biogaspartner – a joint initiative.

Biogas Grid Injection in Germany and Europe – Market, Technology and Players.
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There are many good reasons for biomethane.

One of the most efficient ways of using biomass for energy production is the generation of biogas. Innovative technologies are available on the market, allowing biogas to be upgraded to natural gas quality – also called “biomethane” or “biogas” – and to be led into the natural gas grid. This process enables the replacement of conventional natural gas in many areas, thus representing an important contribution to climate protection. Currently, about 152 plants feed biomethane into the natural gas grid in Germany. Several other projects are currently being planned or constructed.

This brochure provides an overview on the various stages along the value chain of biomethane, from its production to its applications as well as on political parameters and the market development of biogas injection in Germany and Europe. The key virtues and versatility of biomethane are presented in brief in the following.

Active climate protection.

Biomethane extracted from biomass can replace fossil-based natural gas. It can in this way abate the emissions from greenhouse gases, and thus achieve an important contribution to a sustainable and environmentally friendly energy economy.

Natural energy sources like biomethane release only as much CO₂ as is absorbed from the atmosphere by plants as they mature. Thereby, the ideal circumstances for climate-neutral energy consumption become conceivable.

Reduced import dependency.

Some 97 per cent of Germany’s oil and over 85 per cent of the country’s natural gas is imported. Biomethane, on the other hand, is created from indigenous, renewable resources and organic waste and residues. Legitimate prognoses project a sufficient amount of domestic resources for biomethane to supply 10 per cent of Germany’s demand for natural gas by 2030. This approach would allow the country to import less natural gas, and to significantly increase energy security simultaneously.
Regional development.

The production of biogas from regional resources creates jobs, especially in agriculture, supply logistics, engineering, plant construction and maintenance. In particular, this allows local farmers to profit from resulting developments in related “non-food” sectors of local economic development. These sectors provide increased planning security and create an opportunity for alternative sources of revenue.

Eco-friendliness.

A variety of organic materials can be used in biogas plants exclusively, or in combination with others, without substantial technical alteration to the facility. Typically, crops commonly used for the generation of energy are processed together with biogenic waste, thus providing site-specific adaptability of the energy mixture used.

Material flow at local level.

Biogas plants are always located in close proximity to areas where biomass is cultivated. This circumvents the need for energy-intensive transportation of energy crops to the plant location, and minimises the cost of redistributing the byproduct throughout surrounding cropland. The byproduct can be used as a commercial fertiliser, thus reducing the costs associated with the regular purchase of manufactured fertiliser. The use of all biogas byproducts ensures the optimisation of the value-added chain of this resource.

Stabilisation of the energy system.

The supply of biogas and biomethane can be maintained all year round. Slurry, manure and organic waste resulting from food processing continue to accumulate. Similarly, harvested biomass is stored in silos designed to be large enough to maintain the necessary supply of energy from biogas throughout the year. Thus, the production of biogas and biomethane makes an important contribution to a stable and reliable energy supply. The regularity of supply has the ability to balance the fluctuating electricity production originating from alternative renewable energy sources such as wind and photovoltaic.

Versatility of application.

Biomethane is more flexible in its application than any other renewable source of energy. Its ability to be injected directly into the existing natural gas grid allows for energy-efficient and cost-effective transport. This allows gas grid operators to provide consumers with an easy transition to a renewable source of gas.

The diverse, flexible spectrum of applications in the areas of electricity generation, heat provision, and mobility creates a broad base of potential customers. Biomethane can be used to generate electricity and heating in smaller decentralised, or large centrally-located combined heat and power plants. It can be used by heating systems with a highly efficient fuel value, and employed as a regenerative power source in gas-powered vehicles. The utilisation of biomethane as a source of energy thus is a crucial step toward a sustainable energy supply.
1.1 Project description.
In collaboration with industry partners spanning the entire value chain of biomethane, the Deutsche Energie-Agentur GmbH (dena) – the German Energy Agency – has developed the “biogaspartner” project. The aim of this project is to develop the leading platform for the injection of biogas into the natural gas network and the utilisation of injected biomethane. Stakeholders along the whole supply chain are joining the project to support the development of the young market. dena’s role in the project is to act as a neutral facilitator and to provide a platform both for the acquisition and preparation of information and for its distribution both in Germany and abroad. The project’s market-oriented approach will supplement the efforts of the German market actors to establish the injection of biogas into the natural gas network as a fixed component of the future energy mix.

The project started as a national initiative but by now also includes the international scope.

Figure: Fields of activity of the Biogas Partnership.
Cooperation creates added value.
The injection of biogas into the gas grid offers added value at many levels: biomass provision, generation, processing, marketing, transportation, distribution and application in the electricity, heat and transport sectors. Both technical and economic optimisation exists at each of these stages in the value chain. Industry expertise is required to exploit this potential. Dynamic cooperation between the players will allow not only the state subsidy mechanisms to function better, but also boost investment and innovation. dena is therefore offering membership in the Biogas Partnership as a means of supporting this process.

Next to cooperation, acceptance and transparency are the main fields of activity of the Biogas Partnership. The project provides objectively prepared, valid information on economic, legal, technical and ecological questions related to the injection of biogas, making a significant contribution to objective discussion. The aim of the acceptance field is to communicate the desirability of the feed-in of biomethane to external stakeholders, especially in the light of the omnipresent discussions on the competition for use of crops and the impact of energy crop cultivation on nature and the environment.

Political parameters.
Several acts and rules support the injection and utilization of biogas that regulate the grid access for suppliers on the one hand side and incentivise the use of biomethane as fuel for cogeneration plants and in natural gas powered vehicles on the other hand side. A number of interesting business models can be developed to exploit the wide-ranging possibilities for its use. The market players involved have recognised this trend and are positioning themselves strategically in this new business segment.

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Biogaspotentials for 2020 – a prognosis.
A well accepted assessment shows a potential to substitute 6 per cent (6 billion cubic metres) of today’s natural gas consumption by the year 2020 and 10 per cent (100 billion cubic metres) by 2030. The amount of 6 billion cubic metres of biogas by 2020 requires the construction of roughly 1,000 medium-sized (700 m³/h) or 2,000 smaller (350 m³/h) biomethane plants, equalling about 100-200 plants per year. Furthermore, this would approximately equal the energy demand of four million households with an annual consumption of 15,000 kWh. Used as a transport fuel, 4.5 million natural gas vehicles with an annual mileage of 20,000 km could be powered.
1.2 The partners of the Biogaspartnership.

The development of the market for the upgrade and feed-in of biomethane calls for a cooperative collaboration of the market players along the value chain of biogas injection. The following companies and associations are cooperating in the project to jointly face the challenges:

- ABICON GmbH
- AC Biogas GmbH
- Aerzener Maschinenfabrik GmbH
- Agraferm Technologies AG
- AIR LIQUIDE Advanced Technologies GmbH
- ALENSYS Engineering GmbH
- Arcanum Energy Systems GmbH & Co. KG
- AssmannPeiffer
- Atlas Copco / GREENFIELD
- BayWa r.e. Bioenergy GmbH
- BayWa r.e. Green Energy Products GmbH
- BDH e.V.
- Bebra Biogas GmbH
- Berliner Stadtreinigungsbetriebe (AöR)
- Billinger EMS GmbH
- Biogasrat e.V.
- BMW Haase Energietechnik GmbH
- bmp greengas GmbH
- BORSIG Membrane Technology GmbH
- B. KWK e.V.
- Cirmac International bv
- DBFZ gGmbH
- DLG e.V.
- DVGW e.V.
- EISENNANN GmbH
- EnBW Energie Baden-Württemberg AG
- Enovos Luxemburg S.A.
- EnviTec Biogas AG
- E.ON Bioerdgas GmbH
- erdgas mobil GmbH
- erdgas schwaben gmbh
- ETW Energietechnik GmbH
- Evonik Industries AG
- Fachverband Biogas e.V.
- figawa e.V.
- Fraunhofer IWES
- Fraunhofer UMSICHT
- GASAG Berliner Gaswerke AG
- Greenline GmbH & Co KG
- HIWU
- IBKE
- KWS SAAT AG
- Landwärme GmbH
- Leobersdorfer Maschinenfabrik GmbH & Co. KG
- Mabagas GmbH & Co. KG
- Mahler AGS GmbH
- Malmberg Bioerdgastech GmbH
- MethaPOWER Biogas GmbH
- MT-Biomethan GmbH
- NAWARO BioEnergie AG
- ÖKOBIT GmbH
- Pentair Haffmans
- PlanET Biogas Group
- PRIMAGAS GmbH
- Purac Puregas GmbH
- RG ENERGY GMBH
- RWE Vertrieb AG
- Schnutenhaus & Kollegen
- Schwelm Anlagentechnik GmbH
- SFG - Service für Gasaufbereitung
- Städtische Werke AG, Kassel
- STEAG New Energies GmbH
- Thüga Energie GmbH
- TÜV NORD Gruppe
- TÜV SÜD Industrie Service GmbH
- Viessmann Werke GmbH & Co. KG
- VOLKSWAGEN Aktiengesellschaft
- von Bredow Valentin Rechtsanwälte
- VPT Kompressoren GmbH
- WELTEC BIOPower GmbH
2 Market Development in Germany.

2.1 Market development.

The German market for the feed-in of biomethane into the grid is still young. The first two biomethane plants were put into operation at the end of 2006. By August 2014, around 152 plants are feeding into the German gas grid at an hourly feed-in capacity of 95,000 cubic metres of biomethane.

With the plants which are actually installed, almost 7.8 billion kilowatt hours of biomethane can be generated and fed-in. This amount suffices to cover the final energy demand for heating and hot water of 520,000 three-people-households with a yearly consumption of 15,000 kilowatt hours of natural gas each. Applied as transport fuel, 450,000 natural gas-dedicated vehicles with a mileage of 20,000 kilometres per year might be supplied with biomethane.

The plants which have already been erected or are currently in the development or construction stage cover the entire Federal Republic of Germany. While Saxony-Anhalt is leading in terms of feed-in capacity the state of Lower Saxony currently exhibits the most stable growth in terms of the number of projects and is likely to keep this leading role also in the near future.

For more information please visit www.biogaspartner.com.
Due to the diverse amendments to the legal framework in Germany (see page 17), a significant plant growth expansion is expected in the medium term.

Five demand markets are especially relevant for the application of biomethane in Germany:

- Biomethane for power generation (in cogeneration mode)
- Biomethane for admixing products (in blends with natural gas) in heat applications
- Biomethane biofuel as fuel for gas powered vehicles
- Biomethane as raw material in the chemical industry
- Export of biomethane, equipment technology and consultancy

**Biomethane for power generation in cogeneration.**

In order to achieve the best-possible positive impact on the conservation of our climate, the legislation of the German Federal Government is aimed at the application of biogas fed-in for combined heat and power generation. The main instrument for this is the Renewable Energy Sources Act (EEG), which includes the power generation from fed-in biomethane and supports it by means of the feed-in-tariff.

At the moment, the EEG market is viewed as the leading market for biomethane, since based on state-guaranteed tariffs, security and stability can be offered to private investors for 20 years. A remaining risk factor is the development of substrate prices, which could not be compensated due to the fixed tariff system and might directly affect business revenues.

**Biomethane as admixing product for heat applications.**

Biomethane as an admixing product in combination with fossil natural gas is already offered by about 200 gas suppliers in admixing quotas ranging from 5 to 100 per cent. The latter quota is especially common in Baden-Württemberg, where customers thus can fulfill the requirements of the Renewable Heat Law Baden-Württemberg. In contrast to the nationally effective EEWärmeG, which only calls for the utilisation of biomethane in exceptional cases, and only if used in a cogeneration process, the Heat Law of the State of Baden-Württemberg also allows the application in exclusive heat generation.

Other federal states are contemplating the implementation of similar regulations. Due to the existing infrastructure of the gas grid and the existing gas heating system, a significant CO₂ reduction could thus be achieved in the short term.

There is also a trend toward a growing demand in national biomethane product sales. Similar to “green power” offers in the power sector, German private end customers increasingly show a readiness to pay an eco premium for biomethane admixing products. Various municipal utilities and nationwide gas supply companies have developed and implemented such green gas products.
Market Development in Germany.

List of biomethane injection projects in Germany.

Upgrading and injection of biogas into the natural gas grid in Germany is an emerging pathway for energetic application of biomass.

The list of biomethane injection plants documented by the biogaspartner project is the most comprehensive and up-to-date register for realised and planned injection projects in Germany. The project site and related information are figured with the aid of an interactive map. Through the constantly updated project list detailed information e.g. location, year of commissioning and upgrading process are accessible for German and European biomethane plants.

Furthermore, detailed descriptions for chosen projects are listed (as shown on the following pages), too.

Data sources of the list are, apart from information of market players and press releases, own inquiries and continuous market monitoring.

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Biomethane as fuel for gas powered vehicles.

As a substitute to natural gas, biomethane can be used to fuel natural gas-dedicated vehicles. By means of gas grid feed-in, it can be distributed to the German gas station network and substitute fossil fuels.

Compared to other biofuels, even those of the second generation like biomass-to-liquid (BtL), biomethane is a highly effective biofuel with a high specific cropland yield. Therefore, from an economic and technological point of view, it is one of the most promising alternatives to sustainably apply biomass in the vehicle sector. However, the demand in this sector is very much dependent on the development of the natural gas-dedicated vehicle market. Currently, there are about 98,000 natural gas vehicles in Germany. The share of biomethane at the amount of natural gas for natural gas vehicles was round about 22 per cent in 2013.

Material use in chemical industry.

In chemical industry about 3 per cent of German natural gas consumption is applied for material usage in chemical industry. In most cases natural gas will be converted into synthesis gas (mixture of carbon monoxide and hydrogen). Many base chemicals are made of synthesis gas providing the basis for lots of chemical products. Therefore, the substitution of naturals gas through biomethane decreases the usage of fossil commodities in chemical industry.

Export of biomethane, equipment technology and consultancy.

International and especially European markets have become more important for Germany’s biomethane industry in recent years. Biogas production and upgrading technology and equipment from Germany as well as know how and consultancy services are very popular. Additionally, biomethane is imported of an increasing number of neighbouring countries.
2.2 Project examples.

### Altenstadt/Schongau
- **Country**: Germany
- **State**: Bavaria
- **Location**: Altenstadt/Schongau
- **Start of operation**: 2009
- **Biomethane feed-in capacity**: 690 Nm³/h
- **Feed-in capacity**: 66 million kWh p.a.
- **Upgrade process**: pressurised water scrubbing
- **Produced gas quality**: Natural Gas H
- **Pressure level**: 4 bar
- **Raw material**: 33,000 t/a organic waste
- **Investment**: €3.2 million

The Altenstadt biogas plant started operation in 2001. In 2009, the CHP plant on site was put out of service; ever since the biogas is upgraded and fed into the gas grid. 33,000 t of organic waste are turned into biogas in the plant each year, such as expired food, cheese and dairy residues, slaughterhouse and organic waste. The raw material is processed in 8 fermenters with an overall capacity of 7,700 m³ biogas.

All of the biogas produced is fed into the distribution grid of schwaben netz gmbh. A calorific value boiler operated with biomethane generates heat necessary for the fermenter heating.

A natural gas station was erected on the biogas plant site to supply company vehicles with biomethane. Since biogas based on organic waste can be offered at comparatively low prices, it is applicable not only for cogeneration of heat and power utilisation, but also for heating purposes. erdgas schwaben offers two products: Bio 100 and Bio 20. Heat customers thus can be provided with 100 per cent or 20 per cent climate-friendly biomethane. erdgas schwaben uses biomethane for her own heat demand coverage. All CHP plants run by erdgas schwaben are also supplied with biomethane.

*The Altenstadt / Schongau project won the "Biogas partnership of the Year" award presented by the German Energy Agency in 2009.*

### Osterby
- **Country**: Germany
- **State**: Schleswig-Holstein
- **Location**: Osterby
- **Start of operation**: 2011
- **Biomethane feed-in capacity**: 350 Nm³/h
- **Feed-in capacity**: 33 million kWh p.a.
- **Upgrade process**: pressurised water scrubbing
- **Produced gas quality**: Natural Gas H
- **Pressure level**: 4.5 - 5.0 bar
- **Raw material**: 35,000 t maize silage, cow manure and renewable raw
- **Investment**: €3.2 million

The biogas upgrading plant in Osterby started operation in December 2011 and processes 350 Nm³/h gas in natural gas quality. Through an on site feed-in plant the biogas is injected into the natural gas grid of Schleswig-Holstein Netz AG. Two existing biogas plants were modified and provide the upgrading plant continuous with 700 Nm³/h raw biogas.

Most substrates were cultivated on local farmers land. The biggest share of the raw material is used for biogas production but also for own dairy farming. At the beginning applied materials were maize silage and cow manure. From 2012 on more and more corn and beet is digested.

Generated biomethane is marketed nationwide with aid of Landwärme GmbH. Most gas is delivered in Baden-Württemberg and Bavaria where among others nurseries, hospitals and swimming baths purchase it and convert the gas to heat and power in combined heat and power plants (CHP).

*The Osterby project was awarded the "Biogas partnership of the year" award presented by German Energy Agency in 2012.*
Market Development in Germany.

The “Biogas Pool 1 for Utilities” is a business model developed by Arcanum Energy from Unna. It is an innovative alternative to other business cases in the biomethane market. The “Biogas Pool” provides utilities with long-standing access to biogas without having to produce raw gas themselves. The investment is carried out by farmers willing to thus diversify their income base by producing energy. Currently the project consists of 4 biogas plants in Lower Saxony and Mecklenburg-Western Pomerania with an injection volume of 350 Nm$^3$/h each.

