively high concentration (< 2 %). We then use an amine scrubbing process to remove the carbon dioxide, for which we use a special amine from BASF with very low energy consumption. Before the biomethane is injected into the natural gas grid we set the dew point to minus 70 °C. Our process chromatographs continuously measure up to 20 components, e.g. oxygen, nitrogen and the dew point, to ensure that our biomethane is always of natural gas quality. We then extract the nitrogen from the liquid fermentation residues, which consist of almost 98 % water, and convert the nitrogen into ammonium sulphate. This ammonium sulphate solution is a liquid nitrogen fertiliser, which is used as a substitute for fossil nitrogen fertilisers.

What are the particular challenges in producing biomethane?

Oliver Lüdtke: With the mono-fermentation technique, you have to find an operating window in which the plant can be stably operated, taking into account the inhibitors produced, the one-sided element input and the dwell time in the fermenters. In addition, you have to control very large volumetric flow rates of 20 to 80 t/h, caused by the coupling with the ethanol plant. The main challenge is implementing all this under economic aspects in the daily operation.

Factory complex in Schwedt/Brandenburg

Factory complex in Zoerbig/Saxony-Anhalt.
photos: Verbio AG

Where is there still potential to optimise the production of biomethane?

Oliver Lüdtke: One area we are currently focussed on is optimising the process to achieve energy savings. This would not only improve our CO_2 balances but also the economic efficiency of our plants. We are trying to optimise the amine scrubbing and hydrogen sulphur separation, but we also see plenty of potential for optimisation in the nitrogen fertiliser production. Each year we invest more than one million euros in optimising our plants. Economic and competitive production of biogas can only be achieved through energy-optimised plants on an industrial scale.

What are the production capacities of the plants?

Oliver Lüdtke: The plants in Schwedt/Oder and Zörbig each currently have an output of 30 MW. That is equal to a production capacity of 240 GW/h per year each. The total natural gas demand at German natural gas filling stations is currently around 2.000 GW/h, of which, theoretically we can already produce a quarter. We plan to increase the size of the plants in future, to 70 to 80 MW in Schwedt and to 50 MW in Zörbig. Our target is to expand our production capacity, from around 500 gigawatt hours today to around 2.000 GWh per year in 2015.

You started researching in 2007. How successful was the market launch of verbiogas?

Oliver Lüdtke: We started building the plants in 2009; we have been selling verbiogas on the market since 2010. The biogas we inject is completely identical to natural gas, so that there are no quality problems. We sell verbiogas for the same price as natural gas. In energy terms, it costs only half as much as petrol. With CO_2 savings of 90 % compared to petrol or diesel, our "verbiogas" enables us to achieve the by far most climate-friendly mobility. Virtually all the gas filling stations we supply offer 100 percent biomethane. We believe that this is more attractive for customers than a biogas blend of 10 to 20 %. Our verbiogas enables the customer to combine almost climate-neutral mobility with sparing their wallet. Most of our production is now used for mobility. The rest is injected into the natural gas grid. Our objective is to supply a large proportion of the gas filling stations in Germany with verbiogas.

Are further plants planned?

Oliver Lüdtke: Yes, our expansion strategy is clearly focussed on biogas. The next step will take place at the end of 2011 with the starting up of our two straw plants, each of which will ferment 20.000 t of straw per year. In the next two years we want to expand our sites in Schwedt and Zörbig and develop additional pure biogas locations.

What is your forecast for the future fuel market? What role will biomethane play?

Oliver Lüdtke: In future, the fuel market will diversify more. The dominance of petrol and diesel will be broken, as can already be seen with LPG and CNG. We believe that natural gas will reach double digits. For example, we are currently testing the use of biomethane in heavy goods vehicle traffic.

Thank you for the interview.

Gas mobilises

100 % biomethane at the fuel dispenser

In Swabia and Upper Bavaria there are many owners of gas-run vehicles. In April 2011, the first filling station that only dispenses biomethane made from waste materials opened in Gersthofen. The regional energy service provider, erdgas schwaben GmbH, is a pioneer in the use and sale of biomethane.

Heike Gröber

In recent years, the regional gas supplier erdgas schwaben GmbH, which supplies the administrative district of Swabia and the neighbouring parts of Upper Bavaria, has become a biomethane supplier, which uses local raw materials and above all the biogenic residues arising to produce biomethane. Each year, in addition to around 10 billion kWh natural gas, 200 million kWh biomethane is already fed into natural gas network operated by schwaben netz GmbH with a total length of 5.000 km. This means biomethane accounts for a 2 % share. Under the federal government's energy concept, the share of biomethane is to be increased over the next 10 years to 10 % throughout Germany. erdgas schwaben GmbH is therefore well on the way to achieving this target value for its region in several years.

In close cooperation

At present if feeds biomethane into its natural gas network from four biogas upgrading plants. The company cooperates with commercial and agricultural biogas plant operators for the production of the raw biogas. Apart from a plant for recycling biogenic wastes and residues in Altenstadt, they include biogas plants for the fermentation of renewable raw materials, which are cultivated on farmland. The fermentation residues are returned to the agricultural cycle and are applied to the fields as fertilizer.

The raw gas is bought at a price based on the remuneration rates of the EEG ("Erneuerbare-Energien-Gesetz" – Renewable energy sources act). This cooperation is worthwhile for the biogas plant operator, as they save investment, maintenance and repair costs for the CHP they would otherwise have to operate. The problem of all-year heat use can also be avoided by upgrading the gas to biomethane, as the process commonly used at present produces little to hardly any heat.

The fermenters of the biogas plant operators, which require heat, can be heated as required with a condensing boiler and the biogenic fuel approved under the subsidy conditions, in this case biomethane.

erdgas schwaben GmbH sees itself as being an expert partner for natural gas processing and feed in. Since 2007, its subsidiary schwaben netz GmbH has been responsible for logistics and operation of the natural gas network.

	Arnschwang/Cham	Altenstadt/Schongau	Maihingen	Graben/Lechfeld
Started operation in Upgrading plant	2010	2009	2008	2008
Feed-in rate	700 Nm³/h	700 Nm³/h	600 Nm³/h	500 Nm³/h
Feed-in capacity	65 million kWh/a	66 million kWh/a	52 million kWh/a	42 Mio. kWh/p. a.
Upgrading method	Pressurized water scrubbing (DWS)	Pressure swinging adsorption (PSA)		
Gas quality on site	Erdgas H			
Biogas plant output	2,8 MWel	2,5 MWel	2 MWel	
Production Raw biogas	1.400 Nm³/h	1.200 Nm³/h	1.000 Nm³/h	
Raw materials of the biogas production	Maize silage 35,000 t/year Grass silage 15,000 t/year	Biogenic wastes 36,000 t/year	Maize silage 25,000 t/year Clover/grass 7,000 t/year Grass 4,000 t/year Cereal, whole crop silage 7,000 t/year	Maize silage 28,000 t/year Grass silage 5,000 t/year Cereal 2,000 t/year
Cooperation partner Biogas plant	"Grüngas GmbH"	"Öko-Power GmbH & Co. Biogas KG"	"Energiezentrum Ries I GmbH & Co. KG"	"Biokraftwerk Lechfeld GmbH & Co. KG"

Overview of the methane upgrading plants of erdgas schwaben GmbH (source: erdgas schwaben GmbH)

The methane upgrading plant in Graben/Bavaria

The refining

erdgas schwaben GmbH started up the first upgrading plant in 2008. This plant operates according to the pressure swinging adsorption principle, or PSA. Relatively high methane losses of around 2 - 4 % occur with this method. This methane is carried in the waste air flow to a lean gas combustion process. The heat produced is used to heat the fermenters.
The three other plants were connected to the natural gas network at sites in Maihingen (2008), Altenstadt (2009) and Arnschwang (2010). These three plants clean the raw biogas with the more widely used method of pressurised water scrubbing, which is more efficient. In this process, carbon dioxide and harmful gas constituents (e.g. hydrogen sulphide) are filtered out of the gas in the counterflow. The methane loss is max. 1 % and cannot be recovered. The harmful methane is therefore oxidised via thermal oxidation.

The methane upgrading plant in Altenstadt/Baden-Wurtemberg which is fully operated with biogenic waste. photos: erdgas schwaben gmbh

Bonus for more gas

Under the EEG 2009, the gas upgrading was subsidised through the technology bonus. The bonus for plants with an upgrading capacity up to 350 Nm³/h methane was 2 ct/kWh, and for those up to 700 Nm³/h methane it was 1 ct/kWh. Under the new renewable energy sources act (EEG) 2012, the so-called gas upgrading bonus for plants with a production capacity up to 700 Nm³/h is increased to 3 ct/kWh. This will considerably improve the position of gas upgrading. “We see our commitment confirmed by the politicians and are already planning another plant in the order of 700 Nm³/h biomethane”, explained Georg Radlinger, the head of renewable energy and innovation.

At the filling station

Apart from feeding into its natural gas network, erdgas schwaben GmbH has also set up a network of biomethane filling stations. In Donauwörth, Gersthofen, Kaufbeuren, Landsberg and Nördlingen, car owners can refuel with so-called CNG (compressed natural gas), which is 100 % biomethane. The Swabians are particularly proud of their sole use of biogenic and food wastes (expired food, slaughterhouse waste, biowaste, residues from dairies and cheese makers) in the Altenstadt biogas plant. No agricultural areas are used to cultivate for energy crops here, i.e. the emphasis is on sustainability. The gas upgrading plant refines around 1,400 Nm³ raw biogas an hour to produce 700 Nm³ biomethane. Until now around 20 % of the biomethane produced by the plant in Altenstadt has been marketed through the filling stations, and the trend is increasing.
There are many private customers with gas-run vehicles within the area supplied by erdgas schwaben GmbH. The pioneer was the city of Augsburg, which was the “model city for natural gas” 16 years ago and, among other things, converted its own bus fleet to natural gas in 2005. Since this year, erdgas schwaben GmbH has supplied the local public transport company in Gersthofen with 100 % biomethane. In Gersthofen, situated to the north of Augsburg, the first 100 % biomethane filling station in Germany was put into service in the spring of 2011. Georg Radlinger is certain that in future the transport sector (trucks) will also be more interested in environmentally friendly and cost effective fuel, and does not keep his optimism to himself: “Biomethane produces almost zero emissions during combustion, reduces carbon dioxide and nitrogen oxide emissions and gas vehicles create less noise. What more could you want?”

Sustainability - a top priority!

Bioenergy park „Güstrow“ certified to new criteria

Brigitte Holland

The energy change has already begun in Mecklenburg-Western Pomerania. The NAWARO BioEnergie Park “Güstrow” has been producing biogas from plants on an industrial scale since 2009. In 20 large fermenters, the microorganisms produce raw biogas, which is refined to natural gas quality directly on site. The plant produces 46 million m^3 biomethane annually. This can be used to cover the energy requirements of more than 50.000 households: that’s around 160 million kW/h of electricity and 180 million kW/h of heat per year. Producers now have to produce a sustainability certificate to prove that biogas is a real alternative to fossil fuels.

In 2009, the sustainability regulations came into force for liquid biomass for electricity generation and biomass for the production of biofuels. With these two legal standards, Germany implemented the EC Directive 2009/28 of 23 April 2009 in its national law. The two regulations define where the energy crops used for the generation of electricity or to produce biofuel may be grown and where not. They may not originate from areas with high nature conservation value such as forests or green spaces with large biological diversity, or from areas with a high carbon inventory such as wetlands or moors. In short: No forests may be chopped down or meadows ploughed for energy generation.

Set off against the quota

The sustainability regulations also specify that the farmers must cultivate the biomass on sustainably managed farmland, if the biofuel produced from it is to be set off against the national biofuel quota and is to be exempted from energy tax. This also requires that, in the interests of the environment, the climate and nature conservation, the biomass is produced and transported so that its used in the energy production causes at least 35 % less greenhouse gases than use of fossil energy sources. In 2017, the greenhouse gas reduction value (GHG reduction figure) should be 50 % and from 2018 it should be 60 %.

The Bioenergy park “Güstrow”
Mecklenburg-Western Pomerania

As a link in the process chain, biogas plant operators must prove that their raw materials do not come from "taboo zones" and that the greenhouse gas reduction begins with the cultivation. In March 2011, the BioEnergie Park "Güstrow" was one of the first biogas plants in Germany to be certified to the new criteria. NAWARO BioEnergie AG, started up in Leipzig in 2005, operates a plant which injects around 5000 cubic metres of biomethane per hour into the adjacent natural gas grid. "As far as we are aware, with a thermal output of 50 megawatts, the plant is the worldwide largest to operate with renewable raw materials", says Felix Hess, managing director of NAWARO BioEnergie Park Güstrow GmbH.

Green breeders

The "green breeders" in Güstrow are mainly stocked with silage from maize, grass and rye. Microorganisms ferment the mass to produce biogas. The raw gas produced, which as a methane content of around 54 percent only, is further processed directly on site. The hydrogen sulphide and carbon dioxide is removed from it in the pressurised water scrubbing process; and as a result the methane content and purity increase. "We can inject our biogas with a 96 percent methane content directly into the natural gas network, because chemically it is no different to natural gas", explains Felix Hess. The main customer is Verbundnetz Gas (VNG) AG in Leipzig, which sells on the biogas from Güstrow: to utility supply companies for electricity and heat generation or as fuel to natural gas filling station operators.

Cross compliance

The binding of the EU agricultural payments to commitments in environmental protection, food- and feed-safety, animal health and animal welfare is called „Cross compliance". (source: German Federal Ministry of Nutrition, Agriculture and Consumer Protection (BMELV))

Only sustainability pays

The production and trading of biomethane as a fuel are now only worthwhile if the fuel is recognised as being sustainably produced. Because only this biomethane remains exempted from energy tax or is offset against the national biofuel quota, which is currently 6.25 percent. In this respect, the fast certification, although it cost more than 10000 euro, was a "business necessity", admitted managing director Hess. The independent service provider PCU Deutschland certified that NAWARO BioEnergie Park "Güstrow" fulfils the sustainability requirements and in particular, with a GHG reduction value of 58 percent compared to the fossil reference value, it is already achieving the reduction potential of greenhouse gases not required until 2017.

From the field to the raw gas

The certification required a great deal of work. "We had to record the value chain, from the farming to the raw gas production through to the refining", says Felix Hess. 100 farms supply the biogas plant in Güstrow, 30 large und 70 smaller ones. The farms had to prove that they manage their fields according to the "cross compliance" provisions and where they cultivate biomass. "We know the farmers and, on the basis of the area verifications they have to provide, we also know what they harvest, explained Felix Hess. The legislator requires a continuous mass balance system, in order to trace the biomass along the entire production and trading chain. To do this, the quantity of sustainably produced biomass must be precisely recorded at each step.

The trucks of BioEnergie Park "Güstrow" are not yet running on its own biomethane, but with diesel, in order to collect the biomass from the farmers. "We are considering whether we should build a natural gas filling station" says Hess. Yet the transport causes less than two percent of the greenhouse gas emissions of the energy park, because only fields within a maximum radius of 50 kilometres are travelled to and empty trips are avoided, by taking the residual

substrate from the fermenters on the outward trip. Because the material left behind by the microorganisms during fermentation of the silage is a valuable organic fertiliser, which re-enriches the fields around the biogas plant with humus. This helps to save mineral fertiliser and therefore further greenhouse gases when it is applied.

