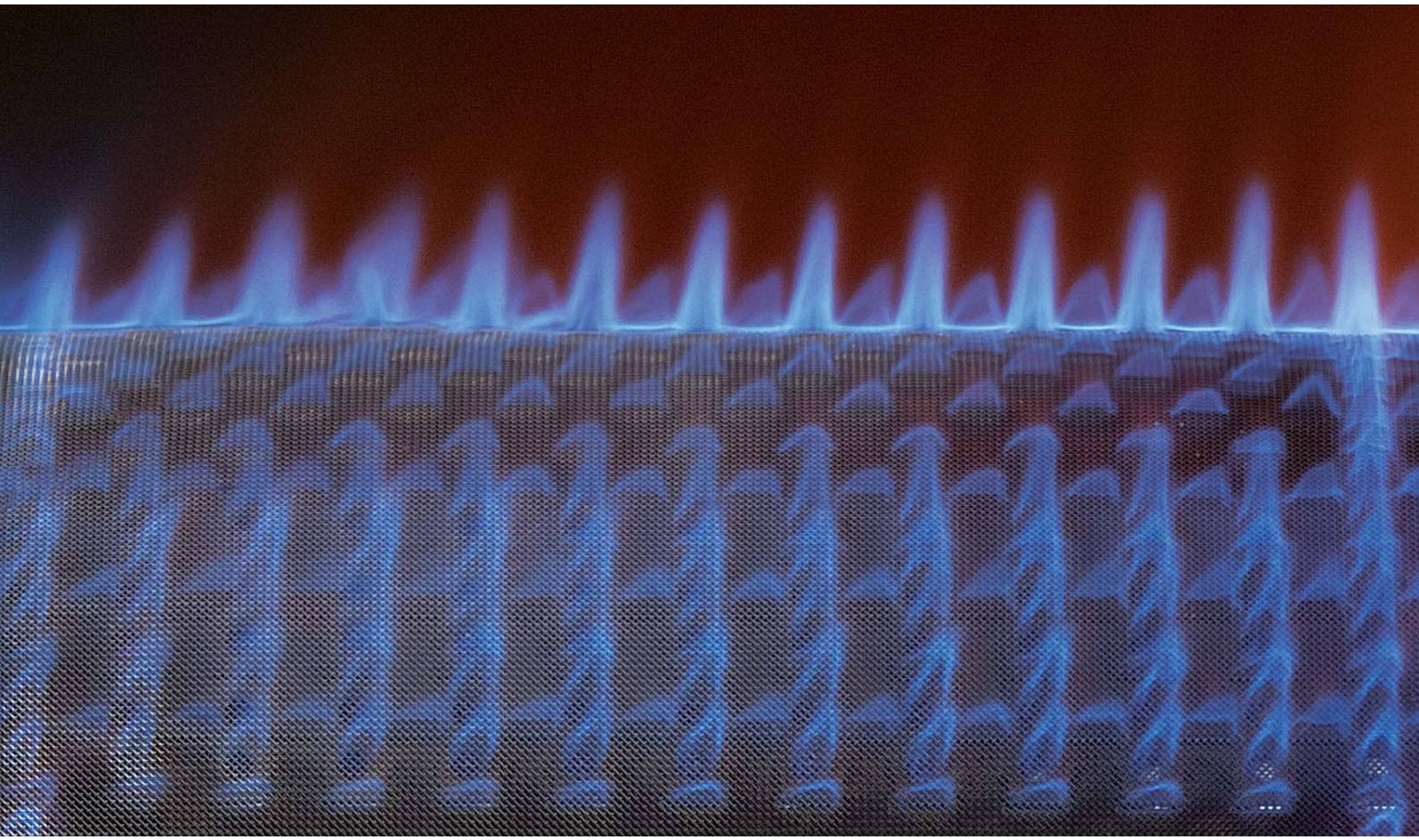
Carbotech

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 the conventional gas pipeline.

Supplies of fossil fuels such as coal, crude oil and natural gas are getting shorter all the time – effects of this phenomenon can already be seen in ever increasing energy prices. The introduction of sustainable renewable energies into the market is crucial; this is where biogas plays an important role. Biogas can be produced from sustainable raw material and organic waste – locally, reliably, simply, efficiently and with environmental responsibility.

