Carbotech

VIESMANN Group

Biogas upgrading plants

The Carbotech system: From Biogas to Biomethane

Biomethane gas is an attractive alternative to fossil fuels. Its production is environmentally responsible, efficient and renewable. It can be mixed with natural gas and injected into conventional gas pipelines.

Supplies of fossil fuels such as coal, crude oil and natural gas are gradually running out and the effects can already be seen in ever increasing energy prices. For this reason, the introduction of renewable energies into the market is crucial, and it is here that biogas can play an important part. Producing biogas from sustainable raw materials and organic waste is a local, reliable, simple, efficient and environmentally responsible process.

The upgrading of biogas to natural gas quality is, from efficiency and economical aspects, a vital prerequisite for its optimum utilisation. Only cleaned and upgraded biogas can be successfully mixed with natural gas and transported through the natural gas grid for wide ranging applications in industry, transport and heat and power generation. Nowadays, biogas production and upgrading processes are proven technologies; they are reliable, efficient and safe, with the advantage of full integration into new and existing power and heat generation plants.

Pioneer in the industry

Carbotech is a recognised pioneer in Europe when it comes to the cleaning and upgrading of biogas; it is one of the leading suppliers of complete biogas to grid injection systems. The company has been actively engaged in the biogas industry for more than 30 years. Furthermore, Carbotech draws on extensive experience in gas purification and gas generation processes such as the production of hydrogen and nitrogen (see page 13). Carbotech biogas plants have been in operation in numerous countries for many years, reliably and efficiently upgrading biogas into biomethane whilst conserving resources and helping to protect the environment.

The patented pressure swing adsorption (PSA) process developed inhouse at Carbotech is simple and yet remarkable for its low energy consumption. As a result, most of the biomethane gas to grid projects in Germany are equipped with the Carbotech PSA system.

Upgrading plant for biomethane, space-efficient installation in standard containers.

Biogas upgrading plant in Aiterhofen.

Efficient and environmentally responsible production of biomethane

Biogas is upgraded into biomethane by means of the pressure swing adsorption process developed by Carbotech.

Simple and reliable technology
The biogas upgrading process from Carbotech is a simple procedure. The raw biogas is first compressed, following the condensation of water content through a temperature exchange system. Then follows the removal of trace elements, such as hydrogen sulphide (H2S), using activated carbon.

The conditioned biogas is finally channelled through the PSA filter which is filled with carbon molecular sieves, especially designed for adsorbing the typical elements found in biogas. CO_2, H_20, residual H_2S, siloxane, NH_3 and odours are then extracted. Furthermore, through the patented Carbotech system, oxygen and nitrogen are partially removed. The result is a highly enriched methane gas referred to as biomethane.

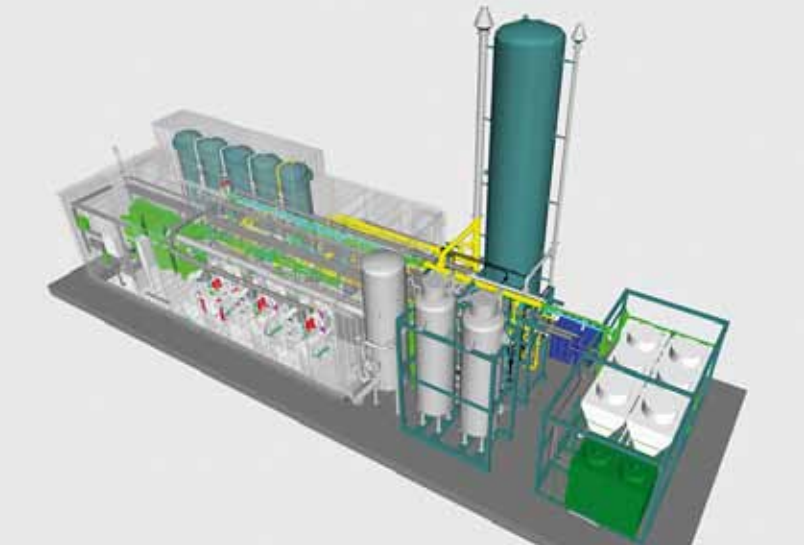
Biomethane is produced in each vessel at specific intervals allowing the plant to switch to another filter whilst the first filter is fully regenerated by means of a vacuum process. The programmable logic control (PLC) and the online gas analysis ensure an automated, safe and reliable operation.