By means of founding a “Biogas Pool” several utilities jointly invest in the upgrade and feed-in of the gas. The synergies thus generated allow for an efficient use of biogas at minimum risk. The pooling effect enables flexible, individual biogas quantity supply. The business case offers a high level of planning and financing security due to a clearly defined and fair raw biogas supply.

The Biogas Pool 1 project won the “Biogas partnership of the Year” award presented by the German Energy Agency in 2011.

The biogas plant runs exclusively on raw material. This consists mainly of maize as well as farm fertilizer (manure, dung). More than 30 per cent of the input is manure, ensuring that the majority of the regional farm fertilizer is put to additional use as energy production source.

The raw material is subject to strict crop rotation and is produced by farmers owning shares in the Biogasgesellschaft Biogas Homberg GmbH & Co. KG organisation. Thereby, long-standing supply security as well as raw material quality are ensured.

Compression lost heat of the pressurised water scrubbing and lost heat generated in the CHP plant is used to cover heat peaks in the fermenter. The power used in the operation of the pressurised water scrubbing is supplied by Städtische Werke AG and is produced from renewable sources (hydro power).

The biomethane is used by Städtische Werke AG to feed it into the public gas grid. The energy supply company from Kassel transports the biomethane and utilizes it in CHP plants where the heat is used all year round, such as in public swimming pools, hospitals or industrial production sites.
Kißlegg-Rahmhaus runs on food products unfit for consumption, such as food residues and expired food. Only material in compliance with the Biomass Ordinance are used in the plant, supplied by the local BRV company.

The biogas plant, which exists since the mid-1990ies, utilizes about 17,000 t of residues each year. Before the gas upgrade unit was installed, the raw biogas was put to use in several CHP-modules with an overall electrical performance of about 1 MW<sub>e</sub>. The generated heat (approximately 2 MW<sub>th</sub>) could only in part be used for heating purposes on site.

For the first time in Germany, the plant uses membrane technology in order to separate carbon dioxide from the raw biogas. Used at a high pressure level, only the CO<sub>2</sub> molecules pass the membrane polymers, while the membrane is concentrated in the product gas stream.

With the help of a compressor, the biomethane is fed into the PN70-high pressure pipeline of Thüga Energienetze. Since the flow path is consistent at the feed-in point, a new calorific value area was created in accordance with calibrating authorities. No extra conditioning is therefore necessary.

The Kißlegg-Rahmhaus project was awarded a special award for innovative membrane technology in the “Biogaspartnership of the Year 2010” awards.

The biogas facility in Neuss has first (2007) been operated with a CHP-plant, which should have provided heat for a nearby Elementary. But only 1/3 of the energy could have been used there. With this concept, only 47 per cent of the produced heat would have been used appropriate.

So the farmers decided in 2009 to modify the plant with a biomethane upgrading and injection unit with help from PlanET Biogas Group. Such a relatively small facility was nationwide unique at this moment. With support from the local utility company (Stadtwerke Neuss), which participated with 400,000 euro and a delivery contract over 10 years, there has been enough planning security for commissioning the amine scrubber upgrading unit by Cirmac International bv in 2010.

The facility now runs on a high utilisation of 8,500 annual full load hours.
In 2012, the Bioerdgas Hallertau GmbH has been awarded the “Biogaspartner Innovation Prize” for their use of hop residue, the first project of its kind world-wide.

So far the hop remains had been returned to hop gardens to decompose, leaving its energy potential unused and, during transport, dropping so-called hop spikes on the street, small pieces of wire posing risk to tires.

For the biomethane plant the hop residues are being transported in closed containers so that no spikes can fall on the street. The use of wires and high lignin content are challenges for further processing. Before fermentation, the wires are removed magnetically. By means of pressurized water scrubbing the biogas is being upgraded and then fed into the gas grid. Fermentation remains are returned to farms. Due to decomposition of the organics nutrients are more easily available than in the original material.

The facility’s shareholders contribute to its success through their complementary expertise: The E.ON Bioerdgas GmbH is a pioneer in biomethane injection and is responsible for plant management as well as gas marketing.

The Högl Kompost- und Recycling-GmbH has long experience running their own biogas plant and in logistics, thus being responsible for the operation and logistics of the plant.

The HVG Hopfenverwertungsgenossenschaft e.G. forms the network of all Hallertau hop farmers and is in charge of buying the chaffed hop vines.

On a former military base in the years 2012 and 13 the biomethane facility Kleinlüder has been developed. The facility includes all value chains of biowaste disposal on one location. Annually 11,000 t liquid manure, 29,000 t commercial waste, 22,000 t municipal waste from the biowaste bin and 6,000 t green waste are being processed. In one wet fermenter and on dry fermenter biogas is produced out of the raw material, in combination with the production of liquid fertilizer and compost.

The biogas is being upgraded in an upgrading unit working after the pressure-swing-absorption-principle and on this way 47 million kWh of biomethane injected into the gas grid of the local grid operator GVW.

*The Kleinlüder project was awarded the “Biogas partnership of the year” award presented by German Energy Agency in 2013.*

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**Table:**

<table>
<thead>
<tr>
<th>Wolznach</th>
<th>Kleinlüder</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Country</strong></td>
<td>Germany</td>
</tr>
<tr>
<td><strong>State</strong></td>
<td>Hessia</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>Kleinlüder near Fulda</td>
</tr>
<tr>
<td><strong>Start of operation</strong></td>
<td>2010</td>
</tr>
<tr>
<td><strong>Biomethane feed-in capacity</strong></td>
<td>160 Nm³/h</td>
</tr>
<tr>
<td><strong>Feed-in capacity</strong></td>
<td>1,000 Nm³/h</td>
</tr>
<tr>
<td><strong>Upgrade process</strong></td>
<td>pressurised water scrubbing</td>
</tr>
<tr>
<td><strong>Produced gas quality</strong></td>
<td>Natural Gas H</td>
</tr>
<tr>
<td><strong>Pressure level</strong></td>
<td>40 bar</td>
</tr>
<tr>
<td><strong>Raw material</strong></td>
<td>72,000 t chaff of hop vine, 31,000 t maize/grass</td>
</tr>
<tr>
<td><strong>Feed-in capacity</strong></td>
<td>94 million kWh p. a.</td>
</tr>
<tr>
<td><strong>Feed-in capacity</strong></td>
<td>13.1 million kWh p. a.</td>
</tr>
<tr>
<td><strong>Upgrade process</strong></td>
<td>PSA</td>
</tr>
<tr>
<td><strong>Raw material</strong></td>
<td>50,000 tons biogenous waste, 10,000 tons manure</td>
</tr>
<tr>
<td><strong>Investment</strong></td>
<td>€ 23 million</td>
</tr>
</tbody>
</table>
The substrate basis for the biogas production consists of three major components. A great part is cow manure, generated in the agricultural unit on-site. The biggest share stems from glycerine, which is generated in the close-by Süderlohn as by-product of bio diesel production. The digestate is used both on fields near-by, which in turn are used to produce maize for cattle and maize for the agricultural distillery. The mash left over from distillery processes is then in turn used as animal feed, guaranteeing that the biogas plant is fully integrated into the raw material and nutrient cycle.

The Rhede plant, built in 1980 on the Wenning family farm, was one of the first industrial biogas plants in Germany. It has been expanded in several steps and currently amounts to 5,500 Nm³ fermenting volume. The amendment of the gas grid access ordinance in 2008 offered the chance to upgrade the gas and feed it into the natural gas grid. The partners developed a concept which aims at feeding the gas into the local medium pressure gas grid operated by Rhede utilities. Amine scrubbing technology by CIRMAC is used to upgrade the gas.

E.ON Bioerddgas GmbH buys the biomethane produced in Rhede and brings it to market via the E.ON group. Thus, the Wenning family can concentrate on plant operation and raw material supply, while all issues of marketing and sales are taken care of by an experienced partner.

The Rhede biomethane plant was awarded the “Biogaspartnership of the Year” award in 2010.

Five farmers from the area of Ronnenberg jointly established Biogas Ronnenberg GmbH & Co. KG, in short “BiRo”. The farmers all have made equal contribution of 20 per cent to the investment costs and substrate supply. The facility runs on maize silage. As an addition, grain of wheat and maize are fed-in.

The biogas facility was made by the manufacturer MT-Energie GmbH. It consists of two fermenters with a diameter of 26 meters, a downstream fermenter and end storage with a diameter of 30 meters each. All containers are 7 meter high and fitted with a gas storage ceiling. Usually approx. 60 tons of maize silage and currently an additional 2 tons of wheat are fed into two solid matter entries per day. The biogas facility generates up to 650 m³ of raw biogas per hour with a methane content of approx. 52 per cent. BiRo sells the raw biogas at a defined interface to Stadtwerke Hannover AG. The upgrade technology is provided by Haase Energietechnik GmbH.

The biomethane is fed into the natural gas grid of enercity Netzgesellschaft (eNG) in Ronnenberg (0.8 bar) via connection line (2 bar) of approx. 2 km in length. From here it is transported to CHP locations in the city limits of Hanover, where it is converted to power and heat at heat customers. Until sufficient CHP purchase capacity has been developed, part of the biomethane will be sold in the market.

The Ronnenberg project won the “Biogas partnership of 2008” award.
2.3 Political framework for biogas injection in Germany.

The legal framework for biogas feed-in in Germany is laid out in various statutes and regulations. A guaranteed compensation per kWh does not exist for biomethane fed into the gas grid—unlike for electricity generated from renewable energies. Producers of biomethane have to market their gas individually. The government employs various measures to support biomethane and to develop demand in the market. Aside from its application to heat and combined heat and power (CHP), biomethane is also used in gas-dedicated vehicles. Many diverse regulations are employed to promote the feed-in of biogas in Germany, due to its various stages along the value chain and different required processes.

Renewable Energy Sources Act (EEG).

The most important instrument for the promotion of renewable energies in Germany is the Renewable Energy Sources Act (EEG). The main purposes of the EEG are the protection of our climate and the environment, to promote a sustainable energy supply, to minimize the economic costs of energy supply, the protection of fossil resources, and the continued development of renewable power generating technologies. To achieve this goal, the EEG gives plants generating power from renewable energy sources priority within the public power grids. Also, it regulates preferred sales and transmission.

The EEG gives the operator of a CHP plant, which uses gas from the natural gas grid, a subsidy for every kWh of electricity generated. However, the operator has to demonstrate that during the same calendar year at least as much biomethane was fed into the natural gas grid as was taken out of the grid for the generation of electricity in the CHP. Additionally, mass balance systems have to be used for the entire transportation process of the biomethane from the biogas upgrading plant to the CHP plant. The tariffs are then guaranteed from the onset of the first year of operation and continue over the following 20 years. Thus, biomethane can efficiently be used in cogeneration plants, which are operated in places with a significant heat demand.

The EEG was first implemented in 2000 and was amended several times ever since. The latest amendment was put into effect on August 1, 2014.

The EEG 2014 implements fundamental changes in comparison to its previous versions. For operators of any new renewable power plants, the direct marketing of electricity became mandatory. However, they can receive funding in the form of a flexible market premium. Direct marketing is mandatory for all new plants with more than 500 kW of installed nominal capacity, which have been put into service after August 1. Starting January 1, 2016, the threshold will be lowered to a maximum of 100 kW. In the long run, only small units will keep their entitlement for fixed feed-in tariffs. A full conversion of the funding system into a tendering procedure is supposed to be implemented by the beginning of 2017.

Further increases in capacity of biomass and biogas plants are immensely stagnated under the regime of the 2014 EEG. Pending an annual capacity in excess of 100 MW (gross), the federal legislator has intended an annual increase in degression from 0.5 to 1.27 per cent.
The 2014 EEG significantly decreased the level of funding tariffs. In particular, the compensation for the usage of certain input material as well as the gas treatment bonuses were abolished completely without replacement.

The operator of a biogas plant put into service between August 1, 2014 and January 1, 2016 shall receive a maximum of 13.46 ct/kWh feed-in compensation. For electricity from biogas generated from certain biodegradable waste, the feed-in compensation will be at the level of 15.06 ct/kWh maximum. Small manure plants with an installed capacity of 75 kW maximum will be compensated with 23.53 ct/kWh. Plants which have been authorized before January 23, 2014 and put into service before January 1, 2015 are exempt from this rule. Those plants still receive the considerably higher feed-in tariffs according to the EEG amended in 2012.

Concerning new plants with an installed capacity of over 100 kW, an entitlement for compensation will exist only until the rated power of 50 per cent of the installed capacity has been reached. Electricity produced in excess of this limit will not be compensated with the market premium in direct marketing and the operator will only receive his or her electricity revenue. In the case of the feed-in compensation, the entitlement for the part that exceeds the 50 per cent of the installed capacity will degrade to the monthly market value of electricity at the stock exchange. However, plant operators may be entitled to a flexibility bonus of 40 Euros per kW per year for their whole installed capacity.

Those plants that were put into service before August 1, 2014 are granted the feed-in compensation in the same manner prior to the amendment. Direct marketing remains an option for those plants.

Further information on the EEG 2014 is available on www.biogaspartner.com.

Biomass Ordinance (BiomasseV).
Effective since 2001, the Biomass Ordinance sets guidelines on which materials qualify as biomass, which technologies for power generation from biomass are within the scope of application of the EEG, and the environmental requirements of generating power from biomass.

Biomasses, according to the biomass regulation, are energy sources from phyto and zoo mass. This also includes secondary and by-products, residues and waste whose energy content is made up of phyto- and zoomass.

The definition of biomass in Paragraph 2 (2) Number 5 also includes biogas generated by anaerobic fermentation. Excluded, however, is biogas which has been produced from the following material (according to Paragraph 2(3) Number 2):

- mixed settlement waste from private households,
- mud and sediments,
- by-products from animal husbandry.

Renewable Energies Heat Act (EEWärmeG).
The Renewable Energies Heat Act (EEWärmeG) came into effect on January 1, 2009 and was amended in May 2011 as required by EU law. According to the EEWärmeG, 14 per cent of the German heat demand (final energy) shall be produced from renewable energy sources.

Crucial elements of the law are:
- Obligatory utilisation for new buildings
- Obligatory utilisation for existing official buildings (role model)
- Financial promotion
- Specific promotion of heating networks
Owners of buildings constructed after January 1, 2009 are obliged to employ renewable energies for their heat supply. This obligation applies to all owners (private, state, economy). Exempted are buildings for which a building application or building listing has been issued before January 1, 2009. All forms of renewable energies can be used and also in combination. When using biogas, the obligation is generally met if 30 per cent of the heat energy demand of the respective house is covered. Therefore, the biogas is to be used in a cogeneration plant. In the case of utilisation of biomethane, the same requirements of the 2012 EEG, including the efficiency and climate protection requirements for the biogas upgrading bonus (methane emissions ≤ 0.2 per cent, power consumption not exceeding 0.5 kWh per Nm³ raw gas, process heat coming from renewable energies or thermal discharge of the upgrading or feed-in plant) are to be observed.

Gas Network Access Ordinance (GasNZV).

Preferred Network Entry
According to § 34 GasNZV, grid operators are to grant preference to biomethane transport clients when it comes to concluding feed-in and offtake contracts, as long as these gases are compatible with the grid. At the same time, the grid operator is obliged to take all necessary and economically sensible measures to optimise and ensure an availability of at least 96 per cent.

Extended Balancing
For biogas transport clients, § 35 GasNZV provides special regulations on the extended biogas balancing. For natural gas transport clients, the grid operator is obliged to offer free-of-charge the opportunity to balance within hourly tolerance boundaries, he is, in the case of biomethane, obliged to offer a flexibility of up to 25 per cent. This flexibility applies to the specific biogas accounting time span of 12 months. Within this accounting time span, the flexibility is applied to the accumulated difference of the quantity fed in and the quantity taken out. For the use of the flexibility a fixed sum of 0.1 ct/kWh is to be paid to the grid operator.

“DVGW” Worksheets.
The worksheets published by the German Technical and Scientific Association for Gas and Water (German: DVGW) provide the overall requirements for gases in the public supply grids. The basic guideline for the quality of gas from renewable sources is DVGW worksheet G 262. If the gas is to be fed into the public gas grid, it needs to meet the regulations of DVGW worksheet G 260. In particular it has to comply with the second gas family within the local gas groups.
DVGW worksheet G 265-1 provides detailed information on minimum requirements for technical safety and summarises all plants and components necessary for biogas utilization. These include plant upgrades, conditioning, pressure setting, measurement and gas grid feed-in as substitute gas.

DVGW Data Sheet G 415 presents minimum requirements for the planning, construction and operation of gas pipelines in which raw biogas or partly upgraded biogas is transported.

DVGW worksheet G 1030 defines requirements for technical safety management systems (TSM) of biogas plants.

**Biofuel Quota Ordinance (BiokraftQuG).**
When selling fuels in Germany, since 2006, it is mandatory that a certain amount of biofuels is to be mixed to petrol and diesel. On January 1, 2007, for the first time, a minimum quota was introduced. At first, biomethane could not be added to the fulfillment of this quota. In the amendment from June 18, 2009, however, biomethane was explicitly added to this list of compatible biofuels. However, it was only attributable to the petrol quota and the overall quota, but not to the diesel quota. From 2015 on, the energetic quota will be substituted by a predefined greenhouse gas reduction quota. This means, that biomethane can then be used universally on all quotas.