More than 50 % less greenhouse gases

"The calculation of the reduction potential was difficult, because there is no standard greenhouse emission value for maize", explained the head of the BioEnergie Park. The Deutsche Biomasse-Forschungszentrum (DBFZ) in Leipzig and PCU Deutschland took up the problem. Each party involved in the production and supply chain must calculate the greenhouse gas emissions arising in their part of the chain. In the biogas plant they are produced during transport of the biomass and the residual substrate and in the plant itself. In addition to our own emissions, we must also include those produced during cultivation of the biomass. From this, a greenhouse gas emission was calculated for the Güstrow biomethane of 32 g carbon dioxide equivalent per mega joule and therefore a reduction potential of 58 percent. This means that 58% less greenhouse gases are emitted when biomethane is used than if fossil fuels are used.

Political target and reality

According to the German Energy Agency, around 6.500 biogas plants were in operation in Germany at the beginning of 2011. Of these, 60 plants currently inject their biomethane directly into the natural gas grid – around 340 million Nm^3 annually –, as the DBFZ Leipzig calculated. Incidentally, the political target for 2020 is for six billion Nm^3 biomethane per year. The institute calculated that to achieve the target, around 100 plants with an average feed-in capacity of 700 Nm^3 must be added each year The experts agree: biogas can replace fossil natural gas, but not at any price. In Mecklenburg-West Pomerania, where there are one million hectares of arable land, they know that too. "Cereal is grown on 58 % of this, rape on 24 %, maize on only 13 % and other types are cultivated on 5 %", says Felix Hess, naming the figures which should prove that plant cultivation for the tank by no means displaces cultivation for the plate.

Substrate delivery.
photos: NaWaRo GmbH

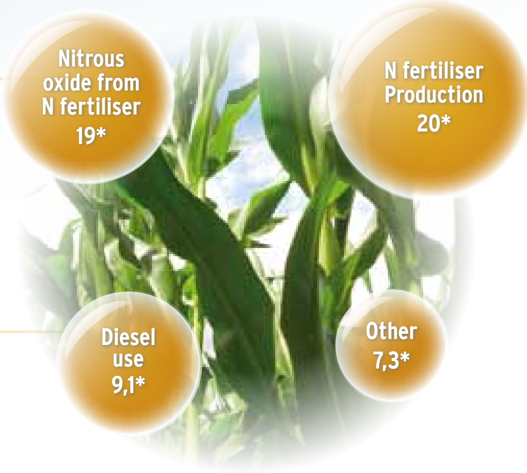
The climate balance of biomethane

Katja Oehmichen and Stefan Majer

One of the main drivers for the use of biomethane is the wish to reduce anthropogenic greenhouse gas emissions (GHG emissions). In order to determine whether greenhouse gases can be reduced by using biomethane (e. g. for electricity production), it is necessary to calculate all emissions associated with its production and use. The scope of such a balance includes the entire process chain, from the biomass production to its transport, the biogas production, its upgrading to biomethane through to use for the CHP facility. For the GHG balancing, an inventory is drawn up of the greenhouse gases carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) including all process steps. The greenhouse gases are then converted into CO_2 equivalents using characterisation factors. The following diagram shows the main drivers of GHG emissions throughout the entire supply chain for the generation of electricity from biomethane. All the values shown refer to one kilowatt-hour of electricity.

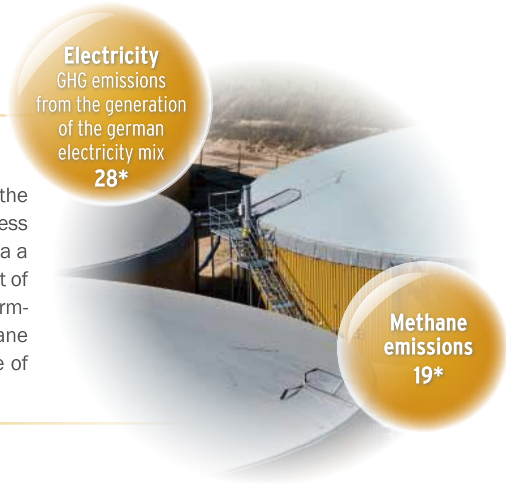
Biomass cultivation

The GHG emissions from agricultural cultivation (shown here for the using the example of silage maize) are essentially influenced by the yields per acre/hectare, the use of diesel in agricultural machines and the use of fertilisers. The proportion of emissions originating from the use of nitrogen is particularly large. GHG emissions are produced here during the production of nitrogen fertilisers and as direct field emissions by the applied nitrogen fertiliser.



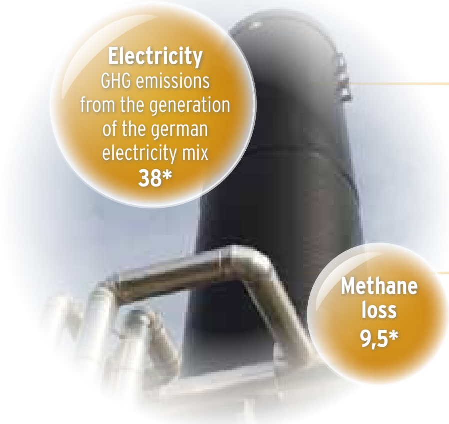
Transport of the biomass

The emissions from the transport of the biomass from the field to the silo are mainly caused by the use of fossil diesel fuel.



Biogas production

From the silo, the substrate is transferred into the actual biogas production process, the fermentation. Apart from the expenditure for supplying the biogas plant with process energy (in this example covered by electricity from the public power grid and heat via a biogas condensing boiler), the consideration of direct methane emissions as a result of leaks is mainly relevant. As the greenhouse gas methane has a far higher global warming potential (according to IPCC, 2006 the global warming potential of one kg methane is approximately that of 23 kg CO_2) than, for example, CO_2, the order of magnitude of these emissions can have a decisive effect on the overall result.



Biogas processing

In the stage of biogas upgrading and injection into the natural gas grid the methane losses occurring and the corresponding energy requirement are significant for the GHG emissions. The power required for operation for the plant in the example shown here was covered by electricity from the public power grid.

* the bubbles show the level of GHG emssions. The numbers represent the gCO_2-equivalents per kWh of electricity generated from biomethane

Gas transport

The emissions from the transport of the biomethane in the natural gas grid are mainly influenced by the energy required by the compressor stations.

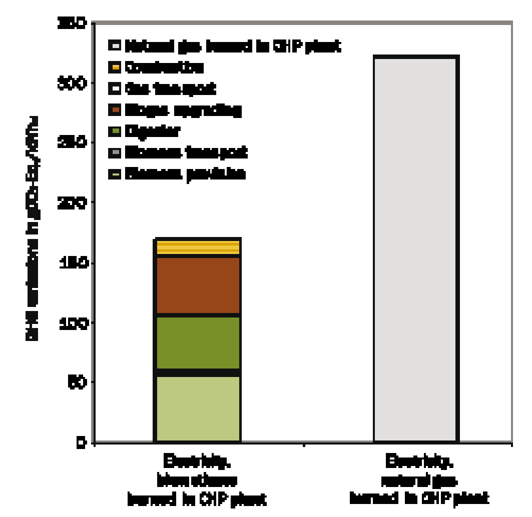
Biomethane use in the CHP facility

Use of biomethane in the CHP plants is the last step in the process chain. As CHP facility are not usually equipped with exhaust gas cleaning, its exhaust gas flow represents a source of emissions with direct climate-relevance. The proportion of uncombusted methane in the exhaust gas flow primarily depends on the type of engine used.

1 kilowatt-hour electricity

The greenhouse gas emissions

The following diagram shows the results for the exemplary process chain for production of electricity from biomethane compared to the electricity generation from the use of natural gas in a CHP facility.



Source: Stefan Majer, Katja Oehmichen: Umwelteffekte der Biogasproduktion; in: Graf, F.; Bajohr, S.; (Hrsg.) Biogas-Erzeugung, Aufbereitung und Einspeisung, Oldenburg, 2010

Why are the CO_2 emissions from the combustion of the biomethane not taken into account?

Even during the combustion of bio-methane carbon dioxide (CO_2) is produced. In this respect bio-methane doesn´t differ from natural gas.

The CO_2 that is released during the combustion of bio-methane is balanced due CO_2 uptake of a crop from the atmosphere during its growth (a few months or a few years). It thus forms a closed circuit. This differs from fossil fuels, whose carbon content was for a very long time removed from the atmosphere. Through burning fossil fuels, the carbon is released as CO_2 back into the atmosphere and contributes to increasing the CO_2 content permanently.

Since biomass burning has only a short term influence on the CO_2 content of the atmosphere, the CO_2 emissions from combustion in the GHG balance will not be considered. The following diagram shows the carbon cycle.

The journey of the carbon atom

A CO_2 molecule floats above a field. The gas penetrates a plant through pores in its leaves.

Photosynthesis produces glucose. Part of the sugar is converted into starch in the plant as a reserve.The carbon is now part of a chemical energy store

After the harvest the plant is ensiled and is added to the fermenter. Different bacteria convert the macromolecules via acetic acid, CO_2, hydrogen and to methane and carbon dioxide.

In the subsequent upgrading, CO_2 and other interferents are removed from the biogas. The methane content of the gas increases from 55% to approx. 96%.

The upgraded gas is dried and compressed and is injected as biomethane into the natural gas grid.

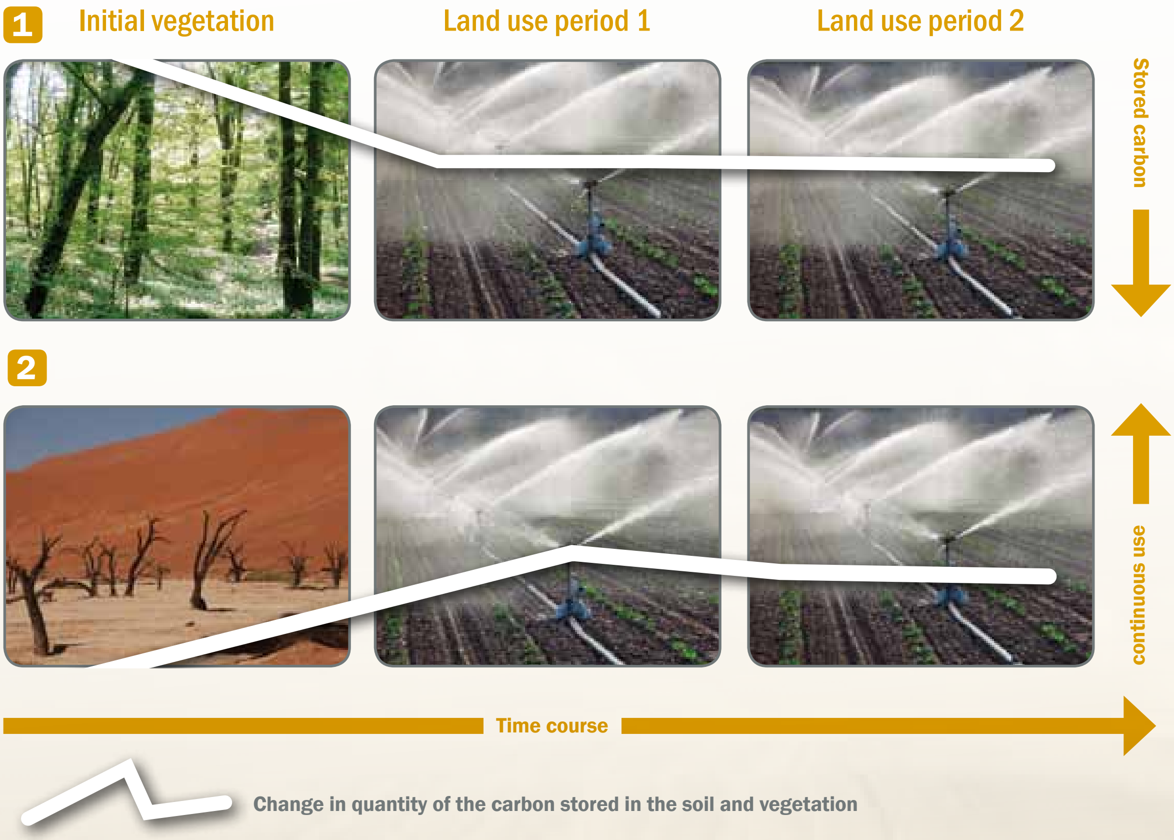
Monocultures

Energy crops for biogas production are cultivated according to the requirements and obligations of traditional agricultural production. Legal standards on good agricultural practise (e.g. through the Plant Protection Act (PflSchG), thefederal soil protection act and the fertiliser ordinance) are just as relevant for the cultivation of energy crops as for the cultivation of other crops (for example, for the feed market). The cultivation of energy crops within the fremwork of multiple crop rotation has significant advantages from an agricultural point of view.

For example, multiple crop rotations with a sensible mix of shallow and deep-rooted plants, humus augmenters and digesters reduce attack by weeds, fungal diseases and other pests and increase general nutrient and water availability in the soil compared to monoculture cultivation. Among other things, this reduces pesticide costs. Due to possible all-year ground cover, energy crop cultivation in crop rotation also provides opportunities for reducing soil erosion and possible nitrogen washout during the winter months.

Changes in land use

If natural areas are ploughed up for the cultivation of biomass for bioenergy production, the carbon inventory on the respective area can change. This has a direct effect on the GHG balance of the respective bioenergy pathway.



Incentives for biomethane use

What policy makers do for the expansion of biomethane use?

Johan Grope, Franziska Schories

Biomethane is a versatile renewable energy source. It can be obtained from organic residues, from agricultural fertilizers, from sewage sludge and renewable raw materials. Unlike wind power and solar energy, biomethane can be stored and therefore supply in line with demand. The existing gas infrastructure can be used to transport it from the production site to any place of use and can be utilised there in a number of use options: namely as an energy source for the generation of power, heat and as fuel.

These advantages have been recognised by politicians – biomethane is considered to be a very promising climate protection option. However, like most forms of renewable energy, biomethane relies on comparatively high (initial) subsidies. For this reason, biomethane production and use is incentivised through various statutory provisions (see tab. 1). This legal framework must be considered within a broad political context. In environmental policy terms the focus is on the climate protection effect, but in energy policy terms the aim is ensure security of supply and reduced dependency on imports. New sales channels for agriculture, structural development in rural areas and the development of innovative branches of industry are other political objectives.

The subsidy of biomethane supply and use is not regulated at EU level, but is a matter for the individual countries. As these face very different energy policy challenges, the supporting and funding instruments differ substantially in some cases. For example, in Sweden and in Switzerland, power supply can be almost completely covered by hydroelectric and nuclear power. Therefore, there is no particular incentive to use biomethane to generate electricity from a climate and energy policy point of view. Considering that, the development of biomethane as a fuel has priority in both countries, in order to reduce their dependence on imports of oil and natural gas based fuel in the transport sector. Biomethane has already been used there for many years as fuel for buses, cars and trucks. Both countries also have in common that they mainly use residual materials for the biomethane production, as there are no special subsidies for renewable raw materials. Plants based on biowastes and sewage sludge therefore dominate.

In Germany too, the intention is to increase the share of biofuels through the Biofuel Quota Act (BiokraftQuG). Since 2009, the provisions have been adjusted in a way that biomethane can be used to fulfil the biofuel quota. Nevertheless, compared to Sweden and Switzerland, the use of biomethane in natural gas vehicles is still at the beginning. The largest obstacles to increased use of biomethane in the fuel sector in Germany are, on the one hand the comparatively small number of natural gas vehicles and on the other the inadequate development of the natural gas filling station network. With approx. 900 natural gas filling stations currently in Germany, convenient infrastructure for natu-al gas vehicle users is not yet available. Politically, the main focus in the transport sector is also on the development of electric cars: the federal government has specified the target, to get one million electric vehicles on German roads by 2020.

