Efficient systems and renewable energies

Technology and Energy Panel

BDH
Federation of German Heating Industry

ISH

Federal Ministry
for Economic Affairs
and Energy

Message from the patron:

Source: © Bundesregierung/Kugler

Ladies and gentlemen,

The energy revolution is in full swing. But we should not be thinking only of the power sector. Without a revolution in heating, the energy revolution would be incomplete. After all, heating accounts for half of our total energy consumption, and is twice as high as the electricity consumption. Therefore, from the policy point of view, we are now focusing more intensively on the challenges in the heating market. With better energy efficiency, renewably generated heat, district heating and sector coupling, tremendous amounts of energy and CO_2 *can be saved in industry, in the trading, commerce and service sectors, as well as in private households. We will be initiating effective measures particularly in the building sector, and will be accelerating the use of renewable energies.*

The energy and heat revolution is a societal responsibility which will shape the future of our economy. The ISH Energy is an important stimulus for exporting German products. As the leading platform for future-based building technology, it promotes global dialogue on technical concepts, innovation, vision and strategies, especially for efficient technologies and coupling renewable energies.

I am therefore pleased to become the patron of the Technology and Energy Panel of the Federation of German Heating Industry at the ISH Energy. I am especially pleased about the large number of medium-sized companies in the German HVAC industry that are responsible for the high innovative power and "Made in Germany" product developments. Above all, the forum addresses the trendsetting networking of buildings in the energy system of the future with the "Digital Star" – a digital key topic of the Federal Ministry of Economic Affairs and Energy!

I wish the Technology and Energy Panel of the BDH, as well as ISH Energy, all the very best.

Peter Altmaier
Federal Minister for Economic Affairs and Energy

 

Foreword

Messe Frankfurt and the Federation of German Heating Industry (BDH) are organising the Technology and Energy Panel of the ISH for the eighth time on the occasion of the leading international trade fair ISH.

Technologies and energy as a system

The heating market, which is the largest energy consumption sector in Europe and in Germany, accounts for more than 50 % of total energy consumption. The ambitious climate protection goals of Europe and Germany can be achieved only by exploiting the enormous CO_2 reduction potentials in this sector. The Technology and Energy Panel shows how high efficiency, CO_2 reduction and supply security can be implemented together in the energy systems of the future. In line with our vision, technologies and energy form one system: Innovative technological approaches provide high efficiency, and, parallel to this, the proportion of renewable energy in the energy sources of the heating market is gradually increasing. This refers not only to electricity, but also to the main energy sources in the heating market, such as natural gas, heating oil and biomass.

Partner country France and 14 other strong partners

The partner country France is also represented by our French sister association UNICLIMA in the Technology and Energy Panel. The kick-off event is a French-German colloquium on the topic of efficiency and renewable energy. Based on the agreement between UNICLIMA, BDH and Messe Frankfurt, the French-German dialogue will be carried forward on a continuous basis, taking place next at INTERCLIMA in Paris.

Once again, the most important industrial associations, as well as associations from the energy industry, will be involved in the Technology and Energy Panel. We and our partners stand for the dual strategy of efficiency and renewable energy and provide practical answers to the international professional community, as well as to policy makers, about the challenges facing the heating market both today and in the future.

ISH Energy: innovative – efficient – digital

The largest international platform for efficient technology and innovation for the heating and cooling market showcases the latest developments in technology, innovation and market trends to visitors from around the world.

The focus in 2019 will be on the following key issues:

- Efficient systems for all energy sources in the heating and cooling market
- Hybrid systems, which are using and efficiently implementing a combination of several energy sources with increasing amounts of renewable energy
- The digitisation of systems in the building with high efficiency, cost savings and enhanced comfort
- IOT@home: The networking of energy systems via HEMS, Home Energy Management Systems. HEMS is demonstrated by the Digital Star of the Technology and Energy Panel.
- Power-to-X: Future strategies of the energy industry

We would like to thank the Federal Minister for Economic Affairs and Energy, Peter Altmaier, for becoming the patron of the Technology and Energy Panel. Federal Minister Altmaier thereby supports the common cause of using the innovative strength and capabilities of the German heating industry and energy economy in protecting the climate and resources.

Over 200,000 visitors are expected at the ISH in Frankfurt. Experience the pioneering innovations, visions and strategies for the major challenges in the international heating market at the ISH Energy.

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Senior Vice President,
Messe Frankfurt
Exhibition GmbH

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Managing Director
BDH

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Technology and Energy Panel of ISH 2019:
A strong alliance for climate protection

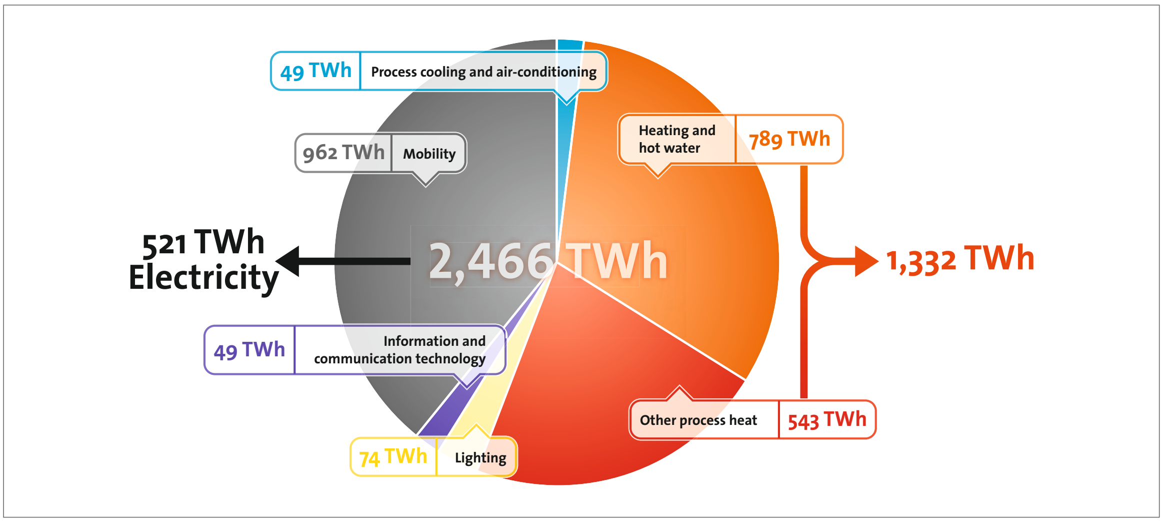

Fig. 1: More than half of Germany's final energy consumption can be attributed to the heating market.

One third of the European and German final energy consumption can be attributed to heat generation in buildings. If industrial process heat is added, the percentage is even well above 50 %.

The Paris agreement on climate protection, as well as the national energy policy strategies, are unanimously driving ambitious CO_2 reduction and energy-saving goals, up to an almost complete "decarbonisation" of national economies. In Germany, the current federal government set a goal of reducing CO_2 emissions by at least 55 % by 2030 based on the year 1990.

Anyone setting such ambitious climate and resource protection goals has to fully consider and mobilise the enormous CO_2 reduction and energy-saving potentials in the largest energy consumption sector in Europe and in Germany, the building sector. However, at the moment this is happening only tentatively, if at all. The energy modernisation market, the key to achieving the CO_2 reduction goals, has been stagnating in Europe and in Germany for years and is contributing hardly anything to help solve the problem. The heating industry wants to change this and is therefore working closely with the associations of the energy industry, other industry associations and Messe Frankfurt to achieve the goals.

For the eighth time, Messe Frankfurt and BDH are organising the Technology and Energy Panel of ISH with the participation of the following partners:

Energieeffiziente Gebäude BDI initiativ
BSW German Solar Association
bwp German Heat Pump Association
DEPV Deutscher Energieholz- und Pellet-Verband e.V.
DIN NHRS
Smart Living Made in Germany
DVGW
Initiative EEBUS
Fachverband Gebäude-Klima e.V.
geea Die Allianz für Gebäude-Energie-Effizienz
HEA Fachgemeinschaft für effiziente Energieanwendung e.V.
HKI
iwo Institut für Wärme und Oeltechnik
Zukunft ERDGAS e.V.

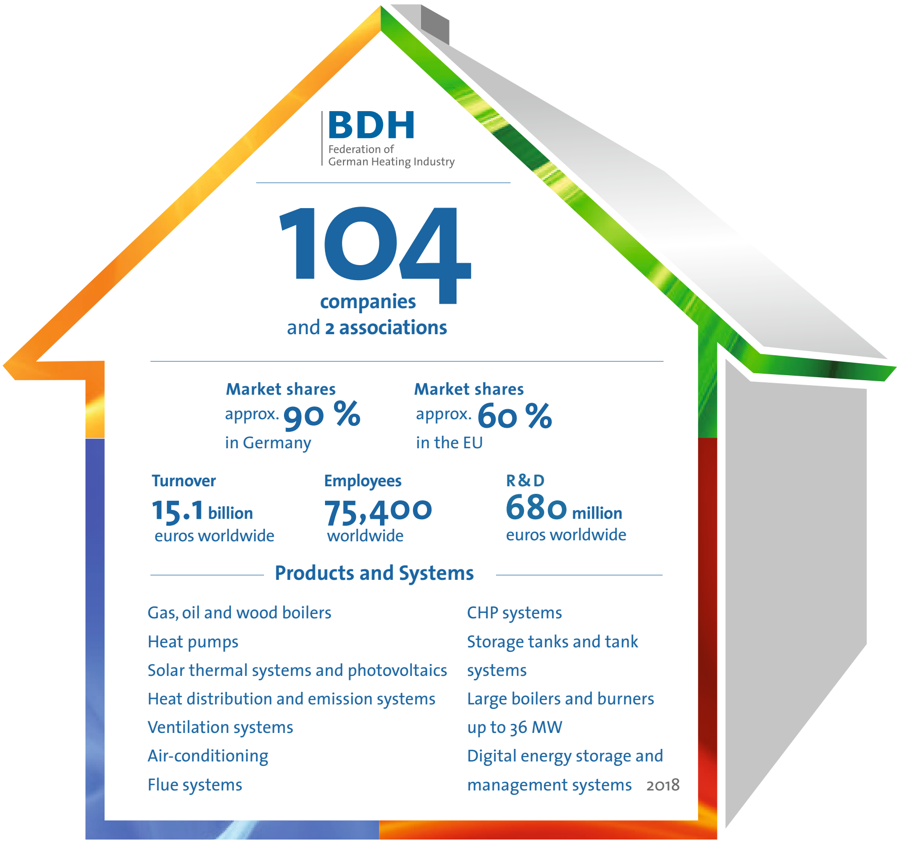

Fig. 2:
The BDH stands for the dual strategy of efficiency and renewable energies

The organizers and partners of the Technology and Energy Panel consider the energy sources and the technologies for using these energy sources as one system. They are focusing on the most efficient use of scarce energy resources and, at the same time, constantly increasing the proportion of renewable energy in the energy mix of the heating market. For example, the proportion of electricity from renewable energy sources in the electricity mix is expected to increase gradually with simultaneous network expansion. Gaseous and liquid energy sources – natural gas and heating oil – contain incrementally higher proportions of renewable energy, thanks to increased development and use of power-to-liquid and power-to-gas.

One key aspect of the Technology and Energy Panel of ISH 2019 is the subject of digitising heating and energy systems. Digitisation is expected to open up additional energy-saving and CO_2 reduction potentials. There are also significant benefits for the end user, such as higher energy efficiency, security and better operability. The energy system benefits from digitisation by means of a significantly improved load management not only of electricity but also of the gas network. Decentralisation, along with energy storage and generation in buildings, reduces the load on the electricity grids and reduces demand peaks without a corresponding supply of renewable energy in the electricity grid.

The Technology and Energy Panel in 2019 will present “Digital Star” as an example of a smart energy system in the building and also invites start-ups, digital natives and digital science in addition to the previous target groups of the ISH – the trades and international experts.

Technology and Energy Panel of ISH 2019: A strong alliance for climate protection

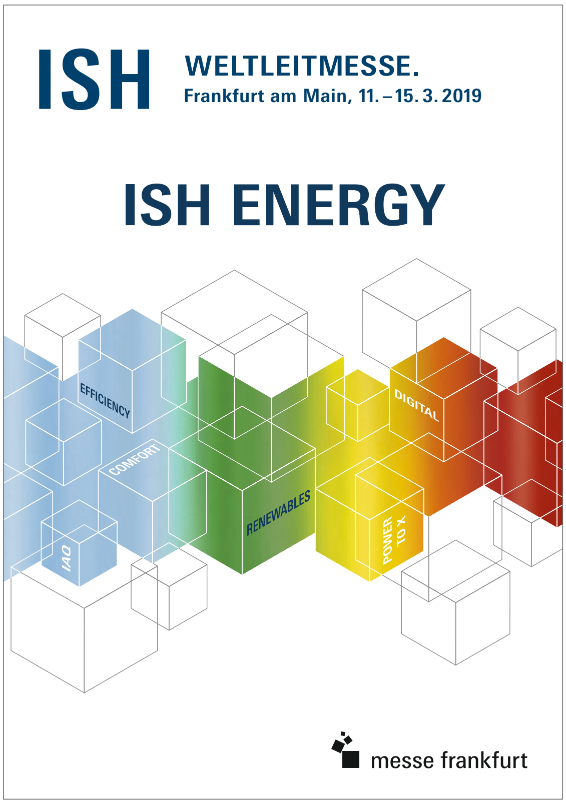

Fig. 3: The industry meets at the ISH Energy in Frankfurt every two years

BDH: Dual-strategy incorporating both energy efficiency and renewable energies

The organisers of the Technology and Energy Panel, the BDH and Messe Frankfurt are jointly organising the ISH. Messe Frankfurt provides economic support and the BDH provides ideas, together with the Central Association of Plumbing, Heating and Air Conditioning (ZVSHK), the German Sanitary Industry Association (VDS), the Association of Building Air Conditioning (FGK) and the VdZ forum for energy efficiency in buildings.

Within the international trade fair ISH, BDH plays a key role as the idea promoter in shaping the ISH Energy, which takes up more than 50 % of the ISH area. In addition to proven system technology that efficiently utilises all the energy sources used in the heating market and, at the same time, integrates renewable energy, the ISH Energy and the Technology and Energy Panel present "Digital Star", which represents the Internet of Things (IoT) in single and two-family houses.

Fig. 4: "Digital Star" shows how energy can be used efficiently and how renewable energy can be integrated

The Strategy: Efficiency and renewable energies

The international trade fair ISH has as its motto "Water, Energy, Life" and forms the two pillars, the ISH Energy and ISH Water. The ISH Energy takes up more than 50 % of the area and showcases state-of-the-art technologies to the international public in the field of heating, cooling and ventilation. The ISH Energy is also the platform for the associations of the energy sector, which demonstrate the current status here, as well as the innovations and visions towards renewable energy.

- About the Federation of German Heating Industry (BDH):

  104 manufacturers of heating systems and components, as well as 2 associations are part of the BDH. The industry organised under the BDH manufactures systems with a capacity between 6 kW and 36 MW based on natural gas, heating oil, wood, solar energy and other renewable energy sources. In addition, the digitisation of system technology has benefits over conventional solutions in the field of energy efficiency, operability and security. At the international level, the German heating industry assumes a leading position, both in terms of technology as well as of market importance. The degree of organization of the BDH is 90 % in Germany and 60 % in Europe as a whole. In 2018, the industries organised under the BDH achieved sales of 15.1 billion Euro and had 75,400 employees. The high R&D expenditure of over 680 million Euro per year demonstrates the great innovative strength of German industry.

- About the Messe Frankfurt:

  Messe Frankfurt is the world's largest trade fair, convention and event organiser with its own premises. More than 2,500* employees at 30 locations generate annual sales of around 715* million Euro. Using far-reaching networking within the sectors and an international sales network, the Group provides effective support for its customers and their business interests. By offering a wide range of services, both on-site and online, Messe Frankfurt provides its worldwide customers with a consistently high level of support in the planning, organising and running of their events. This wide range of services includes renting exhibition premises, trade fair setup, marketing services, human resources and food services. The Group has its head office in Frankfurt am Main It is owned partly by the City of Frankfurt (60 %) and partly by the State of Hesse (40 %).

* provisional figures for 2018

Fig. 5: The leading world trade fair ISH Energy presents both the current state and the future of the heating market

Technology and Energy Panel of ISH 2019:
A strong alliance for climate protection

ISH Energy 2019: Making climate protection work

The European Union is calling for "Clean Energy for all Europeans". For the European Parliament and the European Commission, as well as the European Council, this implies achieving the requirement of far-reaching decarbonisation of all the energy consumption sectors in terms of climate protection goals. However, the focus of European discussions is mostly on the topic of electricity and therefore underestimates the importance of the largest energy consumption sector in Europe, that of the heating market. After all, more than 50 % of the final energy consumption in Europe can be attributed to the heating market and only about 20 to 25 % to electricity. The number 1 energy source in the heating market in Europe is natural gas, with a share of more than 80 %, followed by heating oil, electricity and solid biomass. The renewable energies in the heating market still take a backseat with only about 10 %.

With the Heating and Cooling Strategy published in 2016 and the "Clean Energy for all Europeans" motto, the heating market is finally getting some attention.

Figure 6 clearly shows that only about one third of the 125 million heating systems are state of the art. No other energy consumption sector in Europe has such a high energy-saving and CO_2 reduction potential as the heating sector. However, about 75 million outdated heating systems would have to be replaced and upgraded to state of the art in order to harness this potential and thus to achieve the climate protection goals. This would result in a win-win situation.

"win" 1:
Energy efficiency and renewable energies reduce CO_2 emissions for climate and resource protection.

"win" 2:
Energy efficiency and renewable energies save scarce energy sources and reduce European dependency on imports.

"win" 3:
Lower energy consumption through greater efficiency and greater shares of renewable energies reduces the burden on the citizens through cost reduction.

"win" 4:
Investments in higher efficiency and renewable energies create jobs in industry and in the trades.

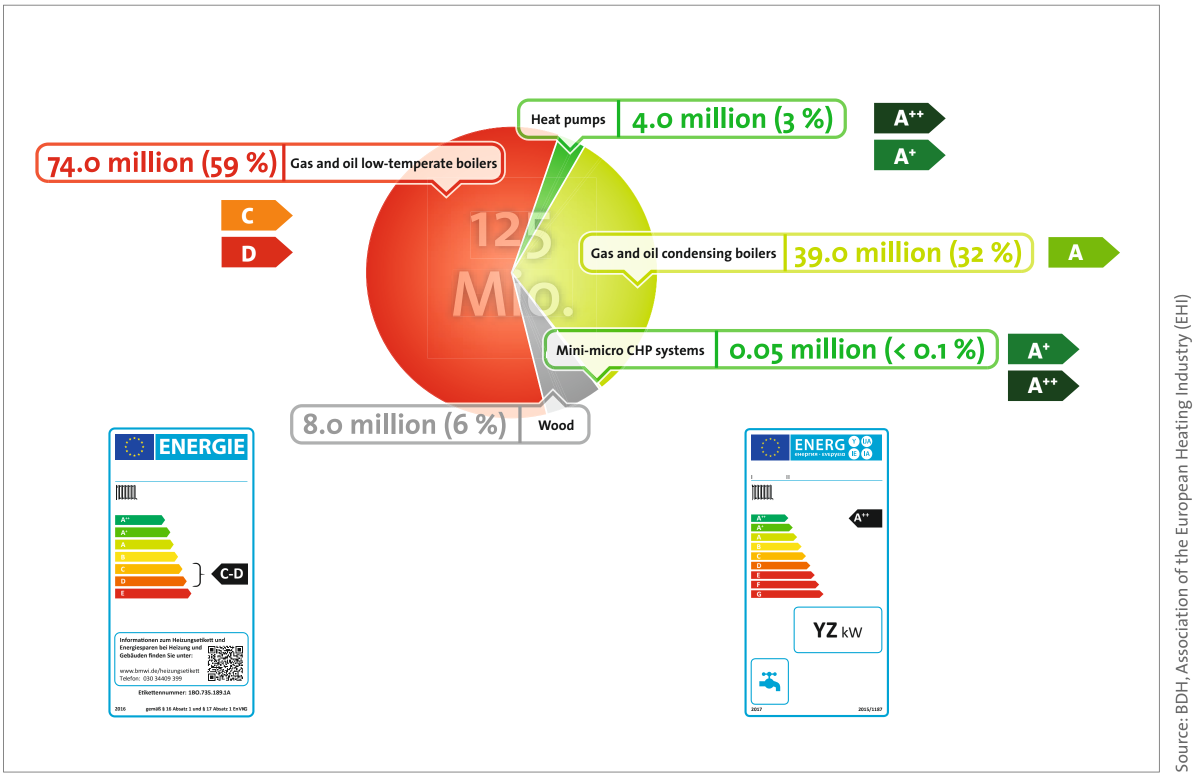

Fig. 6: The European installations

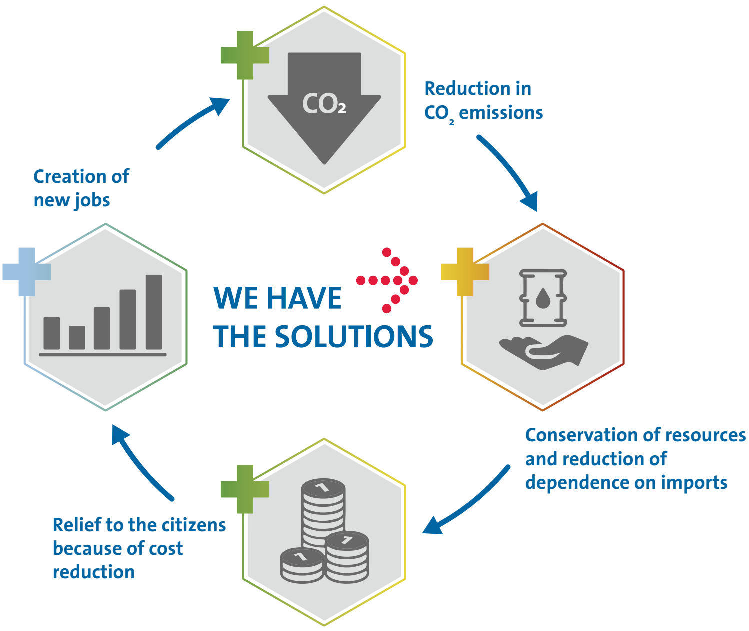

Fig. 7: Win-win situation by means of accelerated modernisation of the outdated heating systems

We have the Solutions

To achieve the goals and to implement the four 'win' situations, technical solutions already exist, but have not yet gained traction in the installed outdated systems.