**Biofuel Sustainability Ordinance (Biokraft-NachV).**
Standards of the EU renewable Energy directive were implemented through the Biofuel Sustainability Ordinance as well as the Ordinance on the Generation of Biofuels from Biomass. The Biokraftstoff-Nachhaltigkeitsverordnung (Biokraft-NachV) ensures that in the course of biofuel production such as biomethane, binding ecological and social sustainability criteria are met. Only sustainable biomass is supposed to be financially supported or be counted towards biofuel quotas. Also, the specific greenhouse gas emission reduction potential compared to the use of fossil fuels is laid out in the Biokraft-NachV. This regulation mandates an increase of these minimum standards from 35 per cent today to 50 per cent until January 1, 2017 and finally up to 60 per cent until January 1, 2018.

**The German Biogas Register.**
The purpose of the German Biogas Register is to provide a standardized and simplified tool for biomethane proof of origin and quality. dena has developed the system in cooperation with 14 leading market actors, among them many biogaspartner project partners. The IT-based system has started operation in February 2011 and is led by dena. Since 2014 the balancing of power to gas is included too. In the course of development, documentation and certification of biogas feed-in tariffs or other incentives have been standardized for the first time. Further information can be found on www.biogasregister.de.
3 Market Development in Europe.

GreenGasGrids – supporting biomethane EU-wide.

In cooperation with 12 international project partners and support of the European Commission dena developed and conducted the GreenGasGrids project. In the framework of project activities the international market development was supported and a contribution to EU wide increase of biomethane production was achieved. Important impulses for configuration of framework conditions for biogas injection were set up regarding the issues sustainability, technical standards, legislative support and trade. A milestone has been the letter of intent signed by six international biomethane registries stating more cooperate between the bodies to boost European biomethane trade.

Project website: www.greengasgrids.eu

3.1 Market development.
Biomethane has huge extension potentials regarding the European market. An assessment of the European biomethane potential within the GreenGasGrids project shows that three per cent of European natural gas consumption can be supplied by biomethane by 2030. Furthermore, biomethane can deliver a valuable contribution to Europe’s security of supply and to the ambitious European greenhouse gas reduction targets.

The upgrade and feed-in of biomethane into the natural gas grid is currently not subject to a consistent European standard. The parameters and basic conditions were first defined by Directive 2003/55/EC on the European natural gas single market and were further detailed in Directive 2009/28/EC on the promotion of the use of energy from renewable sources by the European Parliament and the European Council of April 23, 2009. Article 16 on grid access and grid operation states:

Member States shall ensure that the charging of transmission and distribution tariffs does not discriminate against gas from renewable energy sources.

Where relevant, Member States shall assess the need to extend existing gas network infrastructure to facilitate the integration of gas from renewable energy sources.

Where relevant, Member States shall require transmission system operators and distribution system operators in their territory to publish technical rules, in particular regarding network connection rules that include gas quality, gas odoration and gas pressure requirements. Member States shall also require transmission and distribution system operators to publish the connection tariffs to connect renewable gas sources based on transparent and non-discriminatory criteria.
Some can look back on decades of experience and know-how on the injection of biogas into natural gas grids. Political framework and sometimes also incentives are available not only in Germany, but also (e.g.) in France, Great Britain, Luxembourg, the Netherlands, Austria, Poland, Sweden and Switzerland.

While the German market for the upgrade and feed-in of biogas is relatively young, the technologies for this special gas application have been in use already for decades in other European countries. According to recent research more than 245 biomethane plants are operating all over Europe. Out of these, according to the information available to the German Energy Agency, 230 feed biogas upgraded to local natural gas quality into the grid by mid 2014.

Basis for a working international biomethane trading is a close cooperation of European biogas registers. This enables the standardised documentation of origin and properties of biogas in the natural gas grid. With support from the GreenGasGrids project a Letter of Intent is being signed, in which six biogas registers from Germany, Austria, Denmark, France, Switzerland and Great Britain agree to reach an compatibility of the separate Registers as well as mutually recognition of proofs of origin of biomethane.

Foundation of a working international biomethane trade system is a tight cooperation of European biomethane registers. These registers enable standardised documentation of guarantees and quality of origin for biomethane in the gas grid. With support of GreenGasGrids project a Letter of Intent was signed in which the six international biomethane registers of Germany, Austria, Denmark, France, Switzerland and Great Britain advise themselves to achieve compatibility of individual registers as well as mutual recognition of biomethane guarantees of origin.

More information about the market development of European biogas grid injection projects please refer to our website www.biogaspartner.de

**Technology for the upgrade of biogas.**

Regarding the total number of projects realized so far, chemical water scrubbing and pressure swing adsorption technologies are dominating the European market [see figure].

Membrane technology is currently in use only in the Netherlands, Austria and Germany. Lately, first plants have also been connected to the grid in Great Britain. One of these plants operates on cryo technology which is still rather rare in the biogas upgrading sector.
Market Development in Europe.

Figure: Geographical distribution of biomethane plants in Europe and worldwide.

- Germany, DE, 152
- Netherlands, NL, 22
- Switzerland, CH, 14
- USA, US, 12
- Sweden, SE, 11
- Austria, AT, 9
- Great Britain, GB, 7
- Canada, CA, 6
- France, FR, 5
- Luxembourg, LU, 3
- Finland, FI, 3
- Denmark, DK, 2
- Norway, NO, 1
- Hungary, HU, 1

Planning:
- China, CN
- Brazil, BR
Market overview.
The Netherlands, Sweden and Switzerland are the European countries with most and longest experience in the upgrade and feed-in of biogas. The Netherlands, for example, feature a biomethane plant with a feed-in capacity of 500 Nm³/h which has been operating on a pressure swing adsorption for 20 years, since 1989.

Germany owns the largest number of plants upgrading biogas to biomethane and leads in feed-in capacity in comparison to all other European countries. Differences are partly related to the state of the infrastructure of the public gas networks in the different countries, but also to the fields of application best supported by the respective political structures. Thus, the German market has seen a significant growth in the last few years, with the first plants, however, having started operation only in 2006. In recent years, a stable market growth can also be tracked in countries like Austria, for example, where the high state-guaranteed feed-in tariffs have, similar to the German situation, resulted in a significant boost.

Substrate.
While in Germany the majority of the overall biogas production is based on the exclusive fermentation of agricultural waste, liquid manure, and cultivated renewable primary products (energy plants), the market in countries like France, Luxembourg, Sweden and Switzerland is dominated by gas produced in landfills managing community and household waste.

Application fields.
Most of the overall European biomethane production is applied as biofuel in natural gas dedicated vehicles. Sweden and Switzerland in particular are front runners in this application. The German biomethane trade, however, is focussed especially on the application of biomethane in combined heat and power plants. The application of biomethane as biofuel here only plays a minor role in comparison to the other European countries.
3.2 Project examples

<table>
<thead>
<tr>
<th>Bruck an der Leitha</th>
<th>Poundbury</th>
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<tbody>
<tr>
<td>Country</td>
<td>Country</td>
</tr>
<tr>
<td>Austria</td>
<td>Great Britain</td>
</tr>
<tr>
<td>Region</td>
<td>Region</td>
</tr>
<tr>
<td>Lower Austria</td>
<td>Dorset</td>
</tr>
<tr>
<td>Plant location</td>
<td>Plant location</td>
</tr>
<tr>
<td>Bruck an der Leitha</td>
<td>Poundbury</td>
</tr>
<tr>
<td>Start of operation</td>
<td>Start of operation</td>
</tr>
<tr>
<td>2007</td>
<td>2012</td>
</tr>
<tr>
<td>Biomethane feed-in capacity</td>
<td>Biomethane feed-in capacity</td>
</tr>
<tr>
<td>100 Nm³/h</td>
<td>400 Nm³/h</td>
</tr>
<tr>
<td>Upgrade technology</td>
<td>Upgrade technology</td>
</tr>
<tr>
<td>membrane technology</td>
<td>membrane technology</td>
</tr>
<tr>
<td>Substrate</td>
<td>Substrate</td>
</tr>
<tr>
<td>grass, maize and manure as well as residues from the food industry</td>
<td>maize and gras silage</td>
</tr>
</tbody>
</table>

The biogas plant in Bruck an der Leitha, close to Vienna, started operation in 2004. The gas production is based on the combined fermentation of grass and maize together with residues from the food industry.

In 2007, the Energy Park Bruck an der Leitha, the Technical University of Vienna and the plant manufacturer Axiom GmbH jointly undertook the repowering of this plant to upgrade the raw gas to natural gas quality with the help of an innovative technology.

For the first time in this scale, the reference project employs membranes in order to upgrade biogas. The methane to be later fed into the grid is separated from the CO₂ by means of semi-permeable membranes.

The upgraded biogas is fed into the EVN grid and is transferred to the gas station operator OMV and Vienna Energy to be applied as biofuel.

The facility is the biggest and first agricultural biomethane facility in Great Britain.

The plant ferments 41 tons of maize, grass and potato waste to biogas, which is partly converted into electricity, but 400 cbm/h – after being upgraded – are injected into the gas grid to supply the community, which has been designed by Price Charles, with electricity and gas.
More than 30 farmers and business associates around Kielen have joined forces in the initiative "Naturgas Kielen" in order to assemble the 50,000 t of renewable primary products, liquid manure as well as residues from the food industry for the biogas plant in Kielen. Their motivation to opt for the feed-in of biomethane derived from the rural structures of the region where the heat could not be marketed as well as when transported via the natural gas grid.

The biogas is upgraded to the local natural gas quality (more than 98 per cent of methane) with a pressurised water scrubbing process and fed into the near-by gas grid.

The project is the first biomethane plant in Luxembourg and enjoys the full support of public stakeholders as well as the media.

On the site of an old landfill, the Tilburg utilities erected a gas upgrading plant in 1986. In this plant, gas from a landfill is upgraded together with gas from a close-by sewage plant and a biogas plant, which operates on organic waste from the food industries and private households. About 70 per cent of the raw biogas stem from this biogas plant. The raw biogas thus generated possesses a methane concentration of 55 per cent and is then upgraded to the local natural gas quality of 88 per cent.

Both the biogas and the landfill gas are upgraded with a pressurised water scrubbing technology, which represents an investment of 3.6 million Euros. The maximum biomethane feed-in capacity amounts to 1,300 Nm³/h. The yearly overall energy production of the plant amounts to 18 GWh, of which 3.3 GWh are used for internal processes, while the rest is sold to the regional gas supply company.
Market Development in Europe.

The Laholm Biogas plant in Sweden was started in 1992 with the purpose of reducing eutrophication in the area. It is a central co-digestion plant that receives manure and different kinds of organic waste from the region and turns this into bio-fertilizer and biogas. The biogas has since 2001 been injected into the local natural gas distribution grid.

The biogas has replaced around 25 per cent of the regional natural gas consumption and is partly used in the city of Laholm for heating in industries and houses. A part of the biogas is also used as vehicle fuel in a filling station located on the outskirts of Laholm, thereby reducing the local emissions of particulates and hydrocarbons.

The Laholm biogas plant has successfully and substantially reduced the regional eutrophication and nitrogen leakage into the Laholm bay area. It has also reduced the CO₂-emissions by 3,700 tons a year by annually replacing 18,000 MWh natural gas.

Since 2008 the water treatment plant in Meilen (ARA Meilen), canton Zürich Switzerland, is connected to a biogas upgrading plant. The ARA Meilen exists since 1966 and was extended in 1996. The produced biogas was used till 2008 to generate electricity directly in a block heat and power plant.

The gas upgrading takes place through amine scrubbing and was considered to be a pilot project in Switzerland at the point of start of operation. A part of the used thermal energy is recycled to the ARA in order to assure an ideal temperature for the sewage sludge.

The plant operator assigned in 2009 an evaluation study about the environmental performance of the plant, which is publicly available.

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<table>
<thead>
<tr>
<th>Laholm</th>
<th>Meilen</th>
</tr>
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<tbody>
<tr>
<td>Country</td>
<td>Switzerland</td>
</tr>
<tr>
<td>Region</td>
<td>Canton Zürich</td>
</tr>
<tr>
<td>Plant location</td>
<td>Meilen</td>
</tr>
<tr>
<td>Start of operation</td>
<td>2001</td>
</tr>
<tr>
<td>Biomethane feed-in capacity</td>
<td>300 Nm³/h</td>
</tr>
<tr>
<td>Upgrade technology</td>
<td>PWS</td>
</tr>
<tr>
<td>Substrate</td>
<td>sewage sludge</td>
</tr>
<tr>
<td></td>
<td>manure, industrial waste, household waste, other organic waste</td>
</tr>
<tr>
<td></td>
<td>biomethane feed-in capacity</td>
</tr>
<tr>
<td></td>
<td>ca. 65 Nm³/h</td>
</tr>
<tr>
<td></td>
<td>chemical scrubbing</td>
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</table>
The plant in Chaumes-en-Brie has been the first French plant in 2013, which injected biomethane directly into the gas grid. The biogas is mainly being produced from food waste and manure and upgraded to natural gas quality by using membrane upgrading technology. Through a 3 km pipe it is then injected into the gas grid of GrDF.

Before the first injection, 3 years of negotiation with legislator and authority has been necessary, to enable the injection. Finally French authorities determined remunerations for biomethane injection in the first instance, then the building permission has been approved.

Due this, the Chaumes-en-Brie plant set a foundation for more similar biomethane plants, to use the huge potential of agricultural and food waste in France.

Till 2050 73 per cent of the French gas are planned to be “green gas”.

Abbotsford has been the first biomethane injection plant in Canada, and built by PlanET Biogas Group. In 2010 the fermenter has been feeded the first time with poultry litter, whey, grease, slaughterhouse waste and maize. In early 2011, biomethane has been injected into the gas grid of British Columbia the first time.

Due to financial support from the public purse, the project has been able to be put into praxis. 1.5 million of 4.5 million dollar of investment costs are coming from public funds.

Due the lack of remunerations for biogas/methane, the plant operator is forced to market the gas by himself. The biomethane is thereby sold to the local gas supplier with 940,000 gas customers and is being positively accepted by them.

Most of these customers are willing to use natural gas with added biomethane, if thereby a part of their energy consumption has been produced carbon neutral.

In sum the facility is saving 6,500 tons of CO₂ per year.
The generation of biomethane is based on a complex process in various stages. Many factors influence the process from the generation of biomass to the application of the fed-in biomethane—and many diverse players have a stake in the success of any biomethane project. The following chapter describes the value chain of biomethane generation.

### 4.1 Biomass production.

Since biogas can in principle be generated from any organic compound, the biomass feedstock that can be used to produce biogas is diverse. Some biomass feedstock comes from farms in the form of plants. Others come from other processes, or from animals, in the form of waste materials like household garbage and sewer sludge. Biomass suitable for use in biogas production is called “feedstock.” Waste’s suitability for use as feedstock brings every available organic material into question. Especially useful for biogas generation are sewer sludge, kitchen rubbish, and liquid manure, which as waste products are abundant and affordable.

**Energy plants.**

The term “energy plants” refers to crops that are cultivated especially for the purpose of energy production. These especially include crops with high photosynthetic rates that grow quickly in the climatic conditions of a given region. In central Europe, such plants include corn, rapeseed, and rye. Many tropical countries use sugarcane extensively as an energy plant.

**Energy plants for biogas generation.**

Maize is especially well-adapted for use in biogas facilities, though cereals (such as rye) and/or grass cuttings are also acceptable. The plants most suitable for use in biogas generation vary from region to region; they must be chosen against the background of local conditions. From a climate protection perspective, it is important to ensure that local land use changes associated with energy plant cultivation do not lead to negative ecological effects.

### 4.2 Logistics.

With regard to the logistics of biomass energy, one must keep in mind the energetic and economic barriers that make long-distance delivery of feedstock impractical. Because biomass can only be harvested during certain short periods of the year, these barriers necessitate a well-planned biomass logistics chain.

It is necessary to distinguish between the concepts of decentralised and central storage:

If the areas surrounding biogas facilities already possess the capacity to hold the biomass that will be needed by a local area during the year, decentralised storage may be the best approach. In such cases, biomass is delivered to processing facilities on a continual (just in time) basis. Through this, a good utilisation of transport materials is achieved, with remaining dry fermentation feedstock being transported away as back-freight. A downside of decentralised storage is that personnel costs may run high, since biomass must be delivered more frequently.

A second approach is the central storage of biomass at the biogas facility. Advantages of this approach include a consistent quality of stored biomass, along with minimal logistical expenses. These storage facilities may be subject to higher investment costs, however, since new storage capacity must be created. Nonetheless, savings of €2 per ton of silage are achievable in central storage sites (relative to decentralised storage facilities) through reductions in silage loss of up to 10 per cent.

The choice of transport methods should be made in consideration for the distance between energy plant cultivation areas and biogas installations. At short distances, transport with tractors and other farm equipment is more affordable, because nothing but the biomass itself must be loaded. At longer distances, shipping via trucks becomes more affordable.
4.3 Biogas production.

**Raw biogas.**

Raw biogas is generated through the fermentation of feedstock. This process occurs in so-called fermenters, where microorganisms facilitate the process of material conversion that produces the raw biogas. The processes involved in fermentation are exceedingly complex, and are currently understood only in part. Various current research projects seek to improve this understanding. The optimisation of the fermentation processes highly depends also on the measurement and control systems and procedures used.

Raw biogas consists of 45–70 per cent methane (CH₄). The second largest component of the gas is carbon dioxide (CO₂), making up 25–50 per cent of the total. The rest contains minimal portions of hydrogen sulphide (H₂S), ammonia (NH₃), and water vapor (H₂O). Fossil-based natural gas contains 85-98 per cent methane. To guarantee the consistent quality of the natural gas in the grid, the methane content of the raw biogas must increase before being fed in. This methane content “upgrade” occurs through a purification of the raw biogas.