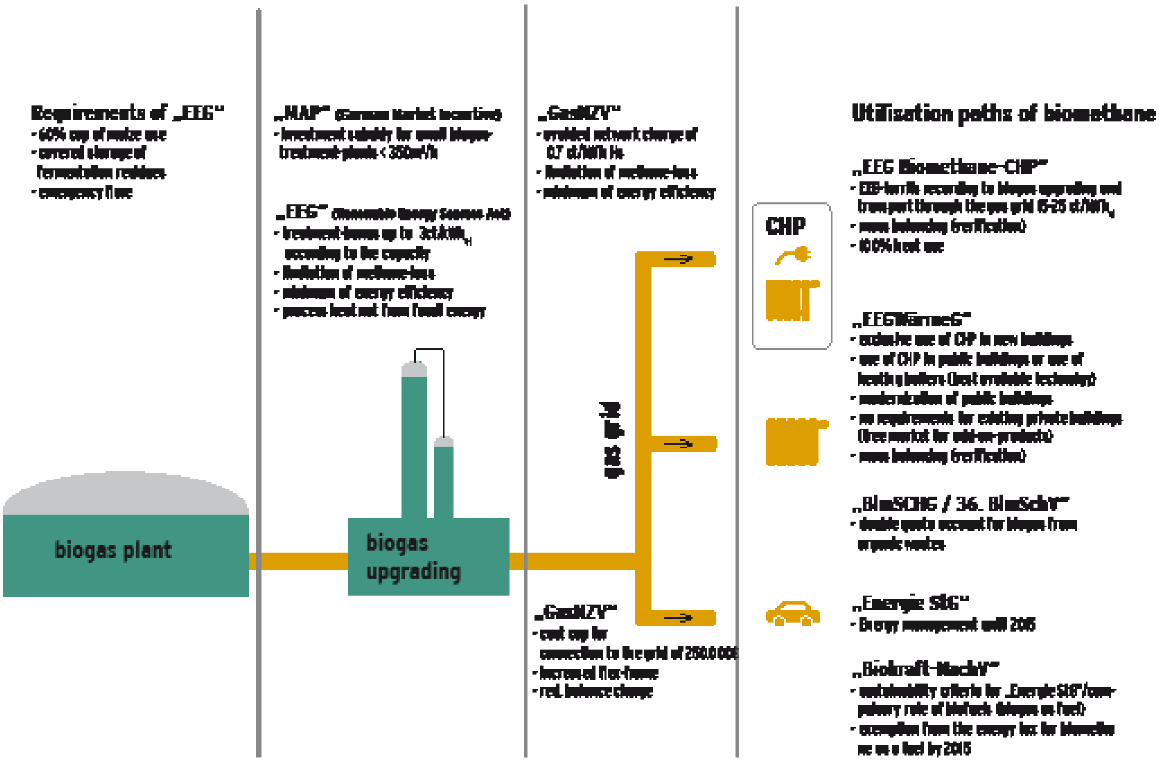
The attention of the subsidy of biomethane in Germany is instead on combined heat and power generation (CHP). In Germany, this use of biomethane is subsidised through the renewable energy act (EEG), under which electricity from biomethane, provided it is generated in CHP, receives a feed-in tariff guaranteed for 20 years. Focus on CHP has two main reasons. On the one hand in Germany, principally fundamental progress have to be achieved in

energy efficiency. On the basis of current sustainability and climate change gouls it makes no sense to produce biomethane purely for thermal energy, as biomethane is a good substitute for natural gas and shows a more favouravble GHG-balance than comparable fossil energies. Also the use of biomethane in the heating sector can not compete with fossil natural gas, because of high production costs of biomethane. Generally, in the heating sector a higher share of efficient technologies is needed. This means besides CHP, also the expansion of local and long-distance heating networks as well as energy-focused building refurbishment. On the other hand the comparable huge share of fossil energy on power and heat supply should be reduced. The relatively high share of coal as a fossil energy source in the electricity sector (approx. 42 %, source: BDEW 2010), causes comparatively high specific greenhouse gas emissions for the kilowatt hour electricity (approx. 563 gCO_2/kWH_{el}, source: Umweltbundesamt, FG I 2.5., Dated: March 2011). Use of biomethane therefore on the one hand has the function of lowering the high greenhouse gas emis-sions in the mainly coal-based electricity production. On the other hand, biomethane is an important option for balancing out fluctuating renewable energy sources, as by using the natural gas network it is possible to decouple biomethane production and use in spatial, temporal and quantity terms.
In order to use the gas infrastructure as a store and as a transport medium for developing efficient CHP locations, biomethane must be injected into the gas grid. In the gas network access regulations ("Gasnetzzugangsverordnung" – GasNZV), which defines the legal framework in this context in Germany, following several amendments in recent years, biomethane has been assigned special condi-tions, which minimise the regulatory and financial obstacles. The use of biomethane in CHP for pure heat supply is incentivised by the renewable energy heat act ("Erneuerbare-Energien-Wärmegesetz" - EEWärmeG). This specifies the pro rata use of renewable energy for the supply of heat in new buildings and existing public buildings. In this respect the federal law applicable throughout Germany, the EEWärmeG allows an exception of the CHP-obligation only in the case of public buildings, which are completely renovated. Biogas/biomethane is only allowd to be used partly for decoupled heating supply. A further exception is the heat law of the federal state of Baden-Wuerttemberg which also enables biomethane to be used for pure heat use and includes existing buildings.

Biomethane in the current energy policy discussion in Germany

At present, the adjustment of the legal framework for subsidising renewable energy and energy efficiency dominates energy policy discussion in Germany. In the context of the exit from nuclear energy and the transformation of the energy system (so-called "Energiewende"), the federal government's objective was to quickly readjust the legal provisions. Therefore, in the summer of 2011, the EEG was amended. Several aspects and politicians' views of the current debates concerning biomethane and biogas in general are then to be examined.

The FDP Member of Parliament Dr. Happach-Kasan emphasised in relation to the EEG 2012: "I consider the amendment to be considerably better than it was. It was important to cancel the coupling of the liquid manure (slurry) bonus and NawaRo bonus, because it caused enormous over-subsidies and unwelcome developments in some regions. And it also cost a lot of acceptance and sympathy. It was high time to turn back this development." Here she addresses the problem of the large increase in the number of biogas plants built in the animal processing and dairy cattle regions, incentivised by the slurry bonus. A subsidy for the total quantity of energy produced from biogas plants which use a minimum of 30 % slurry made biogas production from renewable raw materials (NawaRo) in combi-nation with a minimum proportion of slurry very profitable. This misallocation was recognised and was deleted from the law with the amendment of the EEG effective from 1/1/2012. These unwelcome regional developments also brought about a need for political action, which counteracted the "maizification" of agriculture. This has been dealt with in the new law by the so-called maize cap: the use of maize and cereal grain for the generation of electricity from biogas is limited to 60 %. This is intended to give an incentive for the mobilisation of the use of other materials (feedstocks).
Therefore, it is especially welcomed that the use of animal residues in small biogas plants is subsidised separately: "It was recognised that greater subsidies had to be given to encourage smaller, local farm-based biogas plants with very high use of slurry," says Friedrich Ostendorff, agricultural policy spokesperson of the Bünd-



German laws and regulations associated with the use of biomethane (source: © BMU, KI III 2; 2011) nis 90/Die Grünen parliamentary group. Such localised plants (up to 75 kW_{el}) enable locally produced biomass to be used and provide the opportunity for regional added value in rural areas. Biomethane plants are not addressed by this subsidises. Anyway for the operation of the plant a miniumum ten times higher power is required. The new EEG also provides greater support for large plants – here the focus is on the economic and ecological efficiency of the biogas or biomethane production (cf. tab. 1)

Mr Ostendorff comments, as follows, on the fact that energy from biogas and biomethane relies on a comparatively high subsidy, even compared to other renewable energy sources: "New technologies always need support at the beginning, to make them marketable. However, this must be gradually reducing support, which is degressive. The biogas subsidy is currently too high and biogas must be marketed more. We're already on the market with wind power, with photovoltaics we are well on the way to establishing it on the market. Biogas still needs greater marketing." In order to bring the operators of biogas and biomethane plants to the market, the so-called market bonus was introduced with the amendment of the EEG; this bonus is binding for plants with an installed output of 750 kW_{el} or higher from 2014. Through skilled marketing of the energy in combination with the market bonus, the operators can generate additional revenue compared to the fixed EEG remuneration.

As biomethane is a comparatively expensive energy source, among other things due to the complicated upgrading technology, the grid connection and substrate supply, the Federal Ministry of the Environment (BMU) has made it its central concern to ensure that biomethane is used as efficiently and ecologically useful as possible: "In particular, the biomethane supply and the energy demand should be brought together in the CHP, with which the highest total efficiency rate can be achieved," says Wolfgang Urban, Fellow of the Ecologic Institute and advise of the BMU in issues concerning the energetic use of biogas and biomethane. The EEG 2012 therefore specifies a minimum heat use of 60 % for biogas on-site power generation and 100 % for biomethane power generation. This requires a meaningful heat concept, i.e. a heat sink, for example, public buildings or residential buildings as well

A gas meter in a german household, photo: DBFZ

as industrial sites.
Overall, biogas and biomethane are considered to be important balancing energy for wind power and solar energy. Here too, through the flexibility and market bonus in the amended EEG, instruments have been created which incentivise flexible and therefore demand-adjusted energy supply from biogas and biomethane. However, in order to move further towards the target of covering 80 % of the electricity requirement in Germany through renewable energy sources by 2050, in view of the Liberals, further storage technologies are required, e.g. pumped storage power stations.

All things considered, Dr. Happach-Kasan is optimistic about the further development of biogas and biomethane: "We can see that in general, farmers and businesses have proven to be very resourceful. And that is what a law such as the EEG relies on. A law is ultimately only as good as the farmers and businesses that fill it with life. Because that is what we as politicians always have to rely on: that there are people who use the legal framework for constructive action."
The ability to support an energy system based on renewable energy, the variety of use options and the issues of sustainability along the biomethane value chain give biomethane a special role in the energy policy discussion. All the players involved will therefore eagerly track which political courses are set in future, in order to best integrate the biomethane joker into the changing energy system.

Law / regulation	Support mechanism	Speciality for biomethane
EEG	• Entitlement to feed-in • entitlement to tariff payment applied for 20 years • tariff payment for electricity depends on the resources and power of the installation	• CHP-obligation • Bonus for technology for electricity from biomethane (graded according the size of the biomethane installations)
EEWärmeG	• Obligation to generate heat from a share of renewable energies or energy efficiency measures • Fulfilment by biomethane as an option	• Nationally only in new buildings and CHP-obligation for biomethane • In public buildings and also in existing public buildings (in case of refurbishment) in Baden-Wuerttemberg and without CHP-obligation
GasNZV	• Entitlement to feed-in of biomethane • Cost reductions of the energy supplier	• The biomethane supplier obtains avoided charge for use of the grid system (0,7 ct/kWh) • Operating costs and the majority of investment costs of the feed-in the grid system shall be borne by the grid system operator (surcharge to all gas custumors)
BioKraftQuG	• Obligation for add-on of a minimum proportion of biofuels • Fulfilment by biomethane as an option	• Compliance of particular sustainibilty requirements • Biomethane does not apply to the fuel tax

Tab. 1: Statutory provisions for subsidy of biomethane use in Germany

Source:
BDEW: Gross electricity generation 2010 by energy sources in Germany, 27/4/2011
http://www.bdew.de/internet.nsf/id/DE_Brutto-Stromerzeugung_2007_nach_Energietraegern_in_Deutschland
Umweltbundesamt, FG I 2.5., Dated: March 2011.

Interview with Prof Frank Scholwin, scientific managing director of the DBFZ

"Biomethane can become the system service provider of the energy system..."

The positive trend of increasing biomethane plants in Germany is immense. We spoke with the scientific managing director of the Deutschen BiomasseForschungsZentrum gGmbH (DBFZ) about the trends in the biomethane sector.

Angela Gröber

Which way is the biomethane production trend moving, in the direction of biochemical conversion or is thermo-chemical conversion catching up?

Frank Scholwin: Indeed, at present the biochemical path is more sophisticated. In Germany we have a dense network of biogas plants, whose raw biogas is upgraded using different methods, so that 95 to 99 % biomethane is produced. This can in turn be injected into the existing natural gas grid or used in another way.
Thermo-chemical conversion is also being pursued, although the technology has not yet penetrated the market. In the demonstration plants already built, e.g. in the Austrian town of Güssing, we are looking to see how far the energy conversion efficiencies are really fulfilled.

How has the number of biomethane plants in Germany developed?

Frank Scholwin: We can look back on very positive development, as the number of plants in Germany doubled in 2011. We expect to break the 100 mark by the end of the year. The size of the plants is relatively homogeneous and lies between 500 and 2000 m^3/h (raw gas production).

Which players are behind the expansion?

Frank Scholwin: The investors are mainly utility companies and institutional investors. But private sector commitment is increasing, even though there is not yet really a significant trend. In this context, a comparison with wind power is very helpful: in the case of wind power, repowering is the term used when a more powerful wind turbine is installed in the same location. We are also observing similar developments among the biogas plant operators for whom, depending on the location, an investment in biomethane processing (upgrading biogas to biomethane) can be worthwhile.

The number of plants is growing. Is the substrate supply secured?

Frank Scholwin: More than 90 % of the raw materials come from domestic biomass. A great deal of attention is directed at using biogenic residues. The potential of the organic waste for use in energy production has a long way to go before it is fully developed. Research is currently focussed on biomasses with very high cellulose content. The microbiologists hope to be able to provide informative statements about the processes which enable biomass to be converted into biomethane.

Is biomethane really already competitive compared to fossil natural gas?

Frank Scholwin: Use of biomethane is currently only worthwhile with a financial subsidy. If we look at the natural gas prices in industry, at present they lie between 17 and 40 €/MWh. By comparison, biomethane production currently costs 60 to 80 €/MWh.
The clearest incentive to invest in biomethane plants is set by the EEG (Renewable energy sources act) and therefore provides investment security. In Germany there is a large growth in the number of plants. We are on the right path, but politically set motivation definitely remains necessary.

Frank Scholwin (39) graduated as an environmental engineer. In 2003, he started to work as the head of the biogas department of the institute of energetics and environment („Institut für Energetik und Umwelt") in Leipzig. In 2006 he became head of the biogas technology department and an authorised representative. Following the merger of the institute he retained this position („Deutsches BiomasseForschungsZentrum gGmbH" – DBFZ). In 2009 he was appointed Honorary Professor of Biogas/Bioenergy at the University of Rostock. Since January 2011, he has been the scientific director of the DBFZ gGmbH.

What about the customer or consumer side? Is there any demand for biomethane?

Frank Scholwin: The consumer group is currently still very manageable. Large natural gas suppliers offer products with at least 5 % biomethane blended with fossil natural gas through to pure biomethane. This product is then at least around 2 cent/kWh more expensive than pure natural gas as is asked for by climate-conscious customers. Apart from direct marketing, in Germany it is combined heat and power (CHP) or cogeneration that plays the largest role. However, the marketing channel serviced by producers depends on the location.

In the mobility sector, for example, we are faced with the challenge of successfully getting across biomethane as an alternative fuel to consumers, although I consider it to be a very important application. As natural gas has already been advertised as a "green alternative" to tried and tested liquid fuels, it is difficult to make an environmentally friendly even more environmentally friendly. Try to communicate that to your customers...

So what is the main advantage of biomethane if the production costs are so high?

Frank Scholwin: We cannot assume that we can substitute all use of natural gas with biomethane. There is too little biomass for that – by the way, the price of the raw materials is the real cost driver of biomethane.