Clean Energy for all Europeans – and three European directives relevant to the heating industry

Energy Performance of Building Directive (EU) 2018/844, EPBD.
In June 2018, the second revision of the EPBD was published in the Official Journal of the European Union. It stipulates, among other things:

- Integration and substantial strengthening of long-term strategies for renovating buildings for 2030 and 2040 and the decarbonisation of existing buildings in 2050
- Promoting the use of information and communication technology (ICT) and "smart" technologies to ensure efficient operation of the building, such as the implementation of automation and control systems
- Option for Member States to introduce a "smartness indicator", which measures the ability of a building to use new technologies and electronic systems that can be adapted to the needs of the consumer and optimise the operation and interaction with the network

Energy Efficiency Directive (EU) 2018/2002, EED

- with an efficiency goal of 32.5 % by 2030 compared to 1990, mandatory however only for the EU, but not for the member states
- Reduction of the European primary energy factor for electricity from 2.5 to 2.1, revised once every four years

Renewable Energy Directive, RED

- with a 32 % share of renewable energy by 2030 at the EU level
- Member states should increase their share of renewable heat by 1.3 % every year


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Energy sources in the heat market

- Natural gas: high availability with integration of renewable energies
- Thinking ahead with oil
- Wood Energy
- Solar Energy
- Geothermal energy and environmental heat: Energy from earth, water and air
- Sector coupling: Using the potential of electrical domestic heating systems
- The networking of heating systems on the micro and macro level

Natural gas: high availability with integration of renewable energies

Natural gas is an important source of energy

Natural gas is a combustible natural product and consists mostly of methane. After crude oil and coal, it is the third most important energy source in the world. The ratio of primary energy consumption in the world in 2017 was 23 %. About 3,760 billion m³ of natural gas was produced in the same time period. The global reserves that can be tapped economically will also satisfy the energy demand over the long-term.

One big advantage of natural gas is that almost no particulate matter and significantly less CO_2 is produced when it is burnt when compared to other fossil fuels. The shift to natural gas therefore offers enormous potential for climate protection. If methane is regeneratively produced, for example, as bio-methane, or using the power-to-gas method, then it is even mostly climate-neutral and can be combined with, for example, wind and solar energy, in many applications. This makes gas as an energy source an ideal partner for renewable energy and the energy revolution.

Gas infrastructure in Germany and Europe

Germany has an extensive network for natural gas. The transport infrastructure available across the country consists of 511,000 km of pipeline. Apart from this, Germany has the biggest natural gas storage capacities in Europe. These can store a gas reserve for a period of up to four months.

The natural gas is imported both through pipelines as well as in the form of liquefied natural gas (LNG) in huge tankers. The majority of the natural gas consumed in Germany currently comes from Russia and Norway. The rest comes from other European countries such as the Netherlands and from domestic production

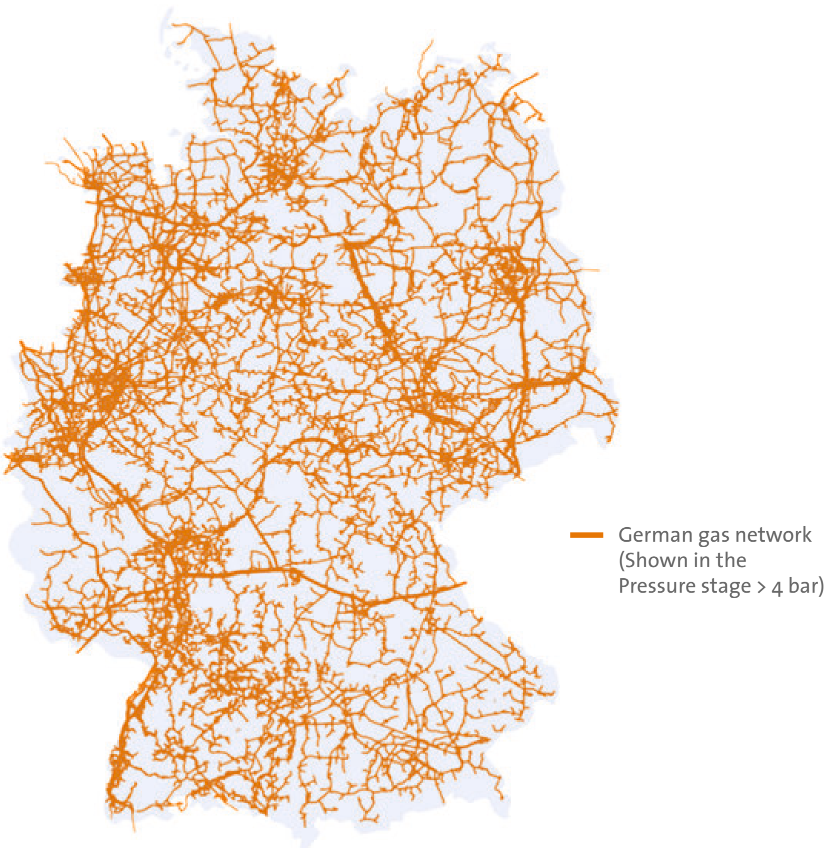


Fig. 8: The German gas network

Gas can be green

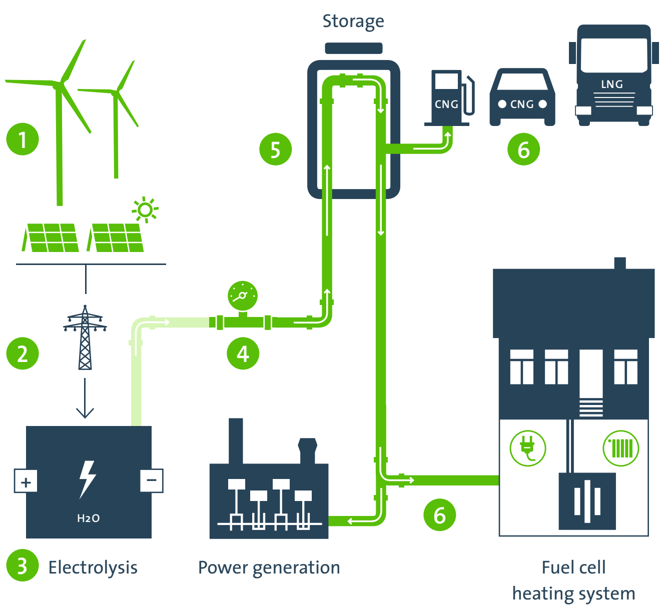
Gas produced in a regenerative manner from Biomass is becoming increasingly important. The biomass includes residual materials such as sewage sludge, biowaste, manure or plant parts. Biogas has a high surface efficiency and can be generated continuously over the entire year, in contrast to wind and solar power. Treated to natural gas quality, it can also be easily stored as bio-methane in the gas network and transported to the place where it is used via the existing infrastructure. This means that biogas consumers are gradually changing over to renewable gases because of the increased supply of biogas.

Power-to-gas: Gas from green electricity

The production of electricity from renewable sources strongly depends on the weather and the seasons. Accordingly, the returns are fluctuating. In view of the steady growth of wind power and photovoltaics with simultaneous slowing down of the power grids, the occasionally extreme peaks in the production of electricity are not being sufficiently used. The power grids can store only a limited amount of energy. Hence, the expansion of renewable energies urgently requires storage techniques that will help to adapt the fluctuating power supply to demand. Thus, electric storage systems such as batteries are suitable to only a limited extent. Even pumped-storage power plants can hardly be built in sufficient quantities owing to geographical conditions.

Power-to-gas is a promising option for the proper use of surplus wind and solar power. The synthetic production of gas makes the energy source into a renewable resource that can significantly contribute to decarbonisation. This applies to all sectors: electricity generation, the transport sector, and the heat market.

With power-to-gas technologies, it is possible to store green electricity in large quantities as needed. Using electrolysis, the surplus power from wind and solar energy systems is converted into hydrogen. In a further step, the resulting hydrogen can be converted into methane. Subsequently, the synthetic methane can be fed along with conventional natural gas into the largest energy storage system in Germany, the gas network. This supply and energy reserve is available to all users via the extensive gas network system, that is, also to the heat market. In this way, gases can contribute significantly to linking the sectors and to the energy revolution.



1 Renewable electricity is produced using wind and solar energy.

2 The electricity flows through the power supply network to the nearby power-to-gas plant.

3 With electrolysis, water is split into hydrogen and oxygen by using green electricity.

4 The hydrogen is fed directly into the gas network or converted into synthetic NATURAL GAS via methanation.

5 The renewable energy can be transported to the consumers in the gas network and stored in gas tanks.

6 Climate-neutral renewable gas can be used, for example, in natural gas vehicles or gas heaters – just like normal NATURAL GAS. By reconversion, it can also be used to generate electricity.

Source: Zukunft ERDGAS

Fig. 9: Power-to-gas: Storage for green energy

Thinking ahead with oil

Heating oil and greenhouse gas-neutral liquid fuels – ideal partners for an affordable heating revolution

Today, heating oil provides safe and reliable heating to 20 million people, about a quarter of all Germans. The total of 5.6 million oil heating systems are used mainly in single and two-family homes in rural areas. Thanks to efficient condensing technology, which is very often combined with renewable energies, modern oil heating systems already contribute measurably to the reduction of greenhouse gas emissions. Heating oil consumption in Germany has more than halved in the past twenty years, while the number of oil heaters has remained nearly the same during this period.

Favourable transition to the heating revolution

Modernisation with oil condensing technology offers a high cost-benefit ratio. Therefore, they are ideal for entry into the heating revolution and can make an important contribution to meeting the modernisation requirements of German heating systems. By expanding into hybrid heating systems and developing and using low-greenhouse gas, and even climate-neutral liquid fuels in the future, modern oil heating systems provide possibilities for long-term use.

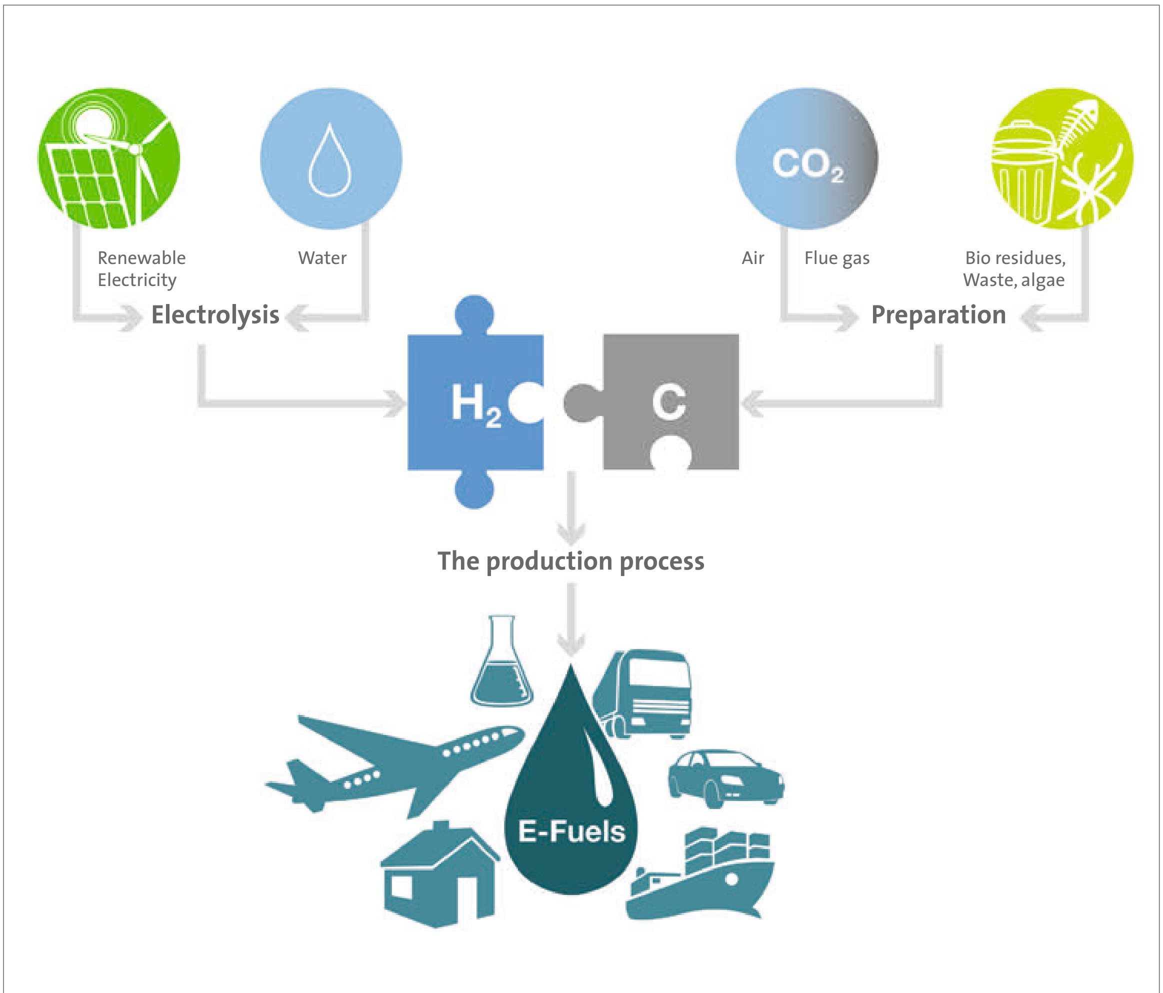


Fig. 10: CO_2 neutrality ensured by closed carbon cycle

Source: IWO (Institute for Heating and Oil Technology)

Modern fuel for efficient technology

Liquid fuels can be stored conveniently and are easy to transport. To continue to use these benefits, work is being carried out to develop marketable, innovative fuels which can supplement existing heating oils such as kerosene, petrol and diesel. Every litre of heating oil contains at least 10 kWh of energy. This is, for example, sufficient for heating 200 litres of water from 10 to 55 °C. Owing to this high energy content, heating oil is particularly economical. The energy density in liquid fuels is about 20 times higher than, for example, in a lithium-ion battery. These liquid sources of energy currently provide about 98 % of the energy required in the transport sector and about 22 % of energy for heating in Germany.

Since heating oil is a storable and non-output-related energy source that ensures constant supply, oil heating systems are ideally suited as the basis for hybrid heating systems, which incorporate renewable energy technology.

New fuels for the future

Bearing the future in mind, work is being carried out on processes with which renewable synthetic fuels can be produced. An important criterion in the development of these new fuels is the drop-in ability to mix them to the fuel oil in increasing quantities and to use them in modern condensing technology without any major retrofitting.

Currently, there are many different approaches to the development of new fuels: From A, such as algae use, to X, such as XtL, which refers to be the production of synthetic liquid hydrocarbons from a wide variety of carbon sources, for example, from waste material residues. On the basis of these research projects, liquid fuels could also be used in a climate-neutral manner in the long term. Thus, in combination with fluctuating renewable energy sources, storable energy will also play an important role in the future energy mix.

Research on different "paths"

Typical liquid fuels usually consist of carbon and hydrogen. Water (H_2O) and carbon dioxide (CO_2) are the main products obtained during combustion. If this CO_2 is reused in the process of producing the fuel, this results in a closed carbon cycle and thus becomes greenhouse-gas neutral: Carbon dioxide becomes the sustainable raw material, since the same amount is released during combustion as extracted from the atmosphere during production.

Hence the research on liquid fuels with reduced greenhouse gases focuses on the production of alternative liquid hydrocarbons from different renewable sources. When selecting the raw materials, a utilisation conflict with agricultural land or food is consciously avoided. The researchers refer to different "paths": There is the biomass "path", also called "biomass-to-liquid" or simply BtL, which examines the production of fuels from waste materials and biogenic residues.

Another important 'path' is "Power-to-liquid", PtL in brief. Here, electricity from renewable sources is used for producing hydrogen, which is then linked with the carbon from biomass or CO_2 obtained, for example, from the air, into a synthetic liquid fuel.

It requires sufficient availability of renewable electricity. This could be used mainly in countries with significantly higher solar hours where solar power can be generated at lower costs.

Wood Energy

Wood is on the rise

The use of wood as an almost climate-neutral energy source is attractive both for economic reasons and from the perspective of climate protection: On the basis of wide domestic availability, wood as a fuel displays a constant and stable price history. In addition, many people, especially in rural areas, have access to affordable split logs or wood chips. Wood as a fuel can be used in modern wood centralised heating in a clean and efficient manner. Moreover, wood is an indigenous, renewable fuel, which in turn means short transport distances, local jobs and domestic value creation. So, there are good reasons why nearly 20 % of households in Germany nowadays rely completely or partly (in the form of hybrid systems) on wood for heat generation. A fifth of these consumers have centralised wood-fired heating, which is also used for water heating. That is not surprising! Modern automated fireplaces now make the operation more comfortable than ever before. Wood almost matches the traditional fuels, oil or gas, in terms of its comfort.

Good for the forest – good for the climate

A sustainable use of wood has positive effects on the maintenance and protection of the forest: Thinned-out forests are more resistant to environmental effects. And the notions of being close to nature and commercial utilisation do not contradict each other. On the contrary, forests used sustainably generally have a high ecological value. The various wood energy assortments are usually manufactured from non-sawable joint products, which are produced during timber harvesting or cutting in the sawmill. Using wood is also good for the climate. This is because wood, as a renewable resource, is CO_2-neutral: When burned, only the amount of CO_2 that is absorbed by the tree during its growth is released. Only the CO_2 emissions generated when providing the fuel are recorded in the balance sheet.