**Methane yield.**

The flammable and thus relevant component of biogas is methane. Hence, the amount of methane contained in the biogas should be increased to as large a per centage of the whole as possible. The initial methane content of raw biogas varies chiefly with the feedstock used.

The upgrading of biogas’s methane content is achieved through the optimisation of facility systems for particular feedstock, and through the implementation of measurement and regulation systems.

4.4 Biogas upgrade.

**From raw biogas to biomethane.**

There are several processes available for upgrading biogas to natural gas quality. In this context increasing the calorific value of biogas by separating the containing CO₂ is the most important process step. Additionally, gas drying and removal of sulphur components and of other trace components are necessary. The order of the single process steps is thereby depending on the overall process concept. Furthermore, injecting biomethane into the natural gas grid may require additional processes for adjusting the calorific value (e.g. by adding Liquified Petroleum Gas/LPG) and odorising the biomethane. Due to the additional expenses needed for biogas upgrading and injection the specific investment costs for biomethane plants are higher compared to biogas plants with a CHP at site. Therefore, biogas plants with small capacities may consider the option of collecting the raw biogas via a micro gas grid and lead the gas to a joint gas upgrading and injection plant. The figure above provides an overview on the different process steps of the biogas upgrading process.

**Sulphur removal.**

Depending on the source of the substrate, biogas can contain high concentrations of sulphur components. Often sulphur is present in form of hydrogen sulphur (H₂S). Other sulphur components are considered in the parameter “Total sulphur”. These trace components have corrosive effects and therefore must be removed from the biogas. Otherwise they endanger plant parts and gas utilisation devices. The available processes for desulphurisation are divided into two categories: crude sulphur removal on the one hand, and fine sulphur removal on the other.

**Crude sulphur removal.**

The process of crude sulphur removal can either be operated using the biological way or the chemical way. Biological processes employ microorganisms that convert hydrogen sulphur to sulphur which than can be removed from the process. Biological processes are for example:
Value Chain of Biomethane.

<table>
<thead>
<tr>
<th>Manure</th>
<th>Energy crops</th>
<th>Organic waste</th>
<th>Sludge</th>
</tr>
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<tbody>
<tr>
<td>raw sulfur removal</td>
<td>raw sulfur removal</td>
<td>raw sulfur removal</td>
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<tr>
<td>compression</td>
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<tr>
<td>gas cooling</td>
<td>gas cooling</td>
<td>gas cooling</td>
<td>gas cooling</td>
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<tr>
<td>PSA</td>
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*If needed calorific value adjustment with LPG or air*  

**Substitute natural gas**

**Figure: Process steps of raw biogas upgrade. Source: Fraunhofer UMSICHT (2013), own research.**

Injecting ambient air or pure oxygen into the fermenter unit, trickling filter process with air dosage for internal regeneration of the washing fluid, trickling filter process with external regeneration of the washing fluid.

In contrast, the chemical processes for sulphur removal base on adding chemical substances to the fermenter or to the gas that bind the sulphur. In the field most often the following processes are used for chemical desulphurisation:

- Adding of iron salts to the fermenting substrata in the fermenter,
- gas adsorption on iron containing compounds in a packed-bed adsorber,
- gas scrubbing with sodium hydroxide solution (NaOH).

**Fine sulphur removal.**

With the exemption of just a few CO₂ removal technologies often removing sulphur components down to lowest concentration is necessary. In praxis removing sulphur with active char coal has been successfully proven.

**Gas drying processes.**

For the drying of biogas, adsorption and condensation processes are the methods of choice.

**Condensation processes.**

High moisture content cause troubles when operating compressors, active char coal filters or gas engines. Therefore, the biogas is cooled, and the condensing water is removed from the process. However, the moisture content reached by the condensation process usually does not meet the specifications DVGW G260 and G262 for biomethane preparation. For this reason, the process often needs to be extended by an additional gas drying process.

**Adsorptive gas drying processes.**

The principle of adsorptive processes is water vapour adsorbing at specific compounds (e.g. molecular sieves, silica gel and aluminum oxides). Using packed-bed adsorbers, biogas passes by and water vapour is removed from the gas. The desiccant must be regenerated after adsorption. If the biogas facility is to feed into the gas grid on a continuous basis, it is necessary to apply at least two separate packed-bed adsorbers so that one may be used when the other is regenerating.

**CO₂ separation.**

Separating CO₂ from the raw biogas is important to increase the calorific value of the gas. Different technologies are applicable for CO₂ separation, whereby the following technologies have been successfully proven at the European market:

- pressure swing adsorption (PSA)
- pressurized water scrubber
- chemical scrubbing with amines or polyglycol
- gas separation using membranes
- hybrid process of membrane technology and cryogenic separation

Other processes are in pilot plant or F&E stage. In the following you find a brief overview of some selected CO₂ separation technologies.

**Pressure swing adsorption (PSA).**

Adsorption refers to the exit of molecules from fluids and their subsequent attachment to solid surfaces. The PSA technology uses this principle to remove the CO₂ and any remaining traces of other gases from raw biogas. Before adsorption, sulphur components and water vapour must be removed from the raw biogas, since these substances can damage the material used for adsorption (e.g. molecular sieve).

**Pressurised water scrubbing.**

Pressurised water scrubbing makes use of the different solubilities of CH₄ and CO₂ in water. Raw biogas is led through scrubbing column in counterflow to the water, and first of all the CO₂ contained in the biogas is dissolved. The process runs under the pressure of several bars to increase the solubility of CO₂ in water.
Besides CO₂, this process is able to remove hydrogen sulphide (H₂S) and ammonia (NH₃) present in raw biogas. In case the concentrations of hydrogen sulphur are very high, an additional crude sulphur removal is required. The loaded water can be regenerated by pressure drop and be recycled.

Chemical scrubbing with polyglycols.
The chemical scrubbing with polyglycols follows the principle of a gas wash. However, in contrast to the water wash different types of polyglycol are used as washing agents. This washing agent has a higher capacity and selectivity towards CO₂ compared to water. The loaded washing agent can be regenerated by pressure drop and temperature increase up to 50 - 60 °C.

Chemical scrubbing with amines.
This scrubbing process employs different types of amines as washing agent. CO₂ reacts with amines in a chemical reaction. Therefore a much higher loading of the washing agent becomes possible. The washing agent is regenerated using temperatures in a range of 110 - 160 °C. The temperature level depends on the pressure level at the absorption stage. In Germany most often processes without pressure increase have been implemented which require high temperatures for the regeneration. The heat demand can be covered by using waste heat from combined heat and power plant at the site.

Membrane technology.
Gas separation at membranes is a physical process. Raw biogas is compressed up to several bars and is led through the membrane. Here, CO₂ passes the membrane and is separated from CH₄. Thus, the CH₄ concentration in the biomethane increases. Up to three separation steps are necessary to meet the specifications for feed-in into the natural gas grid.

Hybrid process from membrane and low-temperature-cooling (cryogenic separation).
CO₂ can also be separated from biogas in its liquid aggregate state under the influence of low temperatures (cryogenic separation). Due to different dew points of CO₂ und CH₄ a very clean separation and a low level of methane slip can be ensured. Besides the low methane slip the process offers the advantage of an additional side product. The gained CO₂ is very pure and can be marketed in food industry. Pure cryogenic upgrading of biogas have rarely been implemented at big scale due to the high energy demand of this technology.

An innovative hybrid process combines the low-temperature-cooling and the membrane technology. In a first step a membrane is used to increase CH₄ concentration. Afterwards the biogas with the remaining CO₂ is cooled down to low temperatures and CO₂ is separated. The hybrid process has been implemented at several sites at industrial scale.

The following table (page 33) provides an overview of the respective upgrade technologies and their most important process parameters.

4.5 Grid feed-in.
The feeding of biogas into the natural gas grid is an efficient energy solution, even if the sites in which the gas is to be applied are far away from the sites at which it is produced. Gas feed-in is facilitated via a compressor, a device raising the pressure level of the biomethane to that of the gas in the closed pressurised lines of the grid. Given European regulatory realities, new gas producers have the opportunity to feed gas into the conventional gas grid. For biogas generators, this multiplication of the possible number of consumers is attractive. For purposes of injection, however, the gas must meet the quality specifications of the relevant legal provisions and may only deviate within the range of these quality standards. Such standards are realised using technologies for reconditioning gas.
Because a non-negligible quantity of energy is necessary for gas compression, the energy balance and the economic feasibility of the compression and feed-in process must be reviewed on a case-by-case basis.

Accessory gas/exchange gas.
With regard to feeding biomethane into the natural gas grid, it is necessary to distinguish between exchange gas and accessory gas. The difference lies in the quality of the gases. An exchange gas has the same qualitative standards as conventional natural gas and can be exchanged in the grid as such. Accessory gas possesses a composition that is not equivalent to that of the natural gas, and can therefore only be mixed into the grid beneath a certain threshold.

The types of natural gas available in Germany vary with geography. Similarly, the degree to which biomethane is upgraded depends on the region of its origin.

Quality standards.
Regulations distinguish between low-quality natural gas (“Natural Gas L”) and high-quality natural gas (“Natural Gas H”). Natural Gas H possesses a higher methane content, and is used mainly in the GUS federal states and extracted principally in the North Sea.

Natural Gas L contains roughly 89 per cent flammable gases (primarily methane, but also small amounts of ethane, propane, butane, and pentane), while Natural Gas H contains about 97 per cent flammable gases (the same as those listed for Natural Gas L).

4.6 Sales and trade.
The transport and sales of the injected biomethane is usually coordinated by a biogas or natural gas trading company. To transfer biogas from its production site to its end customer, these trading companies enter various business and contractual relationships with different partners. The following overview gives an idea of the biomethane sales dynamics in Germany.

Biogas Accounting Grid Contract.
In order to transport the injected biomethane via the gas grid, the trading company (also called “transport client”) is required to close a biogas accounting grid contract with the accounting grid operator. The grid operator balances the account of the biomethane amounts fed-in and out of the grid in an accounting grid and settles surplus and shortage quantities with the transport client.

Grid Entry Contract.
In order to be allocated to an accounting grid, the biogas supplier enters a contract with the Entry Grid Operator. In this Grid Entry Contract, the parties agree on the quality criteria for the injected gas.

Grid Exit Contract.
The final customer enters into a grid exit contract with the exit grid operator settling the gas withdrawal at the physical gas exit point. The costs for the grid transport are the same as in natural gas transport transactions and are covered by the final customer together with grid access fees regardless of the feed-in location.

Biomethane sales and trade in Germany differs from classic natural gas trade regarding the necessary proof of origins. The amounts of biomethane fed into the natural gas network must be documented along the value chain regarding the attributes required by law (“produced from renewable primary sources”, for example). These attributes mostly derive from the legal and political conditions.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>PSA</th>
<th>PWS</th>
<th>Polyglycol</th>
<th>Amine</th>
<th>Membrane technology</th>
<th>Membrane/cryo hybrid technology</th>
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<td>Methane loss</td>
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<td>Required pressure (bar)</td>
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<td>5-10</td>
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<td>0-5</td>
<td>5-16</td>
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<td>Consumption of electricity (kWh/Nm³ RGB)</td>
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<td>0.2-0.25</td>
<td>0.24-0.33</td>
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1 MDEA less sensitive to H₂S
2 Methane loss depends on type and mode. Given values are the practical minimums for common construction. Partly installations are operated with a higher proportion of methane in the lean gas than possible, for the purpose of the reduction of electricity consumption. The methane proportion in the lean gas can be used thermally for heat supply.
3 Basic: product gas capacity 700 Nm³/h, ambient temperature 15 °C, raw gas 55% CH₄, clean gas quality with CO₂ proportion <3%, RGB (raw biogas)
4 in dependency of pressure
5 with energy recovery from CO₂ liquefaction

Status of August 2014
Next to transport logistics and accounting matters, the trading company also coordinates a gas portfolio. The company buys biogas quantities from various producers and delivers it to different (end) customers. Also, the trading company is able to provide ongoing and steady supplies as well as singular deliveries on the spot. These classic portfolio structuring are accompanied also by structuring regarding biomethane attributes. The different origin attributes lead to a variety of different biomethane products of different value and with versatile application fields. By structuring these attributes the trading company can serve customers’ individual needs resulting from the field of application they are aiming at. The certificates or quantity attestations are the basis for biomethane clients to prove their claims for the feed-in tariffs in context with EEG or EEWärmeG.

Since the beginning of 2011, the Biogas Register has set a standard for biomethane proof of origin and quality criteria. With this system, biomethane producers, traders and users are able to document the gas quantities fed into the gas grids. The criteria catalogue used in this context is applicable to all potential fields of utilization for the biomethane. The information provided by the producer is cross-checked by an independent auditor. It may then be allocated to its utilization. Therefore, consistent proof is guaranteed also while the biomethane is in the gas grid, between its feed-in and abstraction.

4.7 Application fields.

The application fields for biomethane are the same as are currently satisfied by conventional natural gas. The main advantage is its good heating characteristics. In the early stages of biogas generation in Germany, it was mainly used for power generation in so-called combined heat and power plants (CHP) right on the production site. A major part of the generated heat remained thus unused.

The upgrade and feed-in of biomethane broadens the application fields of biogas to equal those of natural gas.

Heat generation.

Like natural gas, biomethane can be applied in industry and private households for heating purposes. No adaptation of the end devices (gas-fired boiler, gas stove, e.g.) is necessary since the biomethane presents the same heat value characteristics as the natural gas in the local gas grid. The fact that biomethane thus can resort to existing infrastructure is a central advantage of this innovative technology also from an economic perspective.

Cogeneration of heat and power (CHP).

In combined heat and power processes, biomethane is used in combustion machines (gas engines, (micro-)gas turbines, stirling motors). These machines generate mechanical energy and, as a byproduct, heat. The mechanical energy is transformed into electrical energy via generators and fed into the power grid. The generated heat is used for heating purposes. The CHP process operating on biogas mainly takes place in CHP plants, where the heat energy generated can be applied in a local heat network. Regarding the energy yield, CHP achieves very good results since the heat which is generated during the process of power production can also be utilized. CHP has come to play a more and more important role in recent years and is especially advisable for edifices and facilities presenting a high heat demand all year long, such as public swimming pools, factories etc.

Mobility.

Biogas upgraded to natural gas quality can be used to fuel natural gas dedicated vehicles. A further adaptation on the vehicles is not necessary. By feeding biomethane into the grid, it is made available on a national basis and can be distributed via the existing natural gas station infrastructure.

In comparison to other biofuels, biomethane is to be ranked among the most efficient ones. Per hectare cropland, a similar mileage can be achieved with biomethane as with biomass-to-liquid (BtL)-fuels of the so-called second generation.
This chapter presents German and European companies and market players in the biogas injection sector. The table provides an overview of their core activities.

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Project development</th>
<th>Engineering</th>
<th>Plant engineering</th>
<th>Plant operation</th>
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Note: The table columns represent different activities or roles that companies and market players might engage in within the biogas injection sector.
### Companies and Market Players

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<th>Engineering</th>
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The DVGW’s technical standards ensure a high-quality gas and water supply for Germany. The DVGW assists gas and water enterprises with the cost-effective implementation of technical measures necessary for maintaining Germany’s clean, secure gas and water supply. As a setter of technical standards, the DVGW with its more than 13,000 members is instrumental in defining collaborative processes designed to improve these enterprises, and to ensure effective, autonomous industrial management under rapidly changing conditions.

With respect to biogas, the DVGW takes a holistic approach to setting gas and water standards: the focus is on supply security, supply diversity, sustained access to native energy sources, and the gradual development of processes for producing biomass energy from the most commonly used plants.
We are where our customers are.

erdgas schwaben looks back on a long history as an energy provider in the German regions Swabia and Upper Bavaria. The current pipeline system connects 183 cities and communities, covering an area of roughly 6,000 km. Public facilities as well as private households utilize our services which cover the full spectrum of natural gas supply. For the past three years, the Swabian energy supplier has been following its own unique energy strategy: “The erdgas schwaben way”.

Central principles of the "erdgas schwaben way" include the professional consultation for the reduction of energy costs, the support of more efficient natural gas utilization practices, and the resulting expansion of renewable energies.

The erdgas schwaben way.

Bioenergy, the renewable energies from Swabia have an enormous development potential! We have successfully expanded this business sector continuously. erdgas schwaben currently manages four operating bio-natural gas plants. The first plant has been in operation since 2007, and is located in Graben, near Augsburg. The others are located in Mailingen, near Nördlingen in Donau-Ries (since 2008), in Altenstadt/Schongau (since 2009) and in Arnschwang/Cham (since 2010).

210 Million kWh are produced and anually fed into the grid. This amount equals 12,000 households which are currently experiencing the benefits of green energy use.

Three additional biogas projects for bio-heat and bio-electricity are currently in operation in Dillingen, Mindelheim and Kaufbeuren.

The regional supply of energy from sustainable natural resources makes Swabia independent from the international energy market, thus strengthening the region as a whole. That is why erdgas schwaben annually invests 10 million Euros into the expansion of renewable energies in the region and, through this measure, in our future generations.