But the advantages of biomass – of biomethane in particular – are clearly obvious in the interaction of all renewable energy sources: biomethane can be flexibly produced and used in line with demand. It can become the system service provider of the energy system. Thanks to the existing natural gas infrastructure it can be easily stored, transported and above all it can also be used without any technical changes. Optimisation of the energy efficiency is still expected – and talking of energy efficiency brings us back to CHP.

What conditions have to be fulfilled if we want to continue the market development of biomethane?

Frank Scholwin: Two conditions must be fulfilled to stabilise the initiated biomethane expansion:

1. On the political side it is necessary to ensure long-term reliable framework conditions, which must also be acceptable to the market, and to fix these for a longer period
2. The tax difference between natural gas and biomethane must be made far more visible, as with biomethane we can halve the greenhouse gas relevant emissions produced by using natural gas.

Thank you for talking to us!

Calculate your feed-in tariff!

The biomethane remuneration calculation according to EEG 2012

(Version 1.3, dated: September 2011)

Alexander Krautz, Diana Pfeiffer

photo: pixelio

What can the remuneration calculator do?

The remuneration calculator for biomethane provided by the Deutsches BiomasseForschungszentrum gGmbH (DBFZ) offers CHP operators the opportunity to calculate the tariff for their plant according to the new tariff system under the Renewable energy sources act (Erneuerbare Energien Gesetz – EEG) effective from 1 January 2012.

On what legal provisions is it based?

The amended EEG 2012 contains a comprehensive change in the remuneration structure for bioenergy plants, which are started up after 1 January 2012. In addition to the basic tariff, the new tariff system of the EEG 2012 differentiates between 3 different feedstock tariff classes, in which the substrates are classified and remunerated according to their ecological-economic favourability. A further innovation is the changeover of the feedstock tariff to the feedstocks' energy share of the total tariff. All other bonuses of the old tariff system under the EEG 2009, and the combined heat and power (CHP) bonus, have been transferred in minimum requirements and are taken into account accordingly in the basic tariff. The upgrade bonus for the gas feed-in/injection is the only remaining bonus retained in the new tariff system.

What has to be noted?

The calculator:

- is only for calculating the fixed annual feed-in remuneration within the scope of the EEG 2012. Other provisions have to be noted for further calculations outside the fixed feed-in remuneration of the EEG (direct marketing obligation for plants with 750 kW_{el} and higher from 2014, green electricity privilege, market premium and flexibility premium). It is not possible to change from the EEG 2009 to the EEG 2012.
- Not for liquid bioenergy and biogas produced from biowastes

The calculation assumes complete heat usage!
The current statutory provisions must always be followed for the assignment of the feedstocks and the plant operator's claim for remuneration from the grid or network operator.
If the tariff calculator does not give the correct tariff claims in an individual case, e.g. due to an unclear legal situation, only the statutory tariff claims are relevant.

The biomethane tariff calculator and two other tariff calculators for "solid biomass" and "biogas" are available as free downloads under the following link:
http://www.dbfz.de/web/aktuelles/details/article/verguetungsrechner-eeg-2012-verfuegbar.html

Contact: alexander.krautz@dbfz.de

<table>
<tr><th></th><th colspan="5">Remuneration for biomethane from</th></tr>
<tr><th></th><th colspan="4">Biogas plants (without biowaste)</th><th>Biowaste digestion plants [5) 6)]</th></tr>
<tr><td>Performance equivalent of plants</td><td>Basic tariff [1) 6)]</td><td>Feedstock tariff I [2)]</td><td>Feedstock tariff II [2)]</td><td>Bonus for gas treatment [4) 6)]</td><td></td></tr>
<tr><td>[kWel]</td><td colspan="5">[€ct/kWh_{el}]</td></tr>
<tr><td>≤ 150</td><td>14,3</td><td rowspan="2">6</td><td rowspan="2">8</td><td>≤ 700 Nm³/h: 3</td><td rowspan="2">16</td></tr>
<tr><td>≤ 500</td><td>12,3</td><td>≤ 1.000 Nm³/h: 2</td></tr>
<tr><td>≤ 750</td><td>11</td><td>5</td><td rowspan="2">8 / 6[3)]</td><td>≤ 1.400 Nm³/h: 1</td><td rowspan="3">14</td></tr>
<tr><td>≤ 5.000</td><td>11</td><td>4</td><td></td></tr>
<tr><td>≤ 20.000</td><td>6</td><td>–</td><td>–</td><td>–</td></tr>
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1) Amount of compensation to the border of the rated power
2) According to the definitions of the biomass-regulation
3) For the energetic content of slurry from a rated output of 500 kW_{el} a feedstock compensation of 6 cents/kWh_{el} is granted
4) Is granted in compliance with the eligibility-criteria in Appendix 1 of the EEG 2012th
   a) Methane emissions from processing not more than 0,2%
   b) Maximum power consumption of the upgrade-process of 0,5 kWh/Nm_ raw-gas
   c) Use only renewable energy sources for the provision of process heat during the upgrading process
   d) max. rated output of the the methane upgrading plant of 1,400 Nm
5) Applies only to plants which ferment certain organic waste (according to § 27a Section 1 EEG) and which are equipped with a device for the post-rotting of solid fermentation residues. The fermentation residues are required to be used materially. For injection into the gas grid the feed-in bonus will be granted in addition.
6) The basic remuneration, the feed-in remuneration and the the remuneration of biowaste-plant is subject to an annual degression of 2%. The remuneration to the commissioning date applies for the entire duration of the compensation.

- The remuneration claim was only attached to the electricity generated in CHP operation.
- The remuneration claim was only attached if biomethane from upgrading plants (which feed-in after the 01/01/2012) is generated by the use of max. 60 mass-percent corn and grain (§ 27 paragraph 5, sentence 1).
- For the entire supply- and production-chain a mass balance system has to be used.
- The liquid biomass which is used for the ignition and auxiliary firing can count torwards electricity production in relation to the energy production. I.e. that the biomass which is used for ignition and auxiliary firing has no effect on the level of remuneration.
- From the year 2014 the compulsory use of the market premium is mandatory for plants which have an installed capacity of 750 kW_{el} (§ 27 para 3 EEG).

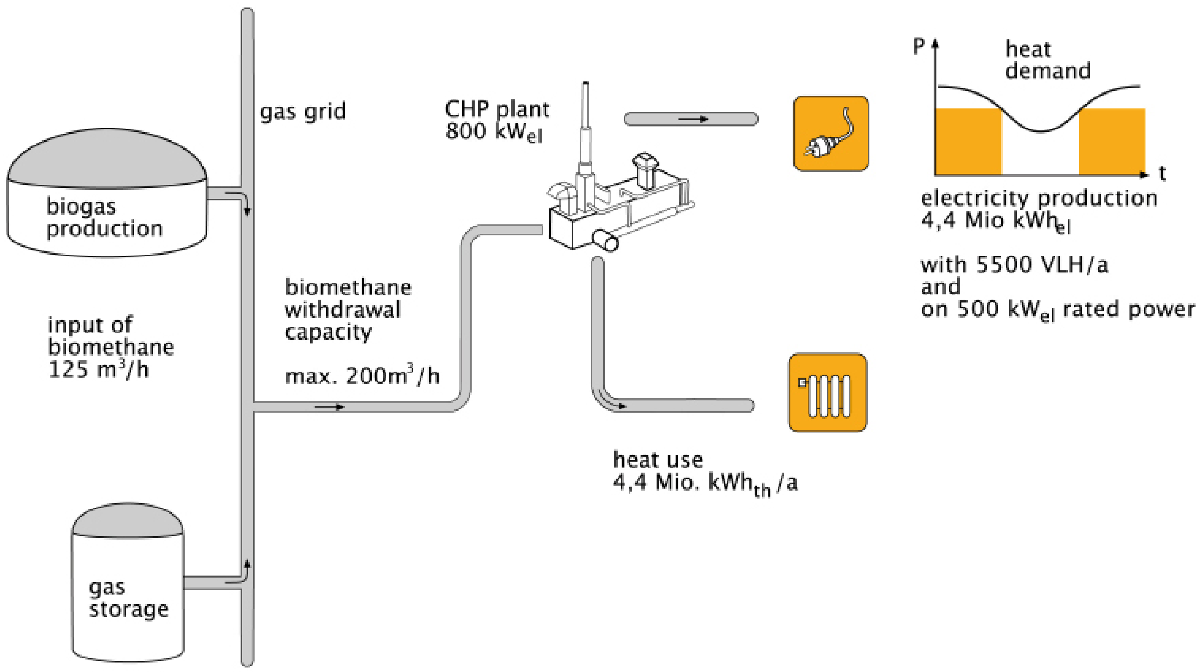
Demand-responsive energy supply from biomethane

photos: VNG AG

Uwe Holzhammer

Future energy demand, especially electricity demand, will be covered by very large proportions of renewable energy sources (EE), in order to reduce greenhouse gases by relevant quantities. The federal government therefore plans to achieve an EE share of the electric power supply in Germany of at least 80 % by 2050. By far the greatest share of the electricity requirements will be provided by weather- related renewable energy sources, such as wind and solar power. The remaining electricity requirement, which also has to be covered – usually called the residual load – must be provided e.g. with the help of different technologies for storing electricity or flexible power stations. Power supply from biomethane can take on the role of a flexible power station and contribute to balancing out the fluctuating renewable energy sources by means of generation management. Biomethane is also particularly interesting in energy management terms, as the existing infrastructure of the natural grid and natural gas stores, with their enormous gas storage capacities, can be used for balancing.

Power generation from biomethane usually takes place in so-called combined heat and power stations (CHPs). A significant proportion of the heat produced during electricity generation can also be made available. The achievable total efficiency of between 80 to almost 100 % (with the use of latent heat (condensing)), in relation to the calorific value of the fuel gas used, constitutes a very efficient energy supply. These quantities of heat can be used for heating purposes or for industrial purposes. Sale of the electricity



Classical power generation by biomethane in a CHP plant, source: Uwe Holzhammer, Fraunhofer IWES generated by means of biomethane, is secured by the provisions of the Renewable Energy Act ("Erneuerbare-Energien-Gesetz" -EEG). The legal framework specifies that the entire quantity of heat produced must be used.

Against the background of these framework conditions, demand-response energy supply from biomethane CHPS, must take into account that there are principally two options for designing the size of the CHP:

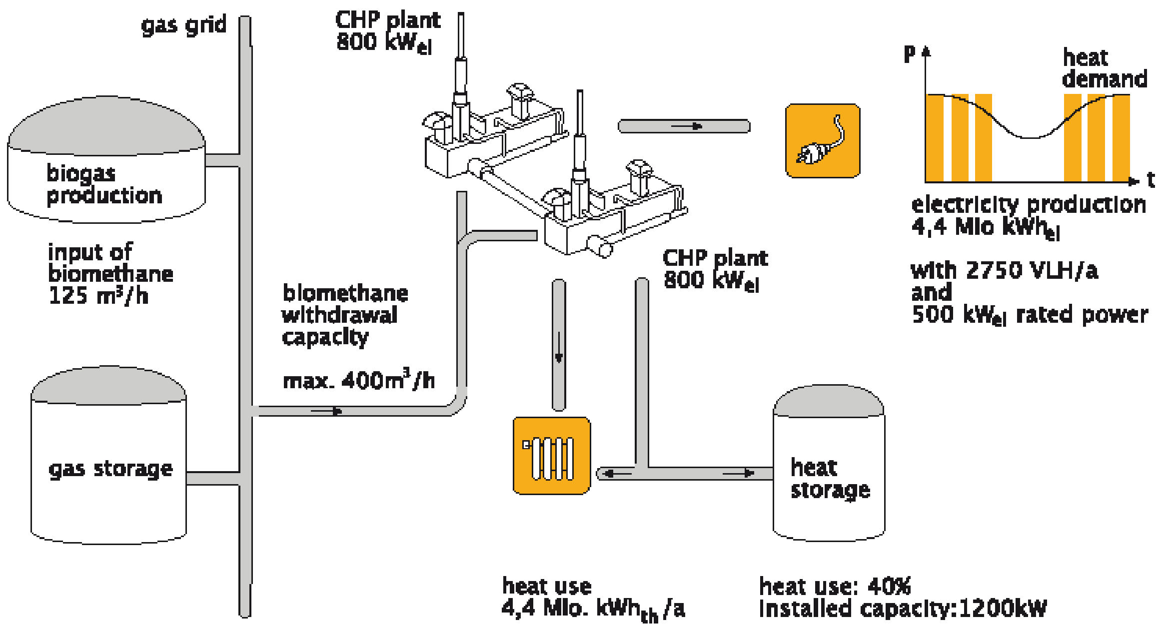
Energy production depending on the heat demand profile

The capacity is designed depending on the heat requirement (demand) over the year (annual load duration curve) viewed from a possible location (e.g. apartment block, trade center, industrial plant). At the same time, the following simultaneously effects play a particular role: The smaller the CHP output design the more hours it can be operated during the year. The electricity and heat quantities produced annually, relative to the CHP capacity under consideration, are then comparatively high. The electricity and heat quantities are in turn used to refinance the overall plant. The quantity of energy produced in absolute terms by a smaller CHP module with high capacity utilisation can be smaller than that of a larger CHP at the same location (then with lower capacity utilisation). In addition, the specific investment costs relative to power output (kW) and the specific running costs for maintenance increase with increasing plant size. The correct size of a CHP module must be determined and adapted to each location and therefore each individual project, taking into account the alternative heat producers. From an economic point of view, a full-load hour's figure of at least 5500 h a year appears to be establishing itself, at least for building heating by means of biomethane CHPs. The quantities of electricity produced are remunerated per kWh according to the EEG depending on the origin of the gas, the plant technology used and the gas utilisation of the biomethane, regardless of the time and with a fixed amount. Remuneration of the renewable electricity from biomethane is necessary, as the price of biomethane is roughly twice the price of natural gas. Without this remuneration (feed-in tariff) for the generated power, which is higher than the electricity prices on the market and is generally higher than the electricity delivery costs at the location, economic operation of biomethane CHPs and the associated greenhouse gas reduction would not be possible.
If the CHP has been designed for the heat demand profile of the heat sink at the CHP's location, simultaneous power and heat production by the CHP is generally strictly dependent on the heat demand. In detail, this means that the power production and its feed-in into the public grid take place continuously or uniformly during times of high heat demand. As soon as the heat demand falls below a certain value, which depends on the part-load behaviour of the CHP, the CHP stops producing power and heat. During this time the required quantity of heat must be provided by alternative heat sources (e.g. peak load boilers). As soon as the heat demand exceeds the generation output of the CHP, the additionally required heat is also usually provided from this heat source,

Power generation by CHPs run on biomethane, which sell the electricity to the power transmission operator at the fixed EEG tariff, takes place independently of the electricity demand at the site of the CHP. CHPs run on biomethane are therefore used especially at locations in which the price of electricity delivery is low, or the power demand is relatively low and at the same time the heat demand is very high. The remuneration specified under the EEG is then often economically interesting. But the greenhouse gas reduction potential is also frequently an additional decision-making criterion for CHP technology that uses biomethane, as a result, operation of biomethane CHPs is generally purely heat-led.