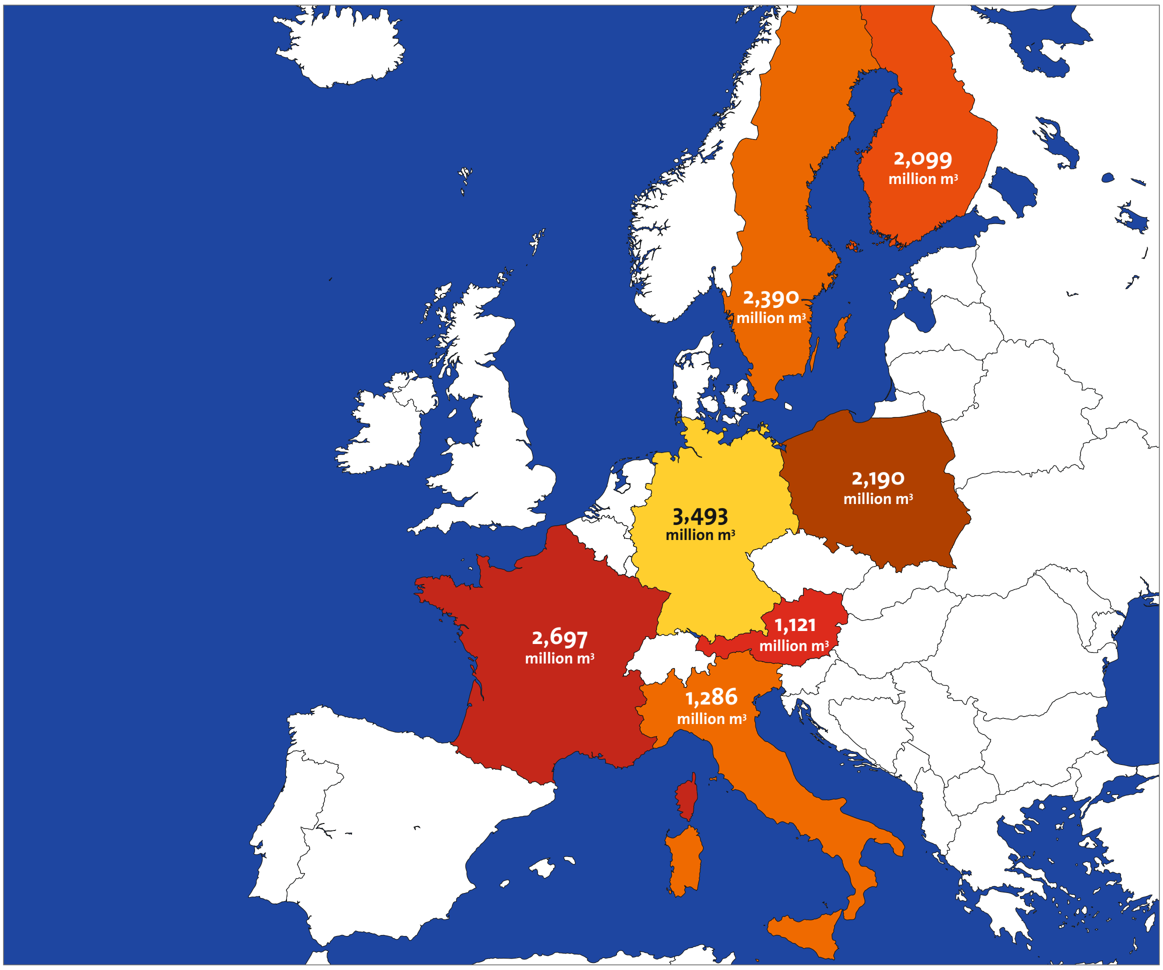


Fig. 11: Wood reserves of selected European countries in 2010

Fig. 12: Pellets

Fig. 13: Split logs

Fig. 14: Briquettes

Pellets, briquettes, split logs and wood chips

Modern heating systems use the energy source wood in the form of pellets, briquettes, wood chips or split logs.

Wood pellets are small, standardised cylindrical pellets made from natural, untreated wood. For their manufacture, the wood chips produced in the sawmill are first dried and then pressed into pellets under high pressure in dies. Lignin in the wood becomes liquid due to the high temperature and binds the wood particles. In many cases, the pellet production is integrated into sawmills. 2 kg of wood pellets correspond to the energy content of about 1 litre of heating oil.

The production of wood briquettes is similar. These are available in various shapes – round, square, with holes or without holes. They are mostly heated in single room furnaces, such as split log burners, open fireplaces or tiled stoves. They are suitable for split log boilers only if the manufacturer explicitly mentions the suitability.

Split logs have also been increasingly used for heating in recent years. Basically, any wood type is suitable for this purpose. To ensure a high energy output and a clean combustion, the wood must be as dry as possible. Two years storage in the open air under a rain shelter are ideal. Wood with a water content of between 15 % and 20 % has an average energy value of 4 kWh/kg.

Wood chips are produced in different ways – either in the forest when cutting the timber from the parts of the tree which cannot be used as recyclable wood, during landscaping, or in the sawmill as waste wood generated from cutting processes. The quality can be very different with regard to various water content and bark proportion.

In addition to their use in energy generation, wood chips are also used in other sectors of the timber industry (e.g., for paper manufacturing).

For quality assurance, the international standard ISO 17225, under which the quality classes and specifications are defined, is applicable for the individual types of wood fuels. For pellets, wood briquettes and wood chips, this standard has been implemented in the ENplus certification, with a few additional requirements, such as for the transport and delivery of pellets.

Sustainably available

Nearly one-third of Germany is covered by forest, and this forest area has been constantly increasing over decades – by about 1 million hectares since the Second World War. The Federal Forest Inventory 3 (BWI 3) has identified an increase of 50,000 hectares of forest for the period between 2002 and 2012.

The forests in Germany have a timber stock of approx. 3.7 billion m^3. Each year, more than 11 m^3 of wood are grown per hectare of forest – this amounts to more than 121 million m^3 over the entire forest area. This puts Germany in second place in Europe, after Russia, and even ahead of the "traditional" forest countries such as Finland and Sweden, where trees grow slowly because of the climate.

One reason for this is a legally secured sustainable management in Germany, which ensures that only as much wood is cut as can be regrown. This economic approach was first described in Saxony in 1713. The BWI 3 has not only identified a quantitative improvement (surface area, reserves) but also an increase in qualitative factors. Forests in Germany have therefore come closer to nature, which can be seen in the higher proportion of mixed forest, more mature trees, a higher proportion of natural regeneration, or an increase in proportion of dead wood.

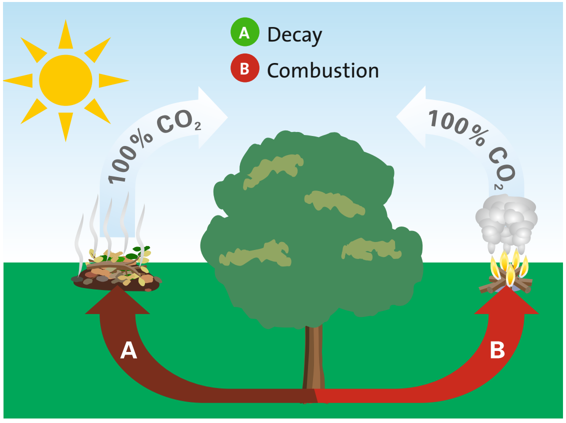


Fig. 15: If there is decay in the forest (A), the same amount of CO_2 is generated as during combustion (B)

Solar Energy

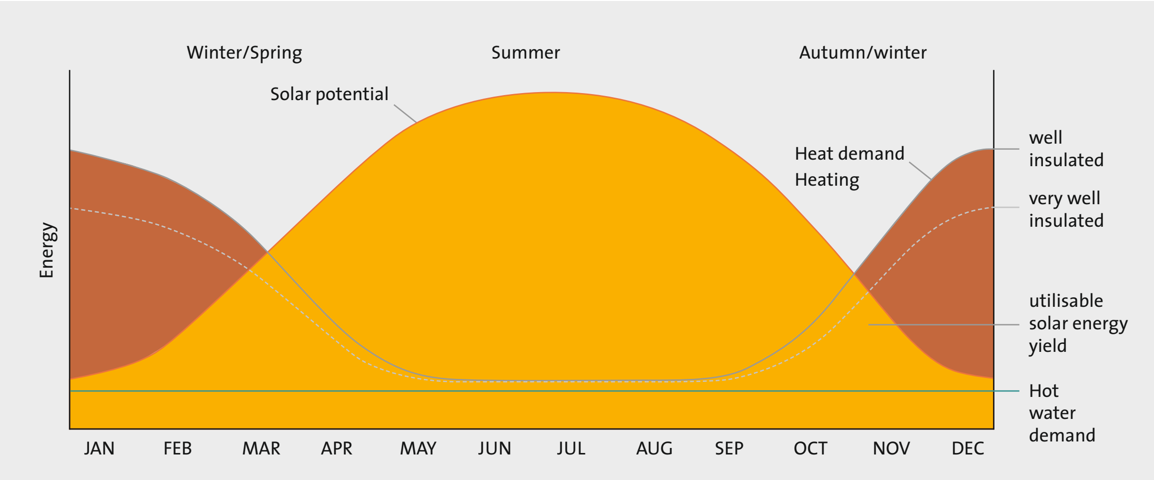


Fig. 16: Usable solar heat of a solar thermal system in Germany during the year

Solar heat: ideal addition for all heating systems

Solar thermal systems are mostly used for domestic hot water heating, auxiliary heating or for heating swimming pools. In Germany, about 60 % of the annual domestic hot water requirement of a single-family home can be met by a solar thermal system of typical size. Auxiliary heating solar systems of typical dimensions cover 10 to 30 % of the total heat demand, depending on the design and insulation of the building, and even up to 100 % for passive houses. State-of-the-art heating technology is a combination of a modern condensing boiler, an efficient heat pump or a central wood-fired boiler with a solar thermal system.

Especially in summer, a modern solar thermal system can supply the entire domestic hot water demand and heat demand of a house. During this period, the heater is switched off. Solar energy for the heating market can provide optimum support for all the primary heat generators available in the market. In addition to domestic hot water heating and auxiliary heating, other applications of solar thermal energy include air-conditioning and process heat, as well as the provision of district and local heating.

Photovoltaic systems: Integrating regenerative power with heating systems

Another use of solar energy is direct power generation using photovoltaic systems. A photovoltaic system is primarily used to partly meet the household electricity demand. Any excess beyond the normal consumption opens up the possibility of generating heating energy. Using this excess current for heating can be more sensible than feeding into the grid. This is all the more true since the feed-in tariff is constantly falling and has by now fallen below 11.5 cents for new plants up to 10 kWp in Germany. The utilisation of the excess PV current is particularly efficient in combination with a modern electric heat pump.

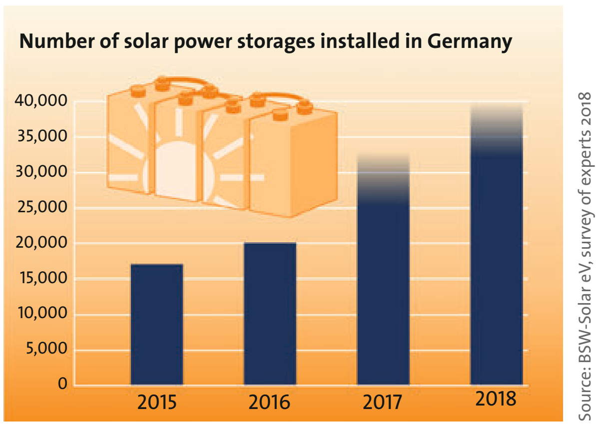


Fig. 17: Trend of the global expansion in photovoltaic systems

Geothermal energy and environmental heat:
Energy from earth, water and air

Both on the national and international level on climate and re- source protection, the application of near-surface geothermal energy and ambient heat are given serious consideration and form an integral part of sector coupling. Application is usually via air-water, brine-water or water-water heat pumps, which draw up to 80 % of the energy for heating and domestic hot water from the ground or the environment, and the remaining 20 % from electric drive energy. The more "green" the electricity becomes, the more environmentally friendly is the heat pump operation. In addition to providing the required heat energy for space heating, heat pumps can also be used for domestic hot water preparation and for lowering the room temperature in summer.

The utilisation of near-surface geothermal energy and environmental heat via heat pump systems can be optimally combined with the "Power-to-Heat" concept. According to this concept, the electricity generated by wind power plants and photovoltaic systems is to be used and stored in the form of heat in the future. The consumption of energy can be adjusted to the power generation using the Smart-Grid-enabled heat pump. As switchable and controllable systems, they can flatten out local power peaks during power generation and store the environmental energy in the form of heat energy. With about 1 million systems in operation, heat pumps provide a lot of potential for use in smart systems even today. Heat pumps are particularly well suited for sector coupling applications at the interface between the electricity sector and the heating sector.

Heat pumps in the cold district heating network:

Similar to traditional district heating networks, the building is provided with a service connection by means of which the heat is supplied to the building in the case of cold district heating network. However, cold district heating networks operate at much lower temperatures (below 30 °C). The temperature level needed for heating and hot water is raised by a highly efficient heat pump in the building. The actual heat source (e.g., groundwater, heat from waste water or from industry, etc.) is in a different location.

Compared to conventional district heating networks, thermal losses can be reduced here, and a high system efficiency is achieved. Cold district heating networks are often used for neighbourhood concepts in new residential areas.

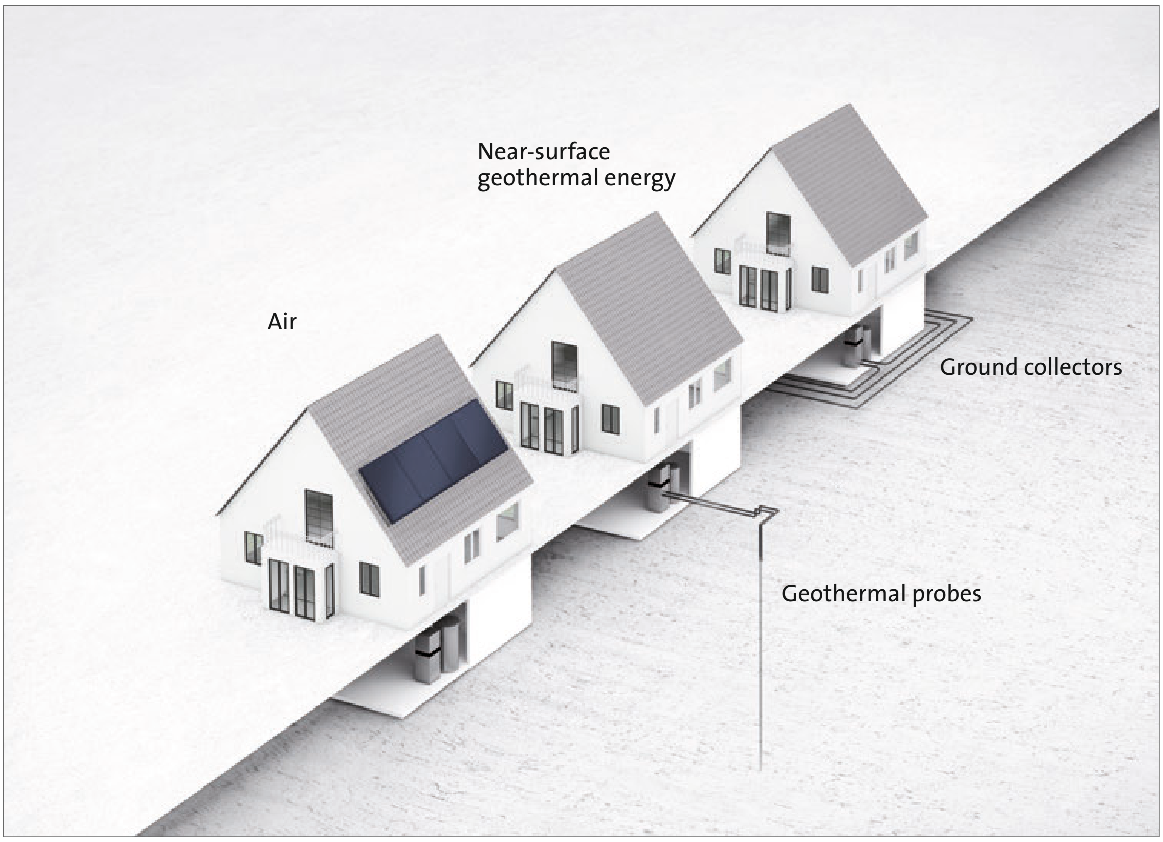


Fig. 18: Various sources of near-surface geothermal energy and environmental heat

Sector coupling: Using the potential of electrical domestic heating systems

Integrating renewable electricity

The word "energy revolution" is generally associated with the use of renewable energies for the production of electricity. But the energy system is more than just the supply of electrical energy: Especially in the heating and transport sectors, the share of renewable energy is low. Fossil fuels still dominate the energy supply. An energy revolution in all sectors can be achieved only if the conversion to renewable energy takes place in each and every sector. This can take place directly in the sector itself, for example, in buildings, using solar thermal heat generation, but also by using renewable electricity from the power generating sector.

Electrical energy can be used across sectors: Electricity is being produced in Germany today to a large part from renewable energy sources, the share of the German gross domestic electricity consumption was 38 % in 2018 according to BDEW. By 2030, the share is expected to be around 65 %. This means that electrical energy will develop into "green energy" in the coming decades. A recent study commissioned by the HEA expert group shows the impact for the year 2017: Both the cumulative energy consumption (CEC) and the greenhouse gas emissions for generating an average kilowatt hour of electricity are continuously reducing. The research institutions have pursued a comprehensive accounting: To determine the CEC, the environmental effects of generating electricity based on "life cycle data" for energy, material and transport systems were taken into account. The "result CEC", i.e., the inclusion of upstream-chain losses up to the primary energy, can be considered as a bridge to the so-called primary energy factors (PEF). PEF are being used by the law makers to evaluate the energy in heating energy sources in the heating market and are crucial for selecting the heating systems in the market.

Many consumers are already using green electricity tariffs and therefore CO_2-free electrical energy. For the integration of these volatile renewable sources, an approach that considers the energy revolution as a whole is required. Only the systemic approach opens up possible solutions that could hardly be developed if isolated sectors are considered. This means that the energy potential of one sector can be used in another sector.

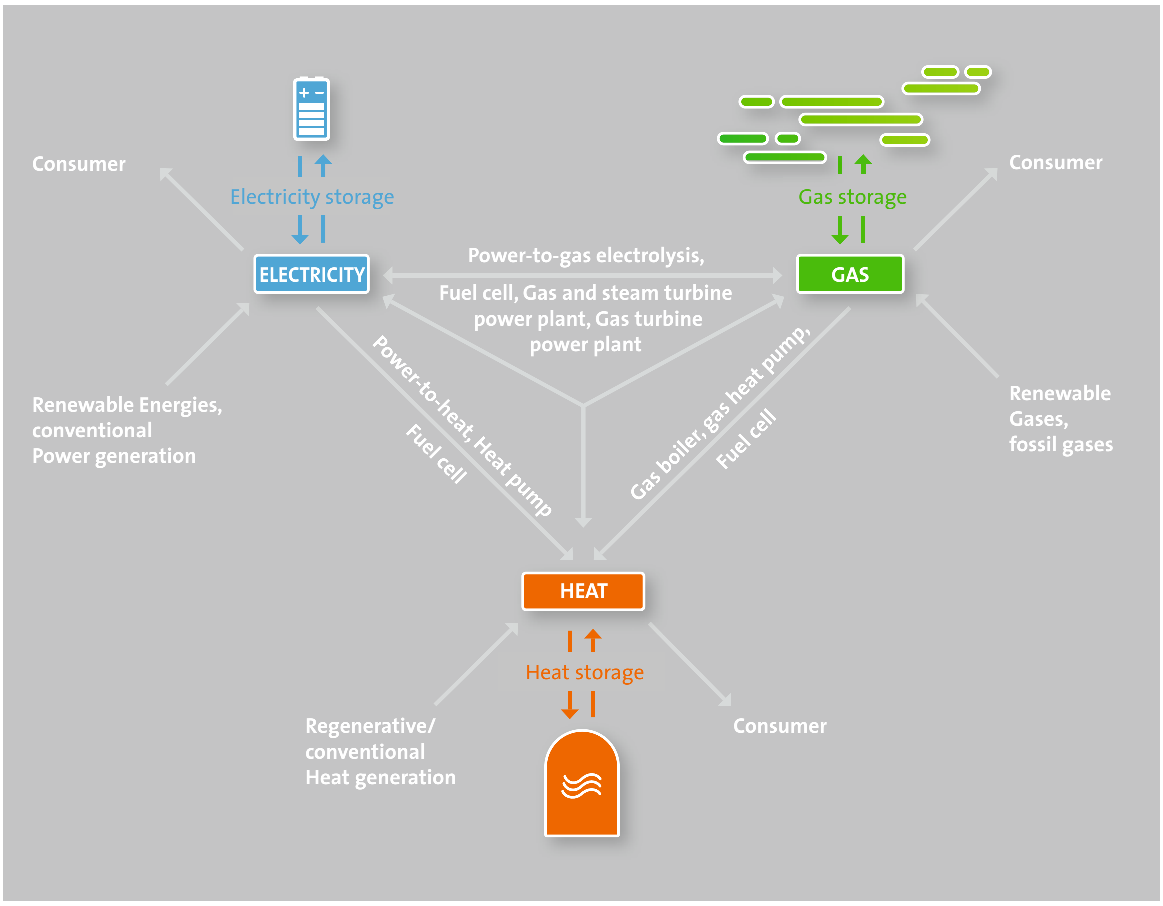


Fig. 19: Sectors and interlinked conversion and storage technologies of a CO_2 reducing energy system

Source: BDEW/DVGW 2018

Old flexibility creates new opportunities

Electricity is safe, flexible and can be used efficiently. In a comparison of international standards, Germany has traditionally been a leader in supply safety. However, electrical energy can only be stored with restriction at present compared to fossil fuels. The sector coupling extends the range of possible conversions beyond conventional storage by including other sectors. The flexible use of electric energy in the heating market is an excellent example in this regard. The heat can be converted for buildings using heat pumps, electronic water heaters or direct electric heating systems. The latter can also be used as a component in hybrid heating systems. In this way, a condensing boiler, for example, can be expanded using a direct electrical heating element in thermal storage which is operated using self-generated PV electricity.