Low upgrading costs
The pressure swing adsorption (PSA) process from Carbotech is a dry biogas upgrading process characterised by minimal running costs. This means:

- Low power consumption
- No heat demand
- No process water, no process water conditioning
- No waste water, no waste water treatment
- No chemicals
- No offgassing of toxic contaminants

As an option, the ZETECH$_4$® system can be implemented. It represents a unique and emission free patented process for upgrading biogas, that meets international environmental regulations. In addition, it increases the methane gas yield and improves the overall efficiency through the patented heat recovery technology.

Biogas production, upgrading and gas to grid injection plants from a single source
The comprehensive range from Viessmann includes all necessary equipment for biogas production, upgrading and injection. Schmack Biogas and BIOFerm are also members of the Viessmann Group, offering wet fermentation or dry fermentation for biogas production, consequently both processes can be supplied from a single source.



Schematic diagram of a complete system.

View inside a biogas upgrading plant from Carbotech.

Gas to grid injection system from Carbotech.

Economical planning and future proof investment in sustainable energy

Carbotech makes a vital contribution to the development of sustainable energy systems with its operationally reliable and environmentally responsible plants for the upgrading and gas to grid injection of biomethane gas.

The Federal Government of Germany has set a target of six billion cubic meters of biomethane to be fed into the natural gas grid by 2020. According to the latest survey, Germany consumed around 100 billion standard cubic meters of natural gas. According to a calculation by the Federal Department for Food, Agriculture and Consumer Protection (BMELV), every year approximately 100 industrial biomethane gas to grid injection systems should be built to achieve this target.

Carbotech can make a vital contribution to this ambitious target with its durable and efficient technology. Its high level of expertise covers every aspect from project planning support, through engineering and building, right up to the commissioning of biogas upgrading plants and gas to grid injection systems.

For this, it makes no difference whether the investor or the user decides in favour of producing raw biogas for use in a dry or wet fermenter.

How much gas will be produced?
When planning a biogas plant it is essential to calculate the amount of raw gas that is going to be produced. The main factor to consider is the amount of feedstock available for the fermentation process, such as organic waste, energy crops or liquid manure.

The output spectrum of the plants offered by Carbotech range from a few hundred to several thousand cubic meters of biogas. Furthermore, the containerised module designed by Carbotech ensures low installation and commissioning costs, as well as simple interfaces for easy assembly on site.

The PSA design of biogas upgrading plants enables up to 3000 m^3/h of raw gas to be processed. Systems for larger amounts are developed as individually engineered plants.

In general, the production of biomethane gas from biogas by means of the pressure swing adsorption process is efficient and environmentally responsible. In comparison to the typical chemical and water scrubber systems and the membrane technology, the PSA process not only removes carbon dioxide from biogas, but also water, siloxanes, hydrogen sulphide, CFCs, etc.

Biogas upgrading plants (BUP)
The BUP standard series includes all of the features already described: safety, economy, reliability, compact design and easy operation and maintenance. The turn-key containerised design ensures low installation costs and rapid commissioning: only power and gas needs to be connected to be able to produce biomethane of high purity.

Biomethane Gas to Grid Injection Plants (BtG)
The entire gas to grid injection plant is designed, built and tested in accordance with the German Gas Regulations and Standards (DVGW). The complete containerised system is pre-assembled and fully tested at the factory. As a result, installation and commissioning on site take little time. Subject to local requirements, the gas to grid injection plant may comprise the following system components:

- Gas pressure control equipment
- Biomethane booster station 1/2/3-stage compression system subject to pressure grid type. The constellation redundancy can be offered with 2x50 % / 3x50 % / 2x100 % capacity
- Oxygen extraction module (EASEE gas requirement)
- LPG or air enrichment system (as option with pump station)
- Air admixing system
- Odorising station
- Gas quality and flow instrumentation

Costs
Because of the highly efficient process with well-developed reliable and durable systems that meet international standards, the exceptional low consumption will be reflected in the specific operating costs, as well as the life cycle costs. In industrial plants, average costs are less than €0.01/kWh.

Plant type		BGAA250	BGAA500	BGAA750	BGAA1000	BGAA1200	BGAA1400	BGAA2000
Raw biogas	Nm^3/h	250	500	750	1000	1200	1400	2000
Biomethane[1]	Nm^3/h	133	267	400	534	640	747	1067
Export heat[2]	kW	–	–	–	–	–	–	–
Power consumption[1]	kW	45	63	135	180	216	252	360
Other resources		–	–	–	–	–	–	–
Footprint								
Length	m	28	30	30	30	32	32	32
Width	m	11	12	12	13	136	13	15

Note: Data for general information only. Individual projects may vary.