The upgrading of biogas to natural gas quality is, from the 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, transportation as well as for power and heat generation. Nowadays, the biogas production and upgrading process 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 and 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).

For many years, Carbotech biogas upgrading plants have been in operation in numerous European countries with reliable, highly efficient and low operational costs for the processing of biogas to biomethane as well as the gas to grid injection.

The patented pressure swing adsorption (PSA) process developed by Carbotech is simple and distinguished by 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 and finally trace elements, such as hydrogen sulphide (H_2S), will be removed with 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, H20, residual H_2S, siloxane, NH_3 and odours are then removed. Furthermore, through the patented Carbotech system, oxygen and nitrogen are partially removed. The result is a highly enriched methane gas referred to as biomethane.

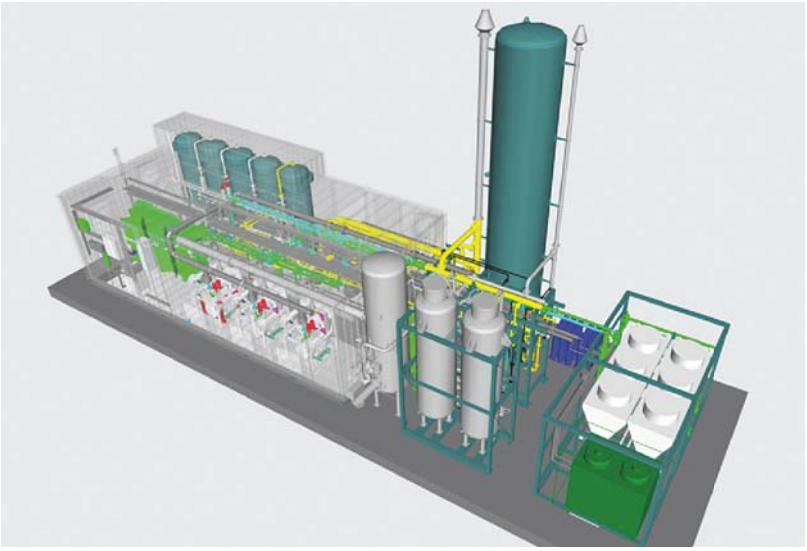
The production of biomethane in each vessel runs through specific intervals and the plant switches to another filter while the first one is fully regenerated by means of a vacuum. The programmable logic control (PLC) and the online gas analysis ensure an automated, safe and reliable operation.

Economical treatment process
The pressure swing adsorption (PSA) process from Carbotech is a dry biogas upgrading process with low operational costs. That means:

- No process water, no process water conditioning
- No waste water, no waste water treatment
- No chemicals
- No off gas with toxic contaminants

$ZETECH_4$®: Zero Emission Technology
As an option, the $ZETECH_4$® system can be implemented. It represents a unique and patented process for upgrading biogas, free from emissions, 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 product 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.

For 2020, the Federal Government [of Germany] set a target of six billion cubic meters of biomethane to be fed into the natural gas grid. 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.

An ambitious goal, to which Carbotech makes a vital contribution with its durable and efficient technology. The know-how of Carbotech includes every step, from project planning support, through engineering and building as well as 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?
One essential aspect while planning a biogas plant is the available amount of raw gas that would be produced. The main factors to consider are 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 assembling 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 as well as the membrane technology, the PSA technology 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 and a compact design as well as 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 from biomethane of high purity biogas.

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 can compromise 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
- 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	BGAA750	BGAA1200	BGAA1400
Raw biogas (Nm^3/h)	250	500	750	1000	1200	1400
Bio natural gas (Nm^3/h)	125	260	390	520	624	728
Power consumption (kW)	60	120	180	240	290	340
Dimensions, length x width (m)	21 x 6	21 x 6	24 x 6	24 x 6	24 x 6	24 x 6

As an option, conditioning units for L and H natural gas networks, biomethane booster stations from 16 to 100 bar as well as gas pressure control and gas measuring instrumentation are available.

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 and 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 Bern

Owners:	ARA Region Bern
Location:	Herrenschwanden/Bern (Switzerland)
Commissioning:	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 and 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 and 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

BUP 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 and 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 Emmertsbühl

Owners:	EnBW Gas GmbH
Location:	Emmertsbühl/Blaufelden
Commissioning:	10/2010
Plant type:	BGAA500
Source of raw biogas:	Liquid manure, NaWaRo
Raw biogas:	500 Nm^3/h
Bio natural gas:	255 Nm^3/h
Gas quality:	DVGW G260 and 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

BUP 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 and 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 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 and 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 (Germany) 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 characterised by innovative, efficient processes and methods for the upgrading, purification and production of industrial gases or biogas.