Even the use of existing storage heaters is a good way to store electricity from renewable energy to help the system and then use it as needed. About 1 million storage heating systems are installed in Germany, which represents a substantial storage potential. The storage system is usually charged during the night and the stored heat is again released on the next day at different times depending on the needs of the user. Older systems can be upgraded with a modern charging controller and so operated more efficiently. At present, pilot projects by equipment manufacturers and energy companies are being undertaken where the conventional, fixed charging in the night is removed and replaced with flexible charging times. In this way, storage heaters or even electric hot water storage can take up excess capacity from wind power and reduce the load on the power grid.

By using renewable electricity, the modern electric domestic heating systems make it possible to expand the flexibility of traditional energy sources based on storable energy sources such as coal, oil and fossil natural gas.

Power-to-Heat as a solution across buildings

Harnessing the described electrical energy in the heating sector, also known as Power-to-Heat (PtH), can also be used beyond the limits of buildings. An electrode boiler or heat pump can thereby convert large amounts of electricity of up to several megawatts into heat for supply. Heating networks play an important role in bridging any spatial gaps of heat sources (e.g., in the PtH boiler) and heat sinks (e.g., in private households or businesses). The integration of "green electricity" also increases the proportion of renewable energy sources (RES) in supplying heat to existing buildings in urban areas. The potential is huge. Thus, for example, the RES proportion in the supply of heat in cities is only one percent on average, whereas the RES proportion in heating network systems is 13.6 %. This means that remote heating is already making the urban supply of heat "renewable". PtH systems therefore represent an important building block for decarbonisation of the heating sector in the future.

The networking of heating systems on the micro and macro level

In recent years, digitisation has become one of the top subjects being discussed in heating technology. Today, "digital heating", i.e., a heat generator with a digital interface, is already a standard.

But the use of this interface is just beginning. In the first step, digitisation allowed the heating system to be controlled via a user interface such as a smartphone, and ensured remote operation, more energy efficiency and savings for the customer.

A much greater amount of potential benefit for consumers, tradesmen, industry and society can be realised by implementing the digital interface. Networking has become a central topic here. On the one hand, networking means connecting the heat generator to other systems at the micro levels within the four walls. In addition, however, there is a networking of heating systems as a flexible consumer at the macro level of supply networks.

While heating was previously an isolated product, such networking at different levels provides considerable benefits today, both for the individual end users as well as from the perspective of society.

Networking at the micro level

Within your own home, a comfort-based networking of electrical devices via Smart Home Systems (SHS) has been possible for some time now, for example, in light or multimedia controls.

However, the networking of energy-related products within your own home using a Home Energy Management System (HEMS) is relatively new. This linking includes the local generators (such as photovoltaic system or solar thermal energy), electrical and thermal storage, as well as other energy consumers. Here, heat generation has a very special significance due to the high amount of energy demand for the building and the potential for storing the thermal energy.

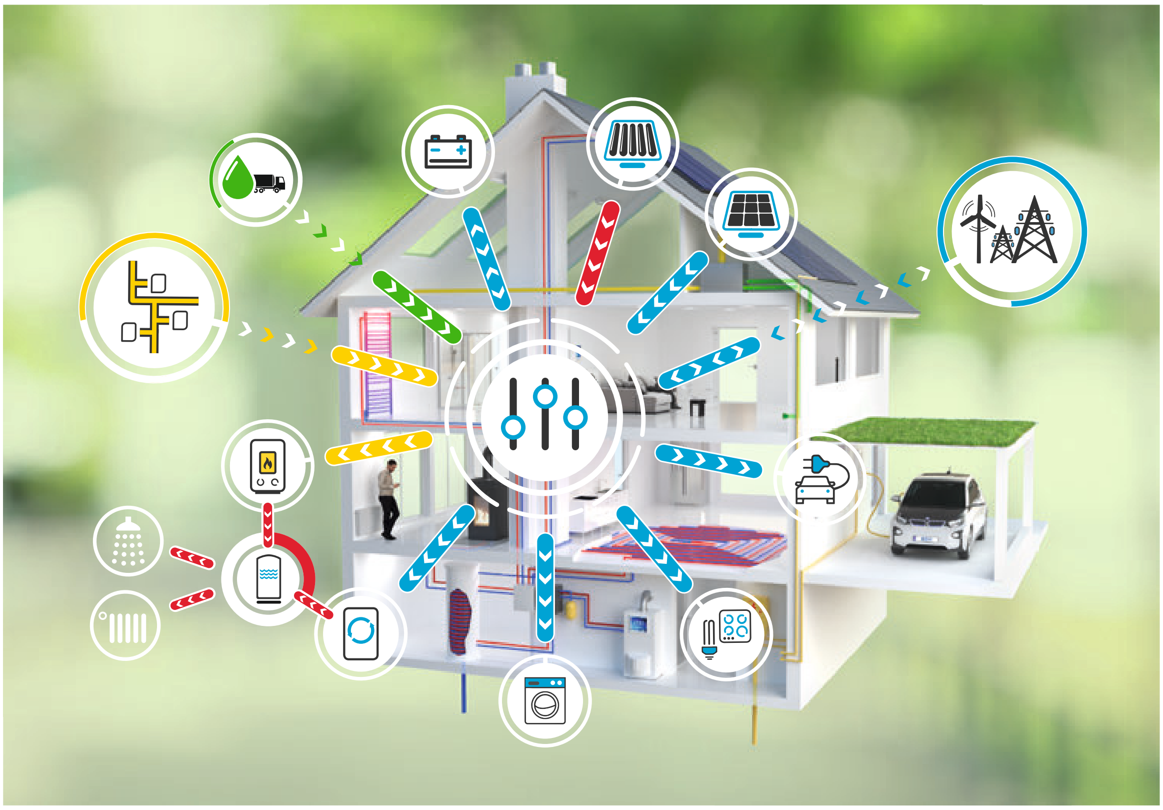


Fig. 20: Networking of energy-related products with an intelligent Home Energy Management System (HEMS)

Home Energy Management System (HEMS)

On the one hand, a Home Energy Management System makes it possible to increase the self-sufficiency level of the building by matching the local generation, storage and consumption of energy to each other. For example, the locally generated PV electricity can be temporarily stored and used later, instead of supplying it to the power grid at a low price and purchasing it back later from the grid at the higher price. The increase in the self-sufficiency level of their own home has a cost-saving effect for the end customer in this way.

In addition, the linking between HEMS and SHS enables a new way of convenient control and visualisation of the energy-related processes at a central control unit within the building. In this way, customer awareness and interest in energy efficiency issues can be promoted.

Networking at the macro level

In addition to the advantages provided by the networking of heating systems at the micro level within one's own home, it is also necessary to look at the overall energy system. A building that uses a Home Energy Management System can still act in a flexible manner even after optimising it to meet the needs of the end user (from the cost and convenience point of view) with regards to procuring and supplying energy. For example, HEMS can vary within certain limits without loss of comfort for the end user, when energy is being drawn from the grid and temporarily stored thermally or electrically if necessary. This flexibility can be provided to the energy system and so can be used to compensate for peak loads in the grid. In the case of variable electricity prices, there would be further cost benefits for the end user.

From the perspective of the energy system, this mechanism may stabilise the grid and reduce the grid expansion costs needed for achieving climate protection goals. Depending on the expansion of electric mobility, the capacity requirements of the distribution network could increase quickly and significantly. In this case, this sort of load management might even be necessary to avoid escalating network expansion costs.

Combining electricity and Power-to-X

But the use of decentralised flexibility in energy generation and consumption will not be able to compensate for the fact that an increasing proportion of volatile energy available from renewable sources is confronted by higher electricity consumption for heat generation and electric mobility as part of the energy revolution and sector linking. To use this energy optimally, a combination of electricity from renewable sources and Power-to-X technology is necessary. The storage and transport of energy from volatile sources are possible using such methods so that supply is ensured in the cold dark seasons. Hybrid heating, which is a heating system that uses both electricity and a gaseous or liquid energy source, allows it to be used in one's own home.

Interoperability between products

An important prerequisite for networking products is interoperability. All the generators, storages and loads in the house will not necessarily be from the same manufacturer. The desire to connect all the energy-related devices to each other, so as to realise the maximum benefits for the end customer, necessarily means that a technical basis has to be established for cross-manufacturer and even cross-industry interoperability between devices.

In addition, a uniform interface has to be designed into the power grid. This interface will be the Smart Meter Gateway.

Furthermore, the networking in the local area, and beyond this into the energy system, requires that maximum security requirements have to be met in order to protect customer data and also to protect it against unauthorised interventions in the system.

These issues are discussed in detail in Chapter 6.


-20
-10
COMFORT
DIGITAL
EFFICIENCY
RENEWABLES

Modern
Heat Generators

- Modern heating systems
- Condensing technology with solar thermal energy
- Heat pumps: Principle and variants
- Hybrid heat pump systems
- Heat from wood
- Power generating heating
- The Fuel cell heater
- Solar thermal systems

Modern
heating systems

Energy efficiency and renewable energies

Today, in the construction of new buildings and the renovation of old ones, optimum system solutions are available to heat buildings using all types of fuels. The correct system ultimately depends on the framework conditions: In addition to legal requirements, particular attention should also be paid here to the heat load of the building, its intended purpose, user behaviour and, of course, the preferences of the building owners. If cooling is also required in summer, then the corresponding cooling load has to be taken into account. Some of the heating systems and their components described below can perform this function.
The systems presented in this brochure for the heat supply of buildings, as well as for domestic hot water and apartment ventilation, are regarded internationally as state of the art. They convert fuels such as gas, oil, wood and electricity very efficiently into heat and also use renewable energies (e.g., solar thermal energy or ambient heat) during this process.

The system concept is always at the forefront

All the components of the heating system must be perfectly matched to be able to realise the energy-saving potential of modern heat generators in an optimum way. Therefore, heat generation, storage, distribution and transfer – if required – are to be considered always as a total system.

Heat generation and heat storage

Heat generation is the starting point for the operation of the heating system: In a centralised heat generator, the fuels (gas, oil, wood or electricity) used will be converted into heat. This is then used for heating and/or domestic hot water heating. Renewable energies are integrated here, including ambient heat, geothermal energy, renewable electricity, wood and gaseous and liquid biomass. In addition, solar thermal energy can be coupled as renewable energy for all systems.
A special feature is shown by cogeneration of heat and power plants (CHP), which are also known as "power-generating heating systems": They generate heat and electricity simultaneously.
The scope of this technology extends from small one-family houses (micro-CHP systems, up to 2 kW_{el}) to apartment houses and medium-sized businesses (mini-CHP plants up to 50 kW_{el}) to the industrial sector. By using such systems, a total efficiency of over 90 % can be achieved.
Installing a hot water storage tank is particularly important as the heat provided by the heat generator is not always immediately used at 100 %. Today, hot water storage tanks form a central component of the heating system and domestic hot water supply system in residential and office

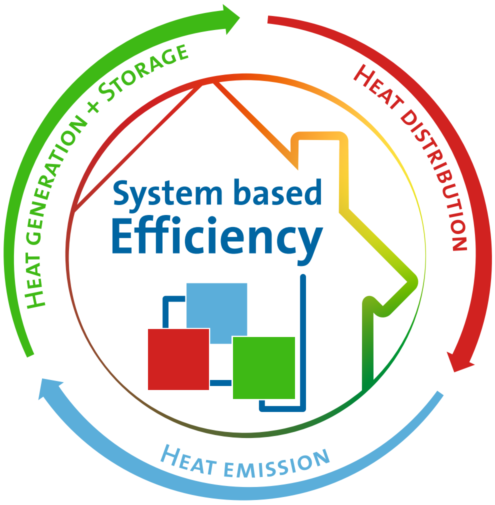


Fig. 21: The system concept is at the forefront

Fig. 22: Interaction between heat generation and storage

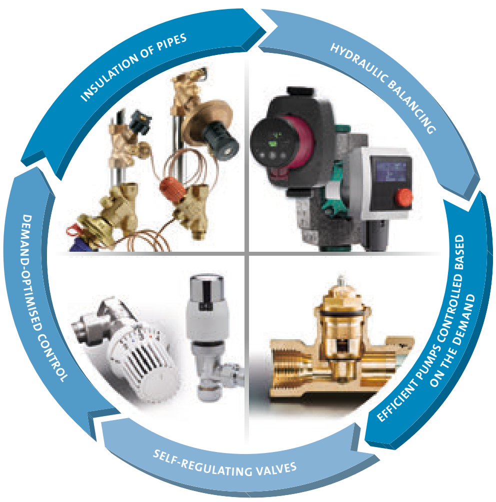


Fig. 23: Influencing factors for efficient heat distribution

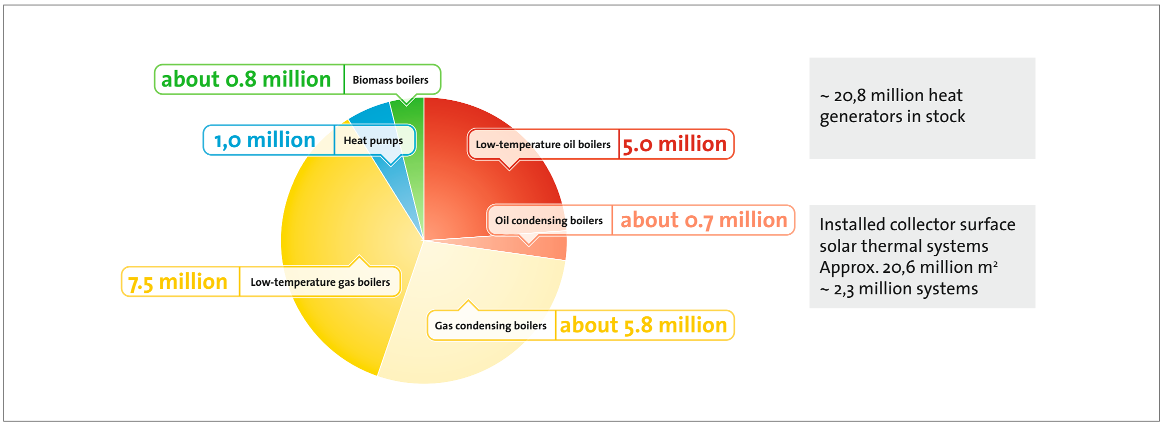


Fig. 24: Total number of centralised heat generators in Germany (2017)

buildings. Thanks to their great diversity of types, they can perform different functions:

- Domestic hot water storage tanks store the heated domestic hot water which is needed for showering, bathing or cooking.
- Buffer storage tanks ensure that the heating system is securely supplied with domestic hot water for a long time. In this way, they permit the coupling of heat from renewable energies and CHP systems.
- Combination storage tanks join both functions together.

The thermal energy losses can be kept low by means of optimised heat insulation of the storage tank, as well as optimised heat transfer and temperature gradient in the storage tank. In this way, hot water storage tanks enable the reliable supply of domestic hot water and heat at intervals of demand and supply.
In addition to the individual heat generators described, a combination of two or more heat generators is increasingly being planned (so-called “hybrid systems”). On the basis of optimised interaction, the strengths of the individual products are utilised for greater operation efficiency.

Heat distribution

The heat distribution forms the link between heat generation/storage and heat transfer. In addition to the pipes, the heat distribution system includes heat circulating pumps, the forward and return flow of the hydraulic heating system, as well as the fittings and regulators.
Efficient distribution of heat in the heating system also requires insulation of the forward and return flow, as well as hydraulic balancing of the entire heating system. For optimum regulation of the ambient temperature, modern thermostatic valves, on the one hand, equipped with pre-settable valve bodies and thermostat sensors with high control quality, are quite suitable. On the other hand, smart, timer-based controllers can be used to achieve accurate control as required. One thing is clear: Only efficient heat distribution allows the reduction of system and indoor air temperatures and high controllability of the system.
Meanwhile, digitalisation has also arrived in the field of heating technology and the described regulators can also be controlled externally, for example, using a smartphone. This allows not only user-specific regulation of the heating system, but can also lead to energy savings when operated optimally.

Heat transfer

The heat transfer is the link between heat distribution and the consumer. Either an embedded surface heating system or radiator is available as a heat transfer system. They can be installed in combination when requested.
Both systems can be combined freely with all types of heat generators of a hydraulic heating system. This makes them sustainable and future-proof.
Low system temperatures in the heating system are a prerequisite for actually achieving the high efficiencies of modern heat generators and for the effective integration of renewable energies. Huge and properly installed heat transfer systems ensure and increase the room's comfort. The various options with regard to the shape, colour and design of radiators allow builders and planners to create an attractive, individual interior design for the residents. Additional functions and smart accessories, such as towel bars or racks, hooks or even lighting, allow the radiators to be used for the deliberate setting of feel-good features.
An embedded surface heating system is installed permanently in the floor, wall or ceiling during the construction phase, thereby becoming an integral part of the building. Apart from heating in winter, it can also be used for cooling in summer. Thus, owners consider them as an investment

Modern heating systems

for the future. The large-area installation allows a uniform distribution of heat in the room and ensures a constantly comfortable ambient atmosphere.

Other components of an efficient heating system

Modern flue gas systems ensure safe removal of the flue gases and low flue gas temperatures, as well as condensate drainage.
For the operation of an oil-fired heating system, modern oil tank systems in a broad range of options are nowadays available to consumers. Today, double-walled tank systems made of plastic are the state of the art.
Solar thermal energy can also be used in all types of heating systems as a support for heating domestic hot water and for central heating.
Independent of the heating system, facilities for controlled residential ventilation with heat recovery reduce the energy demand of the building significantly and, at the same time, ensure the required hygienic ambient conditions in the building. Both centralised and decentralised equipment should be used with heat recovery as appropriate.
Smart control and communication facilities enable the optimal interaction of all components. The heating can be remotely controlled and diagnosed via radio or online access. This makes operation extremely convenient.
However, the optimised use of modern heating systems should always be regarded in conjunction with the energy-related quality of the building shell.

Fig. 25: Influencing factors for efficient heat transfer

Examples of modernisation in the energy field are shown on pages 76–81, using a typical, partially renovated single-family house constructed in 1970. The examples are to be understood as an approximation, considering the improvement that can take place in the quality of energy in the heating system. In the next step, an energy consultant and/or a heating specialist firm should be consulted. The following energy-related modernisation measures are taken into account:

Renovation as per the KfW Efficiency House-70-Standard, controlled residential ventilation with heat recovery	
Pages 76–77	**Variants with gas/oil condensing boilers**
	Modern gas/oil condensing boiler
	Modern gas/oil condensing boiler with solar domestic hot water heating and auxiliary heating
	Modern gas/oil condensing boiler with solar domestic hot water heating and auxiliary heating, renovation as per the KfW Efficiency House-70-Standard, controlled residential ventilation with heat recovery
Pages 78–79	**Variants with heat pumps**
	Modern air-water heat pump
	Modern brine-water heat pump
	Modern air-water heat pump, renovation as per the KfW Efficiency House-70-Standard, controlled residential ventilation with heat recovery
Pages 80–81	**Variants with wood burning systems/CHP systems**
	Modern gas/oil condensing boiler with solar domestic hot water heating and incorporation of a wood burning stove/pellet stove with collection basin
	Micro CHP system with gas condensing boiler
	Modern pellet/split log boiler with solar domestic hot water heating

Fig. 26: Modern heating systems

Condensing technology
with solar thermal energy

Gas-fired condensing technology with solar thermal energy

The scope of application of fossil fuels in the building sector is mainly determined by their compatibility with renewable energies. Natural gas technologies can be best operated in combination with solar thermal systems.