[1] relative to NaWaRo- raw biogas with 52 % methane and 3 % CO_2 content in the produced gas; power consumption excluding SGV

[2] from compressor and lean gas combustion at T > 85 °C available as renewable heat for heating fermenters to EEG 2012

Biogas upgrading plant, Wüsting/ Oldenburg, Ostfriesland.

The raw gas for the upgrading plant in Bern (Switzerland) is yielded from sewage gas and waste.

Carbotech – leading in Europe

BUP Wüsting

Owners:	EWE AG
Location:	Wüsting/Oldenburg (Ostfriesland)
Commissioning:	08/2009
Plant type:	BGAA1200
Source of raw biogas:	Energy crops
Raw biogas:	1200 Nm^3/h
Biomethane:	635 Nm^3/h
Gas quality:	DVGW G260 und G262
Plant operation:	Automatic, remote monitoring (DSL), local support by biogas plant operator
Regular maintenance:	Twice annually – Machine maintenance (compressor and pumps) – Gas alarm sensors (calibrating) – Analyser (calibrating) – H_2S activated carbon (demand-dependent)

BGGA Bern

Owners:	ARA Region Bern
Location:	Herrenschwanden/Bern (Switzerland)
Commissioned:	01/2008
Plant type:	BGAA350
Source of raw biogas:	Sewage gas, waste
Raw biogas:	350 Nm^3/h
Biomethane:	192 Nm^3/h
Gas quality:	SVGW G13
Plant operation:	Automatic, remote monitoring (DSL), local support by biogas plant operator
Regular maintenance:	Twice annually – Machine maintenance (compressor and pumps) – Gas alarm sensors (calibrating) – Analyser (calibrating) – H_2S activated carbon (demand-dependent)

Biogas is the source product for the BUP in Schwandorf II.

The Minden-Lübbecke district operates its biogas upgrading plant with waste.

BUP Pohlsche Heide

Owners:	AML Immobilien GmbH
Location:	Hille, Minden-Lübbecke district
Commissioning:	09/2009
Plant type:	BGAA500
Source of raw biogas:	Municipal waste
Raw biogas:	500 Nm^3/h
Biomethane:	258 Nm^3/h
Gas quality:	DVGW G260 und G262
Plant operation:	Automatic, remote monitoring (DSL), local support by biogas plant operator
Regular maintenance:	Twice annually – Machine maintenance (compressor and pumps) – Gas alarm sensors (calibrating) – Analyser (calibrating) – H_2S activated carbon (demand-dependent)

BUP Schwandorf II

Owners:	Feldgas GmbH & Co. KG (E.ON)
Location:	Schwandorf
Commissioning:	01/2008
Plant type:	2 x BGAA1000
Source of raw biogas:	Energy crops
Raw biogas:	2000 Nm^3/h
Biomethane:	1087 Nm^3/h
Gas quality:	DVGW G260 und G262
Plant operation:	Automatic, remote monitoring (DSL), local support by biogas plant operator
Regular maintenance:	Twice annually – Machine maintenance (compressor and pumps) – Gas alarm sensors (calibrating) – Analyser (calibrating) – H_2S activated carbon (demand-dependent)

Biogas upgrading plant
Emmertsbühl/Blaufelden.

Easy handling on site with turnkey container model.

BGAA Güterglück

Owners:	RWE AG
Location:	Güterglück/Sachsen-Anhalt
Commissioning:	07/2009
Plant type:	BGAA1200
Source of raw biogas:	Energy crops
Raw biogas:	1200 Nm^3/h
Biomethane:	635 Nm^3/h
Gas quality:	DVGW G260 und G262
Plant operation:	Automatic, remote monitoring (DSL), local support by biogas plant operator
Regular maintenance:	Twice annually – Machine maintenance (compressor and pumps) – Gas alarm sensors (calibrating) – Analyser (calibrating) – H_2S activated carbon (demand-dependent)

BGAA Emmertsbühl

Owners:	EnBW Gas GmbH
Location:	Emmertsbühl/Blaufelden
Commissioning:	10/2010
Plant type:	BGAA500
Source of raw biogas:	Liquid manure, energy crops
Raw biogas:	500 Nm^3/h
Biomethane:	255 Nm^3/h
Gas quality:	DVGW G260 und G262
Plant operation:	Automatic, remote monitoring (DSL), local support by biogas plant operator
Regular maintenance:	Twice annually – Machine maintenance (compressor and pumps) – Gas alarm sensors (calibrating) – Analyser (calibrating) – H_2S activated carbon (demand-dependent)

In Wrams, food and slaughterhouse waste is converted into valuable biomethane.