Competent and close to the customers 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 sales of plants, as well as 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 world-wide under operation. These raw gases may be reformer gases from natural gas, ammonia or naphtha, or coke oven gas, ammonia tail gas or others.

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 used as inert or purge gas anywhere, where oxygen reduces the shelf-life of products, impairs their quality or could result in critical or undesirable reactions.

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

Carbotech plants are used around the world in the most diverse applications in the food processing, as well as in the metal and chemical industries. Their high level of technical reliability, both as stand-alone systems as well as base load systems in conjunction with a tank facility by suppliers of industrial gases, make these plants truly outstanding.

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 downloading on the internet at www.carbotech.info provide extensive information on hydrogen generators and systems for the production of nitrogen.

The comprehensive range of products and services from Viessmann

Individual solutions with efficient systems

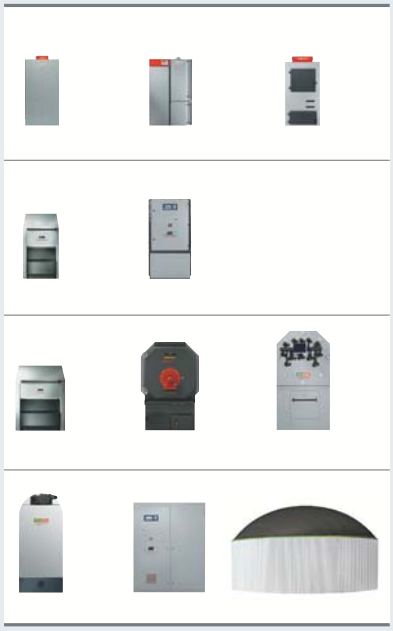
The comprehensive range of products and services from Viessmann
The comprehensive range of products and services from Viessmann offers individual solutions with efficient systems for all applications and all energy sources. As environmental pioneers, the company has, for decades, been supplying particularly 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 range of products and services 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 efficient
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.

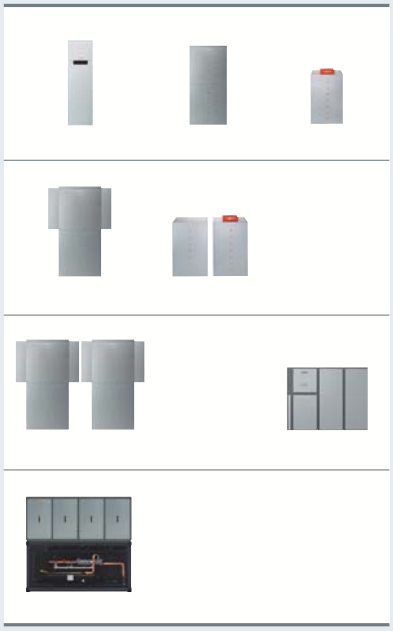
Wood combustion technology, CHP and biogas production

4 – 13,000 kW

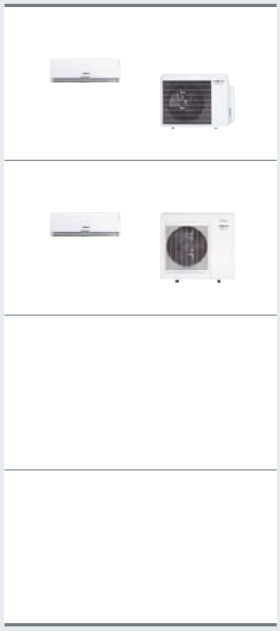


Heat pumps for brine, water and air

1.5 – 2000 kW



Air conditioning technology



System components

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

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.