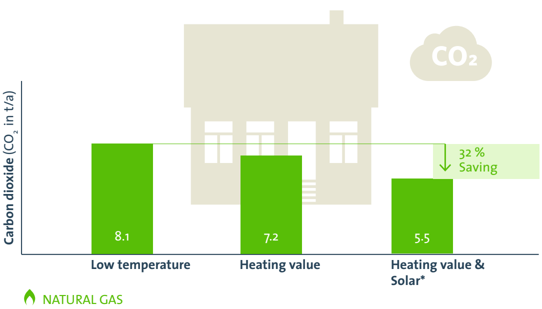
Solar thermal energy for heat generation

As against photovoltaic systems, which generate electricity using solar energy, solar thermal energy supports the process of heat generation. This heat can be used for preparation of domestic hot water and also for heating rooms.

In a four-person household, a solar thermal system with a collector area of 4 to 6 m² can provide up to 60 % of the energy required for the preparation of domestic hot water over the year. Today, more than 2.32 million solar thermal systems are installed in Germany. Since 2006, their number has increased by more than double. For new buildings, natural gas condensing technology based on solar thermal energy is one of the most favourable heating options for builders, considering the investment as well as heating costs.

Preparing domestic hot water using solar energy is the most common use of solar energy. The installation of a corresponding system is easy and cost-effective and the system itself is sufficiently variable to work efficiently for large households as well as in smaller one-family houses. During the summer months, the required domestic hot water is generated almost exclusively with solar energy. In the colder months, the gas condensing technology bridges this gap efficiently. The system operates even more efficiently if the solar thermal energy is also used for auxiliary heating.

Source: www.zukunft-erdgas.info



* Domestic hot water preparation and heating support
Source: GWI 2017, values based on small single-family houses

Fig. 27: Modernisation with gas condensing technology. A third of the CO_2 can be saved

Condensing vs. low temperature – less fuel, better output

Low temperature boilers are widespread in German boiler rooms and still often do a good job. Although newer low-temperature heaters consume 20–30 % less fuel than the standard and constant-temperature boilers of the 1970s, a lot more is technically possible today.

Unlike low-temperature technology, condensing boilers use the hot water vapour generated during gas combustion to improve their output. In contrast, a low-temperature boiler is designed in such a way that no condensation can take place. The flue gases, which are at a temperature of up to 200 °C, escape unused from the chimney. About 10 % of the energy used is lost in the form of water vapour contained in it.

Another difference lies in the operating principle itself: Low-temperature heaters heat the boiler water to 40–75 °C, depending on the ambient and desired room temperature. If it is cold outside, higher flow temperatures are necessary. Compared to this, the condensing boiler provides its output independently of the ambient temperature. Compared to a low temperature heating system, savings of up to 32 % are possible if solar thermal energy is additionally used. An even higher value can be achieved in case of a standard boiler. Therefore, the costs of replacing a low-temperature heater is almost entirely covered by the lower consumption.

Efficient heating with oil condensing technology and renewable energies

Oil-fired condensing boilers are among the most efficient heating technologies. The highlight: While older heaters exhausted hot flue gas to the chimney, modern condensing boilers use the energy contained in it for heating. Condensing technology cools the hot flue gases to the extent that the water vapour generated during combustion condenses. Heat is also released in the process. This is the advantage of condensing technology: It uses the heating oil more efficiently. It is converted into heat almost without any losses. If old heaters are replaced with a new oil-fired condensing boiler, they can consume up to 30 % less energy. This also reduces the amount of greenhouse gas emitted by up to 30 %.

Efficient oil-fired condensing technology is suitable for both, heating modernisation – where it offers oil users a relatively cost-effective entry into energy transition – as well as new buildings.

Same principle, same efficiency

Oil and gas condensing technology are equally efficient: The maximum utilisation factor of 98 % applies to both variants, because they work according to the same principle. Different degrees of utilisation or efficiency do not depend on the fuel, but on the design of the boiler. The energy used can never be fully used, since surface, cooling and exhaust gas losses cannot be completely avoided in practice.

Ideal partner for renewables

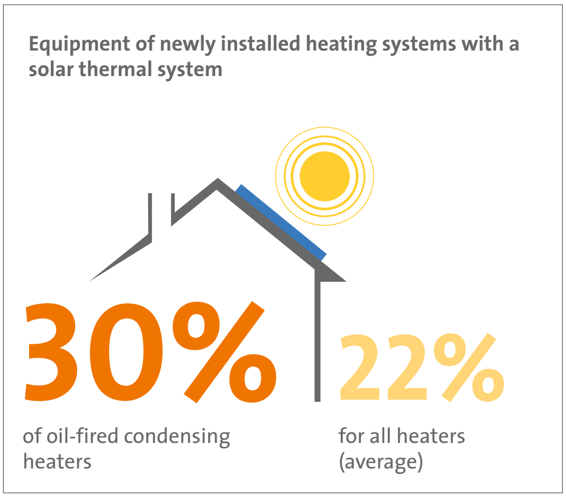
The integration of renewable energies offers further potential savings. Oil condensing technology is an ideal partner for renewable energies. The basic principle is simple: Any available renewable energies are used. Nevertheless, the oil heater automatically and reliably pitches in when the sun does not shine or the wind does not blow. Therefore, a hybrid heating system always links at least two energy sources, such as heating oil with solar thermal energy, firewood or renewable electricity. With such a combination, owners of oil heaters can easily contribute to energy transition.

Here they are most successful: Modern oil-fired condensing boilers are in a disproportionately large number coupled with solar thermal systems. About one third of the newly installed oil-fired condensing boilers are combined with a solar system – a higher proportion than with all other energy sources. In addition to domestic hot water heating, solar energy is ideally suited as auxiliary heating in single and two-family homes. Particularly in single-family homes, it is attractive to use the solar system for preparation of domestic hot water in the kitchen and bathroom. Up to 40 % heating oil can be saved in buildings with low heat demand and embedded surface heating systems, such as floor heating. Up to 50 % savings are possible if a fireplace stove is also integrated into the heating system in addition to the solar system. This way, in the summer months, the energy required for hot water can be generated almost exclusively by solar energy. During the transitional period and in winter, the wood-fired stove contributes to the heating of the building. The oil heating system is automatically switched on only when the solar system and the stove can no longer cover the heat demand.

Of course, biomass by itself already contributes to savings: Especially during springtime and autumn, a stove next to the efficient oil-fired condensing technology offers the ideal heating facility in the living room. If more than one room is to be heated with split logs or pellets, some stoves can feed their heat into a buffer storage tank and also make it available for the entire building and for domestic hot water heating.

Power-to-heat:
Cross-sector application of electricity and heat market

Heating-oil-based hybrid systems offer a good opportunity to also use electricity from wind power and photovoltaic plants that is otherwise down-regulated for heating purposes – in keeping with the cross-sector coupling of electricity and heat market. Until now, wind power and photovoltaic systems are down-regulated if they produce more energy than the power grid can assimilate. This current can be absorbed by power-to-heat module and used for the heat supply. Oil condensing boilers require only a hot water storage tank, in which the water is heated with an electrically operated heating element. The necessary technology could be installed as part of a heating modernisation project. There are still some hurdles to be overcome before this new heating technology kicks off and the solution is ready for mass use. And of course the legislators as well must do their bit.



Source: IWO Plant Engineering Survey (business year 2015)

Fig. 28: Hybrid systems in modernisation of heating systems

Heat pumps:
Principle and variants

Free environmental energy from air, water and earth

With the help of a heat pump, the regenerative energy stored in the ground, ground water or air can be used for heating purposes.

The working principle of a heat pump is identical to that of a refrigerator or freezer. The refrigerator uses the effect of heat extraction. The heat extracted from the refrigerated product is delivered to the room as a “waste product”. In the case of the heat pump, the heat generated from the environment heats the hydraulic heating system.

A refrigerant is evaporated by absorbing heat from the environment. The refrigerant vapour is then compressed in a compressor. This increases the pressure and temperature of the refrigerant. The absorbed heat is now at a usable temperature level and is released to the heating water. Here, the refrigerant condenses and then expands in the expansion valve, and the cycle starts again.

Electric heat pumps use electricity as a drive energy and are very economical. A heat pump with a coefficient of performance of 4.0 can generate four kilowatt hours of heat from one kilowatt-hour drive current. The heat pump must be designed precisely to match the individual heat demand, so that it can actually achieve this high efficiency in daily operations.

Heating, cooling and ventilation

The higher the source temperature, the more efficiently heat pumps work. It is therefore worthwhile to use a heat source with a temperature as high and constant as possible. State-of-the-art heat pumps heat up drinking water as required, and can be used to ventilate and cool a building, depending on the model. If the heat pump obtains its power from renewable sources such as wind power or photovoltaic system, it is also emission-free and contributes even more to climate protection.

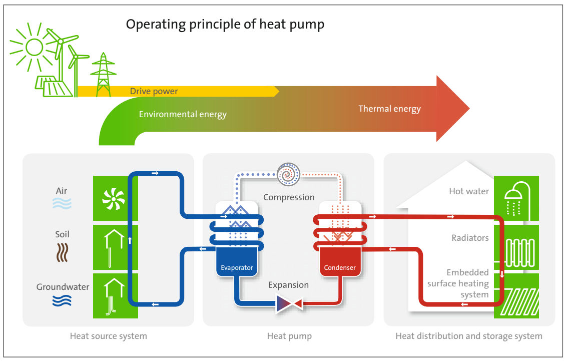


Fig. 29: Working principle of an electrically driven heat pump

Many power supply companies also offer special tariffs for operating heat pumps.

Three versions of heat pumps

Brine-water heat pumps

With brine-water heat pumps, the heat from the earth (geothermal energy) is principally used as the heat source. There are mainly two ways to use geothermal energy near the surface: Geothermal probes (Fig. 30) and ground collectors.

Geothermal probes are inserted into the ground through holes of up to 200 m (usually up to 100 m) and make use of an average ground temperature of about 10 °C. Approval has to be obtained from the water authorities for probe holes up to 100 m and from the mining authorities if the holes are deeper. If the plot is large enough or if drilling is not possible, the geothermal energy can also be tapped using a flat plate collector that is placed at a depth of about 1.5 to 2 m.

Brine-water heat pumps use “brine” to tap the heat source. This liquid is a mixture of water and anti-freezing agent and circulates in the geo-thermal probes or in the flat plate collector.

The heat extracted from the ground is transferred to the relevant heating system after raising it to the heating water temperature. Brine-water heat pumps can achieve a coefficient of performance of up to 5.0 and more. They are available in different designs, with and without integrated domestic hot water storage tank.

If a cooling function is part of the heat pump, it can also be used to heat rooms in summer: The cycle is then reversed and the heat removed from the rooms is discharged via the geothermal probe or the collector. If probes are present, even passive cooling can be used in which the refrigeration cycle is not operational.

Water-water heat pumps

In the water-water heat pump, the heat is extracted from the groundwater. A suction well conveys the water for heat recovery and the heat pump transfers the energy contained in the water to the heating system. The cooled water is then returned to the groundwater by means of an injection well. An annual coefficient of performance of over 5.0 can be achieved because the water-to-water heat pump uses the nearly uniformly high temperature level of the groundwater of about 10 to 15 °C. Permission must generally be obtained from the local water authorities for installation.

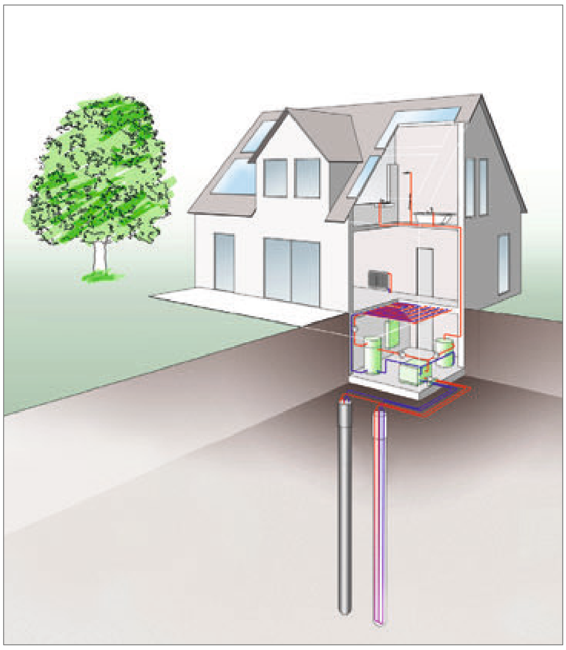


Fig. 30: Brine-water heat pump with ground probe

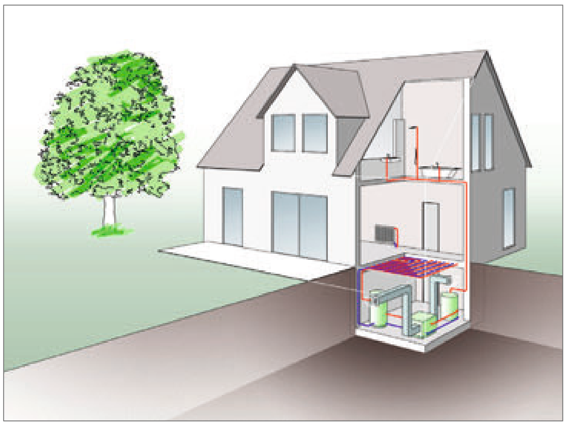


Fig. 31: Indoor air-water heat pump/monoblock

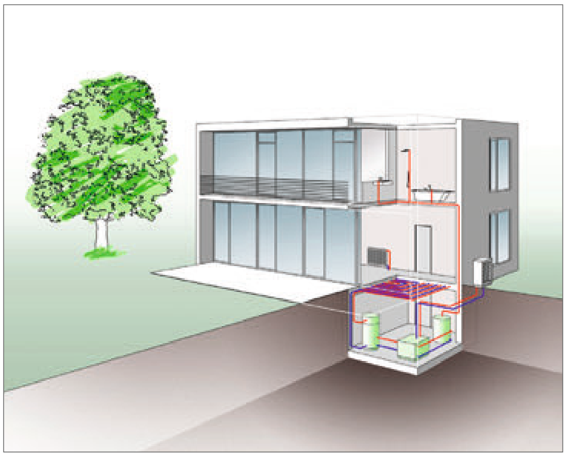


Fig. 32: Outdoor air-water heat pump/Split system

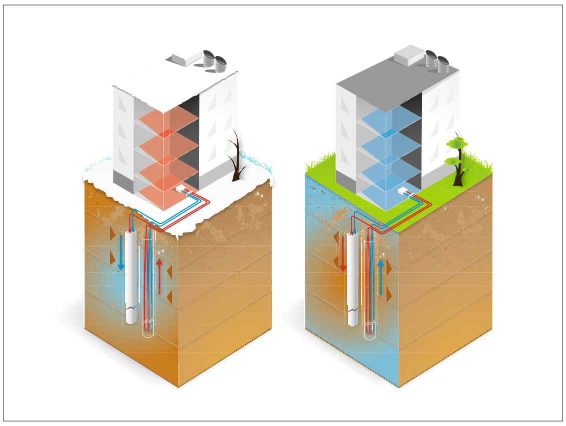


Fig. 33: Illustration of heat or cooling distribution of a heat pump in heating mode (left) and in cooling mode (right)

Air-water heat pumps

Air-water heat pumps extract the heat from the surrounding air. They can draw energy from the outdoor air even if the temperature is –20 °C or less. The investment costs of an air-to-water heat pump are lower because tapping the heat source is not required. Due to the fluctuating ambient air temperatures that are also low during the heating period, a decrease in efficiency must be expected. Air-to-water heat pumps achieve a slightly lower annual coefficient of performance between 3.0 and 4.0 because the temperature of the heat source fluctuates and is often lower during the heating period than in other types of heat pumps.

Cooling via heat pump

Basically, two different types of cooling have to be distinguished with heat pumps: active cooling where the compressor of the heat pump is operational, and passive cooling where the heat source is directly used. Therefore, only earth and groundwater-coupled systems can be used in passive cooling. In the case of active cooling, the refrigerant circuit of the heat pump has to be reversible. This is possible with all the heat sources.

The particularly efficient passive cooling usually takes place by means of floor or wall heating. The excess room heat is therefore absorbed via the pipe system of the embedded surface heating system and dissipated into the ground via a heat exchanger (Fig. 32).

Hybrid heat pump systems

Optimum combination for optimised heating

Hybrid heat pumps are heating systems with an electrically operated heat pump in combination with one more primary heat generator (e.g., oil, gas or solid fuel boiler) and one comprehensive control system. Hybrid heat pumps are available either as compact devices for use in single-family and two-family houses or are assembled together from individual components as bivalent systems for multi-family houses.

Functionality Flow temperature of the heating system (heating and preparation of domestic hot water):

If the heat pump is unable to provide the flow temperature required for the heating system throughout the year on its own, or the efficiency is low due to low ambient temperatures, the second heat generator switches on. The hybrid heat pump offers a economic variant.

Heat output (heating and preparation of domestic hot water):
If the heat pump is unable to provide the essential heat output throughout the year on its own, the second heat generator helps in covering the peak load.

Temperature of the heat source:
If the minimum permissible heat source temperature is fallen short of (e.g. when an air-water heat pump is used in colder regions), the hybrid heat pump system balances the temperature difference.

There is a number of good reasons for using hybrid heat pumps

Optimisation of operating costs:
Depending upon the current energy prices, the hybrid system can determine on its own, which heat generator should be operated, thus reducing the operating costs.

Minimisation of CO_2 emissions:
For minimising the environmental burden, the hybrid system independently decides, depending upon the expected CO_2 emissions, which heat generator features minimum environmental burden at the current operating point.

Long-term sustainability due to gradual renovation:
An option for step-by-step modernisation and for clearing the renovation backlog, is to extend the existing heating system with a heat pump. By subsequent renovation of the building envelope, the heat load of the building reduces and the existing boiler can be put out of operation at a later point of time.