Bioenergy for us is a means to set the stage for the environment. Bioenergy from regenerative natural resources, 100% eco-friendly, always available and directly from Swabia.
Viessmann Werke GmbH & Co. KG

Biogas expertise from a single source

The Viessmann Group is one of the leading international manufacturers of heating systems. Founded in 1917, the family business maintains a staff of approximately 11,400 employees and generates 2.1 billion Euro in annual group turnover. With its subsidiaries, Schmack Biogas, one of the leading suppliers of biogas plants based on the wet anaerobic digestion method, biogas upgrading pioneer Schmack Carbotech and BIOFerm, a company specialising in dry AD systems, Viessmann spans the entire range of expertise in biogas technologies.

Full-service provider of biogas plants

Since 1995, Schmack Biogas has been setting the standard for biogas plants that are highly efficient and cost-effective to operate. The product portfolio includes plant systems with outputs ranging from 50 kWel for compact plants up to 20 MWGas biogas plants. Worldwide, over 400 plants have been built. Schmack Biogas has been part of the Viessmann Group since January 2010.

The company’s range of services encompasses the entire biogas value chain: from project development and engineering to feedstock management and operational management. Schmack Biogas is thus one of the few full-service providers in the sector. In addition to technical support, a key area is its comprehensive microbiology service. The company’s in-house research and development laboratory is used to identify and exploit potential efficiencies in the area of process biology. Schmack has won several awards for its innovative technologies and processes.

Specialist in wet and dry fermentation

With systems for wet and dry anaerobic digestion, Schmack Biogas covers the whole field of digestion. Schmack biogas plants are distinguished by high levels of flexibility and reliability. By using high-quality components manufactured in-house, particularly in the key areas of agitator and feeding systems, Schmack is able to offer process- and energy-optimised systems. In addition, Schmack Biogas also offers BIOFerm dry AD technology for non-pumpable feedstocks. This method is used to convert biogenic waste materials (e.g. municipal bio-waste) into energy.

Schmack is also active on the international markets. The company has subsidiaries in Italy and the USA in the form of Schmack Biogas Srl in Bozen and BIOFerm Energy Systems in Madison, Wisconsin.

Market leader in gas upgrading

Schmack Carbotech GmbH is one of the pioneers of biogas processing, with more than 40 years of experience in the development, engineering and manufacturing of turnkey plants for gas processing and gas injection. Based on the pressure swing adsorption (PSA) process, the company has constructed more than 60 processing plants worldwide.

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Schmack Carbotech GmbH
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mail@carbotech.info
www.carbotech.info
The Volkswagen Group.

As one of the world’s leading vehicle manufacturers, the Volkswagen Group increased the number of vehicles it delivered to customers to over 9.7 million in 2014.

The Group’s aim is to offer attractive, safe vehicles with lower environmental impact, which are competitive in an increasingly tough market and which set world standards in their various classes. Under the brand name SunGas®, Volkswagen is involved in the production of largely CO₂-neutral biomethane. Natural gas, biomethane and synthetic methane (manufactured using Power-to-Gas technology) are components of Volkswagen’s powertrain and fuel strategy, which demonstrates an evolutionary way to achieve sustainable mobility.

**Natural gas drive – efficiency meets dynamics.**

In order to offer users a tailored mobility solution to suit their various requirements, Volkswagen uses all kinds of modern drives. Vehicles with a natural gas drive are clean, efficient and economical. The engine in natural gas models has been specially developed and optimised for the permanent use of natural gas: modified components such as valves, pistons and the engine management system have been designed for the specific requirements of natural gas operation. Volkswagen has been developing natural gas engines for approximately two decades. One of the greatest advantages of natural gas vehicles is the fact that these models can be powered using not only natural gas, but also alternative fuels such as regenerative biomethane. Synthetically manufactured natural gas also offers a way to save electricity harnessed from regenerative sources such as wind energy in the form of methane and to use this for mobility.

The **eco up!** is currently the most efficient natural gas vehicle in the world. This four-seater Volkswagen uses only 2.9 kg of natural gas (CNG = compressed natural gas) over a distance of 100 km; this value corresponds to CO₂ emissions of just 79 g/km. In addition to reduced fuel consumption, the vehicle also offers considerably lower fuel costs: with the eco up!, costs for the 100 km quoted come in at just over three euros in Germany; in Italy, Europe’s largest market for natural gas-powered vehicles, costs are actually less than three euros. No other all-round vehicle offers such inexpensive mobility.

Volkswagen Aktiengesellschaft
Group Research, Powertrain
Dr. Tobias Loesche-ter Horst
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www.sunfuel.de
AC Biogas GmbH was founded in 2006 and is a spin-off of AUDIT GmbH, a company active since 1994 focusing on quality and environmental management.

Led by its managers Dr. Andreas Möller and Thomas Knieling, ABICON is by now a well-established market player, known not only in Hesse, but in all of Germany.

The core competences of our teams focus on the development and support of projects in the biogas, wind and photovoltaic fields. The teams consist of civil engineers and agriculturists as well as business managers with special knowledge in the various sectors of renewable energies. Thus, we can offer a broad spectrum of practical and theoretical know-how from planning to commissioning and beyond.

Additionally the AUDIT GmbH offers services for the running commercial operation, e.g. environmental report preparation as well as consultancy & certification in process management standard. We can offer special competences in the field of biomethane production. The biogas-plants of “Schwälmener Biogas GmbH & Co. KG” in Ransbach as well as the “Karbenener Biogas GmbH & Co. KG” near Frankfurt are two of the most sustainable biogas plants in Germany because of optimal agriculture structures. More biomethane plants are in process of construction. More biomethane plants are in process of construction. Additionally wind energy plants are planned, which contribute to value via energy cooperatives and citizens’ participation.

Our main virtue lies in the interdisciplinary approach which enables us to meet all individual customer needs.

*ABICON GmbH*

**Development of bigas and wind energy projects**
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Dr. Andreas Möller
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Fax +49 (0)6696 9129 39-20
info@abicon-gmbh.de
www.abicon-gmbh.de

*AC Biogas GmbH*

The AC Biogas GmbH is one of the largest decentralised biogas based energy generators in Germany. Apart from its core business areas of electricity and heat generation from biogas, the Münster based company also produces and feeds biomethane into the natural gas network. AC Biogas GmbH currently operates biogas facilities in 91 different locations across Germany. Electricity production is presently around 89 megawatts. In addition, roughly 550 million kilowatts/hour of biomethane are fed into the natural gas network every year.

AC Biogas expertise encompasses the complete supply chain:

- Project development
- Acceptance planning
- Financing
- Construction
- Business and technical operation
- Raw material management
- Biological maintenance
- Network connection
- Sales of electricity, heat and biomethane

AC Biogas currently runs 15 facilities for feeding biomethane into the natural gas network in Angermünde, Blankenhain, Hage, Holleben, Hohenhameln, Kannawurf, Könnerl I, Könnerl-Süd, Lambsborn, Lüchow, Neuburg-Steinhausen, Pliening, Röblingen, Stresow, Wriezen. Additional facilities are already under construction or in the planning phases. The redevelopment of existing biogas facilities to provide biogas feed-in also presents an ecological and economically sage alternative and AC Biogas is also pushing such developments. The biomethane produced is sold to gas dealers, energy providers, municipal utilities and CHP operators, to meet the growing demand for environmentally friendly gas.

*AC Biogas GmbH*

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AERZEN products for biogas and biomethane applications.

For many years, AERZEN blowers and compressors have been conveying and compressing all types of gas and gas mixtures in plants of the chemical and petrochemical industry. Thereby, energy efficiency, plant safety and reliability are the decisive criteria. Based on this know-how and the experience gained, Aerzener Maschinenfabrik GmbH offers products especially developed for the biogas market.

Aerzener Maschinenfabrik GmbH supplies suitable products for biogas applications in a pressure range from 200 mbar up to 20 bar overpressure. A large number of sizes and pressure stages makes it possible to offer individual and high-efficient customer-specific solutions.

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www.aerzener.de

Agraferm Technologies AG is a leading supplier of turn-key AD plants throughout Europe and has built 70 AD plants to date, including ten in the UK. Agraferm Technologies AG with headquarters in Pfaffenhofen, Germany operates internationally to plan and build biogas plants. The company employs around 70 people in its German locations in Pfaffenhofen, Konz, Kiel and Zerbst. It is one of the few full service providers for agricultural and industrial AD plants. Its range of services includes project management, construction, re-powering, as well as technical and biological services for AD plants. In addition to the German market the company operates in the UK, Italy, Slovakia, and the Czech Republic. Agraferm offers robust, efficient and cost-effective technology, which allows flexibility of feedstock and constructs

AD plants for a variety of customers, such as farmers, food and beverage companies, the energy industry (biomethane gas upgrading and gas to grid) and investors.

Agraferm Technologies AG
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www.agraferm.com
Companies and Market Players.

AIR LIQUIDE Advanced Technologies GmbH

As the world leader in gases for industry, health and the environment, Air Liquide has more than 50,000 employees present in 80 countries and serves more than 2 million clients. Oxygen, nitrogen and hydrogen are at the center of the company’s activities since its creation in 1902, and Air Liquide had revenues of 15.3 billion Euros in 2013.

Air Liquide is active on the German market since 1971, and in 2013, with more than 4,000 employees, its revenues exceeded 2 billion Euros. Technical and medical gases are its core businesses.

The mission of the Air Liquide Advanced Business & Technologies division, created in 1962 and headquartered in Sassenage (France), is to develop trendsetting technologies and open up new markets and business areas for their applications. Its German subsidiary is AIR LIQUIDE Advanced Technologies GmbH, which has its headquarters in Düsseldorf, along with another location in Bremen. The main activities of the company concentrate on the fields of hydrogen energy, biogas upgrading, and the development of the European rocket Ariane 5 ME (Midlife Evolution).

In the field of biogas, Air Liquide provides upgrading (membrane separation) and liquefaction solutions. More than 30 reference plants are currently operated in the world. On the German market the company positions itself as an owner-operator of biogas upgrading units. The produced biomethane can both be internally used (for production of green gases) and externally commercialized. In the future Air Liquide will get more deeply involved in the fuel industry (CNG and LNG) and is thus seeking suitable partners for this.

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www.airliquideadvancedtechnologies.com

ALENSYS Engineering GmbH

With more than 10 years of experience the ALENSYS Engineering GmbH guarantees for technically and commercially optimized solutions for your biomethane project.

The implementation of your projects is always based on the high commitment of our engineers. By separating development and implementation processes we exclusively act according to the interests of our clients. A team of dedicated and experienced engineers provides you with tailor-made solutions.

Our industrial standard and our technical expertise secure a highly sustainable productive efficiency of our facilities.

Technical project development is a matter of trust. Ask us.

ALENSYS Engineering GmbH
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ARCANUM Energy

Germany’s leading service and consulting company for biomethane.

We connect the supply and demand of biomethane. As an independent company we bundle our expertise in the renewable energy market since several years. Our team has the economic and technical know-how, but also the experience and power of innovation which is required by the market. For that we were awarded by dena with the “Biogas product of the year” for the biomethane spotmarket and we were honored for the biogas pool.

We offer customers and partners:
- Consulting and services along the entire value chain
- Largest and independent balancing group cooperation for biomethane with approximately 1.5 TWh annual volume
- Operation of an own mass accounting system
- Project development and plant operation for more than 12 injection projects / projects of feeding biomethane into the natural gas grid
- Operation of the online platform www.bioerdgas-spotmarkt.de
- Market analysis and biomethane market report

ARCANUM Energy sees itself as trusted partner, offering everything from project development and plant operation, the balance and portfolio management up to the trading of energy and the development of strategic marketing concepts, which is required for a successful business of biomethane, so that our customers can focus on their own core business.

AssmannPeiffer

AssmannPeiffer is a law firm specialized on the energy industry. We are focused on the needs of businesses in the energy sector. We advise our clients in all matters of private and public energy law as well as in the core areas of commercial law, such as corporate law, negotiating contracts and enforcing rights (out of court and in court).

Within the sector of biogas and biomethane we advise inter alia gas traders, project developers and operators of biogas plants. We have a special focus on the production and marketing of biomethane for the biofuel market.

In the sector of biogas and biomethane our lawyers have inter alia provided advice to clients in the following matters:
- implementing connections to the gas grid (including legal disputes with grid operators and regulatory authorities),
- advising investors on statutory subsidies for biomethane in all sectors (Renewable Energies Act (EEG), tax law, biofuel quota regulation, etc.),
- drafting and negotiating contracts regarding the trade in biomethane,
- certification of biofuel producers and traders pursuant to the sustainability regulation (including legal disputes with the authorities and the certification systems),
- drafting and implementing contracts on the biofuel quota including verification with the biofuel authorities.

AssmannPeiffer
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BayWa r.e. Bioenergy GmbH, a subsidiary of BayWa r.e. renewable energy GmbH, develops, constructs and operates biogas plants. Since 1996, a drive for technical innovation and a pioneering spirit have enabled the company to firmly establish itself in the growth market of renewable energies. Developed by BayWa r.e. Bioenergy GmbH in 2006, the German biogas plant Pliening was the first to inject biomethane into the general natural gas grid on an industrial scale.

The range of services includes:
- Project development, raw material acquisition, securing of sites and permit planning
- Repowering of existing biogas plants
- Manufacturer-independent plant concepts
- Construction and commissioning as general contractor
- Raw material and fermentation residue management
- Technical and commercial plant management
- Energy and on-site consumption concepts
- Engineering and construction of combined heat and power units including financing solutions

The injection and trading of biomethane is carried out via our sister company BayWa r.e. Green Energy Products GmbH, whereby all the crucial elements of a crucial biogas value chain are brought together under single ownership.

BayWa r.e. renewable energy GmbH is a wholly-owned subsidiary of BayWa AG and brings together the group’s activities in the renewable energies sector. Founded in 2009, BayWa r.e. serves as a holding for several companies in the fields of solar energy, wind energy, bioenergy and geothermal energy.

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Atlas Copco is an industrial group with world-leading positions in the field of compressors, construction and mining equipment, power tools and assembly systems.

GREENFIELD is part of Atlas Copco and specialist in high pressure gas compressors for biogas grid injection, natural gas and hydrogen vehicle refueling, filling systems for storage and transport and for seismic and industrial gas applications.

Together with other group brands like CIRMAC or the Gas-Purification-Group, Atlas Copco offers a full range of own products and services for the dynamic and growing biogas industry.

Our experiences range from biogas upgrading over biomethane grid injection up to the end use in vehicle fuelling stations.

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BayWa r.e. Green Energy Products GmbH

BayWa r.e. Green Energy Products GmbH is an energy trading company for renewables in the business areas of biomethane trading, electricity marketing and green energy sales. As a fully owned subsidiary of BayWa r.e. renewable energy GmbH, the company deals in the biomethane sector with the injection, portfolio management and trade of biomethane. Trading takes place throughout Germany at physical injection and extraction points, and via virtual trading points for market areas (H-gas and L-gas) in the application areas of CHP generation, the fuel market and the heating market. Transparent and seamless biomethane proof of origin records are logged by us in the German Energy Agency (dena) biogas register.

An overview of services:
- EEG energy trading and participation in the capacity market
- Biomethane trading in the CHP, fuel and heating markets
- Service for portfolio management and accounting group management
- Sale of eco power and eco gas to private, commercial and industrial customers

BayWa r.e. renewable energy GmbH is a wholly-owned subsidiary of BayWa AG and brings together the group’s activities in the renewable energies sector. Founded in 2009, BayWa r.e. serves as a holding for several companies in the fields of solar energy, wind energy, bioenergy and geothermal energy.

Bebra Biogas GmbH

Bebra Biogas GmbH is an experienced supplier in the field of biogas plants. We develop and build modern and flexible biogas plants for farms and the processing of organic waste. With Bebra methane, Bebra offers a highly efficient membrane technology for the treatment of biogas, which is extremely environmentally friendly, cost effective and flexible.

All Bebra systems are characterized by high gas yields, durable technology and solid profitability. With Bebra geo, our new lagoon-type digesters, Bebra has developed an innovative and trend-setting biogas technology based on 100 per cent proven components. Equally applicable as digestate storage reservoir, Bebra geo combines groundwater protection and reliability with low investment and operating costs.

We provide to our customers a complete service package – from the economic calculation and planning, to implementation and commissioning through to biological and technical system support. Bebra Biogas has branches in Germany, Spain, Italy and Korea.

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With its service portfolio, its eco-friendly waste disposal and its street cleaning including winter services the Berliner Stadtreinigung contributes to Berlin’s quality of life. The acknowledged quality of its achievements and low fees in comparison to cities of similar size are as much part of BSR’s self-concept as its ecological and social responsibility.

When it comes to the future, BSR with its roundabout 5,300 employees is first in line, encompassing all levels of the company: be it the training in future-oriented professions, innovative waste treatment concepts, quality management for street cleaning or winter service which even in rough winters all can rely on.

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Bilfinger EMS GmbH is part of the Bilfinger (subgroup Bilfinger Industrial Technologies) Group and was established in 1975. Its focus is on the chemical, gas and biogas industries. Bilfinger EMS designs and builds complete units as well as individual components, as well as supplying industrial services.

Bilfinger EMS provides services for the entire lifecycle of industrial facilities, with services ranging from consulting, development, planning, assembly and installation to plant maintenance and operation. The focus is on our customers’ needs, both in terms of project support and service options.

For efficient and cost-effective biogas upgrading, Bilfinger EMS has developed a new process together with BASF. The solvent used in the process reacts selectively with carbon dioxide and hydrogen sulfide from the biogas. It is particularly oxygen-stable with a long lifetime, and can achieve very high biomethane purities with methane losses of less than 0.08 Vol%.