The company offers the following:

- Condensing technology for oil and gas
- Solar thermal systems
- Heat pumps
- Wood combustion systems
- CHP modules
- Biogas plants
- Services

Viessmann is extremely 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
KÖB
MAWERA
ESS
BIOFERM
Schmack
Carbotech

The comprehensive range of products and services from Viessmann

	Detached houses	Apartment buildings	Commerce / Industry	Local heating networks
Oil low temperature and condensing technology 13 – 20,000 kW	 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 low temperature and condensing technology 4 – 20,000 kW	 Detached house, Kevelaer, Germany	 "Wohnoase" residential park in Regensburg, Germany	 Porsche Leipzig, Germany	 European Parliament, Brussels, Belgium
Solar thermal and photovoltaics	 Heliotrop Freiburg, Germany	 HafenCity Hamburg, Germany	 City of Tomorrow, Malmö, Sweden	 The Palm Jumeirah, Dubai
Wood combustion technology, CHP and biogas production 4 – 13,000 kW	 Detached house, Wiesloch, Germany	 Hotel Lagorai Cavalese, Italy	 Congressional Centre, Brunstad, Norway	 Monastery St. Ottilien, Germany
Heat pumps for brine, water and air 1.5 – 2000 kW	 Loftcube Regional Garden Show, Neu-Ulm, Germany	 Studio flats, Brandenburg, Germany	 University library, Bamberg, Germany	 Residential estate, Pfäffikon, Switzerland

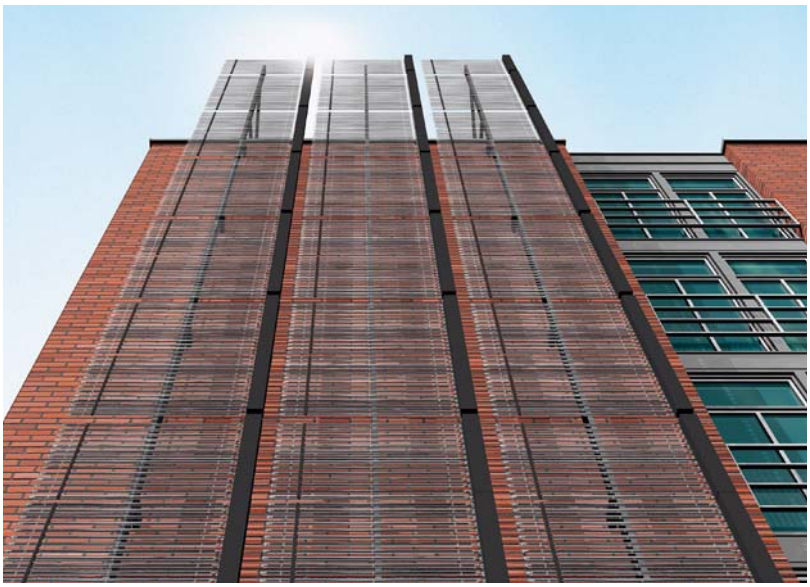
The comprehensive range of products and services from Viessmann:
Individual solutions with efficient systems for all energy sources and applications

Futureproof heating technology for all requirements

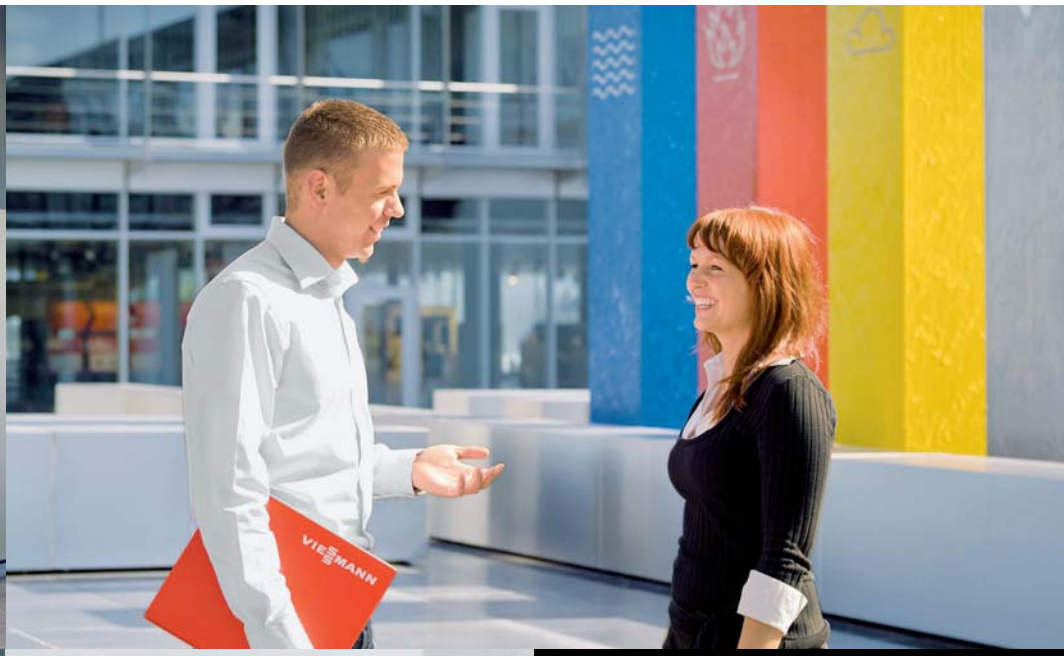
Energy consumption worldwide has doubled since 1970 and will triple by 2030. The result: The fossil fuels, oil and gas, are dwindling, energy prices are on the rise and excessive CO_2 emissions continue to affect our environment. Energy efficiency is a must if we want our future to be secure.