Energy production depending on power demand and heat demand

The amended EEG whose provisions came into force on 01 January 2012, provides a further option for the operation of biomethane CHPs. For the first time, the amendment enables the CHP to be simultaneously run with biomethane, depending on the power and heat demand. This is not the power demand at the site (i.e. building), but the power demand on the market. The electricity price on the electricity exchange (EPEX Spot SE) reflects this and is exposed at times to considerable fluctuations during the day, due to supply and demand. With the introduction of the capacity component (KK) as a new instrument of the EEG from 1 January 2012, there is a structure to make additionally supplied electrical output refinanceable for flexible power production. Only through this increase in the generation capacity will it be possible to orientate power production to power demand or the electricity price. In addition, it is necessary to install additional heat storage capacities to simultaneously implement heat and power-led operation of the biomethane CHPs. The power is then generated at high electricity prices, while simultaneously servicing the heat sink and the heat store. If thermal energy is required during times with low electricity



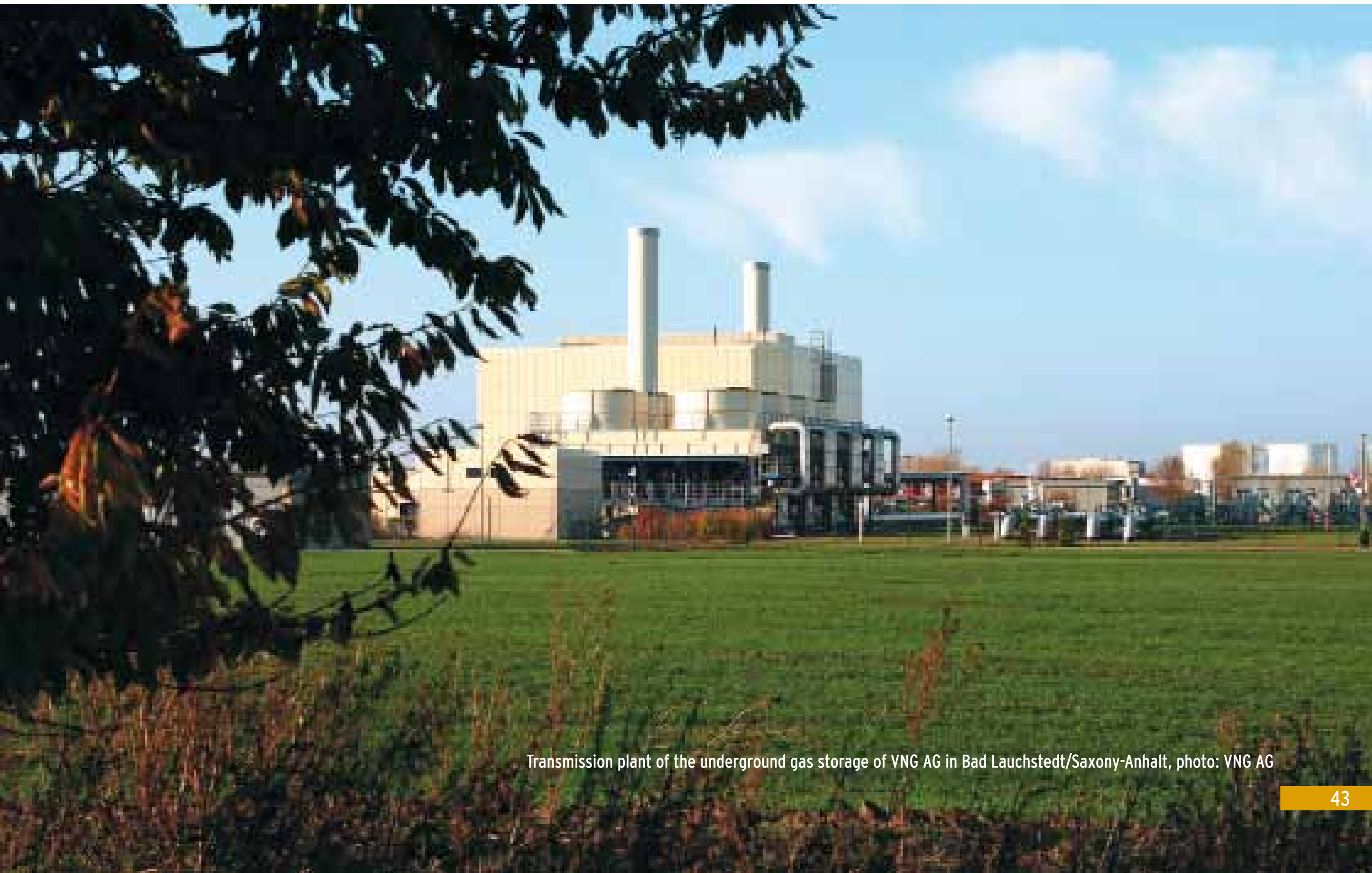
Flexible power generation using biomethane in CHP, source: Uwe Holzhammer, Fraunhofer IWES prices, the previously charged heat store can be used to supply the heat sink without having to operate the CHP. The costs incurred for the additional output, the additional heat store and the electricity trade, must be refinanced using the remuneration covered in the EEG 2012 by the market and flexibility bonus, and the higher income achievable through the sale of electricity.

The design of a CHP run with biomethane to simultaneous supply a heat sink and the EPEX Spot SE electricity exchange with electricity, depending on the electricity prices, is subject to criteria which extend beyond those described in section 1. If this is based on the average daily electricity price spread of the past four years, doubling the installed output would seem sensible, compared to the design described in section 1. With this design, the popular Peak load electricity product (electricity block from 08:00 to 20:00) can be serviced, which in the past included the twelve most expensive hours of the day, (for 98% of the time). The additional income would have been almost 1.00€ct per kWh electricity produced compared to uniform electricity production during the whole day. Plants designed in this way would no longer produce during the low price periods, but only during the high-price phase – and then with twice as much electricity. The full-load hours reached for the installed output falls from the original e.g. 5500 h during the year to half as much, in order to ensure the necessary flexibility for demand-responsive energy production. At the same time, the same total quantity of power and heat is produced at a location with comparable conditions without changing over to a more flexible system.
It is expected that biomethane CHPs based on electricity demand will be used at locations with sufficiently high heat demand and space to install the plant technology. This presupposes that the income on the electricity exchange and the electricity remuneration provided by the EEG is sufficient for economical operation.

The fluctuating renewable energy sources increasingly affect the electricity price, in its changes during the day and its pricing. It can be assumed that if the electricity price is low, the demand is low or there is high feed-in of electricity from wind and solar power, or both. In particular, electricity generation from solar power will change the classic change in electricity price during the day with a peak price during the midday period. If the quantities of electricity from CHPs run on biomethane are now only produced during times with high electricity prices, then in general, only small amounts of fluctuating electricity quantities will be available for electricity supply. The demand for renewable electricity is then particularly high. Electricity generation from biomethane therefore balances out the weather-dependent renewable energy sources. The forecast of the high-price periods and the associated electricity income will be more sophisticated in the future and this will be a challenge for the economic operation of the CHPs run on biomethane. At the same time, current electricity generation by means of biomethane CHPs has high added value due to the very high degree of use. The quantities of heat produced also contribute to the displacement of fossil energy and form another income component.

Energy management classification of the role of biomethane

In future, demand-responsive energy production, especially electricity production from biomethane, will be able to make an important contribution as a manageable manageable renewable energy source. By basing the electricity generation behaviour on the electricity price, additional quantities of renewable energy will be made usable. This represents a valuable contribution to grid and system stability, with simultaneously efficient supply of heat sinks. However, in the future, the electricity from biomethane will not be sufficient to completely cover electricity demand during times in which there is no or only very small quantities of electricity from wind and sun available. Therefore, in order to achieve the high proportion of renewable power supply in 2050 as planned, apart from generation management, the instruments available such as, power grid development (overlay networks, SmartGrid, B2B), electricity storage (e.g. accumulators, power to gas, compressed air store, pumped storage power stations) and load management (demand side management, SmartMeters) must be usefully linked to each other and used efficiently.


Transmission plant of the underground gas storage of VNG AG in Bad Lauchstedt/Saxony-Anhalt, photo: VNG AG

In the joint project on "Image analysis of biogas plants considering socio-scientific and technological aspects" (ID 03KB034), the Fraunhofer Institute for Environmental, Safety and Energy Technology (UMSICHT) in Oberhausen and the Environmental Psychology Research Group (FG-UPSY) of the Saarland university with field office at the University of Magdeburg examined biogas technology acceptance problems. The results of the study are used to develop recommendations for action and communication strategies.

Yes to energy change! But does it have to be a biogas plant?

About acceptance difficulties when new biogas plants are built – an interview with Sabine Strauch

Franziska Schories

How did you research acceptance in your project?

Sabine Strauch: The objective of the joint project is to examine the image and acceptance of biogas technology, not only under social science aspects but also under technical aspects. We selected six representative locations. The data was collected at resident and operator level with the help of standardised questionnaires. This data was supplemented through interviews with other players, e.g. plant manufacturers, local politicians, and plant safety experts. The resulting interim results were discussed in workshops with the relevant target groups.

Overall in Germany, there is a strong consensus in society in favour of renewable energy in general. Why then are there still frequently acceptance problems at local level, e.g. when it comes to building a new biogas plant?

Sabine Strauch: We were able to confirm a general approval of renewable energy in our project. I think that the citizens know that the energy change is necessary and that our energy mix has to become greener. But when it comes to specific projects, to specific forms of energy and their implementation locally, you not only come across the advantages of the individual technologies but also the respective disadvantages. The discussion therefore naturally becomes more critical. In addition to this, biogas technology is currently suffering from an image loss.

What are typical conflict topics when it comes to the construction of a biogas plant?

Sabine Strauch: As expected, the primary issue is the worry about odour nuisance and noise pollution. Also, the energy crop maize has a general image problem. Maize cultivation has increased in recent years. "Maizification" has been much-discussed in the media and is the subject of public discussion throughout Germany. In our surveys we found that the energy crop maize is perceived to be a major problem even in regions with little maize cultivation.
The "plate versus tank" discussion, i.e. the competition between energy crop cultivation and food and feed production flared up again primarily due to the public discussion surrounding the introduction of E10 fuel. We carried out most of our surveys in 2010 – i.e. pre-E10. At this time, the "plate versus tank" topic was hardly mentioned by local residents; it was only in South Germany that any misgivings were expressed. Subsequent interviews with project developers and plant operators show that since the public discussion about the introduction of E10, the ethical dimension of energy crop cultivation has suddenly become very important.
A further topic is the fear of the local residents of loss of value of their own property as a result of a biogas plant in the neighbourhood. These are fears that have to be taken seriously. Until now there have been only a few studies or figures about the effect of biogas projects on the development of property prices.
Project benefits and detrimental aspects are often unevenly dis-

Dipl.-Ing. (FH) Sabine Strauch
(Fraunhofer Institute for Environmental,
Safety and Energy Technology UMSICHT)

Sabine Strauch already dealed with issues of biogas technology in her diploma thesis. After a successful high school graduation, she spent several years working as an international developer of landfill gas and biogas projects. Since 2010 she works at the Fraunhofer UMSICHT and coordinates as a project leader national and international industry R & D projects in the areas of efficient biogas technology, biogas processing and -feeding.

tributed in the local residents' perception. They complain that the plant operators receive large subsidies for producing power from biomass, while as local residents; they themselves have no advantages and instead have to live with odour nuisance and noise pollution. There is also the fact that the operator of a biogas plant is frequently seen as a competitor by other farmers in respect to cultivation areas and substrates. People associate rising leasehold prices with the development of bioenergy and energy crop cultivation.

Are you aware of any special acceptance problems in the case of biomethane plants?

Sabine Strauch: We did not carry out any local resident surveys at biomethane injection plants, only in the area surrounding on-site power generation plants. Compared to these, biomethane plants tend to have a higher gas output and therefore larger fermenters. There is usually more resistance to larger plants. Several citizens also question the large technological cost of biomethane production. However, biomethane plants are not always seen to be negative. The upgrading technology is recognised as being advanced technology. In this case, a fuel gas is produced from plants from the field, which can be used in the household just like natural gas – this holds a certain fascination. In several discussions with local residents near biogas plants it was clear that their personal relationship with natural gas is higher than with electricity. Electricity is more difficult to understand.

What approaches are there for dealing with local acceptance problems of biogas plants?

Sabine Strauch: If there are problems and attitudes have already hardened, it is too late in most cases. This makes it even more important to start early. From the outset, the future operator should make every effort to come up with a concept adapted to the location, i.e. a concept which takes into account the agricultural structures and the residential structure as well as including useful heat usage. In addition, communication and transparency are very important. The local residents must be involved early and their misgivings must be taken seriously. It can be helpful to employ a mediator, who accompanies the project development phase from a neutral point of view and mediates between the operator and local residents.
The PR work should however not be limited to the planning and design and construction phase. It is also important during the operating phase, e.g. to offer tours of the plant, to address the local residents with a farm festival, to inform them in advance of possible negative effects in the event of pending maintenance work, e.g. so that they are aware of short-term odour nuisance in advance. The operator should always show themselves to be open to a face-to-face discussion.
Even though they are the first contact for the population, the plant operator should not be left alone with acceptance issues. Energy consultants, local authorities and associations must give their support here. Local residents should not only be informed about the technology and effect of biogas plants. Advantages through the regional added value, e.g. through trade tax income or falling heating costs due to good heat use concepts are not highlighted enough in many projects.

Can the acceptance of biogas plants be controlled politically?

Sabine Strauch: Our energy supply is changing. Primarily due to the development of renewable energy, an increasing number of small, local power stations are contributing to our energy mix. This development must be coordinated and fitted into the regional structures. Several local authorities have already drawn up a regional energy concept or a climate strategy. However, many have not yet had a good look at this topic. In these regions it is difficult to integrate a new energy project, for example a biogas plant, into the existing supply infrastructure. Coordinators and contacts could provide neutral help and advice for the citizens. But politicians can also promote acceptance of renewable energy through environmental education. For example, it is important to introduce children to the topic of renewable energy in schools. After all, it is mainly their future that depends on whether we master the energy change or not.

Thank you for the interview.

A project the BMU-funding-programme
Biomass
energy use
Partners: Fraunhofer UMSICHT
Saarland University

Potential in Eastern Europe

Case study for the Russian Federation, Ukraine and Belarus

Russia is firmly established as a natural gas supplier in the European energy landscape. Belarus and the Ukraine are transit countries, through which the natural gas pipelines pass. This infrastructure could be used if biogenic gases are produced and fed in along the natural gas network.

Dr Elena Angelova, Martin Zeymer, Katja Öhmichen, Marcus Trommler, Dr Walter Stinner, Johan Grope, Karin Arnold, Magdolna Prantner, Dr Sylvia Borbonus, Johannes Venjakob, Florian Schierhorn, Anton Orlov, Dr Werner Große

The biomass resources here in Germany are limited. Belarus, Russia and the Ukraine are countries with a large potential of biomass that can be used to produce energy, which could then be used to produce biogas and biomethane. However, the bioenergy sector in all three countries is still in its infancy. The first biogas plants have been built, but there are not yet any biomethane plants. The political framework is also an obstacle to rapid development. The question of the conditions, under which the potential could be tapped, was examined by the research project "sustainable European biomethane strategy". The research results were used as the basis for development of a strategy with which impetus could be provided for a functioning biomethane industry in the different countries. It also examines the possibilities of exporting biomethane to Western Europe, with the focus on Germany.

Biomass potential

The country studies come to the conclusion that significant and to date unused potential exists in all three countries for the cultivation of biomass and the use of residual materials for the production of bioenergy (see tab. 1). On the one hand, potential exists for the cultivation of energy crops on fallow land and yield potential by increasing productivity; on the other in developing the unused forest and residual material potential. In addition, it can be assumed that large potential exists for animal residues and municipal wastes, which were not examined any closer. Based on this, if the unused biomass potential were to be fully developed, 174 billion m³ biomethane per year could be produced. By comparison, the Germany-wide natural gas consumption in 2010 was 3,700 PJ or 105 billion m³, which equals 22 % of the total primary energy consumption. Therefore, the theoretical biomethane potential of Russia, the Ukraine and Belarus would exceed current natural gas consumption in Germany by 65 %.