Upgrading units up to a size of 1,500 Nm³/h are designed in a modular way. They are prefabricated to reduce installation works on site. Larger units are skid-mounted. As an example, Bilfinger EMS installed two biogas upgrading units, each with a raw biogas flow rate of 6,000 Nm³/h for our customer VERBIO.
Companies and Market Players.

**Biogasrat+ e. V.**

Biogasrat+ e. V. – distributed generation: a fair partner for future-oriented energy policy.

Biogasrat+ e. V. – distributed generation is an associated of the leading companies in the areas of distributed generation and biogas. Its members represent the entire value chain in the field of distributed generation.

Biogasrat+ e. V. – distributed generation champions a decentralized, sustainable and resource-efficient approach to energy supply. The association’s purpose is to represent the common interests of market participants in the biogas and distributed generation business throughout the value chain, and to develop the market in line with member interests.

Biogasrat+ e. V. – distributed generation promotes the improvement of the statutory framework for distributed generation, biogas and biomethane and the grid integration of renewable energy, and raises awareness for the demands made by Germany’s transition to renewable power through its political and public campaigning.

As well as a strong commitment to international and national climate-change targets, the association is dedicated to the advancement of the German energy industry. It is the Biogasrat+ e. V. – distributed generation’s stated aim to ensure the continued technological leadership and competitiveness of the German biogas industry, under consideration of climate change and sustainability targets. The Biogasrat+ e. V. – distributed generation is a reliable and fair partner for business and policymakers aiming to create energy policy for the future.

**BMF HAASE Energietechnik GmbH**

Manufacturer of components for biogas technology.

BMF HAASE Energietechnik GmbH stands for quality and innovations in the treatment and upgrading of biogas. The international operating company offers repeatedly proven and reliable components, manufactured in the own factory. The focus is on the Biogas-Upgrader for biogas upgrading, flares and CHP units. Due to the connection with the BMF Group, which employs around 850 employees and reaches highest quality standards as supplier for automotive and machine tool industry, BMF HAASE is having high financial stability.

Since the early 1980s BMF HAASE is one of the leading suppliers in the field of biogas technology. Furthermore the company possesses competence in the fields of landfill gas, sewage gas, natural gas and leachate. HAASE combines a state of art industrial production and the Know-how in the fields of engineering, electrical control systems and programming. The company additionally offers respective maintenance services as well as operation of complete plants.

The HAASE Biogas-Upgrader refines biogas to biomethane by organic-physical scrubbing. This process is particularly efficient because the electrical power consumption is very low with a simultaneously low methane loss. The Biogas-Upgrader is also characterized by very low emissions and offers high availability confirmed by long-term studies.

The HAASE Biogas-Upgrader is available in different standard sizes for 500 to 2,000 Nm³/h of raw biogas.

**Biogasrat+ e. V.**

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**BMF HAASE Energietechnik GmbH**

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The company: Germany’s leading biomethane trader

bmp greengas is a nationwide trader and service provider on the biomethane market. With a trading volume of over 1 TWh per year, bmp greengas handles about 15 per cent of German biomethane: from failsafe transportation, to efficient accounting and reliable delivery for producing power in combined heat and power plants, all the way to blending products for producing regenerative heat. bmp greengas is a founding and steering committee member of the biogas register of the German Energy Agency (dena). And it has the biogas registry’s certification for the quantity and quality of biomethane it injects into the natural gas grid for its customers.

Services: Biomethane for every purpose

bmp greengas buys, bundles and sells biogas from a wide range of producers and of varying quality. The company has a diversified biomethane portfolio: bmp greengas offers every buyer the right service and the right product.

The company is a reliable biomethane supplier for public utilities, power plants and biogas dealers, as well as operators of combined heat and power plants, fuel cells or natural gas filling stations. Buyers receive the right quality of gas adapted to their needs: biomethane from organic waste for the heating market, or from renewable resources with the corresponding remuneration for power-heat coupling with power generation according to Germany’s Renewable Energy Act (EEG).

BORSIG Membrane Technology GmbH

BORSIG Membrane Technology provides innovative membrane technology solutions for industrial applications in the areas of gas treatment, emission control and product recovery.

The plant systems of BORSIG Membrane Technology GmbH based on membrane CO₂ separation provide especially efficient and economic process concepts for biogas processing.

Our expertise is based on comprehensive know-how in gas separation with membranes and extensive experience in process technology from hundreds industrial plants realized worldwide.

BORSIG Membrane Technology GmbH
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The Federal Industrial Association of Germany House, Energy and Environmental Technology comprises 103 companies, which manufacture highly efficient systems and components for heating, domestic hot water, ventilation and air-conditioning of buildings. “Efficiency and renewable energies” – That’s the dual strategy pursued by BDH and its members. The range of products offered by the BDH members includes state-of-the-art system technology and components, which convert fossil fuels efficiently and use renewable energies. Their heat output ranges from 4 kilowatt to 36 megawatt. Thus, the area of application extends from the single-family house right up to large industrial installations. Internationally, the BDH member companies are the leaders in technology. They represent nearly 60 percent of the European market in the area of heat supply to buildings. BDH members have about 67,300 employees worldwide and a turnover of more than 13 billion Euro.

Our Objectives.

The B.KWK is non-profit. It pursues its goals by:
- Facilitating dialogue amongst professional groups and institutions
- Minimizing deficient information exchange and permanently establishing the practice of cogeneration among policymakers, market actors and the population at large
- Providing consulting and support for interested persons and institutions
- Encouraging and developing scientific and technical innovations
- Hosting information days, workshops, and conferences
- Organizing booths at trade fairs and exhibitions dedicated to the cogeneration topic
- Collaborating with other national and international organizations

Who is invited to participate?

People, enterprises, institutions and associations, particularly:
- Cogeneration plant owners and operators in industry, trade, sales, and the public sector
- System and component manufacturers, service providers, planners, consultants, contractors, energy agencies, technicians, and installation specialists
- Municipal power providers, utilities, power distributors, and grid operators
- Suppliers of natural gas, coal, petroleum, and biofuels
- Banks, financial services companies, and insurers

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Cirmac International bv

Since 1979 Cirmac International has been a global player in nitrogen generation, gas treatment and the upgrading of biogas into biomethane in order to supply custom-made systems in the oil & gas and renewable energy sector.

We have invested a great effort in the development of sophisticated technologies for upgrading biogas to biomethane. Apart from the membrane separation and VPSA technology we specialize in the Low Pressure CO₂ Absorption (LP Cooab®) amine scrubbing technology, which is developed by our own engineers.

Due to the substantial number of systems that we have realized, you can rely on a professional approach on every technical level. We have delivered and installed multiple Biogas upgrading plants in Europe.

Cirmac is NEN-EN-ISO 9001-certified and has its own service department for total maintenance and the supply of spare parts.

Cirmac International bv
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Deutsche Landwirtschafts-Gesellschaft e. V.

Maintaining the Pace of Progress.

The DLG’s bases: innovation and progress.
The DLG (Deutsche Landwirtschafts-Gesellschaft e. V.) was founded in 1885 by the engineer and author Max Eyth. With 20,000 members, it is among Germany’s leading agricultural and food economy organizations. Politically and economically independent, the DLG serves as a representative for all concerns regarding agriculture and food production. At the heart of the DLG’s mission is the advancement of scientific and technological progress. With its activities and initiatives, DLG provides both the measures and the pace necessary for such progress.

International orientation.
The DLG thinks and works internationally. By pursuing international practices and building and maintaining trade partnerships abroad, it supports an international exchange of information.

Fields of work.
- International trade exhibitions
- Machinery and equipment testing
- Food item testing
- Knowledge transfer

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Deutsches Biomasseforschungszentrum (DBFZ)

The Deutsches Biomasseforschungszentrum is an interdisciplinary working research institute dealing with technical, economic and environmental aspects of the use of biomass for energy, both theoretically and practically addressed. Currently, DBFZ has a staff of approximately 222 employees.

In addition to feasibility studies, expertise, technology assessments, scenario analysis, potential analysis, life cycle assessments, modelling and simulations, the work focuses on experimental research and development work in laboratories as well as in a pilot and demonstration scale. DBFZ conducts comprehensive projects in the fields of bioenergy production as well as the utilization of organic waste materials. Particularly with regard to the supply of biogas, public and private funded research projects, surveys, analysis and potential studies are realised. Nationally and internationally, DBFZ consults energy suppliers and industrial companies as well as public contractors.

EISENMANN AG

Your competent partner for biogas.

Sustainability is in our system.
With more than 60 years of experience in plant construction, Eisenmann is your expert partner for turnkey biogas and biogas upgrading plants - including inspection, maintenance and service. To date, Eisenmann has installed more than 90 biogas plants worldwide.

For biogas upgrading, Eisenmann’s portfolio includes highly selective membranes. The biomethane produced can be put to a variety of uses as a renewable energy source. Mechanical and electrical pre-assembly is performed at Eisenmann’s technology park, and the membrane systems are delivered to the customer as turnkey, containerized facilities. They are capable of concentrating the methane to a content greater than 97% per cent and feature low methane leakage of below 0.5 per cent. The new solution based on highly selective membranes offers a cost-effective alternative to conventional processes for plants with a biogas capacity of less than 750 Nm³/h.

Eisenmann is a leading global provider of industrial solutions for surface finishing, material flow automation, thermal process technology and environmental engineering.
EnBW Energie Baden-Württemberg AG

All EnBW biomethane activities are bundled in the “Renewable Gas” department of EnBW Energie Baden-Württemberg AG. The business model is to purchase biogas from existing or newly planned biogas plants in Baden-Württemberg, to upgrade it to biomethane, inject it into the biogas grid and offer flexible biomethane solutions to EnBW customers.

Since 2010, EnBW is operating an upgrading plant in Blaufelden-Emmertsbühl for biogas from renewable raw materials. Another plant, which produces biomethane from biogenic remnants and inject it into the natural gas grid, has been commissioned by EnBW in 2014 in Geislingen a.d. Steige.

Three more biomethane plants are injecting in Laupheim and Riedlingen, which are operated by our affiliate Ergas Südwest GmbH.

A second element of EnBW’s biogas strategy is the utilization of so far unused biomass for energy generation. A special focus here lies on residues based on food production. In context with a project supported by the Federal Ministry for Education and Research, EnBW is part of a consortium for the upgrade of biogas based on food residues. The gas thus generated will be used as biofuel in vehicles. Commissioning of the research plant with innovative membrane technology was in 2011. Further large-scale plants for generating biomethane from bio residues are in an early stage of development.

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Enovos Luxembourg S.A.

Enovos is a merger of the three energy-supplying companies Cegedel S.A. and Soteg S.A. from Luxembourg as well as the German Saar Ferngas AG. Enovos offers public utilities, industrial companies and private households a wide portfolio of energy- and natural gas products at competitive prices.

Under the claim “Energy for today. Caring for tomorrow” Enovos is presenting itself as a strong company who consequently invests in renewable energy projects, like biogas, biomass, wind and photovoltaics, all around Europe.

In the biogas business, Enovos holds a stake of 80 per cent in the Energiepark Trelder Berg GmbH. The Energiepark consists of three biogas plants with a total electrical power of 5.1 MW. Another biogas plant in Tongeren (Belgium) is currently under construction. In the biomethane production, Enovos holds a stake in the Bioenergie Merzig GmbH. This biomethane plant started commissioning in spring 2011. The plant will produce 550 Nm³ per hour and it is the first of this kind in Rhineland-Palatinate and the Saar-Region. Since June 2012, Enovos holds a stake of 80 per cent in the Biogas Ohretal GmbH. This biomethan plant near Magdeburg, produces 700 Nm³ per hour biomethan and inject it into the natural gas grid. Another biogas plant in the region of Wolfsburg produces 700 Nm³ since summer 2013.

Despite Germany, Enovos is also active in the biogas business in Belgium with its stake in Biopower Tongeren. As trading partner for biomethane, Enovos has long-time experience in the trading business for natural gas with a well established relation to its customers.

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As one of the market leaders EnviTec Biogas AG covers the entire value chain for the production of biogas. In addition, the company also operates its own biogas plants, markets green electricity on behalf of biogas plant operators and offers energy by delivering CHP heat and biomethane.

With EnviThan EnviTec provides a high efficient technology for biogas upgrading. Hollow-fiber membranes of Evonik are applied thereby. Membrane technology is environmentally friendlier, more energy and cost efficient and flexible than conventional procedures. In addition to the pioneering plant developed in co-operation with Evonik, EnviTec has already built two commercial plants in the German towns of Sachsendorf and Köckte, each with a production capacity of 350Nm³/h biomethane. In Forst, Germany, another plant is currently under construction. Later this year, further upgrading plants are supposed to be supplied to China.

EnviTec has already been involved as principal supplier in the construction of the worldís largest plant for the production of biogas to natural gas standards with a thermal output of 55 megawatts in Güstrow, in the German state of Mecklenburg-Western Pomerania.

Within the E.ON Group, the E.ON Bioerdgas GmbH is responsible for the generation, grid injection and trading of biomethane.

The E.ON Bioerdgas GmbH was founded in 2007 with the goal to market biomethane as an innovative and ecologically-friendly energy and heat source.

In 2008, for example, the E.ON Bioerdgas GmbH put into operation the at this point largest plant for biomethane production (Schwandorf) in Germany. The plant generates biomethane in natural gas quality at a rate of 1,000 m³ per hour. This equals a heat capacity of 90,000,000 kWh per year. With this amount, the gas demand of about 5,000 four-person-households can be covered.

While in Germany the generation of biomethane is based mainly on energy crops, E.ON Bioerdgas GmbH is currently also analyzing the application of organic waste in biomethane generation in existing projects all over Europe.

With its biomethane product, E.ON Bioerdgas GmbH as one of the leading companies will contribute to the achievement of the political climate goals until 2030 of the German Federal Government and the EU and play an integral role in the coverage of 10 per cent of the overall gas consumption with renewables.
Companies and Market Players.

erdgas mobil is an initiative of leading power supply companies to establish a stronger market position for compressed natural gas (CNG) and biomethane. Thanks primarily to the addition of biomethane, this alternative fuel has the long-term potential to make a significant contribution to reducing road traffic emissions of CO₂, noise, nitrogen oxides and particulates in particular. For example, with a 20 per cent biomethane mix, CO₂ emissions drop by around 39 per cent compared to a gasoline-powered vehicle.

Currently, there are some 920 natural gas fueling stations throughout Germany, with the majority integrated into well-known gas stations. Every third gas station already offers biomethane in various admixtures, of which more than 180 natural gas fueling stations offer pure biomethane. With an average 22 per cent blend of biomethane, the renewable share is significantly higher than in liquid fuels. Since the redesign of the Biofuel Quota Act in 2009, the trading of biomethane quotas has become an interesting alternative to biodiesel and bioethanol for oil companies.

erdgas mobil acts as a leading service provider to impart biomethane credits to the liquid fuels market.

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ETW Energietechnik GmbH
German engineering expertise.

With ETW biogas upgrading plants and cogeneration units, we offer the key components for a flexible and CO₂ neutral energy supply. As an owner-led family business with a team of 80 committed technicians, we rely on robust and efficient plants, as well as an anytime accessible service team.

Biomethane – the regenerative natural gas.

On sites with biogas, sewage gas or landfill gas production we offer as an alternative to onsite electricity production the upgrading of biogas to natural gas quality by the process of pressure swing adsorption. The key component of these plants is a pressure swing adsorption cycle with a carbon molecular sieve. We developed and optimized this process for high availability and minimum operating and maintenance costs. The key for efficient plants are low operation costs, and in particular the low service cost of the pressure swing adsorption cycle due to a virtually unlimited service life of the molecular sieve in combination with a low electric power demand.

ETW biomethane plants offer:
- Product gas quantity from 200 to 5,000 Nm³/h
- Product gas quality according to DVGW G260 with 96-99 per cent CH₄
- Lowest power consumption
- ISO9001 and AD2000 HP0 certified production facility

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Energy efficient biogas upgrading with Sepuran® Green.

Evonik Industries is one of the world’s leading producers of specialty chemicals, with over forty years of experience in polymer chemistry, and operations in over 100 countries throughout the world. We offer hollow-fiber membrane cartridges and modules for efficient, energy-saving biogas upgrading.

Our membrane technology: offering you every advantage for small- and large-scale system applications.

Evonik’s membrane-based biogas upgrading method results in unusually high plant availability, extremely low energy demand, and low maintenance costs. In addition, upgrading does not generate any waste or emissions, nor does it require any auxiliaries (such as water or sorbents). All of these benefits serve directly to keep costs down. Plus, the tremendous flexibility of the method makes membrane technology applicable to small- and to large-scale systems alike. Yet another advantage of this technology is that it can be easily adapted to changeable flow rates and gas compositions.

Our references

The number of biogas facilities using SEPURAN® Green has been growing continuously since 2012, with plants already operating in Germany, Great Britain, France, Sweden, Thailand, and China. Implementation is also underway at other plants in Norway, Netherlands, Korea, and the U.S., for instance.

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www.sepuran.de

The association for the renewable energy source biogas in Germany.

With about 4,800 members the German Biogas Association is Europe’s biggest biogas lobby. It unites owners, manufactures and planners of biogas plants, and representatives of science and research. The association with its 30 employees promotes the extensive sustainable use of biogas technologies at European, national and regional levels. Besides the headquarters in Freising, the association is represented in Berlin as well as in five regional offices in the north, south and east of Germany.

In addition to the political representation of interests the German Biogas Association has the following aims:

- Advancement of technical development
- Promotion, evaluation and intermediation of scientific expertise and practical experience
- Publications
- Promotion of national and international intermediation of experience
- Formulation of quality standards

Through participation in European projects and its membership in the European Renewable Energies Foundation (EREF), the German Biogas Association is an active initiator of the international pooling of experience. It is represented by a committee elected by the general meeting of members. These are organized into 23 regional groups.