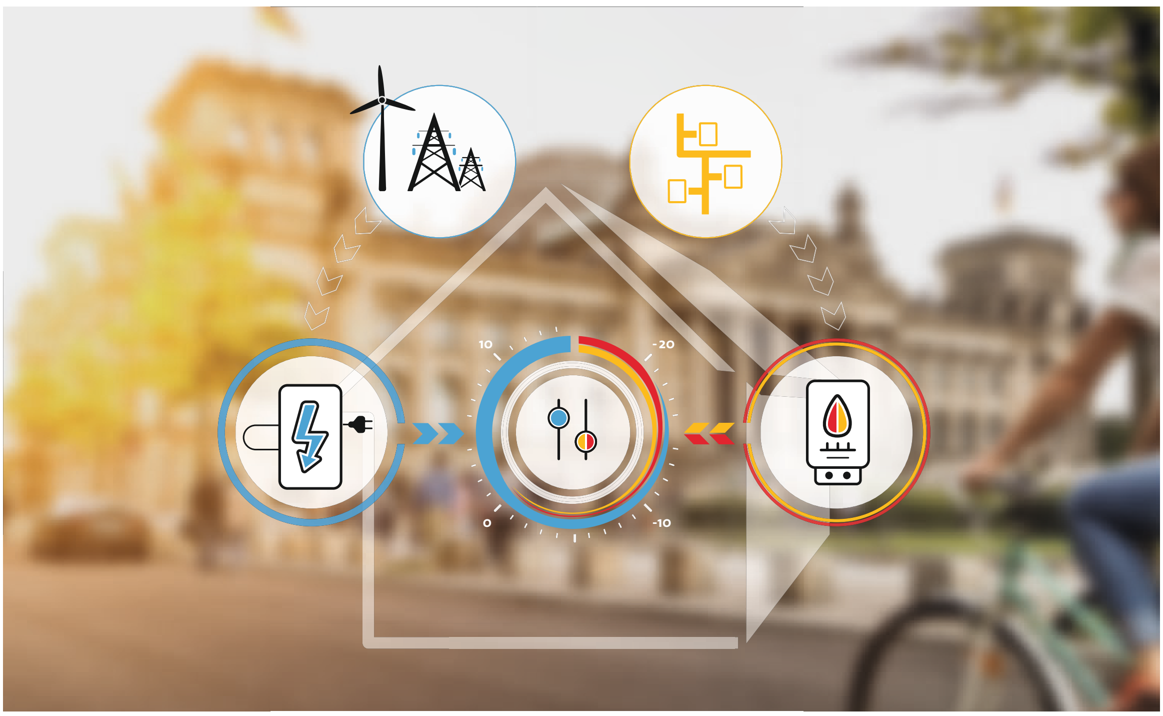


Fig. 34: Hybrid heat pump as technology for linking sectors

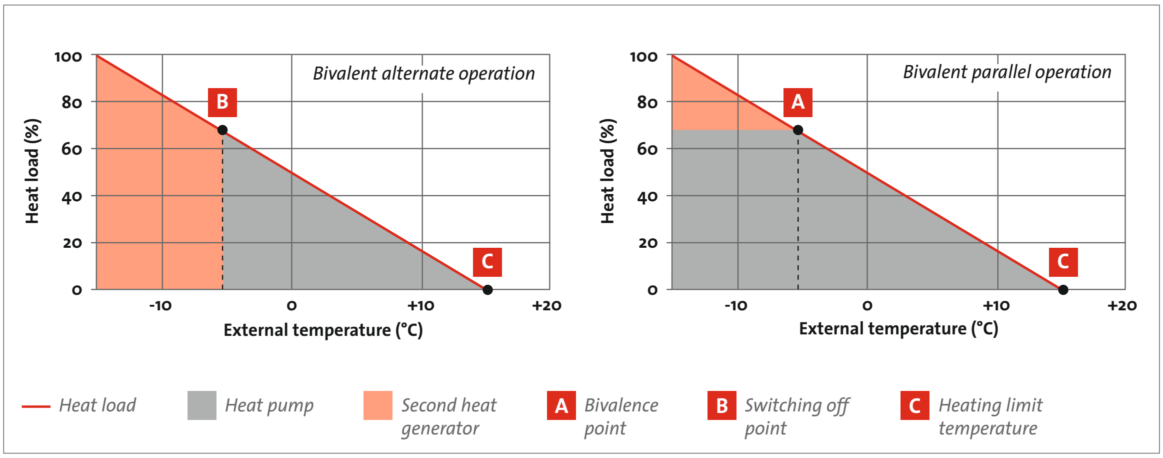


Fig. 35: Illustration of common operating modes for hybrid heat pumps

Fig. 36: Control selects the desired mode of operation

Fig. 37: Hybrid heat pump with split outdoor unit

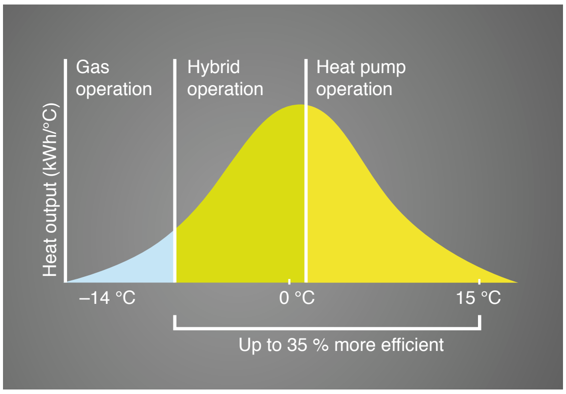


Fig. 38: The hybrid heat pump system automatically selects the most efficient mode of operation

Modes of operation for the production of thermal heat in the hybrid heat pump (Fig. 35):

- Bivalent parallel operation
  Above the bivalence point, the heat is provided exclusively via the heat pump. Below the bivalence point, other heat generators are simultaneously operated with the heat pump.
- Bivalent alternate operation
  Above the switching off point, the heat is provided exclusively via the heat pump. Below the switching off point, other heat generators are used, which provide the entire thermal heat.

A variable system with a wide range of applications

Hybrid heat pumps are suitable for installation in new as well as existing buildings. They guarantee that the building is heated at the most favourable prices at any given point of time; because they can easily react to any fluctuations in the energy price by using the second heat generator. This function is generally integrated in the regulators of most of the hybrid heat pumps.

Basically, hybrid heat pumps could help to clear the existing modernisation backlog. Hybrid systems become “Renewable Energy Heating systems” when high quantities of electricity from renewable energy sources (Renewable Energy Electricity) and high amounts of Power-to-Gas (PtG) and Power-to-Liquid (PtL) are used in natural gas or heating oil.

Heat from wood

Pleasant warmth from nature

Modern heating systems were operated for many years almost exclusively with oil or gas. Today, a fuel with a long tradition is used more intensely again: Wood is a constantly renewable resource, which can be obtained relatively easily with little energy expenditure. Especially in Germany, which follows the principle of sustainable forestry, not more wood is cut from forests than is regrown. This makes wood particularly environmentally-friendly. Moreover, thanks to the high volume of wood in Europe, the long-term supply of wood is secured.

Wood can be used in various forms for heating: The most common is the use of split logs, wood pellets and wood chips. Wood is suitable for heating individual rooms and as a fuel for central heating of the entire building. The heat demand, the storage options, manual labour associated with the wood and the individual preferences of the owners and residents are primarily decisive factors for the selection of the firing installation.

Feel-good warmth – thanks to CO_2-neutral wood single room furnaces for the living space

Two effective device types are available for the heating of individual living rooms: air-guided living room devices and living room devices with collection basins. In both types, split logs and wood pellets or wood chippings are especially used.

Air-guided living room devices

This category includes especially wood burning stoves and pellet furnaces: Both fireplace types burn wood or wood pellets in a separate firebox. Air ducts in which the indoor air heats up go past the combustion chamber. The indoor air is then passed back into the living room.

Moreover, the furnace itself dissipates radiant heat which is felt by many people as particularly pleasant.

These single-room furnaces with direct heat radiation have an output range of up to 10 kW. They are used primarily for heating individual rooms, as additional or transitional heating and to cover peak loads

Living room devices with collection basin

In living room devices with so-called collection basins, heating water circulates inside the fireplace. The devices are integrated into the centralised heating and hot water system of the house via a built-in heat exchanger. In addition to direct heat dissipation to the installation area, heat is also generated in the fireplace for auxiliary heating and/or for the preparation of domestic water.

Especially in low energy houses, such pellet or wood burning stove with collection basin can significantly relieve the load off the main heat generator.

Fig. 39: Pellet furnace with pellet storage container

Fig. 40: Split logs as CO_2-neutral fuel

1. Primary pellet furnace
2. Adapter assembly for hydraulic connection of the furnace to the buffer storage tank
3. Central heat generator
4. Buffer storage tank
5. Hot water consumer
6. Radiators
7. Solar collectors

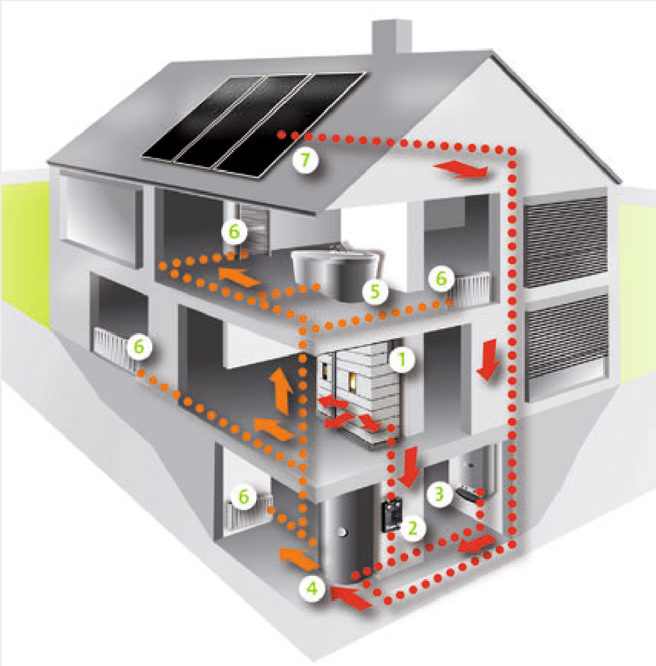


Fig. 41: Pellet stoves and split log stoves with collection basin can be integrated into the heating system

If living room devices with collection basin have to be used for preparation of domestic hot water, they should also be in operation throughout the year – even during summer – when heating of the indoor air is not necessary. Therefore, this heating system is best combined with a solar thermal system: Thus, each of the two heating systems can prove its unique strengths during the appropriate season and completely replace the central heating system in the passive house.

Example: Pellet furnaces for the living room

Pellet furnaces for the living room offer numerous advantages: The pellets are led automatically from the storage container directly into the furnace. The control is electronic – depending on the desired room temperature. It is more accurate, convenient and efficient and features better emission properties as compared to manual firing.

Heating devices of the latest generation have high efficiencies of over 90 %, radiate a pleasant warmth and have low emissions.

Interested parties can choose from a large selection of models in different designs, sizes and price categories. The use of modern control systems, such as indoor or time-controlled thermostats, makes automatic operation particularly convenient. The latest generation of devices can even be controlled via the Internet from any device with a web browser, such as a PC, tablet or smartphone.

Depending on the model, operation that is independent of the indoor air is also possible. This allows the use in modern buildings with controlled residential ventilation, such as low-energy and passive houses.

Heat
from wood

Wood-based central heating

From single-family or multi-family house to commercial enterprises and local heating grid: Modern wood-fired central heating systems provide buildings of all sizes with heat. The big advantage: By using renewable wood as fuel, the generation of heat is climate-friendly since it is almost CO_2-neutral. Attractive government subsidy programs, low fuel prices, and the positive evaluation in the Energy Saving Ordinance (EnEV) are further plus points. In addition to automatic wood-based central heating systems for wood chips and pellets, there are also hand-fed split log boilers. A common factor is the advanced technology and the resultant efficient and low-emission combustion. Modern wood-based central heating boilers are also available as condensing boilers today.

Split log boilers

The two stages of combustion (gasification and combustion) run locally separated from one another in modern split log boilers, also called wood gasification boilers. This efficient technology ensures a high degree of efficiency, low exhaust gas temperatures and low emissions. It is important that the heat exchange surfaces of the boiler are adequately dimensioned. The suction fan and combustion air system are responsible for correct and adequate air supply. While the primary air duct secures optimum wood gasification and therefore, the output, the secondary air feed ensures complete combustion of the wood gases and thereby ensures low emissions.

A suitably dimensioned buffer storage tank is not only required by law, but also technically necessary, because current split log boilers operate intermittently. The boiler is filled and then the fuel is completely burnt within several hours, after which it is filled again. The buffer storage tanks allow replenishment intervals once to twice daily, even in winter. This ensures a noticeably higher heating comfort.

Wood chip boilers

As in the case of pellet heating systems, the combustion material in wood chip heating systems is also automatically transported from the storage room to the heating boiler – often with a screw conveyor or using a similar technology. A microprocessor-regulated controller constantly controls the combustion to achieve high system efficiency. When controlled in such a way, even varying fuels do not have a decisive influence on the combustion values, and power adjustment to approx. 30 % of the nominal heat output is possible.

The output range for wood chip central heating systems range from about 20 kW to several megawatts. Because the economic feasibility of a wood chip heater increases with its size, it is often used in multi-family homes, restaurants or large residential or business complexes. Wood-processing and agricultural companies very often use wood chip heating systems, because the short transport distances of the fuel increases the benefits of the system.

Fig. 42: An automatically fed wood chip heating system with spring core space discharge and screw conveyor for transporting the fuel

Fig. 43: An automatic pellet heater is shown here without a discharge system

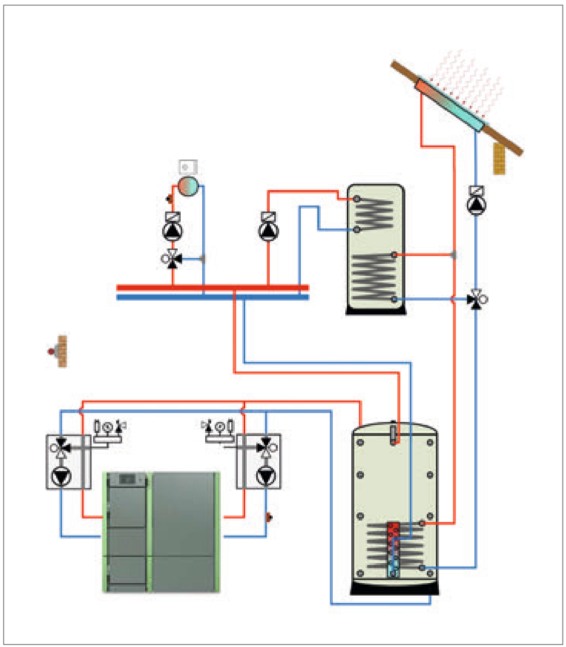


Fig. 44: Schematic representation of a combined boiler (split logs/pellet) with system storage tank, domestic hot water storage tank and integrated solar thermal system

Pellet boilers

Pellet central heating systems are a particularly convenient method of generating heat from wood. As a rule, the wood pellets come from the storage space or tank to the boiler via a suction system or a screw conveyor system. The wide range of options for flexible discharge and supply techniques makes it suitable for almost any building. Pellet heaters are therefore suitable for both existing and new buildings. With low emissions and fully automatic operation, pellet boilers achieve high efficiencies of over 90 % (lower heating value). Pellet condensing boilers achieve efficiencies of up to 105 % (lower heating value). The modular capacity and the compact storage of fuel make them comparable with oil heaters in terms of convenience and areas of application.

Heat from wood in the hybrid system

Wood central heating systems can easily be combined with solar thermal systems and therefore become even more climate friendly. If both the systems are used together, the wood heating system will be the primary heat source. When space heating is not required, e.g., in the summer months, the wood heating system remains switched off and the solar system supplies the hot water. Even in winter and in the transitional seasons, the solar thermal system can significantly support the wood boilers. In doing so, one buffer storage is sufficient for both systems. This receives the energy from both the solar thermal system and the wood boiler.

However, a wood heater can also be combined with other heat generators. In most cases, this is a combination of a split log boiler with an automatic pellet, oil or gas-fired heater, which serves as a "backup" or to cover brief durations of peak loads (so-called hybrid systems). If the generated heat output of the split log boiler is too low – for example, because there is no one at home to replenish them – then the pellet heater starts automatically.

Power
generating heating

Generates not only heat but also electricity

Conventional heating systems work according to a clear principle: The used energy medium is converted into heat. In so-called decentralised cogeneration of heat and power (CHP), the device generates electricity and heat simultaneously. This saves fuel and increases the fuel efficiency of the system. Very high overall efficiency of over 90 % can be achieved through simultaneous production of electricity and heat. Losses due to waste heat, resulting in separate power generation in power plants, are avoided. Local and district heating systems are not needed.

A power-generating heating system reduces energy costs and the primary energy demand, as well as climate-damaging CO_2 emissions. Thus, it makes a direct contribution to environmental protection. In many countries, the use of decentralised CHP is particularly encouraged. Generally, self-generated electricity is subsidised. In addition, there are investment subsidies for installation, incentives when paying taxes on energy, as well as separate tax depreciation options.

Fields of application and their advantages

The range of decentralised CHP solutions is very broad:

- For single and two-family houses, there are so-called “micro-CHP systems” with an output range of up to approximately 2 $kW_{el.}$
- In apartment houses and small and medium-sized businesses, “mini-CHP systems” with power outputs up to 50 kW_{el} are used.
- In the industrial sector and large residential complexes, CHP systems with more than 50 kW of electric power are used.

The decentralised CHP is used in heat, electricity and grid driven modes. In the **heat-oriented** mode, the system is designed depending on the heat demand. Unused electricity is fed into a public network or intermediately stored internally in a battery system. Heat-driven CHP systems are designed mostly on the base load, so that an additional heat generator is needed to cover peak loads. In the **electricity-oriented** mode, as much electricity as possible is generated. The heat generated which is not used immediately is stored in a hot water tank. If the decentralised CHP system is **grid-oriented**, the regulation is performed by the grid operator. The system is switched on and off depending on the power demand on the public grid.

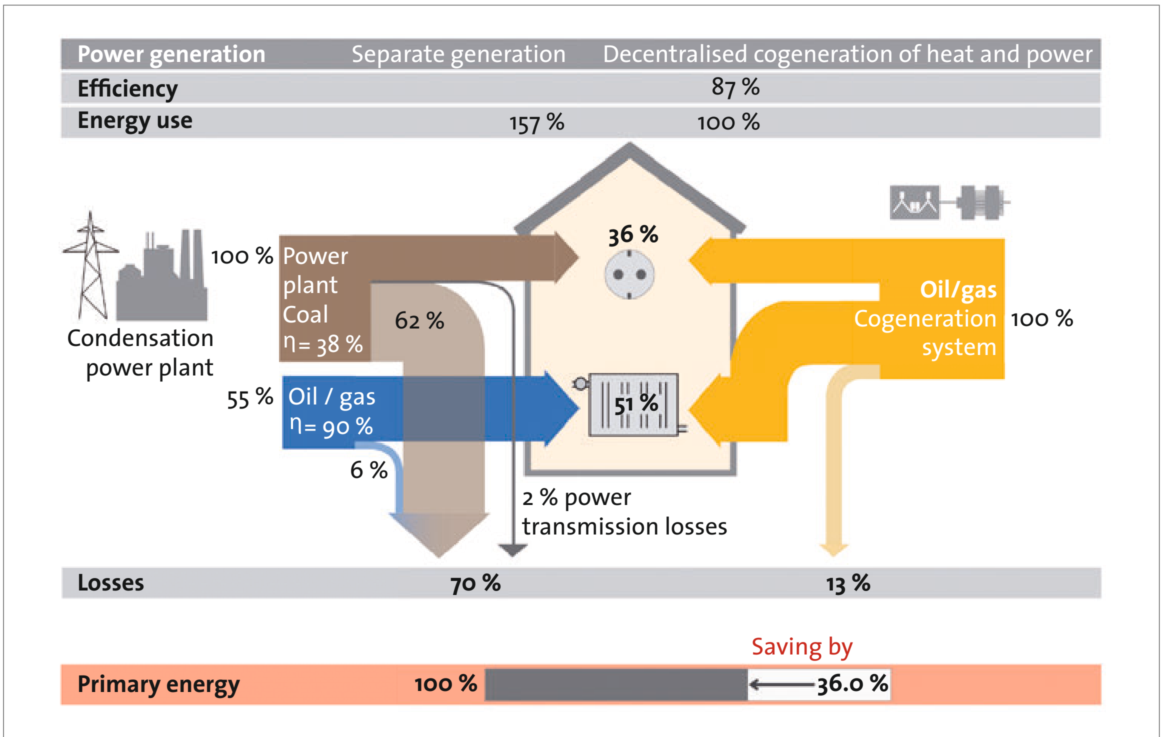


Fig. 45: Primary energy comparison of shared and separated power and heat generation

Fig. 46: Mini-CHP system

Fig. 47: CHP plant in combination with a peak load boiler for supplying an apartment building.

The decentralised cogeneration of heat and power is an important component of cross-sector applications. Decentralised CHP systems can be flexibly used and can help compensate for voltage fluctuations in the public grid, for example, to absorb peak loads. This is necessary, for example, in the case of weather-related grid fluctuations – a foreseeable consequence of the expansion of photovoltaic and wind power plants.

The heat from decentralised CHP systems can be used not only to supply buildings with heat and domestic hot water, but also for generating process heat and technical refrigeration, for supplying compressed air, and other technical applications. Micro- and Mini-CHP systems are generally operated with condensing devices. They are suitable for basement and roof installation. The systems can be easily integrated into existing heating systems.

Micro CHP technologies

Many manufacturers offer micro-CHP technologies today. They can be distinguished by

- the technology used,
- their electrical and thermal output and the ratio between them (CHP coefficient),
- the modulation option and
- the fuel used.

Fuel cells and heat and power units are available as basic technologies. In the heat and power units, a distinction is made between

- internal combustion engines (e.g., petrol engine),
- external combustion engines (e.g., Stirling engine and steam expansion engine), and
- micro-gas turbines.