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.

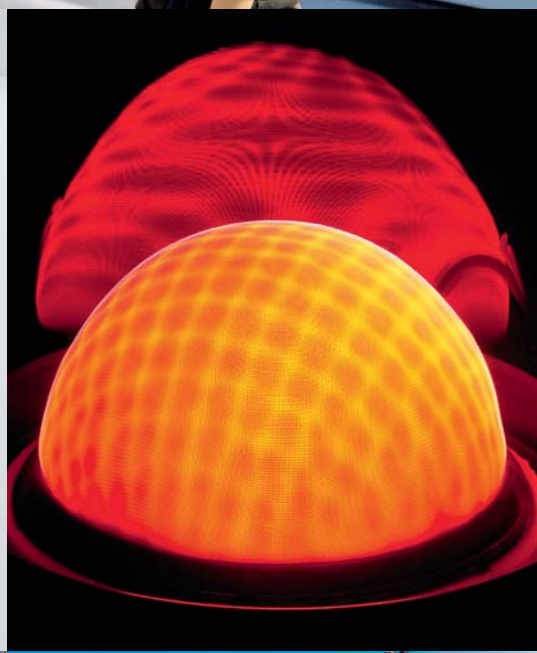
In these projects, Viessmann again and again faces up to the most varied challenges to supply efficient heating technology by offering innovative solutions – in historical listed buildings as well as in modern industrial complexes or in the large-scale residential and industrial arena.



City of Tomorrow, Malmö, Sweden




VIESMANN
VITOLADENS 300




Naturwärme


Audi
VIESMANN

Viessmann – climate of innovation

The Viessmann brand promise concisely expresses all that we hope to achieve. It is our key brand message and, together with our brand label, 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 a promise of high product utilisation and, at the same time, an obligation to protect the environment.

Comprehensive range of products and services for all fuel types

Viessmann is one of the leading international manufacturers of heating systems and, with its comprehensive range of products and services, offers individual solutions in the shape of efficient systems for all applications and types of fuel. As an environmental pioneer, the company has been supplying particularly efficient and clean heating systems.

Acting in a sustainable manner

For Viessmann, to take responsibility, means a commitment to act in a sustainable way. This means bringing ecology, economy and social responsibility into harmony with each other, ensuring that current needs are satisfied without limiting the basis for life for the generations to come.

Efficiency Plus

With the sustainability project "Efficiency Plus" Viessmann shows at its Allendorf site, that the political goals set for 2020 with regard to climate and energy can already be achieved today with commercially available technology.

This project demonstrates:

- Environmental protection
- Efficiency with resources
- Securing manufacturing sites for the future

As a result, fossil fuels have been cut by 40 percent and CO_2 emissions reduced by a third.

Effizienz Plus

Viessmann won the German Sustainability Award 2009 for its commitment to climate protection and efficient use of resources.

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 Werke GmbH & Co. KG

Company details

- Established in: 1917
- Employees: 9000
- Group turnover: €1.7 billion
- Export share: 50 percent
- 16 factories in Germany, France, Canada, Poland, Hungary, Austria, Switzerland and China
- Sales organisation in 37 countries
- 120 sales offices worldwide
- 3 service providers

Performance spectrum

- Condensing technology for oil and gas
- Solar thermal systems
- Heat pumps
- Wood combustion systems
- CHP modules
- Biogas plants
- Services

Carbotech

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