Delivery of the container module for the BUP of EWE AG in Werlte.

BGAA Wrams

Owners:	E.ON Gas Sverige AB
Location:	Wrams/Sweden
Commissioning:	10/2006
Plant type:	BGAA500
Source of raw biogas:	Food and slaughterhouse waste
Raw biogas:	500 Nm^3/h
Biomethane:	324 Nm^3/h
Gas quality:	DVGW G260 und G262
Plant operation:	Automatic, remote monitoring (DSL), local support by biogas plant operator
Regular maintenance:	Twice annually – Machine maintenance (compressor and pumps) – Gas alarm sensors (calibrating) – Analyser (calibrating) – H_2S activated carbon (demand-dependent)

BGAA Werlte

Owners:	EWE AG
Location:	Werlte
Commissioning:	08/2007
Plant type:	BGAA500
Source of raw biogas:	Liquid manure, slaughterhouse waste
Raw biogas:	500 Nm^3/h
Biomethane:	305 Nm^3/h
Gas quality:	DVGW G260 und G262
Plant operation:	Automatic, remote monitoring (DSL), local support by biogas plant operator
Regular maintenance:	Twice annually – Machine maintenance (compressor and pumps) – Gas alarm sensors (calibrating) – Analyser (calibrating) – H_2S activated carbon (demand-dependent)

Integrated solutions for the production and utilisation of biogas

In the development and construction of plants for biogas and industrial gases, Carbotech from Essen draws on the support of renowned German specialists.

Inauguration of the biogas upgrading plant during the delivery of the ready-to-use container module.

Carbotech has its roots in the research and development of processes carried out in the German coal mine industry. Thus, the company's extensive knowledge base draws on more than 40 years of experience in the development, engineering and manufacturing of turn-key plants for gas upgrading and gas production.

The company, which is part of the Viessmann Group, offers integrated solutions for energy conversion – from biogas production to energy utilisation. The company's core competence is centred on the application of innovative, efficient processes and methods for the upgrading, purification and production of industrial gases or biogas.

Professional and close to our customer base through numerous cooperation partners

Carbotech can draw on a wide supply and service spectrum from its centrally based engineering location in Essen/Germany, with numerous cooperation partners handling the build and sale of plants, alongside in-house test and demonstration plants for process optimisation.

For this, customer-specific and application-oriented process design and engineering, together with experience, technical expertise and flexibility, ensure a high level of product quality and customer satisfaction.

Plants for generating hydrogen and nitrogen for various industries

Carbotech can draw on extensive experience with industrial gas purification processes, for example of hydrogen, or the generation of nitrogen.

Hydrogen recovery from hydrogen-rich raw gases

Pressure swing adsorption plants for the generation of hydrogen from various hydrogen-rich raw gases are state of the art and in operation all around the world. These raw gases may be reformer gases from natural gas, ammonia or naphtha, or coke oven gas, ammonia tail gas or similar.

Carbotech has been designing and optimising such plants for more than 30 years and has played a significant part in the ongoing development of this technology.

Plants with a capacity of up to 30,000 Nm^3/h hydrogen can be developed. These are specifically tailored to the requirements of each application with particular focus on minimised investment outlay and operating costs.

Nitrogen increases the shelf-life of many products

Nitrogen is widely used as inert or purge gas where oxygen reduces the shelflife of products, impairs their quality or could result in damaging or undesirable reactions.

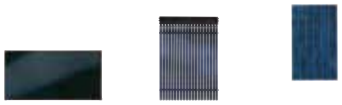
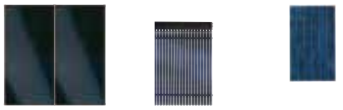
Carbotech plants make the generation of nitrogen possible, whilst offering a long service life at an affordable cost. Customers can improve their own savings potential by means of the respective N_2 qualities.

Carbotech plants are used around the globe in the most diverse applications in the food processing, as well as in the metal and chemical industries, both on and offshore. They are distinguished by their high level of technical reliability, both as standalone systems and as base load systems in combination with the tank facilities of industrial gas suppliers.

Hydrogen plants (above) and plants for the generation of nitrogen are engineered and built by Carbotech specifically for each individual application.

Our advice

The following brochures that are available for download at www.carbotech.info provide extensive information on hydrogen generators and systems for the production of nitrogen.