The
Fuel cell heater

Considering the fact that electricity prices are rising continuously, it is attractive for many consumers to generate their own electricity which is independent of the weather. Therefore, especially in high-quality new buildings and the energy-related renovation of large buildings, a fuel cell unit is an interesting option. As a highly efficient form of cogeneration of heat and power, the fuel cell technology not only ensures up to 40 % lower energy costs, it also conserves the environment. By means of the simultaneous generation of electricity and heat, the fuel cell heater makes an important contribution to resource conservation in decentralised power generation. And even the load on the electricity distribution network is reduced by the in-house generation of energy. Operated with the climate-efficient energy source of natural gas, the future-proof, technically mature fuel cell technology makes a sustainable contribution to the heat revolution and sector linking with their low CO_2 emissions.

Fig. 48: Components of a fuel cell system

Efficient energy generation for residential and commercial buildings

Since natural gas is not combusted in the fuel cell heaters but rather an electrochemical reaction takes place, the technology ensures significantly higher efficiency compared to engine or furnace-based systems. In addition, the CO_2 emissions are significantly lower during the low-noise, low-vibration and low-maintenance operation. Especially in conventional single and two-family homes, there is a huge potential for the technology, as natural gas heaters already have a large market share in existing buildings. Currently, however, every second heater is outdated, which means that it is no longer economical to operate. This results in unnecessary burdens for your wallet and for the climate. It is therefore advisable to change the heating system. But even in new buildings, there are application options because the fuel cell heaters with the energy efficiency label A++ usually meet the criteria of the Energy Saving Ordinance (EnEV). In addition to compact heaters with integrated buffer storage, freely combinable kits consisting of the fuel cell, integrated or supplemented with condensing boilers and a buffer storage are possible. Seven manufacturers currently offer a range of systems – from complete heating systems to supplementary equipment. In addition, high capacity models are also available that are specifically designed for use in commercial or non-residential buildings.

Financial subsidy options

Consumers who opt for a fuel cell heater are supported by the federal government with generous grants. For example, the Federal Ministry of Economy and Energy provides a fixed subsidy of 5,700 Euro via the KfW program 433. In addition, consumers will benefit from an additional amount of 450 Euro for every 100 watts of electrical power that is started. Together with the electricity subsidy from the CHP law (KWKG), the total subsidy comes to 11,000 Euro.

INITIATIVE BRENNSTOFFZELLE
Die Zukunft kommt nach Hause.

Efficiency, innovation and climate protection – the Fuel Cell Initiative (IBZ) was started in 2001 under these aspects As a competence centre for fuel cell systems in the domestic supply of energy, it is campaigning for technology efficiency. The core objective of the initiative is to establish the fuel cell equipment as an important pillar for the sustained success of the energy revolution in the heating market. The main responsibilities include the continuation of government funding, strengthening the perception of technology vis-a-vis the public and politicians, as well as the continuation of standardisation activities. The initiative is supported by the Federation of the German Heating Industry (BDH) and the industry initiative Future of NATURAL GAS. The heating equipment industry, as well as numerous gas utility companies, supported the IBZ as a valuable partner, and have been collaborating since 2001 in making the stationary fuel cell ready for market launch. In particular, the technology introduction program launched in 2016 was an important milestone for the IBZ. Since then, more than 5,000 fuel cell units have already been installed in Germany.

Further information on the fuel cell initiative is available at:

https://zukunft.erdgas.info/zukunft-erdgas/unsere-initiativen/initiative-brennstoffzelle

Solar thermal systems

Application in the system

With solar thermal energy, the solar energy is used to extract heat. Solar collectors convert sunlight into heat which is then used for heating buildings and businesses (heating and domestic hot water heating) or industrial applications. Solar thermal systems are usually operated bivalent in combination with other heat generators. In doing so, all the components of the overall system have to be well aligned. Because in the end the desired savings can be achieved only with an overall system with optimised control technology and hydraulics.

Heating domestic hot water

For heating domestic hot water, collectors are installed on the roof. They heat a heat transfer medium and then deliver the extracted heat to the solar tank via a heat exchanger. The additional heat generator is turned on only when the solar energy is insufficient. Other components of the system include the solar station with fittings and pumps, expansion tank, vent and controller for regulating the solar pump. With the solar system, up to 60 % of the heat demand required for domestic hot water heating is met in a single-family house.

Auxiliary heating

If space heating is required in addition to preparation of domestic hot water, then the collector surface has to be increased by 2 to 2.5 times. In a single-family house, the heat demand of up to 30% can be met depending on the design and insulation of the building. With low-energy buildings, you can save up to 50 % and more.

Large potential

Solar thermal systems for domestic hot water heating and room heating are currently used mainly in residential buildings. They are also especially well suited for single-family and two-family houses, as well as for apartment buildings, hospitals, hotels and sports centres. The integration of large solar thermal systems in small rural district heating networks, urban neighbourhoods or in conventional urban district heating networks is becoming increasingly important. Solar collectors can also produce hot water for outdoor and indoor swimming pools, thereby contributing to a substantial saving in energy costs. Supporting commercial or industrial processes with solar thermal energy represents a further huge potential.

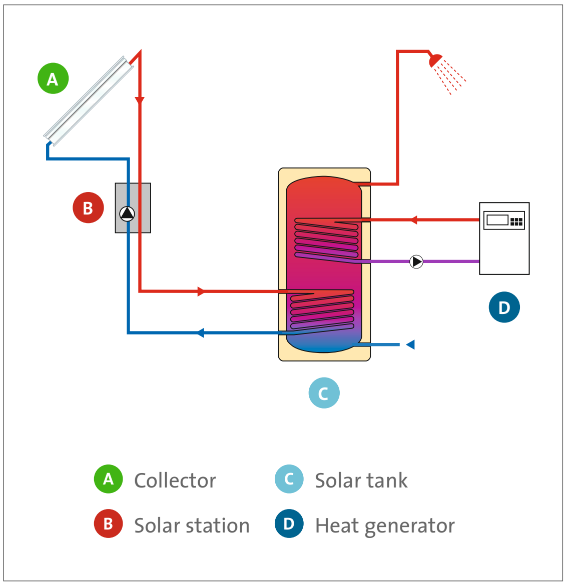


Fig. 49: Thermal solar system for domestic hot water heating in single-family house

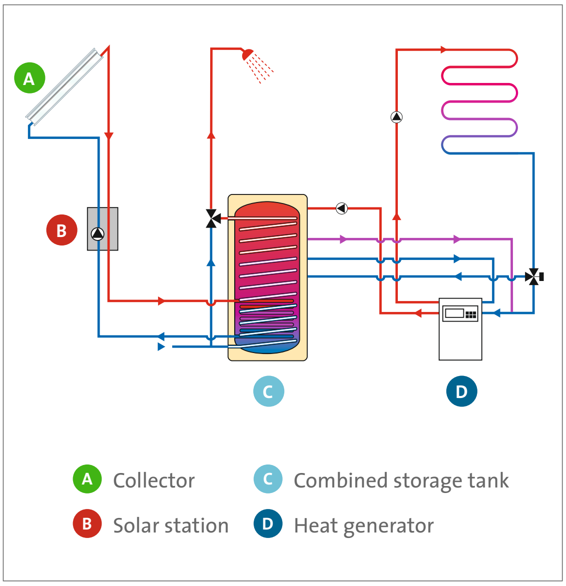


Fig. 50: Thermal solar system for supporting space heating and domestic hot water heating in a single-family house (combined system)

Fig. 51:
System example – Flat plate collector

Compliance with legal requirements

The energy requirements for new buildings and system modernisation all over the world are increasing. Solar thermal systems are contributing significantly to meeting these requirements. When classifying the energy efficiency label of so-called space heaters (gas, oil and wood-fired boilers, heat pumps, CHP units) and domestic hot water heaters, the integration of solar thermal energy increases the energy efficiency class of the original equipment.

Wide scope of applications

Almost all the requirements and technical systems in the heating market can be meaningfully combined with a solar thermal system. Ready-made system solutions are now available for most applications in residential buildings. These pre-assembled systems shorten the installation time significantly.

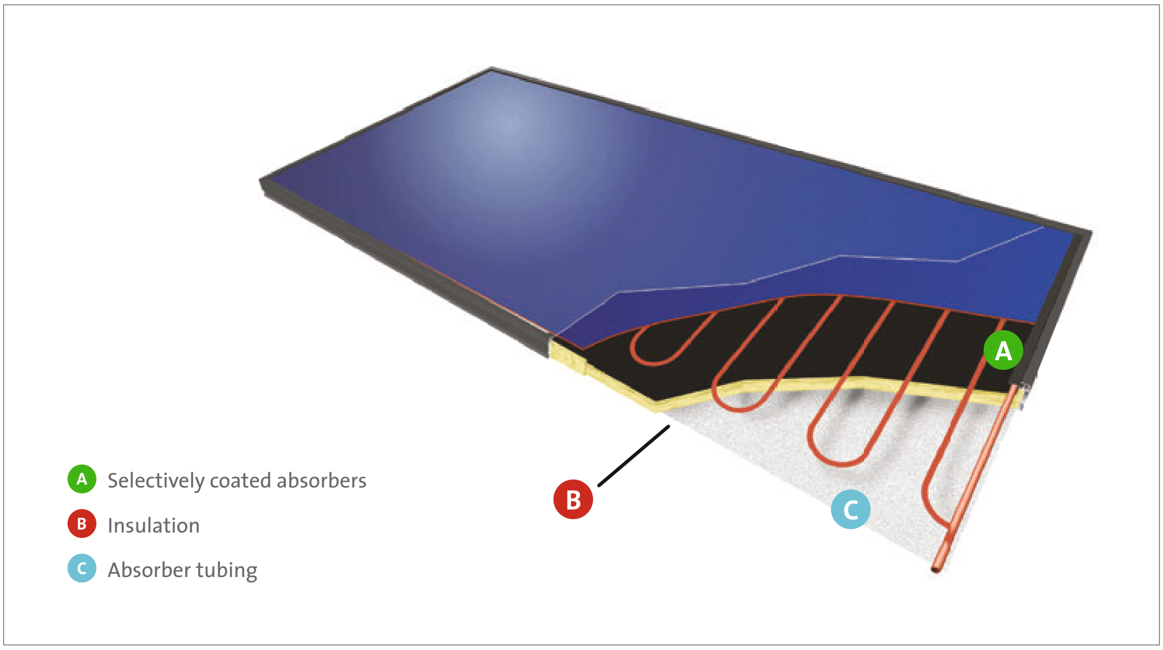


Fig. 52:
Installation of a flat plate collector

Solar thermal systems

Collector types

a) **Flat plate collectors**
Flat plate collectors are currently the most widely used collector type in Germany and Europe. During operation, selectively coated high-performance absorbers always ensure maximum possible heat yields. In addition, these collectors permit versatile architectural design options and are suitable for both in-roof installation, as well as on-roof and flat roof mounting.

b) **Vacuum tube collectors**
Vacuum-assisted insulation (evacuated glass tube) permits the achievement of high outputs in applications with high target temperatures. In standard applications, the vacuum tube collector requires a smaller area than a flat plate collector, based on the average annual output.

Hot water tank

For all applications, sophisticated types of storage tanks are available to consumers (bivalent domestic hot water storage tank, buffer storage tank and combined storage tank). Common quality characteristics are their slim, tall design and seamless insulation, with which the stored heat can be best maintained. All systems are available with batch loading facilities.

Regulator

Modern regulators ensure safe and efficient operation of the entire system. Often, the functions of the solar system are already integrated in the regulator for the heating system. This guarantees the perfect interplay of all components.

Fig. 53: System example – Vacuum tube collector

Solar-based heating networks for villages

Centralised district heating systems have long proven their worth in supplying heat to larger properties or villages. By integrating a solar thermal system, the amount of energy to be supplied, very often using fossil fuels, is significantly reduced (by 10 to 20 %). In these solar-supported district heating systems, the heat extracted by the solar collectors is usually transported via the solar power grid to the centralised heating system in a solar storage tank and distributed from there to the building via the district heating network. In some designs, the solar heat is fed directly into the district heating network without a separate solar storage tank. Many solar thermal networks are operated today in combination with other renewable energies in renewable heating networks. In the process, centralised wood-fired boilers, biogas CHP units or heat pumps are often used.

Fig. 51 shows a solar-supported heating network using the example of the bioenergy village Buesingen in the district of Konstanz. Using vacuum tube collectors with a gross collector area of 1,090 m^3, an average annual heat output of 565 MWh is produced. The solar coverage here is about 13.5 %. The remaining heat is provided using two large woodchip boilers.

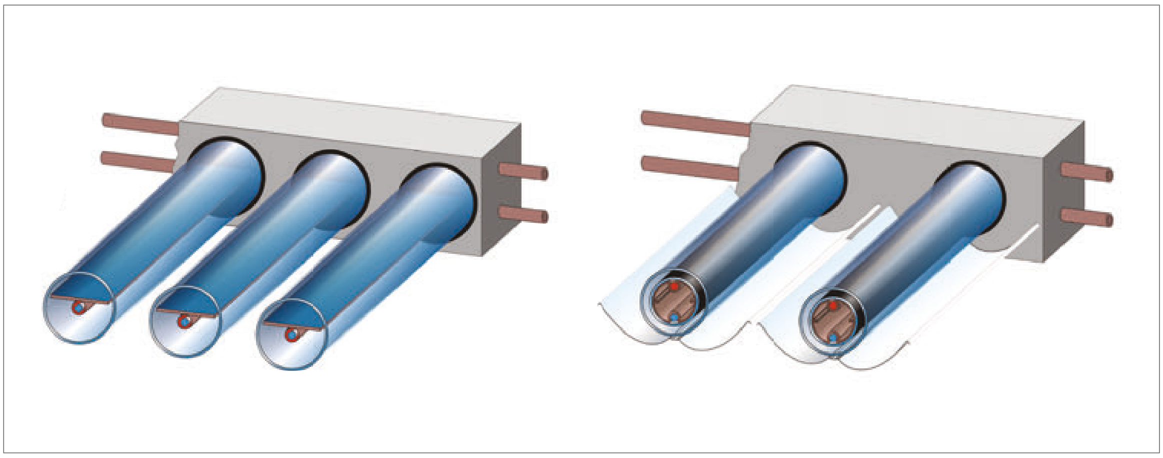


Fig. 54: Vacuum tube without and with an external reflector

Photo www.solarcomplex.de

Fig. 55: Solar-supported heating network for a village using the example of Buesingen


COMFORT
DIGITAL
EFFICIENCY
RENEWABLES

Modern
System Components

- Heat distribution
- Hydraulic balancing and high-efficiency pumps
- Embedded surface heating and cooling system
- Radiators
- Residential ventilation systems with heat recovery (HRS)
- Storage technology
- Flue gas systems – versatile systems
- Tank systems
- Smart Heating: More comfort and energy efficiency

Heat distribution

Components

Heat distribution ensures that the required energy is transported from heat generation to the heat transfer system. In addition to the pipes, the (circuit) control valves and the pumps are mainly used for heat distribution in a hydraulic heating system.

Line layout

For the laying of the pipes of the heating system, there are various ways of laying the pipes between the heat generator and the heating surface. Usually the ascending lines are arranged in a shaft centrally in the building. The horizontal distribution is carried out as a single or two-pipe system within the insulation layer of the screed or in a suspended ceiling below the raw ceiling up to the heating surface.

Pipe network calculation

A pipe network calculation must be carried out within the scope of the system planning to dimension the line cross-sections in such a manner that the specified heating water volume is fed to the heat transfer unit. During the calculation, excessively high flow rates should not be selected so that undesired noises do not occur during operation and the pressure losses are minimised. The result serves as a setting value for the control valves.

Fig. 57: Radiator thermostatic valve

Insulation of pipes

For the energy-efficient installation of the heat distribution, requirements for the thermal insulation of pipes and fittings are defined in the EnEV (Energy Saving Ordinance). It specifies the insulation thickness to be maintained for a specific inner pipe diameter. Suitable design for avoiding heat bridges is of crucial importance. Pipes in wall and ceiling ducts have to be provided with an elastic enclosure to prevent the transmission of structure-borne sound between the building structure and the pipe. When subsequently plastering the lead-through openings, care must be taken that no sound bridges are formed.

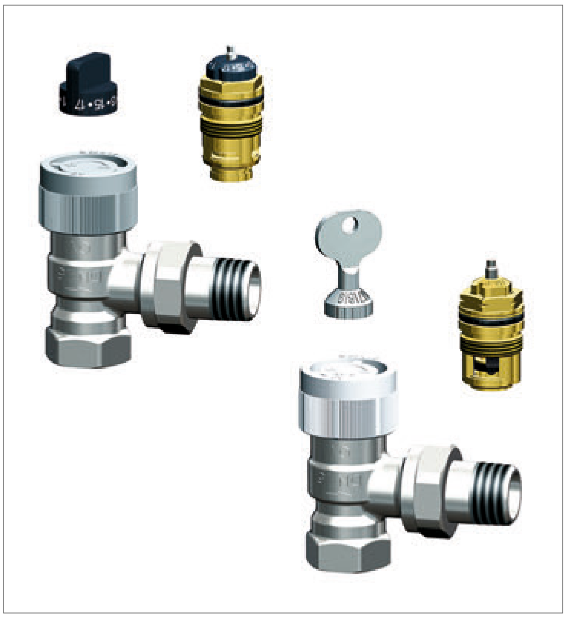


Fig. 56: Fittings

Fig. 58: Valve with pre-settable valve insert for adjusting the flow rates to the required heat load

Fig. 59: Electronic radiator valve

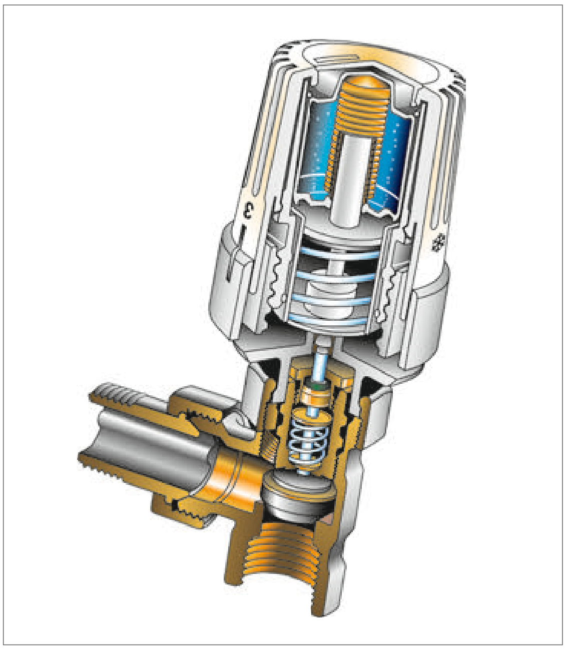


Fig. 61: Sectional model of a radiator valve

Fig. 60: Influencing factors for efficient heat distribution

Control valves

Valves are used for shutting off pipes or regulating the flow rate or pressure. As control valves in the heat distribution system, differential pressure or mixing valves as well as circuit control valves are used. Differential pressure valves are necessary to ensure optimum pressure conditions in the heat distribution. Depending on the system size, the differential pressure control can be carried out centrally or decentrally. Mixing valves are required to mix hot water having different temperatures, so that the desired system temperature is achieved as a result. Two typical products are three-way or four-way mixing for embedded surface heating systems.

In individual distribution pipes/lines of a heating system, circuit control valves are installed to optimally balance the volume flows as needed. As a result, equal pressure losses can be adjusted throughout the entire pipe network, which assists in the hydraulic balancing and the efficient distribution of the heating water is ensured. This is the prerequisite for the efficient use of heating pumps.

Hydraulic balancing
and high-efficiency pumps

Hydraulic balancing enables comfort and saves costs

A major part of the energy utilised in Germany, is consumed by residential buildings, particularly as heating energy. Hydraulic balancing is an effective means of saving heating energy. In hydraulic balancing, the aim is to coordinate the individual components of a heating system exactly in such a way that the heat reaches, where it is required. For hydraulic balancing, modern thermostatic valves or lockshield valves on the heating surfaces are required. Hydraulic balancing with corresponding explanation can be carried out according to DIN EN 14336.