The most important event of the branch is the Biogas Annual Conference. With more than 9,000 visitors this year, more visitors than ever streamed into the 20th Annual Conference of the German Biogas Association and Europe’s biggest biogas trade fair.

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Companies and Market Players.

Figawa e. V.

Figawa has represented the utilities manufacturers and service providers in the gas and water industries at a national and European level for over 80 years.

The association comprises three specialist divisions committed to obtaining value for its more than 1,000 members by involvement in the following:

- Collaborating on the establishment of the relevant rules and standards
- Contributing to the certification of companies and products by the DVGW
- Organising professional training and qualification courses
- Providing a discussion platform for the elaboration of technical and scientific issues
- Acquiring and presenting information
- Contributing to the technical improvement of the facilities and operating equipment needed to generate, extract, process, transport, distribute and use gas and water
- Encouraging and promoting technical and scientific work

Figawa is represented in the national (DVGW, DIN, DKE) and international (CEN, CLC, ISO) standardisation committees and contributes to the development of recognised technical standards at a European level.

Figawa’s activities relate to:

- The public supply of gas (high, medium and low pressure)
- Home gas installations
- The supply of gas to industry
- The generation, processing and injection of gas into the gas grid (biogas) Figawa Bundesvereinigung der Firmen im Gas- und Wasserfach e. V.

Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT

We develop and optimize industry-oriented processes of environmental, process, material and energy technology. Our goal is to harmonize sustainable economy, environmentally friendly technology and innovative action in order to improve quality of life and economical strength.

The focus of our biogas research lies on the optimization of process biology and process engineering as well as on the development of trendsetting process steps e.g. for substrate pretreatment, fermentation, gas cleaning, methanation for PtG concepts.

In the field of biogas upgrading we work at national and international level on the overall development of efficient systems for biogas production, purification, feed-in and utilization. We conduct market, technology and plant monitoring studies and provide consultancy for German and European decision makers.

In GIS-based modeling and balancing of biomass production in rural areas (potentials, emissions, logistics, sites), we offer the development of biomass energy registers for the sustainable development of energy supply concepts and sites. Furthermore we are working interdisciplinary on topics such as public permits, land use planning and public acceptance issues with respect to biogas projects.

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Fraunhofer Institute for Wind Energy and Energy Systems Technology IWES

Fraunhofer IWES was established in 2009 through the merger of the former Fraunhofer Center for Wind Energy and Maritime Engineering CWMT and the Institut für Solare Energieversorgungstechnik ISET e. V.. The research activities of the Fraunhofer IWES cover all aspects of wind energy and the integration of renewable energies into energy supply structures.

In some areas technologies using biomass as energy source have already reached an advanced stage. The research activities of Fraunhofer IWES aim further. Improving energy efficiency, adjusting biogas plants to future requirements (e. g. being part of regenerative power plant parks) and improving usage and commercialization opportunities are core elements. Therefore, drawing comprehensive concepts, which improve energy balances and environmental performances is necessary, in order to increase efficiency and decrease the costs of energy production.

The research is based on analyzing how energy sources, energy conversion technologies and energy grids interact. Fraunhofer IWES also addresses questions related to the production, distribution and utilization of renewable methane. Renewable methane may come from biomass through biogas production and conditioning or from excess grid power, which is generated by other renewable energies (power to gas).

Covering all types of bioenergy applicable for electricity production, Fraunhofer IWES focuses on the demand oriented bioenergy production. In addition, Fraunhofer IWES supports the development of advanced technologies or pilot plants for industries and assesses technology performances.

As a leading natural gas supplier, an innovative energy service provider and multiutility company and an energy network operator, we are an integral part of the economic landscape of Berlin and large parts of Brandenburg. The GASAG group entities help private households, industrial and business customers as well as public institutions and municipalities in a variety of ways to use energy in an efficient and environmentally-friendly manner and ensure the reliable and cost-effective supply of energy to the region. Pioneering technologies such as biomethane production, distributed energy solutions and our smart metering services enable us to constantly drive forward the development of energy use and to tap into new markets throughout Germany.

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Greenline GmbH & Co KG

As an independent planning agency we advise and support comprising investors, farmers, utility companies and municipalities. We plan and supervise construction projects holistically in the areas of process engineering fermentation plants, combined heat and couplings, heat and gas supply networks. Whether it is new construction or re-powering of existing plants: our focus is on the design of a customized, efficient and economical system solution. Here, all factors such as Location, licensing situation, infrastructure and economy are taken into account and are interwoven in terms of current technical capabilities to a human concept. We place great value on-schedule, cost-effective and quality-assured handling.

Be inspired by our expertise and wide range of services from technical advice to convince, feasibility studies, direct planning services, due diligence, project management and general planning. All the planning and implementation processes take place independently of any influence by interests of companies or product suppliers. The specific procedural requirements of the planning task and their economic goals are our main focus of the project realization. A reliable analysis of the problem, a specialist advice, consistent scheduling and transparent cost management are our main line range.

Greenline GmbH & Co KG
Planning, approval management, storage planning, project management, master planning, optimization and support
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Hochschule für Wirtschaft und Umwelt Nürtingen-Geislingen (HfWU)

Institute for International Research on Sustainable Management and Renewable Energy (ISR)

The Institute for International Research on Sustainable Management and Renewable Energy (ISR) is a Research Institute of Hochschule für Wirtschaft und Umwelt Nürtingen-Geislingen. Its research focus lies with economic and social aspects of sustainability and renewable energy.

The ISR’s central research topics:
- Marketing of renewable energy, in particular electricity from renewable energy sources and biomethane
- Financing of renewable energy projects
- Acceptance of renewable energy projects, in particular biogas plants
- Analysis of production costs for renewable energy, in particular biogas/biomethane
- Upgrading and marketing of digestate residues from biogas plants

The ISR’s research results are publicly available. The ISR is engaged in semi-public institutions and carries out consultancy projects.

Hochschule für Wirtschaft und Umwelt Nürtingen-Geislingen (HfWU)
Institute for International Research on Sustainable Management and Renewable Energy (ISR)
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The Institute for Biogas, Waste Management and Energy offers independent scientific consulting services. All its work is based on the sound foundation of the many reference projects it has realised as well as on its extensive collaborative network of experts.

Our international customers are:
- Energy utilities
- Plant owners & operators
- Authorities, courts
- Technology suppliers
- Research institutes

KWS SAAT AG is one of the world’s leading companies in plant breeding, with activities in about 70 countries with more than 45 subsidiaries and affiliated companies. The product range includes more than 250 seed varieties for sugar beet, maize, cereals, oil seeds and potatoes. KWS conducted business in family since 1856 in an independent and sustainable manner. Currently, about 3500 employers work for the KWS group worldwide.

With research, breeding and the production of seeds which yield increasingly stronger results, KWS stands at the beginning of the value-added chain. Bioenergy takes a very special place in renewable energy, as plants represent an almost inexhaustible source of food and raw materials. KWS recognised this early and designed its own breeding programme for energy plants.

KWS relies on whole plant usage and on the production of biogas energy, which is probably the most profitable and efficient form of bioenergy generation in farming at the moment. The greatest efficiency increases in biogas generation are achieved from the perspective of KWS by combining the following efficiency characteristics:
- whole plant usage
- combination of energy plants with liquid manure, dung and organic residue
- power-heat coupling and/or feeding into the existing natural gas network.

The KWS energy plant programme for biogas generation currently includes the cultures of maize, beet, sorghum and rye.
**Landwärme GmbH**

We are specialists for biogas upgrading and make sure that biogas is fed into the gas grid and distributed to our customers. We develop custom-made solutions with biogas producers and trade biomethane in Germany and Europe. Founded in 2007, Landwärme was among the first to actively engage in the German biomethane market. Our know-how at all levels of the biogas value chain allows us to provide innovative and unique solutions for our customers who are either: constructing a new biogas upgrading plant, retrofitting an existing biogas plant, marketing and selling or purchasing and utilising biomethane.

Landwärme offers the following services along the biogas value chain:

- **Production**
  - Feasibility studies
  - Planning and development of biogas upgrading plants
  - Application of permits and licenses
  - Consulting and training

- **Distribution**
  - Contracts with grid operators
  - Verification and certification of biomethane
  - Balancing group management and transportation
  - Portfolio optimisation

- **Utilisation**
  - Biomethane marketing
  - Biomethane sales & purchasing
  - Biofuel quota trading
  - Certificate trading

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**Leobersdorfer Maschinenfabrik GmbH (LMF)**

LMF is the leading Austrian manufacturer of high pressure compressor systems for air, natural gas, technical and industrial gases (process gases), in the power range from 20 to 6200 kW (30 to 8000 hp) and for pressures up to 700 bar (10,150 psi).

As a single source LMF offers design, engineering, production, testing under full load, erection, start-up and related services with 60 years of experience in the compressor business.

LMF with its factory 30 km south of Vienna, exports more than 95% of its production to countries all over the world for many different applications, mainly in the oil & gas producing (and transporting) industry, the chemical, petrochemical and plastics industry, and many more.

- **Industrial Compressor Systems**
  - CNG/NGV – compressed natural gas for vehicles
  - CBG – biomethane
  - NG – individual compressor systems
  - Air- and watercooled
  - PET applications
- **Tailor-made solutions, produces according to customer specifications**
  - **Mobile Systems**
    - seismic research
    - pipeline pressure testing
    - pipeline evacuation
    - on-site nitrogen generation
  - Tailor-made: API 618 / API 11P

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Mabagas was founded at the end of 2008 with the aim to realise biogas projects in Germany, as well as other international markets. The business focus is on the generation of biogas using biogenic waste and other organic residual materials.

Mabagas covers the following business areas:

- **Biogas Fuel**: Mabagas offers biogas from organic waste materials as Bio-CNG (compressed natural gas) for vehicles at fuel stations in Germany.

- **Biogas Contracting**: Mabagas develops, finances, constructs and operates biogas plants together with project partners with large amounts of organic waste suitable for anaerobic digestion.

- **Biogas Trade**: The delivery of biogas to municipal utilities, industrial clients and trading partners is a key business function of Mabagas.

Mabagas is a 100% subsidiary of Marquard & Bahls AG in Hamburg and utilizes expertise that has been successfully applied in the international energy and oil business for more than sixty years. As a leading independent privately owned petroleum company Marquard & Bahls does business in the areas of oil trading, tank storage, aviation fuelling, and renewable energies. Mabagas GmbH & Co. KG

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Mahler AGS GmbH is a world wide active manufacturer of industrial gas generation plants (Hydrogen, Oxygen, Nitrogen, etc.) and gas purification and biogas upgrading plants located in Stuttgart.

For the biogas upgrading plants the Pressure Swing Adsorption (PSA) is used due to its reliability an “simplicity” (dry process, no sewage and no chemicals) in the industrie for many years.

In addition to its high quality plants, MAHLER offers comprehensive service for all plants.

Mahler AGS GmbH
Biogas plants for processing
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Companies and Market Players.

MethaPOWER Biogas GmbH

The Austrian company MethaPOWER Biogas GmbH is one of the leading providers of biogas upgrading plants with membrane technology. MethaPOWER Biogas is a developer of innovative and technically advanced solutions for obtaining high-quality biomethane from raw biogas. The company has its own facilities in Austria and offers power station concepts and turnkey-solutions for gas supply.

For optimal biogas consistency, MethaPOWER offers in addition a metal salt solution enriched with additives named MethaMAXX. It serves for desulfurization and for the process improvement of biogas plants.

Activities Overview
- Investment in Biogas Upgrading Plants
- Production of Biomethane – upgrading solutions:
  - MP Biogas upgrading – small units: from 30 m³ to 200 m³/h
  - MP Biogas upgrading – large units: above 200 m³/h
- Fuel Production
- Bio-CNG (gas - Biogas)
- Bio-DME (liquid fuel and propellant gas)

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Malmberg Bioerdgastech GmbH

Biomethane from different sources.

Malmberg Bioerdgastech GmbH is a subsidiary of the Swedish cleantec company Malmberg Water AB. Besides being active in the fields of environmental services and plant engineering for drinking water, waste water and geothermal energy, Malmberg has its focus on construction of biomethane plants. Starting in this business about 15 years ago, there are approximately 80 plants for upgrading of gas from agricultural anaerobic digestion, sewage sludge and waste digestion in operation. Thanks to own planning, design and production high requirements to attributes such as reliability, flexibility, efficiency and quality are fulfilled.

Malmberg COMPACT™.

Malmberg COMPACT™ is a standardised gas upgrading plant modulated in containers. The plant is available in sizes for biogas flows from 100 up to 3,000 Nm³/h. The standardisation allows a high level of quality within short delivery and installation periods. High availability, low methane loss and low energy consumption contribute to an economical operation of the plant.

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Malmberg Bioerdgastech GmbH

The Swedish cleantec company Malmberg Water AB is active in the fields of environmental services and plant engineering for drinking water, waste water and geothermal energy. Malmberg has its focus on construction of biomethane plants. Starting in this business about 15 years ago, there are approximately 80 plants for upgrading of gas from agricultural anaerobic digestion, sewage sludge and waste digestion in operation. Thanks to own planning, design and production high requirements to attributes such as reliability, flexibility, efficiency and quality are fulfilled.

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Companies and Market Players.

MT-BioMethan GmbH

Biomethane Plants tailored to your Specifications

With more than 40 reference plants in Europe to show for, MT-BioMethan GmbH, based in Zeven, Germany, is one of the most successful providers of biogas upgrading and feed-in technology.

For project-specific tailored solutions, MT-BioMethan can offer two upgrading processes:
- high-efficiency heat-led pressureless amine scrubbing, and
- extra high-performance electricity-led membrane technology

Both fulfil the highest requirements of methane purity for minimum methane loss and also allow the construction of plants for small volume flows.

The service portfolio that is offered by MT-BioMethan ensures the long-term smooth operation of any plant.

The product portfolio is complemented by individual components for conditioning, compression, drying, volumetric measuring, quality measuring and odorisation as well as fine gas purification.

Apart from its biogas upgrading technology, MT-BioMethan also has comprehensive know-how regarding biomethane production from waste gas, sewage gas and landfill gas. In addition, this specialist provider offers compact plants for bio-CNG production as well as technology for separating CO₂ from exhaust gases for use in industrial applications or green houses.

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NAWARO BioEnergie AG

NAWARO BioEnergie AG – Biogas production on the industrial scale.

The NAWARO BioEnergie AG was founded in 2005 in Leipzig. Its business model is the planning, construction and operation of industrial scale bioenergy parks.

With the “NAWARO BioEnergie Park Klarsee”, the company started operation of the world’s largest plant park for power generation from biogas with a capacity of 20 MWₑ in 2006.

Since June 2009, the NAWARO BioEnergie Park “Güstrow” is feeding biomethane into the natural gas grid. With a capacity of 55 MWₑ, this plant is the world’s largest plant for the production of biomethane based on renewable primary sources – yet again setting a new standard.

All sites developed by the NAWARO BioEnergie AG are based on an industrial approach guaranteeing an efficient plant capacity utilisation and thus the best possible resource recovery. All work processes are subject to permanent optimisation by NAWARO’s own research and development.

Thus, NAWARO makes a contribution to the clean, secure and affordable future energy production.

NAWARO BioEnergie AG
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Companies and Market Players.

**ÖKOBIT GmbH**

Established practice.

As a major manufacturer and planner of biogas plants with over 140 national and international projects, ÖKOBIT is one of the most sought-after full-service suppliers within the biogas industry. We develop and build technically intelligent, substrate-flexible biogas and biomethane plants which perfectly correspond to the specific local conditions of our clients.

ÖKOBIT turned its attention to biomethane in 2006 and has since then implemented a large number of projects using different upgrading processes and technologies.

ÖKOBIT provides advice independent of manufacturer and process. We choose, together with you, the best upgrading process and coordinate the overall design according to your requirements and local conditions. Besides the requirements defined by the gas network operator, the choice of the upgrading technology depends on the reliability and economic efficiency of the various processes.

**ÖKOBIT GmbH**
Full-service provider for biogas and biomethan plants
Project/Construction/Service
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**Pentair Haffmans**

Pentair Haffmans, founded in 1947 and headquartered in Venlo, the Netherlands, specializes in carbon dioxide (CO2) solutions. Our products and technologies are used in the brewing, soft drink, wine, bioethanol and biogas industries to recover food-grade CO2 from fermentation processes.

Pentair Haffmans’ biogas upgrading technology offers two substantial advantages compared to conventional systems. Pentair Haffmans’ system recovers 100 per cent of the methane, which eliminates the environmentally-harmful “methane slip” that usually occurs with other upgrading techniques. In addition, the CO2 by-product is recovered and can be sold, providing you with an additional source of income.

Our biogas upgrading systems are based on a combination of membrane and cryogenic technology and range from standard plug-and-play units to custom-designed solutions. An experienced project management team supervises each project from order placement through the Factory Acceptance Test (FAT).

Our dedication to your system continues after the sale. Through comprehensive lifecycle management, Pentair Haffmans ensures that the installation operates at optimal performance. Regardless of where your plant is located, our global network of service engineers is ready to serve you. In addition, product specialists provide 24/7 technical support by phone, e-mail, Skype, or remote service.