	Boilers for oil up to 116 MW heating or 120 t/h steam output	Boilers for gas up to 116 MW heating or 120 t/h steam output	Solar thermal systems and photovoltaics
Detached houses			
Apartment buildings			
Commerce / Industry			
Local heating networks			

Individual solutions with efficient systems

The comprehensive Viessmann product range
The comprehensive product range from Viessmann offers individual solutions with efficient systems for all applications and all energy sources. For decades, the company has been supplying highly efficient and clean heating systems for oil and gas, as well as solar thermal systems along with heat generators for sustainable fuels and heat pumps.

The comprehensive product range from Viessmann offers top technology and sets new benchmarks. With its high energy efficiency, this range helps to save heating costs and is always the right choice where ecology is concerned.

Individual and economical
Viessmann offers the right heating system for any demand – wall mounted or floorstanding, in individual combinations – all are futureproof and economical. And whether for detached houses or two-family homes, large residential buildings, commercial/industrial use or for local heating networks; for modernising existing properties or new build – they are always the right choice.

Key performers
The Viessmann Group sets the technological pace for the heating industry. This is what the Viessmann name represents, and also what the names of the subsidiaries in the Group represent, as they are founded on the same pioneering spirit and power of innovation.

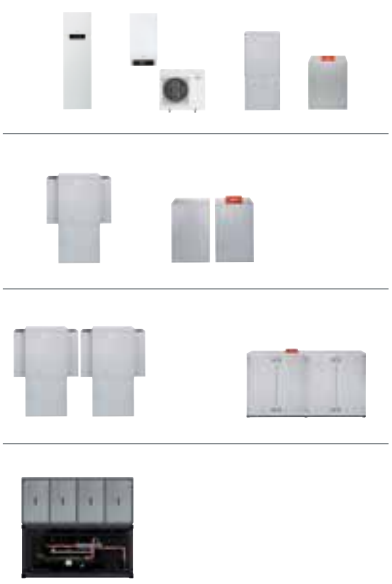
Wood combustion technology, CHP and biogas production up to 50 MW

Heat pumps for brine, water and air

up to 2 MW

Air conditioning technology

Heating system accessories



The comprehensive product range from Viessmann: Individual solutions with efficient systems for all energy sources and applications

The product range for all fuel types and output ranges:

- Boilers for oil or gas up to 116 MW heating or 120 t/h steam output
- Solar thermal systems
- Photovoltaics
- Heat pumps up to 2 MW
- Wood combustion systems up to 50 MW
- Combined heat and power modules up to 30 MW_{el}
- Systems for the production of biogas from 18 kW_{el} to 20 MW_{gas}
- Biogas upgrading plants up to 3000 m^3/h
- Air conditioning technology
- Heating system accessories

Viessmann is highly specialised in all these market segments, yet at the same time the company has a crucial advantage over specialist suppliers: Viessmann understands heating technology as a systematic whole and offers unbiased advice on technology and fuel type. This guarantees the best solution for every application.

Viessmann Group

VIESMANN

KWT

KOB

MAWERA

ESS

HKB

BIOFERM

Schmack

Carbotech

The comprehensive Viessmann product range

	Detached houses	Apartment buildings	Commerce / Industry	Local heating networks
Oil boilers	 Architect's own home, Bad Füssing, Germany	 Residential development, Zi Wei Garden Xi'an, China	 Ameco A380 Hangar Beijing, China	 European Parliament, Strasbourg, France
Gas boilers	 Detached house, Kevelaer, Germany	 "Wohnoase" residential park in Regensburg, Germany	 Porsche Leipzig, Germany	 European Parliament, Brussels, Belgium
Solar thermal systems and photovoltaics	 Heliotrop Freiburg, Germany	 HafenCity, Hamburg, Germany	 City of Tomorrow, Malmö, Sweden	 The Palm Jumeirah, Dubai
Wood combustion technology, CHP, and biogas production	 Detached house, Wiesloch, Germany	 Hotel Lagorai Cavalese, Italy	 Congressional Centre, Brunstad, Norway	 Monastery, St. Ottilien, Germany
Heat pumps for brine, water and air	 Loftcube Regional Garden Show, Neu-Ulm, Germany	 Studio flats, Brandenburg, Germany	 University library, Bamberg, Germany	 Residential estate, Pfäffikon, Switzerland

The comprehensive product range from Viessmann: Individual solutions with efficient systems for all energy sources and applications

Futureproof heating technology for all requirements

Energy consumption worldwide has doubled since 1970 and will triple by 2030. The result: The fossil fuels, oil and gas, are dwindling, energy prices are on the rise and excessive CO_2 emissions continue to affect our environment. Energy efficiency is a must if we want our future to be secure.