Plant concepts and production costs

Biomethane can be produced not only through biochemical conversion to biogas but also through thermo-chemical conversion to bio-SNG. Different plant concepts (see fig. 1) are considered for the supply paths for biomethane from biogas and bio-SNG for each country. These differ in plant capacity, plant technology, raw materials and with regard to the timescale.
Two plant sizes, with 11 and 34 $MW_{Biomethane}$ were examined for the biochemical process (fermentation). The raw material is based on clover/grass growth on fallow land and, depending on the concept, this is fermented with or without slurry. By comparison, for the thermo-chemical supply paths, solid biomass in the form of wood chippings is allothermically gasified, i.e. at high temperatures and with

	Russia	Ukraine	Belarus
Fallow land 2030 (70% recultivation)	26,6 Mio. ha	7,9 Mio. ha	0.9 Mio. ha
Theoretical biomethane yield (fallow land)	60,0 Mrd. m³/a	17,8 Mrd. m³/a	2,0 Mrd. m³/a
Forest 2030 (available wood potential)	51,8 Mio. t/a	12,9 Mio. t/a	9,6 Mio. t/a
Theoretical biomethane yield (forest)	10,0 Mrd. m³/a	2,5 Mrd. m³/a	1,9 Mrd. m³/a
Theoretical overall biomethane yield	70,0 Mrd. m³/a	20,3 Mrd. m³/a	3,9 Mrd. m³/a

Table 1: Areas, wood and biomethane potential in 2030

the exclusion of oxygen, is converted into a gas mixture of CO, H_2, CO_2 and CH_4. Following upgrading, catalysts are used to produce a methane-rich gas and any CO_2 is removed. The resulting bio-SNG therefore has the same product properties as biomethane. Plant concepts with a bio-SNG output of 18 MW and 65 MW were considered for the calculations.
The production costs calculated for biomethane in 2030, for all plant concepts and sizes, are on average 50% higher than the natural gas price forecast for 2030 (see fig. 1).

GHG balance

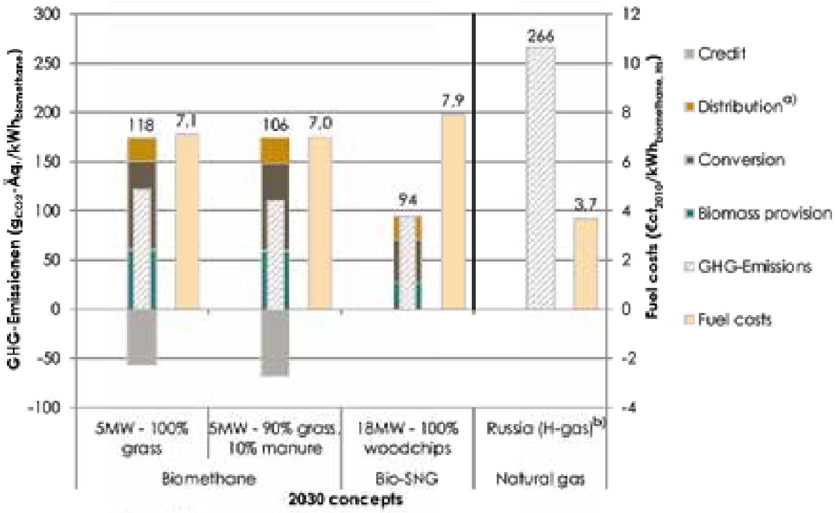
Significant greenhouse gas reductions, not only with the biogas concepts but also with the bio-SNG concepts can be achieved in all three countries compared to the Russian natural gas references. The results for the Russian Federation show that the supply of biomethane could reduce greenhouse gas emissions by up to 65 % compared to the fossil reference (natural gas from pipeline in Russia) in the long-term concept (2030).
The complex and innovative plant engineering of the bio-SNG plants leads to considerably higher production costs compared to the biochemical concepts. However, at the same time, even without credits for heat use, lower GHG emissions can be achieved for the supply of biomethane. Compared to fossil natural gas, all concepts have higher production costs for the forecast year 2030, but also a significant GHG reduction potential.

Strategy

The country studies not only identified the potential, but also the obstacles to the establishment of the biomethane industry in Eastern Europe. Firstly, on the one hand, it is necessary to aim to achieve sustained development of biogas and small-scale biomass gasification plants with CHP, on the other hand, local skilled personnel must be trained. Without training local specialists, it is not possible to guarantee economic efficiency and proper operation of the plants. In addition, suitable financial instruments will be required to support the investment activity. In all three countries, access to loans, especially for small investors, is difficult and the high interest rates reduce the willingness to invest. The legal and political frameworks are also not yet optimal. There are no laws for regulating grid access and the remuneration of electrical power produced from bioenergy or if they do exist they have a very limited effect, as is the case in the Ukraine. Bioenergy as a possible renewable power supply, is currently not attributed much importance at the political levels. The following strategy was suggested in order to nevertheless expand sustainable use of the biomass potential.
In the short-term, local plants without biomethane processing, which require a smaller investment, could be installed in order to initially use the favourable residual material potential for the regional power supply. It would then be possible to train local people to operate the plants and to largely generate the added value in the region itself. With the establishment of regional use of biomass for energy production, the advantages (reduction of energy imports, creation of jobs, and reduction of waste products/residual materials) will be significant and the political will to support bioenergy will probably be strengthened. In the short-term, the strategy is aimed at setting up use of biomass as an energy source and pushing ahead rural development. At the same time, within the scope of technology partnerships, it will be necessary to work on optimising the plant engineering and configuration, in order to achieve a higher GHG reduction in the medium to long-term.
In the long-term a changeover to larger plants based on bio and thermo-chemical concepts is feasible. The previously developed local know-how for the production of biogas and / or bio-SNG enables the operation of large plants, which can also cover the national supply with biomethane. Furthermore, the legal framework should be set up to enable problem-free feed-in of biomethane into existing networks and to enable transport to Germany/Europe. The experience acquired during the first phase will enable the local skilled staff to achieve the necessary quality assurance. In the long-term, the strategy is aimed at integrating the regional production of biomethane and/or Bio-SNG into the European supply structures and for both sides to achieve synergy effects from the international trade.

A project the BMU-funding-programme
Biomass
energy use

Partners: Deutsches BiomasseForschungsZentrum gGmbH
Wuppertal Institute for Climate, Environment and Energy GmbH
Leibniz Institute for Agricultural Development in Central and Eastern Europe – IAMO
Technical University of Dresden, Chair of Forestry and the Timber Industry in Eastern Europe



a) Average haul distance: 3.000 km
b) Source: BfA, World Energy Outlook 2010 (real price increase of natural gas between 2009 and 2030 by 75%)

Figure 1: GHG balance, comparison of production costs (excerpt for the Russian Federation)

Boosting the European market for biogas production, upgrade and feed-in into the natural gas grid – the GreenGasGrids project

Not only Germany promotes the market development of biogas feed-in into the natural gas grid, also other EU members are quite active. A new EU project seeks to bring together the different experiences of ten EU countries.

The GreenGasGrids (GGG) project aims to a more strategic approach towards boosting biomethane markets as well as increase biomethane production and use. The main actions concentrate on finding solutions to market barriers, bringing together potential business partners, know-how transfer in 'starter' countries and promotion of biomethane projects in countries with high potential but few activities. The EU project was launched on 6th June 2011 in Berlin at the 19th European Biomass Conference and Exhibition.

Eliminating still existing market barriers, as different technical standards of the process technology for the biogas feed-in, continue to play the biggest role concerning the establishment of an EU wide biogas grid. GreenGasGrids aims at leveraging the market development for biomethane by combining the expertise of then EU countries by means of

- Finding solutions to market barriers
- Bringing together potential business partners
- Promoting biomethane projects in countries with high potential but few activities
- Moving biomethane into the mainstream so it is taken into account in supply/demand and renewable targets
- Hands-on know-how transfer from "forerunner" to "starter" countries

In forerunner countries (countries with running biomethane projects) the project focuses on the most pressing issues of trade, technical standards, legislation and sustainability, bringing together key market actors and pushing for solutions to existing market problems. In starter countries (countries with projects under preparation and/or high potential) comprehensive biomethane strategies are targeted to provide decision-makers - ministries, regulators, related state agencies - with technical and legislative advice enabling them to introduce the most cost-efficient support measures. Market players - gas industry, plant constructors, project developers - from forerunner and starter countries will be involved in effective business matchmaking that will trigger investments, creating a win-win situation for all relevant players. GreenGasGrids is supported by the European Commission and runs from June 2011 to may 2014.

The GrennGasGrids consosrtium is coordinated by the German Energy Agency (dena) and consists of 13 leading scientific institutions, energy agencies and associations in the EU (Fraunhofer UMSICHT, Renewable Energy Agency (REA), Austrian Energy Agency (AEA), NL Ageny, Polish Energy Agency (KAPE), European Biogas Association (EBA), Croatian Energy Agency (EIHP), Slovakian Energy Agency (SIEA), Italian Biogas Association (CIB), French Energy Agency (ADEME), University of Szeged, Natural Gas Verhicle Association Europe (NGVA) .

Teaming up in four working groups, the consortium covers four focus topics - sustainability, technical standards, trade and legislative issues, all with regard to biomethane:

Sustainability

- Analyse implementation methods and implications for biomethane market development
- Give recommendations for solving open questions of sustainability criteria implementation for biomethane
- Ensure that biomethane is not disadvantaged compared to biogas for electricity under EU Sustainability rules

Technical aspects

- Provide overview by establishing basic data and reviewing existing initiatives (CEN, IEA Task 37)
- Give recommendations for technical standards highlighting min/max requirements
- Support 'starter' countries in relation to establishing appropriate standards to avoid unnecessary barriers/delay

Trade

- Analyse the current market and trading situation for biomethane
- Provide recommendations to overcome trade barriers and for implementation of Green Gas Certificates to ensure an efficient and sustainable market
- Develop biomethane business models

Legislation

- Evaluate support measures and relationship between existing incentives for biomethane production and alternative uses for biogas (e.g. CHP)
- Publish country models and indicative national targets for 2020 and 2030 for partner countries based on assessment of country biomass availability and financial incentives

GreenGasGrids will produce outputs for the support of biomethane market development such as National Road Maps for biomethane strategies, business models including options for cooperation and ways of finding the right partners for biomethane projects, an EU-level Road Map providing recommendations on how to proceed with a biomethane strategy on the EU- level and many more. First results are expected by beginning of 2012.

Find out more about the GreenGasGrids project:
www.greengasgrids.eu

Country profile:
Germany

Ambitious expansion targets

In Germany the expansion targets for biomethane injection have been set high, and the dynamic development of the relatively young market reflects all the efforts made to achieve these expansion targets. Biomethane from energy crops, the dominant substrate, occupies the most important part of the market and its use in combined heat and power is the usage path prioritised to date.

Johan Grope

The upgrading of biogas to biomethane and its injection into the natural gas grid has now established itself as a reliable alternative alongside on-site power generation ("Vor-Ort-Verstromung" – VOV) from biogas. A range of gas upgrading technologies has proven their suitability in practice and the players along the comparatively complex value chain met the challenges with practical solutions. In Germany, as of November 2011, 60 plants injected an annual quantity of approx. 340 million Nm^3 biogas upgraded to biomethane into the natural gas grid. A look at the development of this comparatively young market (see figure 1) shows the steadily growing number of plants built since the first biogas injection plant was started up at the end of 2005. But as the development is not advancing fast enough for many players, reference is often made to the targets set by the federal government, to inject 6 billion Nm^3/a of biomethane into the gas grid by 2020 and 10 billion Nm^3/a by 2030. At present approx. 5 and 3 % respectively of the targets have been achieved, so further speeding-up of the construction of new plants would be necessary, otherwise the targets will not be achieved. Apart from the supply of biomethane from biogas, it is also worth mentioning the provision of biomethane by way of thermo-chemical conversion of solid biomass with the help of gasification to produce Bio-SNG (Bio-Synthetic Natural Gas). While the gasification of solid biomass (primarily wood) is already being demonstrated on a large-scale and biomass gasification plants are being operated commercially, the upgrading of product gas to biomethane with the help of methanation is still in the development phase. Against this background, Germany does not yet have a large-scale plant for the production of Bio-SNG, although a large number of technological developments are very promising and can be implemented in the medium-term.

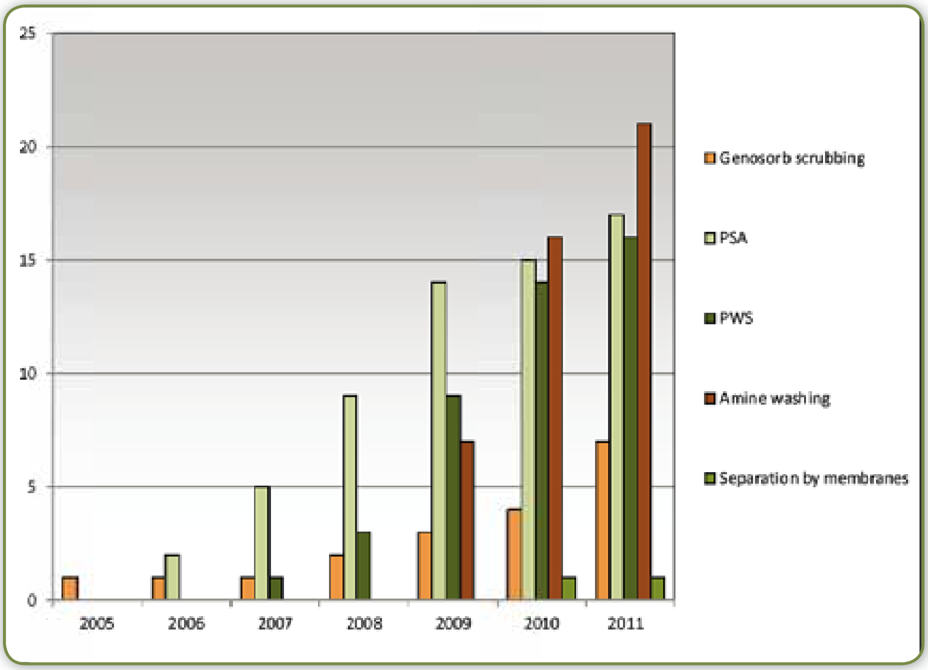


Figure 1: Development of the biogas upgrading plants in Germany according to biogas upgrading technology [DBFZ]

Germany

Total number of biomethane plants: 60
Production capacity: 460 MWHs
Total quantity of biomethane produced: 41,509 Nm^3/h or 340 million Nm^3/a (assuming an average 8,200 full-load hours per year)
Technologies used: Pressure swing adsorption (PSA), pressurised water scrubbing (DWW), amine scrubbing methods, genosorb scrubbing, membrane separation methods

Raw materials/substrates used:
- Renewable raw materials + farm manure (52,600 Nm^3/h raw gas): 74 % maize, 7.5 % grass silage, 6.5 % cereals GPS, 3.5 % farm manure, 3,5 % grain, 5 % other
- Residues and wastes (22,750 Nm^3/h raw gas): Mainly slop from ethanol fermentation, slaughterhouse wastes, food waste and municipal biowastes
- Sewage sludge (120 Nm^3/h)

Biomethane use:
- Combined heat and power (largest share of the quantities, especially NawaRo biomethane, electricity remuneration under the EEG, heat-led, primarily in the output range between 100 and 1000 kW_{el})
- Fuel (above all residue biomethane)
- In the heat market (smaller quantities, as natural gas blend product from 5 to 100 % biomethane content for domestic, commercial and industrial customers. Usually due to the customers' ecological awareness)

Link along the value chain	Players involved
Substrate supply	• Farmers • Agricultural service supply agencies • Agricultural cooperatives • Food/feed processors; biofuel manufacturers
Biogas plant operators	• Farmers (individual or operator JVs) • Agricultural cooperatives • Operator companies (especially set up to operate the plant or several plants) • Municipal works • Regional and national power supply companies
Biogas upgrading plant operators	• Farmers (individual or operator JVs) • Municipal works • Regional and national power supply companies • Operator companies (especially set up to operate the plant or several plants)
Grid injection	• Network operators
Marketing, trading, sale	• Municipal works • Regional and national power supply companies • Gas traders and biomethane traders • Contractors

In Germany, energy crops and renewable raw materials (NaWaRo) are mainly used to produce biomethane. The reason for this is, among other things, the special subsidy for electricity produced from biomethane under the Renewable Energy Sources Act ("Erneuerbaren Energie Gesetz" – EEG), which is produced from these substrates. In Germany, the largest quantities of biomethane are also used along this path (CHP electricity generation). In addition, biomethane is used as a fuel and for pure supply of heat. The biomethane plants in operation are therefore mainly agricultural biogas plants with subsequent gas upgrading. For economic reasons, however, these plants are usually significantly larger than biogas plants with on-site power generation (VOV). The average feed-in capacity of agricultural biomethane plants in Germany is approx. 7 MW Biomass. The operator constellations are diverse and varied. The biogas plant is frequently operated by farmers, who sell the raw biogas to a power supply company (EVU), which then upgrades it to biomethane and injects it into the natural gas grid. The biomethane is then traded and sold either directly by the EVU, through bilateral trading or through special biomethane traders. Apart from the agricultural biomethane plants, there are several plants which ferment residual materials to produce biomethane. In terms of quantity, this is mainly done by fermenting slops, which are a residue of ethanol production. In Germany, the greatest challenge is currently considered to be the marketing of the biomethane, as the high supply costs compared to the competing energy sources (e.g. natural gas) limits the markets. Many players already have the necessary creativity and persuasion, to develop the existing markets for biomethane and to advance expansion in view of the political targets.