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RePowering and new construction with PlanET eco® gas are the best choice to use raw biogas efficiently. PlanET eco® gas is the biomethane module from PlanET and available worldwide. Subject to site, project conditions and feasibility our biomethane department integrates different available technologies for upgrading biogas, which have proven their reliability and efficiency. Reference plants in Germany (amine scrubbing), Canada (water scrubbing) and France (membrane technology) are already running successfully.

The membrane technology – easy and safe.

A recent top seller of PlanET’s biomethane portfolio is the so called “membrane technology”, which impresses with economical and ecological benefits especially for plants between 80 and 1,000 Nm³/h of raw biogas. In order to upgrade biogas into natural gas quality especially developed highly-efficient gas separation modules are used. This method guarantees our customers advanced technology that works without chemicals or heat. The PlanET eco® gas membrane technology is installed easily and quickly with low investment costs.

Overview of Advantages:
- Reduced operating costs
- Low investment
- Easy to control
- Requires small space, less time for installation
- Flexibility
- No heat consumption or chemicals
- No additional drying process

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PRIMAGAS GmbH
Specialist on liquid gas for gas upgrading.

With PRIMAGAS biogas plant constructors, consumers and small and medium enterprises rely on an innovative and service-efficient partner, who is quickly in every corner of Germany.

Since more than 50 years PRIMAGAS is standing for a secure supply with liquid gas. As a part of SHV Gas, a worldwide operating group of LPG companies, also being the largest LPG dealer worldwide, PRIMAGAS benefits from comprehensive resources and perfected logistics.

The gas comes from German refineries and the North Sea area. An international procurement via operated import terminals and storage facilities in the whole of Germany secures the supply of more than 80,000 gas customers.

PRIMAGAS has emerged in the last years to a demanded partner of biogas plants. This achievements and services were officially honored in 2009 by the Biogas association in Berlin. The biogas is upgraded to natural gas quality, under enrichment with liquid gas, to be injected to the public gas grid later. With PRIMAGAS liquid gas the high quality standard of network operators is assured.

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Companies and Market Players.

RG Energy – your strategic energy sector business consultancy.

Converting our energy supply towards 100% renewable energy is a big challenge for the whole sector. RG Energy Gmbh supports energy providers, public services and market newcomers in developing and implementing growth strategies.

Our company.

RG Energy Gmbh was founded by Robin Geisler in 2010 as a consultancy and holding company. After selling investments in early 2014 of bmp greengas Gmbh – one of Germany’s leading biomethane trading companies – RG Energy Gmbh is now completely focused on establishing itself as a consultancy. RG Energy Gmbh is owner-managed and acts independently.

Our Service.

We offer strategic business consulting focused on:
- Biomethane: renewable natural gas production and trade
- Power: electricity production and trade from renewables
- Mobility: renewable energy mobility solutions

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Purac Puregas GmbH

Purac Puregas deliver turnkey solutions for biogas upgrading. Our unique CApureTM process captures >99.9% of the available methane in raw biogas, maximising biomethane yield and customer revenues with very low operational costs whether for grid injection or vehicle fuelling. If needed, the Product Gas can be Ready for Liquefaction (<50ppm CO2).

Purac Puregas is committed to build the lowest life cycle cost biogas upgrading plants in the world. Probably producing the greenest biomethane in the world. The company is part of Läckeby Water Group, a Sweden based, independent, privately owned industrial group. Läckeby Water Group offers contracting, products and service for water and wastewater treatment and biogas production. The company is established on three continents and has built plants in 70 countries worldwide. With sales of approximately EUR 90 million, Läckeby Water Group is a leading company in its field.

Purac’s CApure™ biogas upgrading technology offers a wealth of benefits. The methane efficiency is higher than 99.9%, and the total energy consumption is at the low end of what is currently possible. Probably the greenest biomethane on the market. Our first CApure™, chemical absorption purification plant was up and running in 2002. Constant technological optimization now allows us to offer high availability biogas upgrading plants that are easy-to-operate and easy-to-maintain. Purac Puregas constantly focuses on offering outstanding technical and financial performance for our customers.

Purac Puregas is ISO 9001, 14001 and OHSAS 18001 certified.

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Purac Puregas GmbH

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Schnutenhaus & Kollegen

RWE Vertrieb AG

Law firm Schnutenhaus & Kollegen

RWE Vertrieb AG in Dortmund supplies over 4 million customers in Germany with electricity and natural gas. Within the RWE Group, RWE Vertrieb AG is furthermore responsible for procurement, distribution and trading biogas.

Generating electricity and heat using biogas-fired cogeneration plants (CHP) is a particularly interesting option for commercial and business customers. They are able to use the heat generated from renewable sources either for meeting their own heat demand or to supply heat to third-party customers.

Our energy specialists can find suitable CHP plant sites for customers and develop individual solutions. These contracting concepts are based on the experience we have gathered ourselves as an owner and operator of numerous CHP plants. Customers profit from stable and calculable heat prices through our energy services projects. In addition, RWE also manages the full gas process chain and secures the renewable energy sources act (EEG) subsidies. RWE also offers a service for the electricity produced in the EEG plants in selling it directly to the market.

RWE Innogy GmbH is the biogas production and feed-in specialist within the biogas business segment of the RWE Group. In addition to the biogas plant in Güterglück (Saxony-Anhalt), which has been in operation since 2009, a further biogas plant will be constructed in Bergheim-Paffendorf (NRW) in 2012. RWE Innogy GmbH is also developing an entirely new plant concept which mainly uses liquid manure that is processed into high-quality fertilizer after the fermentation process. In regions with intensive keeping of livestock, this helps to reduce excess nutrients caused by fertilizer.

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Schnutenhaus & Kollegen is a highly specialised energy law firm. We have been dealing closely with the legal and contractual conditions of biogas feed-in from the outset and offer comprehensive legal support of biogas feed-in projects. Based in Berlin, we advise clients in all parts of Germany. The work of our lawyers focuses on renewable energies, in particular on biomass and biogas. Due to our focus on energy, climate protection and renewable energies, we offer a high level of legal expertise, economic and technical know-how and long-standing experience in the energy sector. Depending on the project, we cooperate in interdisciplinary teams with consulting engineers, auditors, tax consultants, business consultants and banks.

Biogas feed-in – consulting is essential.

The successful implementation of biogas feed-in projects requires competent legal, economic and technical consulting. We support feed-in projects at commercial, communal and agricultural level. We advise on all relevant legal issues and support our clients in all legal issues related to planning and the authorisation process and ensure speedy implementation of grid connection. We represent our clients’ legal interests versus gas distribution service operators and draft the necessary agreements and contracts for delivery & purchase of biomass and crude biogas and as well as for feed-in, balancing and trading with biomethane.

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Companies and Market Players.

SfG provides energy suppliers, public utility companies as well as municipal and private operators with an extensive service around maintenance and optimisation of biogas upgrading- and grid injection plants. Due to preventive maintenance, continuously remote support, systematic upgrading and repeating reviews we guarantee efficient operation, maximal availability, long durability and high profitability.

SfG as service partner stands for uncompromising quality, security and ecological responsibility. Our service banks on the advantage of an unique background of experience. SfG is the biogas plant-specialist with detailed knowledge about the machine-, electro- and process technology applied in the plants.

Schwelm Anlagentechnik GmbH

Schwelm Anlagentechnik had been started in 2003 with the staff, the program and the assets of former Schwelmer Eisenwerk. Schwelm Anlagentechnik stands for reliable technology with an excellent price-performance ratio.

As the market leader in the field of natural gas refueling technology with constant relations to the gas suppliers our product range for biogas to the establishment of feeding systems and treatment plants could be successfully expanded. Here, the technique of the treatment process plays a key role; with a total energy consumption of less than 0.21 kWh/Nm³ and a methane loss well below 1% the physical pressure washing from Schwelm is the most efficient method on the market, and not only promised, but also in reality. In the biogas segment more than 20 plants have already been built. The current focus is seen on the treatment of waste gases, here our project in Coesfeld can be seen as indicative.

Schwelm plant technology offers complete solutions regarding engineering, manufacturing and complete customer service in the fields of highly efficient biogas processing and feeding, chemical plants and natural gas refueling.

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SFG – Service für Gasaufbereitung

SIG provides energy suppliers, public utility companies as well as municipal and private operators with an extensive service around maintenance and optimisation of biogas upgrading- and grid injection plants.

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The Städtische Werke AG participates in biogas upgrading plants in Homberg (Efze) Willingshausen-Ransbach, Karben (all in Hessen) and Leizen (Mecklenburg-Vorpommern). The power supply company from Kassel takes and utilizes the biomethane at combined heat and power unit places, where thermal power is needed the whole year like in public swimming pools, hospitals or in other industrial companies. Moreover the Städtische Werke AG trades with biomethane.

For using and trading biomethane the Städtische Werke AG accounted the input and output amounts of biomethane in accordance with the rules of the GasNZV.

Further biogas upgrading plants in whole Germany where the Städtische Werke AG will be involved are in the progress of project planning.

STEAG New Energies GmbH, part of the STEAG Group, is a European specialist in decentralized energy supply. In keeping with present climate protection policy, it specializes in providing custom-tailored solutions based on efficient and sustainable concepts. Energy sources range from biomass, biogas, wind energy and mine gas to utilization of geothermal energy.

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Thüga Energie GmbH

Thüga Energie GmbH is a modern, customer-oriented energy supplier belonging to Thüga AG, the largest municipal energy group in Germany. Approx. 100,000 customers in the regions of Hegau (south of Baden-Württemberg), the area west of Lake Constance and Allgäu-Upper Swabia are supplied with electricity, natural gas and heat.

Renewable energies are not only an integral part of the range of products offered, but Thüga Energie GmbH also invests in most recent technologies. The latest major project is a biogas treatment plant operated in co-operation with the company BRV – Biologische Reststoff Verwertung GmbH.

More efficiency thanks to innovative technology.

In its biogas plant located in Kisslegg-Rahmhaus the company BRV recycles foodstuffs which are unfit for consumption. The ultra-modern treatment plant, put into operation in May 2010, transforms the gas mixture into a biogas which reaches natural gas quality.

Thanks to the innovative membrane technology used in the biogas plant, the treatment of the gas is possible without the need of process water or chemical detergents.

The processed bio-natural gas is fed into the natural gas grid and can be used as fuel and energy source. With the biogas generated in Kisslegg it is possible to supply approximately 1,000 households.

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TÜV NORD Group

Based on many years of experience, the TÜV NORD Group has comprehensive know-how in certification of green electricity and biogas products as well as in the appraisal and final inspection of biogas and biogas processing plants.

TÜV NORD CERT is the BLE-approved certification body according to BioSt NachV / Biofuel Sustainability Ordinance and is working with ISCC and REDcert.

The environmental assessment organisation of TÜV NORD Group fulfils the legal requirements needed to check remuneration claims of biogas plant operators. If the rules of EEG 2009 and EEG 2012 are adhered to, operators can claim different types of bonus.

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TÜV SÜD has long-standing international experience in the field of energy certification. We provide certification services for traditional ecopower products, generation of tradable certificates and renewable energy plants. Our latest TÜV SÜD Service “GreenMethane” offers the certification of biogas which is fed into the natural gas grid.

- The certification service is designed for:
  - Operators of plants for biogas generation and grid injection
  - Traders of biomethane
  - Providers of biomethane end user products
  - Network operators

Documentation and verification of the plant technology and feedstock are vital due to the physical separation of production and consumption. The TÜV SÜD standard GreenMethane provides a reliable system for documentation, auditing and certification. Market participants holding this certificate benefit from the new regulations of the European Renewable Energies Directive, the German Renewable Energies Heat Act, the German Renewable Energy Sources Act (EEG) and the biofuels sustainability ordinance.

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von Bredow Valentin is a law firm specialising in renewable energy projects. Located in the centre of Berlin, we offer legal advice to clients all over Germany in all legal aspects of the production of electricity, gas, heat and Power-to-Gas from renewable energy sources, CHP and energy efficiency.

In the field of biomethane, we can resort to extensive consulting experience in a variety of projects of any size. Our areas of expertise include analysing drafting and negotiating all contracts – particularly concerning the delivery of raw materials, biogas and biomethane. We support our clients in all legal issues relating to the authorisation process, the establishment of grid connections and damages in case of their delay. We also assist buyers and sellers in the process of acquiring biogas and biomethane plants.

Our law firm offers legal advice to project developers, power plant operators, energy traders, agricultural enterprises, energy service companies and investors. Our attorneys regularly publish articles and give lectures on biomethane at various industry events.

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VPT Kompressoren GmbH

The VPT Verdichter-Pumpen-Technik GmbH was founded in 1980 by a group of professionals already acting in the sector of the construction of gas compressors. According to specialization to gas compressor technology, the name was changed in 1988 in VPT Kompressoren GmbH.

In addition to the maintenance of existing compressor stations, VPT has begun very soon with the development of an own compressor series for natural gas, biogas, digester gas, etc. VPT won a steadily growing clientele in the area of the compression based on high quality of the products and the services. Today, VPT supports there customers with a factory in Remscheid and a technical office in Dinslaken.

The VPT product range includes compressor for almost all applications, as well as complete container systems including engineering, planning, pipeline construction, control systems, etc. VPT refers to the individual components for the compressor plants of a variety of well-known German manufacturers. So, the customer has the advantage to get an optimally design of each particular compressor system according to the project requirements. VPT sets also emphasis on intensive customer care. The service on the compressor units will be coordinated from Remscheid on units all over the world.

From consulting and engineering for public tenders, basic engineering for customers, to turnkey installation and support of the customers at the acceptance of the entire system by TÜV, the VPT Kompressoren GmbH accepts a wide variety of tasks. In the field of raw biogas compression and bio methane injection a variety of compressor plants was already delivered and successfully commissioned.

WELTEC BIOPOWER GmbH is a leading provider of complete biogas plants with digesters made of stainless steel, which guarantee a location-independent constant quality and a long lifespan of the plant.

WELTEC BIOPOWER biogas plants are characterised by a modular structure. This enables individual and flexible solutions – from a adjusted compact plant to a biogas park with control systems and remote control in turn-key-ready implementation up to gas-upgrading technology as well as waste-recycling plants.

WELTEC BIOPOWER uses only proven components and technology being developed in house, such as digester, agitator and control technology as well as the sanitation systems and solutions for processing the digestate. Vertical integration of production guarantees the same high standards worldwide – ISO-certificated.

With comprehensive service support, WELTEC BIOPOWER ensures the technical and economic stability of biogas plants. The CHP service guarantees stable performance, the biological management takes care of constant monitoring of the relevant parameters, and through targeted repowering, the biogas plant always remains up to date. The operators can chose among service packages that differ in type and scope.

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Glossary.

Anaerobic biological decomposition Degradation of organic substance with the help of anaerobic bacteria; one effect is biogas release.

Biogas Product of the anaerobic biologic decomposition of organic substances. Consists of 45–70 per cent methane, 30–55 per cent carbon dioxide, marginal amounts of nitrate, sulphide and other trace gases. In legal texts and ordinances, the term biogas may also relate to gas upgraded to natural gas quality (also called “Bio-Natural Gas” or “Biomethane”). For gas right after the fermentation process, the terms raw biogas or bio-raw gas are often used.

Biomethane Coinage, term for methane of biological origin, applied for biogas upgraded to natural gas quality, synonym for bio-natural gas.

Bio-natural gas Coinage, term for biogas upgraded to natural gas quality and injected into the natural gas grid, synonym for biomethane.

Cogeneration of heat and power Simultaneous conversion of implanted energy in mechanical/electrical energy and useable heat. In a cogeneration process, the energy included in an energy source (e.g. biogas) is efficiently used since the heat generated during the power production process is used for the heating of production processes.

Desulphurisation Biogas upgrade process step in which the sulphur portion included in raw biogas is removed in a biological and/or chemical process.

Digestate Biogas production residues after fermentation

Energy plants Plants grown specifically for energy utilisation, whose energy is made usable by processes of fermentation, burning and gasification.

Fermentation Multi-stage process in which organic substances are degraded under conditions of oxygen deficiency and moist surroundings. One product of this process is biogas, synonym for digestion.

H-Gas (Natural Gas H) Gas classification, in which “H” stands for “high”. Natural gas of this quality possesses a calorific value of ca. 10 kWh/Nm³

Manure Collective term for dung and urine of agricultural farm animals, possibly together with litter

Normal Cubic Metre (Nm³) Measuring unit for the amount of gas which under “normal conditions” equals the volume of a cubic metre. Normal conditions include a 1.01325 bar pressure level, 0 per cent humidity and a temperature of 0 °C (DIN 1343) or 15 °C (ISO 2533)

Proof of origin Certificate stating that a biomethane quantity taken from the natural gas grid equals the amount of biomethane fed into the natural gas at another point of injection regarding quality and amount. Especially important for the validation of EEG-feed-in tariffs (such as the renewable primary products bonus) for power generated from biomethane.

PSA Pressure swing adsorption

Raw Biogas Biogas in the raw state right after the fermentation process (before upgrade processes). Often also referred to as bio-raw gas.

Renewable primary products Collective term for resources generated in agriculture and forestry operations such as wood, flax, rape, sugar substances and starch from beets, potatoes or corn. As well as plants for energy use, the term also includes plants or industrial use.

Upgrade Process to enrich the quality of biogas. A CO₂-separation (= methane enrichment) is necessary to achieve natural gas quality by increasing the methane portion of raw biogas (45–70 per cent) to the local quality (Natural Gas L ca. 85 per cent, Natural Gas H up to 99 per cent).

Wobbe index Data used for the quality characterisation of combustion gases. Similar Wobbe data points to the interchange-ability of gases without further modifications of combustion nozzles, for example.