In almost every industrial nation, supplying heat to residential and commercial buildings accounts for the largest share of energy consumption – consequently it also offers the greatest savings potential. Advanced efficient heating systems from Viessmann are in use around the world, not only in many private households, but also in numerous major international projects, where they make a sizeable contribution to the efficient use of energy resources.

In these projects, Viessmann again and again faces up to the most varied challenges to supply efficient heating technology by offering innovative solutions – in historical listed buildings as well as in modern industrial complexes and the large-scale residential and industrial arena.

City of Tomorrow, Malmö, Sweden


VIESMANN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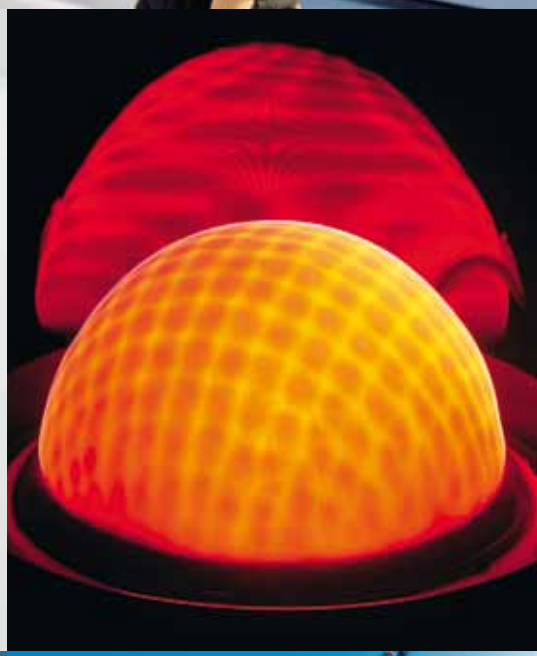


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Viessmann – climate of innovation

Viessmann is one of the leading international manufacturers of heating systems and, with its comprehensive product range, offers individually tailored, efficient systems for all applications and types of fuel.

As a third generation family run business, Viessmann has been supplying highly efficient and clean heating systems for many decades.

A strong brand creates trust
Together with our brand label, our key brand message is an identifying feature throughout the world. „Climate of innovation" is a promise on three levels: It is a commitment to a culture of innovation. It is also a promise of enhanced product benefits and, at the same time, an obligation to protect the environment.

Acting in a sustainable manner
For Viessmann, taking responsibility signifies a commitment to acting sustainably.

This means bringing ecology, economy and social responsibility into harmony with each other, ensuring that current needs are satisfied without compromising the quality of life for the generations to come.

We consider climate protection, environmental responsibility and resource efficiency to be key priorities throughout our company, which has more than 9600 employees globally.

Effizienz Plus
With the strategic „Effizienz Plus" sustainability project, launched in 2005, Viessmann demonstrates at its own site in Allendorf (Eder) that the political goals set for 2050 with regard to energy and climate can already be achieved today with commercially available technology. In 2012, we will already achieve the following results:

- Consumption of fossil fuels reduced by 66 percent compared to 2005
- Use of renewables increased to 56 percent
- CO_2 emissions reduced by 80 percent compared to 2005

The long term goal is to cover all the company's heating energy requirements ourselves.

Deutscher Nachhaltigkeitspreis
Deutschlands nachhaltigste Produktion 2009

Deutscher Nachhaltigkeitspreis
Deutschlands nachhaltigste Marke 2011

Viessmann was awarded the German Sustainability Prize for the "most sustainable production 2009" and as being the "most sustainable brand 2011".

For the particularly efficient utilisation of energy through the innovative heat recovery centre at the company's main site in Allendorf/Eder, Viessmann was rewarded with the Energy Efficiency Award 2010.

Viessmann Group

Company details
- Established in: 1917
- Employees: 9600
- Group turnover: €1.86 billion
- Export share: 55 percent
- 24 manufacturing plants in 11 countries
- Sales companies and representations in 74 countries
- 120 sales outlets worldwide

Comprehensive range of products from Viessmann for every type of fuel and all output ranges
- Boilers for oil and gas
- Solar thermal systems
- Photovoltaics
- Heat pumps
- Wood combustion systems
- Combined heat and power
- Biogas production plants
- Biogas upgrading plants
- Air conditioning
- Heating system accessories

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