Gas pipeline, photo: DBFZ

Country profile:
Austria

Biomethan plays not yet a major role

Sabine Nollmann

Biogas plant Engerwitzdorf, photo: ARGE Kompost & Biogas Österreich

Use of biomass has a long tradition in Austria, especially in agriculture. The country's objectives of achieving energy autonomy and the EU climate targets have caused it to increasingly turn its attention to the production of biogas in the past ten years. "Biogas is a versatile all-rounder among the renewable energy sources" says Austria's Minister of the Environment, Niki Berlakovich. The country wants to improve its use of the available raw material potential and is working on optimising the framework conditions for the injection of biomethane into the natural gas grid. Among other things, the "klima: aktiv biogas" program and a biomethane strategy as one of the most important possible instruments should help. If future, particular attention is to be paid to greater use of existing waste potential.

Biogas, and as a consequence biomethane, is an important element in the decentralisation of the energy supply, says the Austrian compost and biogas umbrella association, "ARGE Kompost & Biogas Österreich". The umbrella association unites around 490 plants in the compost and biogas sector in the federal states of Tyrol, Styria, Upper Austria, Lower Austria and Carinthia and supports the operators with advice on planning, operation and communication with the authorities. The ARGE's ideas: "We must aim to cover 5 % of the current natural gas consumption, which means further development of 450 to 600 million Nm^3/a of green biomethane, which would make Austria's energy supply a good deal more independent."

"There are no specifically defined biomethane targets", says Herbert Tretter of the Austrian Energy Agency. He estimates a natural gas consumption, (according to details of the current energy balance for Austria issued by the national statistics office for 2010), to be around 9.5 billion m^3. Based on his calculations (made in the autumn of 2011), the current total annual biomethane injection into the grid is around 5.6 million m^3, less than 0.06 %. Therefore biomethane accounts for an infinitesimally small share at the present time.

As in the other European countries, there is not yet any free biomethane trading in Austria, supply and demand is not large enough to justify it. Trading is currently limited to individual contracts between larger producers and customers, and is occasionally delivered to neighbouring countries.

Current development is stagnating

Initiated by the Eco-Electricity Law ("Ökostromgesetz") in 2002, there was an initial growth in the number of biogas plants in Austria. New remuneration was introduced for electricity produced from renewable sources, which allowed the use of very energy-efficient renewable raw materials (NaWaRo) and therefore enables particularly high gas yields. In addition, intensive research and technical advances meant that more efficient, larger and higher capacity biogas plants could be built.

Biogas treatment facility Bruck an der Leitha, photo: ARGE Kompost & Biogas Österreich

However, the changes in raw material prices and the feed-in tariff degression introduced with the Eco-Electricity Law of 2006 have caused the market to stagnate. The Eco-Electricity Law of 2008 removed the degression and since 2010, feed-in tariffs fixed for up to 15 years apply, which provides more planning security. The operators unanimously note however, they are unable to earn money with the plants. In general, they complain about the very low feed-in tariffs. These are currently 30 % lower than in Germany. There are also calls for other, better incentive systems. Nevertheless, there are numerous small, committed projects and initiatives.

In 2005, the first Austrian biogas upgrading plant was started up, which can inject biomethane into the public natural gas grid. Two more plants followed in 2007 and 2008, three in 2010 and another two in 2011. Of these eight plants, one is currently not in service.

Biogas plant Gaskraft Reitbach Pankl, photo: www.energiekraftwerk.org

Austria

Biomethane processing plants, which feed into the natural gas grid: 8

- Seven active upgrading plants (Asten/Linz, Bruck an der Leitha, Engerwitzdorf, Pucking, Schwaighofen near Eugendorf, Steindorf and Wiener Neustadt); another plant (Leoben) is currently not in service
- in addition, three biogas upgrading plants, which do not feed into the natural gas grid, but supply public filling stations (St. Margarethen am Moos, Rechnitz and Güssing)
- Planned: construction of a micro-network in Güssing, into which biomethane from the local upgrading plant is to be fed in future

Production capacity (upgrading plants, which feed into the public grid):

- around 1,100 Nm³/h (extrapolated: approximately 9,636,000 Nm³/a); largest plant: Asten/Linz with 380 Nm³/h (extrapolated: around 3,328,800 Nm³/a)
- Total quantity of biomethane produced (injection into public natural gas grid): a good 1,000 Nm³/h (extrapolated: almost 8,800,000 Nm³/a)
- Methane content of upgraded biogas: according to the legally specified quality criteria for fuel, at least 96 % and at least 98 % for injection into the natural gas network

Technologies used:

Anaerobic fermentation: 8 plants

- Substrates used: renewable raw materials (NaWaRo) and organic residues (including waste from the food industry)

Treatment of the raw gas:

- Amine scrubbing (2 plants)
- Pressure swing adsorption, PSA (3 plants)
- Water scrubbing, DWW (1 plant)
- Membrane technology (2 plants)

Thermal biomass gasification:

- 1 plant (does not feed into the public natural gas grid; is due to feed into the micro-network in future)
- The gasification plant coupled with a methanation stage at the Güssing site is the first conversion plant worldwide for large-scale thermo-chemical conversion of solid biomass to biomethane. A biomethane filling station was built at the same time as the demonstration plant. Methanation on this scale was demonstrated for the first time ever within the scope of the EU "Bio-SNG" project. The Deutsches BiomasseForschungsZentrum gGmbH (DBFZ) coordinated this project and was responsible for the technical-economic-ecological assessment.
- Raw material used: solid biogenic fuel (exclusively wood wastes/wood chips)

Biomethane use:

- Biomethane is used to produce electricity and heat and as a fuel. Biogas currently contributes to 0.6 % of the renewably produced end-point energy (source: ARGE Kompost & Biogas Österreich).
- Austria's first biomethane processing plant fed into the public natural gas grid in 2005 (Pucking, operator: OÖ. Gas-Wärme GmbH).
- There are 171 public natural gas filling stations (in 2010), at which biomethane is also available for refuelling.
- 3 public biomethane filling stations are connected directly to biogas upgrading plants (Güssing, St. Margarethen am Moos and Rechnitz).
- Pure biomethane as a fuel is tax free, if it is blended with natural biogas and fed into the public natural gas grid and removed again for refuelling (as CNG blended fuel with at least 20 % biomethane content), the natural gas levy is due (6.6 cent/m³).
- The changeover to low-emission vehicles in the fleets of operators and local authorities is financially assisted; further local authority grants are also occasionally available. According to a declaration of intent made by the government, in future the standard fuel consumption tax ("Normverbrauchsabgabe – NoVA) on new cars is to more highly favour environmentally friendly vehicles. Instead of the insurance tax (MotV) based on engine capacity, taxation is to be based on fuel consumption and therefore CO_2 emissions (progressive pollutant emission classes). The target: by 2020, 200,000 Austrian vehicles should be running on bio-CNG. According to the Austrian statistics office, at the end of 2010 there were around 6,000 licensed CNG vehicles.

Well developed natural gas filling station network

In addition, there are three biogas upgrading plants, which are not connected to the natural gas network, but supply public filling stations with pure biomethane without the detour through the natural gas grid and therefore enable fuelling without the natural gas levy (6.6 cent/m³).

The well-developed natural gas filling station network of Salzburg AG, OMV Gas & Power GmbH, Erdgas Mobil GmbH and OÖ. Gas-Wärme GmbH, can also be used to refuel vehicles with biomethane – a bio-CNG mixed gas fuel (CNG: Compressed Natural Gas) with at least 20 % biogas content through to pure biomethane. This is subject to the natural gas levy, but it is still considerably cheaper than conventional fuels.

Refuelling with biofuel, photo: IFA-Tulln

Small, motivated steps along the path to energy autonomy

Essentially, it is the regional utility companies who operate the large biogas upgrading plants. Some of them, for example, Salzburg AG, are also actively involved in smaller exemplary projects in Eugendorf near Salzburg. The plant was started up in 2008 as the first of its kind in Europe and is operated in cooperation with the agricultural cooperative "Graskraft Reitbach". The compact plant has a biomethane capacity of 40 Nm³/h, and it is still arousing international interest because of its size; a further plant modelled on it is currently being built in Steindorf with a capacity of 80 Nm³/h. A further special feature of the Eugendorf plant is the raw material: It only uses meadow grass, which is produced by sustainable cultivation. "Due to the high rainfalls in the northern barrier ("Nordstau") of the Alps we have very good yields", says Peter Stiegler, designer of the plant and member of the cooperative's board. Yet with the current tariffs, it is not possible to operate the plant economically with electricity generation only. The plant therefore uses the flexibility of biogas and also injects biomethane into the natural gas grid, supplies a small company filling station and the waste heat is used to run a recently purchased gas turbine, which now also supplies numerous properties in the surrounding area with heat. With a total efficiency of more than 90 %, it makes a small contribution to the country's energy autonomy objective.

Country profile:
Poland

Potential in the waiting loop

Sabine Nollmann

At present there are 144 (source: Urzad Regulacji Energetyki (URE) = Energy Regulatory Office) biogas plants in Poland with a total capacity of around 82 MW (dated 01/2011), which primarily operated on the basis of landfill gas and municipal wastewater. There is a large potential for the production of biogas from agricultural products and industrial waste, which must also be increasingly used in the future. The Polish government is aiming to build around 2,000 biogas plants by 2020. Due to the lack of statutory basis and poor subsidies, however at present there are no commercial plants for upgrading raw biogas to produce biomethane. One of the first plants is due to be started up in Olstynek (Woiwodschaft Ermland-Masuren) in 2012/13. [1]

Apart from workshops and conferences on the topic, several preliminary feasibility studies are currently in progress as the basis of investment decisions. Poland is also involved in the GasHighWay, MADEGASCAR, Biogasmax and BalticBiogasBus projects.

Energy independence from its neighbouring states (especially Russian natural gas deliveries) is very important for the Polish energy security policy. Against this background, Poland's political strategic objectives can be more easily achieved by promoting biomethane feed-in. Further decisive positive points are in the increase in local added value and climate protection.

The production of biogas for electricity generation has been promoted since 2005 with the help of a quota system and a system of tradable green certificates. But the legal basis for the feed-in of biomethane was not created until 2011 with the last revision of the energy law. The law specifies the conditions for network feed-in, defines the quality requirements for the gas fed in and introduces the so-called "brown certificates" for biomethane. These certificates are only issued for biogas produced from agricultural raw materials.

Substantial obstacles are currently still obstructing development of the Polish biomethane market:

- promotion of biogas production in general is inadequate, as the system of the tradable green certificates does not differentiate between the different plant sizes and therefore disadvantages small, capital-intensive plants
- The most recent changes to the Energy Law came into force on 30th October 2011 [2]; however, the framework conditions are very unstable; there is no guaranteed subsidy, like that in Germany
- foreign biomethane plant manufacturers have poor knowledge of the specific Polish requirements
- in the transport sector there is neither political nor financial support for the use of biomethane; LPG dominates the fuel market, as it only costs approx. 500 € to retrofit a vehicle compared to 1,500 € for the use of CNG
- the gas filling station network is poor

"There are lots of barriers in Poland especially on a legislative level. At the moment we are waiting for the new renewable energy act which should have been passed in 2010. Many things like the support for biomethane grid injection and thus the profitability of biomethane plants depends on this."

Barbara Smerkowska, Specialist Renewable Energy Department, Automotive Industry Institute (PIMOT)

References

[1] http://www.energobor.nazwa.pl/eei/docs/biogaz.pdf
[2] http://www.ure.gov.pl/download.php?s= 1&id=4571

Country profile:

Great Britain

Biomethane market about to make the breakthrough

Eva Mahnke

The British flagship project for the upgrading of biomethane is the plant in Didcot, which is the first in Great Britain to feed in the gas into the local natural gas network. It was put into service in October 2010 and supplies the nearby town with gas. Sewage gas, which was previously burned off, is upgraded in the plant to natural gas quality. The most recent changes to legislation in 2011 are expected to result in dynamic development of the British biomethane market in the next few years.

Great Britain

Total number of biomethane plants:
2 operational
2 being built; completion 2012 at least 10 others currently being planned (> 1,000 Nm³/h)

Production capacity:
Didcot: 100 Nm³/h
Southwold: 100 Nm³/h
Planned: 250 Nm³/h

Total quantity of biomethane produced:
1,752,000 Nm³/year

Methane content of upgraded biogas:

Didcot:	97 %

Technologies used:

Biochemical anaerobic fermentation:	2 plants
Substrates used:	Didcot: sewage sludge
Southwold:	food waste, brewery waste
Upgrading of the raw gas:	
Didcot:	water scrubbing
Southwold:	cryogenic
Thermo-chemical biomass gasification:	no plants only a feasibility study has been performed (substrate: indigenous waste, woody biomass)

Biomethane use:

- Subsidy framework for the feed-in of biomethane in Great Britain, a fixed remuneration per kWh has existed for the biomethane injected into the gas grid since the introduction of the Renewable Heat Incentive in April 2011. With an adequate remuneration and a guarantee of this for 20 years, the basis has been created for dynamic development of the biomethane market. At the same time, development is limited by the capping of the total sum of remuneration funds to be distributed. An additional renumeration for the heat produced from biomethane provides an incentive to use biomethane for heat production. The company responsible, Centrica (British Gas) has not yet decided how the biomethane quantities of the two existing plants are to be used.

- Grid injection: Biomethane feed-in is possible throughout Great Britain, as it has a very well developed national gas network (gas grid).

- Biomethane trading: The GreenGas Certification Scheme (GGCS), in which each biomethane producer can participate, is intended to enable transparent trading.

- Fuel market: Only one plant produces liquid biomass (LBM) on the basis of landfill gas (Gasrec); part of this is used as fuel for transport. No other LBM plants are cur rently planned. There are no attractive incentives in Great Britain for the direct use of biomethane in the transport sector, so that relevant development of the fuel market for biomethane is not expected in the next few years.

Country profile:
Finland

In Finland there are currently two commercially operated processing plants for biomethane, which both upgrade biogas produced by anaerobic fermentation with the help of water scrubbing. Biomethane is used in the transport sector. To improve the infrastructure, the country is currently in the process of almost doubling the number of gas filling stations from 16 to 30.

Kalmari Farm near by Laukaa, photo: Kalmari Farm

Eva Mahnke

The delayed development of the gas infrastructure is a result of the taxation policy. Since 1965, vehicles run on petrol and diesel have been benefitted from highly preferential treatment compared to alternative fuels and natural gas. It was not until 2004 that this tax on vehicles with alternative drives was lowered; however, it is still more favourable for conventional fuels. The current government (since April 2011) mentions in its government program that biomethane should be advanced in the transport sector, although this is not yet reflected in the specific legislation.

Finland

Total number of biomethane plants:
2 (+ 2 on experimental level)

Production capacity: Kalmari Farm 45 Nm^3/h
Kouvala 300 Nm^3/h

Total quantity of biomethane produced:
670 MWh (2010)

Total quantity of biogas:
74 plants with a capacity of 420 GWh (2010)

Total number of filling stations:
886 (EUROSTAT 2009, most recent figure)

Total number of motor vehicles:
3.3 million vehicles (EUROSTAT 2009, most recent figure)

Technologies used:

Biochemical anaerobic fermentation:
2 (+ 2 plants on experimental level)

Substrates used: cow manure, industrial biowaste, energy crops
Upgrading of the raw gas:water scrubber

Thermo-chemical biomass gasification:
no commercial plants
one plant currently being planned: Bio refinery with 200 MW in Joutseno; production capacity 1.6 TWh_{CH4}/a; implementation 2015/16;

Substrates used: forest chips and bark (by-products of pulp mill wood procurement)

Biomethane use:

- All the biomethane is used in the transport sector.
- No cross-border trading takes place at present. However, negotiations are underway with Sweden.

- Transport: upgraded biomethane was used as fuel in the 1940s
16 public gas filling stations (in the south of the country); 14 new gas filling stations currently being planned/under construction
In future, biomethane is also to be available for fuelling approx. 1,000 gas-run vehicles in operation

Biomethane as tax-free fuel; cars run on gas are exempted from part of the tax until 2013; however, this is expected to change from 2013

- Network feed-in: since 2011, as the first plant Kouvola; sale of the biomethane through gas filling stations belonging to the company Gasum
The local energy company Hamina is also planning to produce and feed-in biomethane, the gas network currently only covers the southern part of the country; new gas pipes are under construction (34 km and 90 km)

Country profile: Sweden

In Sweden, 39 plants produce biomethane, which is almost solely used as fuel. The so-called "fordons gas" for gas-run vehicles already consists of 65 % biomethane. From 2012, the Gothenburg Biomass Gasification Project (GoBiGas) will be the first commercial plant, which produces the biomethane through thermo-chemical biomass gasification and subsequent methane synthesis. The gasification plant will be built in two phases: the pilot plant is planned to have an initial capacity of 20 MW biomethane and will be extended to 80-100 MW biomethane in the second phase.

Eva Mahnke

Biomethane use:

Most of the biomethane is used as fuel. The fuel sold as "fordons gas" already contains 65 % biomethane.

- Transport: In total, in 2010 almost 60 million Nm^3 were sold
  Due to the small range of the Swedish gas grid, most is transported to the filling stations by tanker vehicles.
  CNG on the market since 1995; since then increasing establishment of gas as a fuel in the transport sector: 32,000 vehicles (2010; of which: 1,400 buses, 500 heavy trucks)
  171 gas filling stations (of which: 122 publically-owned)
  Different provisions for the promotion of biomethane as a fuel, e.g. green car premium, discount on vehicle tax, free parking, support for filling stations, investment grants; law on renewable fuel at filling stations
- Grid injection: only 8 plants directly inject biomethane
  The reason: lack of infrastructure (gas grid only developed in southwest Sweden; however, extensions are currently being planned)
  The largest injecting plant: Göteborg, production capacity of 1,000 Nm/h
- Development targets: There are no specific targets for biomethane production or biogas production on a national level in Sweden. There are strong regional forces, but there are no targets on a national government level. The biogas sector has been working towards getting the government to establish national goals, but as of right now there are none.

The only targets set are the same as those of European Union with regards to 10 % renewable energy in the transport sector in 2020. The government in Sweden also has a vision of a fossil-free transport sector in the year 2030. They have not specified or defined what this means though.
According to Swedish Gas Association, Sweden can and will produce 3 TWh of biogas in the year 2013 and 14 TWh in the year 2020. The majority of this biogas will go to the transport sector (biomethane).

Sweden

Total number of biomethane plants:	39
Production capacity:	generally 200 to 800 Nm^3/h Largest plant: Linköping 2,330 Nm^3/h
Total quantity of biomethane produced:	488 GWh (2010)
Total quantity of biogas:	1.4 TWh (2010)
Total number of motor vehicles:	4.9 million vehicles (EUROSTAT 2009, most recent figure)
Total number of filling stations:	1,841 (EUROSTAT 2009, most recent figure)
Technologies used:	
Biochemical anaerobic fermentation:	39 plants
Substrates used:	mainly municipal wastewater and biological wastes, additional slurry; 1 plant each uses distilling residues and slaughterhouse wastes
Upgrading of the raw gas:	Water scrubbing (33 plants) PSA (8 plants) Chemical scrubbing (6 plants) Cryogenic upgrading (1 plant)
Thermo-chemical biomass gasification:	no plants A pilot plant is being planned; start up in 2012 (Gothenburg Biomass Gasification Project - GoBiGas)

Country profile:
Netherlands

Upgrading (cleaning) biogas to produce biomethane is an established technology in the Netherlands. 11 plants feed in the gas with a methane content of at least 88 % directly into the well developed Dutch gas grid. At present, efforts are concentrated on pushing ahead with the development of so-called "biogas hubs". These link several biogas plants to a central processing plant via a low-pressure micro-network. In this way, a plant in the Friesland region is planned to provide 8,000 Nm³ biomethane per hour in the future.

Eva Mahnke

Netherlands

Total number of biomethane plants: 11

Production capacity: generally 600-700 m³/h
The largest plant: Dinteloord 1,000 Nm³/h
Capacities of 2,000-3,000 Nm³/h are expected in the future

Total quantity of biomethane produced: 40 million Nm³/a (2010)
Further plants are planned with a total capacity of an additional 60 million Nm³/a.
A total capacity of 200-300 million Nm³/a is expected for the next two years.

Technologies used:

Biochemical anaerobic fermentation: 11 plants

Substrates used:
- landfill gas (4 plants)
- biowaste only or with manure (4 plants)
- sewage sludge (2 plants)

Treatment of the raw gas:
- membrane separation (3 plants)
- Water scrubbing (3 plants)
- PSA (2 plants)
- Chemical scrubbing (1 plant)
- (Rest: no information)

Plants which produce the biomethane with the help of chemical scrubbing now represent the reference case in the Dutch Renewable Energy Scheme SDE (stimulering duurzame energie), i.e. they are eligible for particular subsidies.

Thermo-chemical biomass gasification: no commercially operated plants
two demonstration plants (one of which: 800 kW_{th})
1 plant being planned; construction phase 2012/13
Phase 1: 12 MW_{th}
Phase 2: 50-100 MW_{th}
Substrates used: wood, chicken dung

Biomethane use:

- Most of the plants feed in (inject) the biomethane into the gas grid, as the network infrastructure is well developed.
- Transport: Biomethane is increasingly being used in the transport sector; transport to the filling stations as compressed biogas (CBG) through the gas grid or as liquid biogas (LBG)
  80 gas filling stations; soon to be 100; target: 200 filling stations in 2012 (so-called "National Green Deal")
  Several local authorities are currently converting their bus transport to run on biomethane
- Grid injection: Here used for: electricity, heat, fuel
  Recently efforts have been made to push ahead with so-called "biogas hubs". These connect several biogas plants to each other by low-pressure pipelines, in order to collect larger quantities of raw gas and to upgrade it in a central plant (lowering of the connection costs; economy of scale effects
  Example: Friesland region; merger of 7 biogas plants; connection to a 40 km long pipeline; total capacity of the plants: 8,000 Nm³/h
- Biomethane used as feedstock: biomethane is soon also to be used to produce biomethanol

Country profile:
Switzerland

Eva Mahnke

Most of the Swiss plants feed biomethane directly into the natural gas network. The natural gas supply companies have set themselves the target of a six-fold increase in the quantity fed in within the next five years to 300 GWh. The industry has its own subsidy model. The substrates used are mainly waste materials such as garden waste, food waste, slurry and sewage sludge.

Biomethane use:

- 12 plants inject the biomethane into the natural gas grid (2010: 64 GWh). Biomethane accounts for 20 % of the natural gas grid (2010). Biomethane used as fuel is exempted from fuel tax and as heating gas is exempted from the CO_2 levy. The gas is injected under a certificate system.
- The gas injection is promoted by an industry biogas compensation fund (compensation or equalisation between companies with high injection rate and those with low injection rate). There is a one-off investment grant, which depends on the size of the plant and a three-year subsidy for each injected kWh.
- Apart from use in transport (49 GWh 2011) and in the heating sector (35 GWh 2011); the generation of electricity from biomethane plays a secondary role in terms of the national electricity generation. However, the government plans to develop this in future.
- Transport: Biomethane has been used in the transport sector for 10 years. There are 130 gas filling stations and around 10,000 gas-run vehicles. Special communication campaigns are aimed at motivating citizens to buy a gas-run vehicle; the natural gas industry supports each purchase of a natural gas vehicle with CHF 1,000. Motor vehicle taxes are collected at canton level, so that there are very different provisions, but these partly favour gas-run vehicles.

Switzerland

Total number of biomethane plants:	17 At least 15 further plants currently being planned
Production capacity:	Typically 50-300 Nm^3/h Largest plant at present: 300 Nm^3/h Planned: 750 Nm^3/h
Total quantity of biomethane produced:	67 GWh (2010) Estimated 2011: 120 GWh
Technologies used:	
Bio-chemical anaerobic fermentation:	17 plants
Substrates used:	biowaste (8) sewage sludge (6 plants) biowaste/manure (1) animal by-products (1) agricultural codigestion (1)
Upgrading of the raw gas:	PSA (11 plants) genosorb scrubber (4 plants) chemical scrubber (2 plants)
Thermo-chemical biomass gasification:	Implementation of a biomass-to-SNG plant with 20-80 MW SNG planned (PSI and industrial partners)

Further information on biomethane

"Biogasrat e.V.":
The Biogasrat e.V. is an association of leading companies of the biogas sector in Germany.
www.biogasrat.de

"Biomethan-Kuratorium" (BioMethane Board):
The "Biomethan-Kuratorium" was founded on initiative of BBK (Federal Association for Biofuels and Regenerative Carburants) and FEE (Society for the Promotion of Renewable Energies) as a result of the EU-project REDUBAR. It is a national cooperative service platform for the strategic contribution of regenerative substitutes to natural gas (as biomethane, bio synthetic natural gas, regenerative hydrogen) to transformation of the energy system.
www.fee-ev.de/arbeitsgruppen/biomethankuratorium.html

bmp greengas GmbH:
bmp greengas is Germany's trading platform for biomethane.
www.bmp-greengas.de/en

"Bundesverband der Energie- und Wasserwirtschaft e.V." (German Association of Energy and Water Industries)
The association represents companies in the sector of natural gas, electricity and district heat, water and wastewater
www.bdew.de

Dena:
The German Energy Agency (dena) in context with its "Biogas Partnership" initiative provides information about the injection of biogas into the natural gas grid and the latest biogas-related developments.
www.biogaspartner.de

Deutsches BiomasseForschungsZentrum gGmbH (DBFZ) – competence field biomethane:
The competence field for biomethane develops new approaches and concepts for the provision and use of biomethane aiming at the practical implementation of pilot and demonstration plants.
www.dbfz.de/web/kompetenzfelder.html#c1597

"Erdgas innovativ nutzen" (Using natural gas innovatively):
The blog presents chances and potentials of gas, methane and natural gas for the promotion of renewable energies. The blog is supported by editors of the scientific journal of the "DVGW energie/wasser-praxis" (DVGW energy/water-practice) and "Blickpunkt Erdgas plus" (Focus on natural gas plus)
www.erdgas-innovativ-nutzen.de

"Erdgas Natürlich mobil" (Natural gas natural mobile):
"Erdgas Natürlich mobil" is an initiative of German gas companies for the expansion of the mobility of natural gas and biomethane.
www.erdgas-mobil.de

European Biogas Association:

The European Biogas Association aims to promote sustainable biogas production and use in Europe.
www.european-biogas.eu/eba/index.php

FNR (Agency for Renewable Resources):

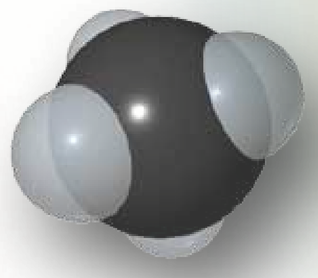
The FNR is the project management institution for the German Federal Ministry of Food, Agriculture and Consumer Protection. The main responsibility is to support research and development in the area of renewable resources, to inform the public about current research results, as well as to give advice on a range of applications of renewable resources. The monitoring of biomethane´s production processes is for example one of the projects supported by the FNR.
www.fnr.de

Fachverband Biogas e.V. (German Biogas Association):

The association represents producers, plant constructors, as well as agricultural and industrial biogas plant operators in Germany aiming for the promotion of biogas production and use for the provision of electricity, heat and fuels considering efficient climate protection.
www.biogas.org

Funding program "Biomass for Energy" (2009-2015):

The funding program, financed by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety („Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit" - BMU) focuses on research and development projects for practical further development of competitive technology, flexible system plant concepts and products for sustainable and efficient generation of electricity and heat from biomass and biogenic residual and waste materials.
www.energetische-biomassenutzung.de/en



Fraunhofer IWES (Bioenergy Systems Engineering Department):

The research activities of the Fraunhofer Institute for Wind Energy and Energy System Technology IWES cover all aspects of wind energy and the integration of renewable energies into energy supply structures. One of the areas of research is also the generation, supply and use of biomethane.
www.iwes.fraunhofer.de/en

Biogas feed-in (Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT):

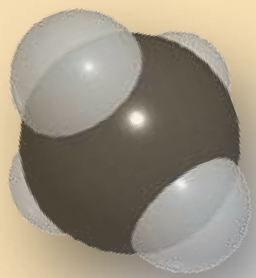
Central objective of the joint project “biogas feed-in” is to extend the possibilities for the energetic utilization of biomass by overcoming restraints in the generation, conditioning, feed-in and distribution of biogas via the gas network.
www.biogaseinspeisung.de

Care Fuel Initiative:

Care Fuel is the franchise model for the distribution of certified, gaseous and liquid fuels which are produced on a license basis by partner companies in plants with GRE certification.
http://guessingrenewableenergy.com/htcms/en/1komma6/wie/carefuel.html

IEA (International Energy Agency) - Bioenergy Task 40:

The IEA Bioenergy Task 40 is an international platform which supports the development of a sustainable, international bioenergy market, recognising the diversity in resources and biomass applications.
http://www.bioenergytrade.org/index.php



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