The path of least resistance

With hydraulic balancing, a uniform heat distribution can be achieved in a building. Here, the heating system setting is such that the system made up of pipes, pumps and valves offers minimum possible resistance to the circulating water. This is because the water in the heating system mostly takes the path of least resistance. If the hydraulic balancing is not carried out or not properly carried out, this may mean that heating surfaces in remote rooms at times do not become really hot. More powerful circulating pumps have to compensate for this. The price of this is very high: Energy consumption and electricity costs shoot up, since the heating pumps consume more electricity than required.

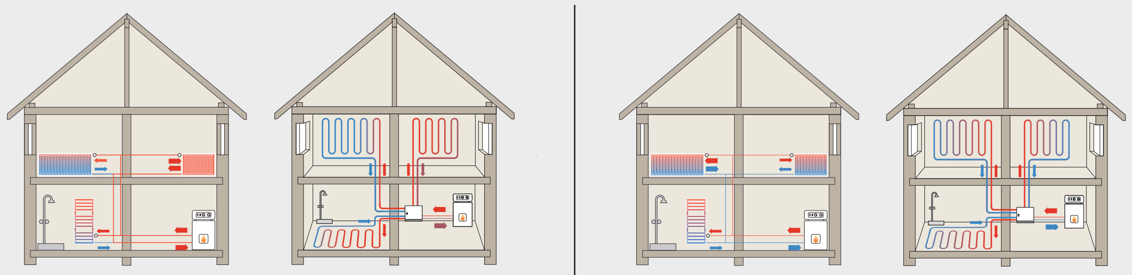
Moreover, a non-balanced system can significantly reduce the efficiency of condensing devices: Oversupply to certain heating surfaces leads to higher return temperatures in the system. The water in the flue gases of the heating system can condense only in a limited manner or not at all. This results in less heat being used and the savings that are usually achieved with a condensing device, are nullified.

Sounds as indicators

The typical signs of absence or incorrect hydraulic balancing include, for example, radiators which do not heat up whereas others are oversupplied. Also, noises in valves or pipes indicate that the differential pressure in the valve or the velocity of flow is too high. It may also happen that the radiator valves do not open or close at the desired inner temperature due to excessive differential pressure. Hydraulic balancing offers several advantages to the residents: The system can be operated with optimum system pressure and a lower volume flow rate. This reduces the energy and operating costs: Saving of up to 15 % of the heating energy costs is possible.

EnEV, VOB & Co.

The EnEV (Energy Saving Ordinance) requires that technicians confirm in writing, as part of the subcontractor declaration, that their services comply with the ordinance, that the hydraulic balancing has also been executed, in case it has been included in the verification procedure. Even according to the German Construction Contract Procedures (VOB) Part C and DIN 18380, it is mandatory for technicians to balance the heating pipe networks hydraulically. In addition, it is required by all relevant funding programmes of KfW or the Federal Office of Economics and Export Control (BAFA).



Heating surfaces (left: radiator or right: embedded surface heating and cooling) – volumetric flow rates poorly balanced – warm return flow

Heating surfaces (left: radiator or right: embedded surface heating and cooling) – volumetric flow rates well-balanced – cold return flow

Fig. 62: Hydraulic balancing

Calculating the heating load, adjusting the heat output

For hydraulic balancing, it is first necessary to calculate the heat load for every room in the building, taking into account the external surfaces, walls, ceilings, windows and doors. According to the calculated heating load, the heating surface with the required heating output is chosen. Additionally, the different pressure drop en route from the heat generator to the heating surface should be taken into account. The setting values for the individual heating surfaces are derived from all these parameters. Hydraulic balancing is achieved when all parallel systems have the same hydraulic resistance.

Thermostatic valves or lockshield valves on the radiators that can be preset, support the hydraulic balancing. It is also important to determine if the concerned system is a dual pipe system, because a single pipe system allows only restricted balancing. The data for a single-family house is recorded in about one and a half hours and analysed in about 1-2 hours. The setting is done in just five minutes for each heating surface. The costs for hydraulic balancing depend upon the size of the building; the costs for a single-family house amount to approx. EUR 500.00, which can however be redeemed quickly, thanks to the energy savings.

Inspection of the installed heating pump is always a prerequisite for hydraulic balancing. Overdimensioned and unregulated pumps need to be replaced so that the benefits of hydraulic balancing can be fully utilised.

High-efficiency pumps: Efficient and controlled depending on the demand

A heating pump in a heating system is responsible for ensuring the flow of the heat transfer medium (heating water) through the system. The pump ensures smooth circulation of the heating water from the heat generator through the heat distributors to the heating surfaces in the room within the heating circuit. The efficiency of a heating pump can be seen when looking at the required electric current. While older models are true power guzzlers, so-called high-efficiency pumps need much less energy.

Four different circulating pumps can be installed in an existing heating system. Unregulated heating pumps always work with full output. During the heating period, they often run at a fixed output level during continuous operation. In the case of multi-stage pumps, the output can be regulated in steps. However, many of these pumps run at the highest level. Electronically controlled pumps automatically control the speed and therefore, also the electrical power consumption according to the set demand

Fig. 63: High-efficiency pumps in accordance with the Eco-design Directive

value. The high-efficiency pumps adapt themselves to the actual demand by means of electronic control.

A high-efficiency pump allows efficient control of both the heating circuit and the drinking water circulation. The high-efficiency pump works only when the heat transfer medium is required. The pump reacts automatically and quickly to the changes in the water pressure in the lines and adjusts the pressure conditions to the new situation. Especially in the so-called partial load range, i.e. the period during which the pump does not have to work at full output, the pump output is continuously reduced to the minimum energy by short reaction times. This partial load range can account for around 90 % of total operating time, which means that considerable energy can be saved by adjusting the pump capacity according to demand.

From August 2015, only circulating pumps with an energy efficiency index better than 0.23 – the so-called high-efficiency pumps – are being used in accordance with the European EC 641/2009 Ordinance. These are much more efficient and adapt to changing performance requirements of the system continuously. This means that they not only save valuable electrical driving power in the full load state, but also in the predominantly encountered partial load condition of the heating system. Compared to conventional pumps they use 80 % less electricity.

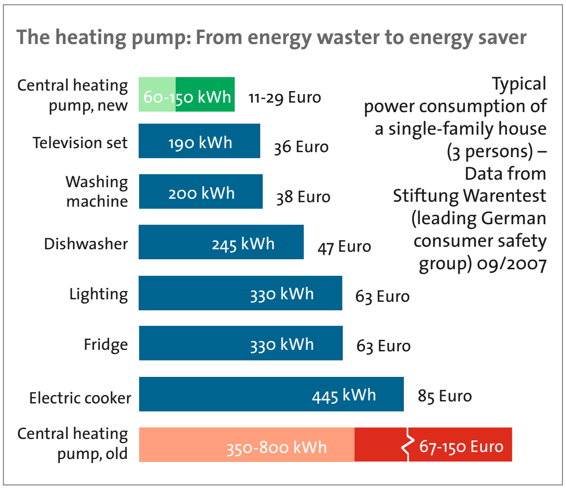


Fig. 64: Savings potential of pumps

Embedded surface heating
and cooling system

Heating and cooling in one system

Most builders opt for an embedded surface heating and cooling system for new buildings. The heating system is permanently installed in the floor, wall or ceiling during the construction phase itself. Because of the large-area span, the embedded surface heating and cooling system makes for a uniform distribution of temperature, thereby ensuring a pleasant temperature throughout the whole year. Taking into account larger window areas and greater building insulation, the option of using the same system to provide cooling in summer is steadily gaining in importance. This functionality is applicable not only in apartments, but also in office buildings or halls. Also, as a rule, the service life of the embedded surface heating and cooling is to be equated with the economic life of the building, so that it represents a sustainable, efficient and convenient solution at the same time.

Wide range of solutions also for old buildings

For old buildings, suitable systems are available for subsequent integration into floors, walls and ceilings without any structural modifications. The versatility of wet systems (screed or plaster), dry systems, and special thin-layer systems offers optimum solutions to the builder for the use in modernisation. The dual function of heating and cooling can also be used in the application in old buildings.

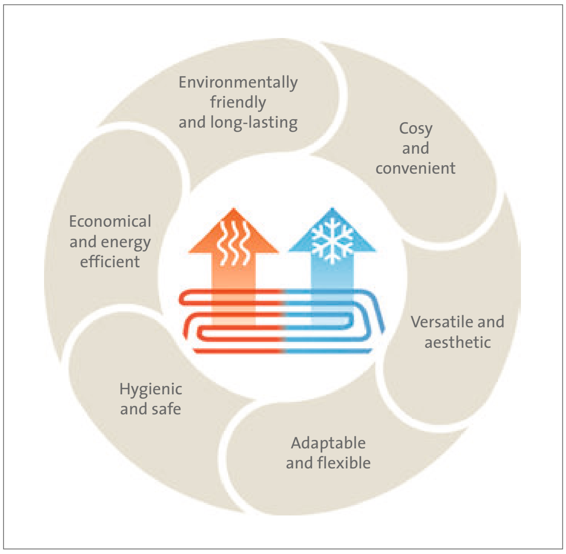


Fig. 65: The features of a embedded surface heating and cooling system with the dual "Heating and Cooling" function

Practically unlimited range of application

In addition to the field of residential buildings already described, the embedded surface heating and cooling system can be used in office buildings and halls. As part of a central heating system, the embedded surface heating and cooling system also ensures a pleasant atmosphere throughout the year as well as energy efficiency.

More comfort, less costs

In embedded heating systems, only low system temperatures are generally required (35 °C flow temperature/28 °C return temperature). They are therefore an energy-efficient supplement for condensing boilers, heat pumps and solar thermal systems. The low system temperatures benefit the residents in two ways: they provide for a large energy savings potential, and create an enormous increase in cosiness and comfort. This can be supported with intelligent single-room controls.

Last but not least, the invisible embedded surface heating and cooling system in the floors, walls and roofs has the advantage of leaving the residents ample space for interior decoration.

Effective cooling in summer

In summer, the embedded surface heating system can also be used for simple room cooling, cost-effectively, with the help of an extra "Cooling" function. In this process, cold water circulates through the pipes and lowers the temperature of the floor, wall or roof and therefore of the rooms by up to 6 Kelvin (K) – without any draughts whatsoever.

The efficiency of an embedded cooling system is determined by the difference between the flow and return flow temperature of the coolant. While the temperature difference during the heating process is normally about 8 K, an embedded cooling system should be operated with a spread of no more than 3 K. Due to the low temperature difference between the temperature of the coolant and ambient air, e.g., 18 °C coolant flow temperature, an embedded cooling system is also ideal for making use of natural heat sinks such as groundwater or soil for allowing an energy-saving cooling operation.

Due to these temperature differences between the coolant and room air, an embedded cooling system is best suited in terms of thermal comfort and energy efficiency to contribute to room cooling. The area-specific cooling capacity has a positive effect on the well-being of the users.

Fig. 66: Easy installation of an embedded surface heating and cooling system using the example of a floor heating

Fig. 67: Controlling the heating circuit distributor via a remote controlled single-room control

Controller prevents condensate formation

A controller which covers both the heating and cooling functions is required to regulate the system temperature during cooling operation. The controller maintains the temperature of the embedded cooling system above the dew point, thereby preventing condensate formation on distribution pipes and transition areas.

The different designs of the embedded cooling system in the living areas of a residential building or office building reach an average cooling capacity of about 35 W/m² in the floor, about 35 to 50 W/m² in the wall (depending on the layout) and about 50 to 110 W/m² in the roof (depending on the layout).

Remote-controlled room temperature control

The options provided by the current control technology for embedded surface heating and cooling systems can be utilised fully only in combination with state-of-the-art communication technology. This means that the embedded surface heating and cooling system can be controlled from home, remotely or via App, through WLAN, or also via Internet when not at home. An embedded surface heating and cooling system can be controlled from a central computer that manages all data, programmes and information. In principle, this sort of "on-board computer" can be operated intuitively via a touch screen.

This means that residents can create individual heating profiles for every room and also modify them, define a basic temperature or adjust it, or control the functionality of the entire system (e.g., day mode/lower mode/frost protection mode). Sensors detect the ambient conditions, which are evaluated by the system and implemented accordingly. In this way, the control and communication technology facilitates an energy management system that is tailored precisely to the needs of residents.

Conclusion

The heat load of a building is always fully covered by using an embedded heating and cooling system. In summer, the ambient temperature can be reduced to a comfortable/pleasant level. This means that the ambient temperature can be set to a comfortable range throughout the year – in apartments and office buildings as well as halls.

Radiators

Efficient, comfortable and sustainable

Modern radiators can be used flexibly and integrated into any heating system in a reliable, sustainable and future-proof manner independent of the energy source. For long-lasting benefits, heating surfaces that can react quickly to changes in heat demand are required. This requirement is met by modern radiators with low installation depths, low water content and high transmission areas. There is a wide range of solutions for new buildings and renovation projects, ranging from products for low temperature ranges, e.g. when using a heat pump, to systems suitable for district heating. With the appropriate design, the desired additional function, and the optimum technology, the ambient temperature can be adapted instantly to the wishes of the residents, creating maximum cosiness by means of radiant heat, thereby saving energy.

Quality, efficiency and design

However, the quality is determined not only by the output of a radiator: The heat can be optimally delivered only if the radiator is mounted in the right place. The classic space under the window is still recommended. From the point of view of energy, correct positioning combined with the design requirements of the room provides an optimum tailored solution. For efficient heat dissipation, the radiator should not be hidden behind furniture or curtains.

A comfortable temperature at just the right setting

Thermostatic valves that keep the indoor heat constantly at the desired temperature play an important role in the efficient transfer of heat. To this end, they are dependent on the correct differential pressure on the radiator, which is determined by hydraulic balancing.

In order to achieve maximum heat dissipation even with reduced water flow, modern thermostatic valves and fittings for hydraulic balancing support the heating system in exactly setting the individual "comfortable" temperature also at different heating times. Time-controlled thermostat valves specify when the radiators should start heating – exactly at the desired setting, including an automatic cut-off.

Beautiful design and intelligent features

The many variations in shape, colour and design allow for an attractive, individualised interior and create new interior design possibilities for the residents, since the radiators fit seamlessly into the architectural environment. New radiators are available in many colours – chrome versions are also possible. If you want something special, the radiator can, for example, be powder-coated with a matt finish or made available in a stainless steel design. Additional features and smart accessories such as towel rods, mirrors or racks, hooks and lighting create feel-good accents. Often, radiators are also used as design objects which fit into the ambience and match the colour and design of the room.

Fig. 68: Numerous design options and intelligent accessories

Fig. 69: Modern radiators for individual living comfort

Between modernisation and comfort

Radiators are subject to wear and tear, which primarily affects their quality and functionality. For this reason, the increase in service life is often accompanied by higher energy consumption, increased wear and tear of heating components, as well as loss of comfort. Therefore, modernisation of existing equipment aims at increased efficiency by means of energy-saving operation and optimum heat transfer using modern radiators.

When planning the modernisation of heating systems, owners particularly weigh the costs against the benefits. This is because renovations, disturbances, dirt and noise are often unavoidable during modernisation. The fitting accuracy to the existing connections is taken into account when planning and installing new radiators, so that the replacement of old radiators with new high-performance models is no longer a problem in practice. Simple and quick installation of the radiators is the rule: empty, unscrew, screw, fill – finished!

Fig. 70: Fitting accuracy at the time of modernisation of the radiators

Fig. 71: Easy replacement

Residential ventilation systems
with heat recovery (HRS)

Comfort without limitations

Fresh and hygienic air is crucial for our well-being indoors. Ventilation systems with heat recovery ensure the air quality and so the well-being of residents, safely ensure the required minimum air exchange as specified under the Energy Saving Ordinance, and reduce the energy demand for heating.

Daily use gives rise to carbon dioxide (CO_2) and water vapour. For proper control and a good comfort level, the rooms must be sufficiently ventilated (Fig. 73).

Ventilation systems with heat recovery are capable of doing this independently and help to save heating energy by means of heat recovery (Fig. 74).

- They provide fresh outdoor air to the rooms, ensuring controlled air exchange.
- Pollutants in the indoor air are discharged outside.
- With a controlled residential ventilation, the windows need not be opened. This provides additional protection against noise and burglary.
- The building is therefore also protected. Accumulated moisture in the air, e.g., caused by showering or cooking, is reliably dissipated to the outside. This removes the nutrient medium for ventilation-induced mould growth.

If desired, the outdoor air can be cleaned additionally by a pollen filter, which limits the exposure to pollen and allergens largely.

Thus, house ventilation systems offer numerous opportunities to find a customised solution for each individual requirement.

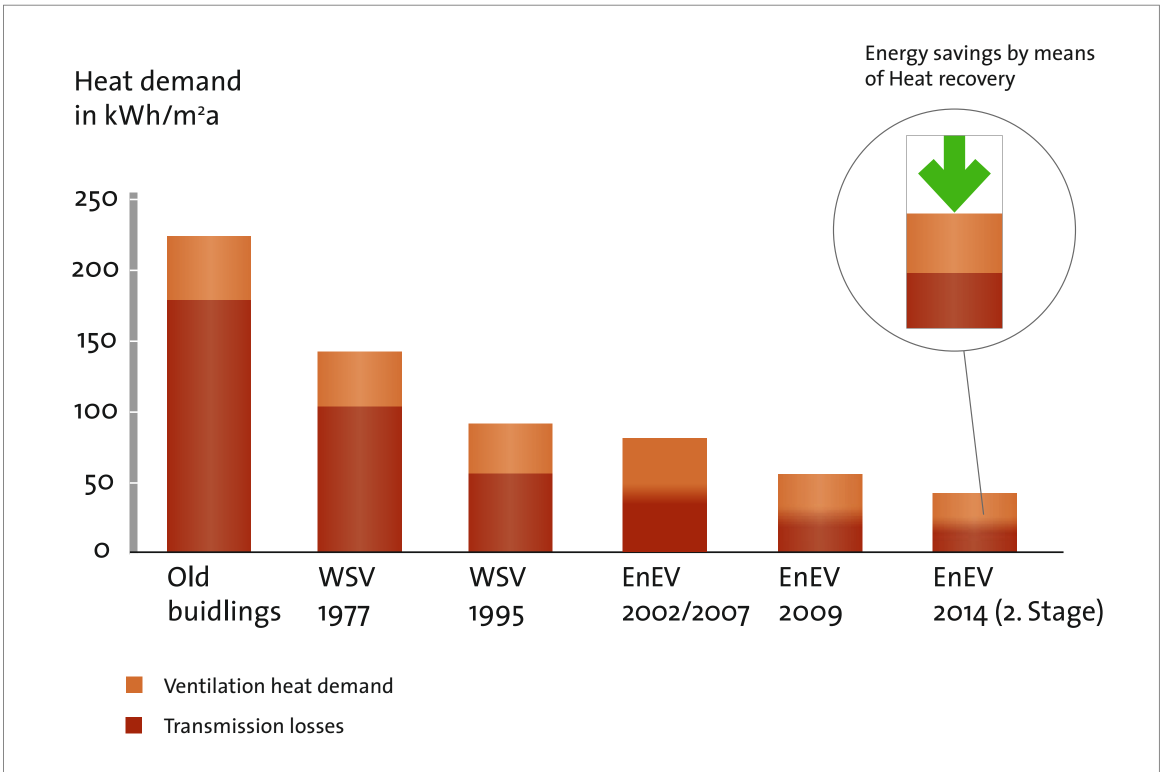


Fig. 72: Relative proportion of ventilation with respect to the total heat demand

Systems with HRS

You can't do without ventilation. However, normal ventilation with open windows is associated with high thermal loss because the inside air heated by the heater moves out and cold fresh air from outside moves into the building. Only automatically operating ventilation systems can guarantee optimum balance between the required outdoor air supply and minimal thermal loss.

The energy losses of a building are made up of the transmission thermal losses (energy losses through walls, ceilings and floors) and the ventilation thermal losses. The transmission thermal losses can be reduced further thanks to specified requirements for the building shell, which means that the ventilation thermal losses are the dominating factor. In modern buildings, up to 50 % of the heat demand is required to heat the necessary fresh air supply (Fig. 72).

A maximum amount of energy can be saved if the energy of the hot extract air is used to preheat the cooler outdoor air (HRS). Modern systems are able to recover up to 90 % of the heat present in the extract air.

In case of mechanical residential ventilation systems, we distinguish between room-wise/decentralised and centralised ventilation systems for each residential unit.

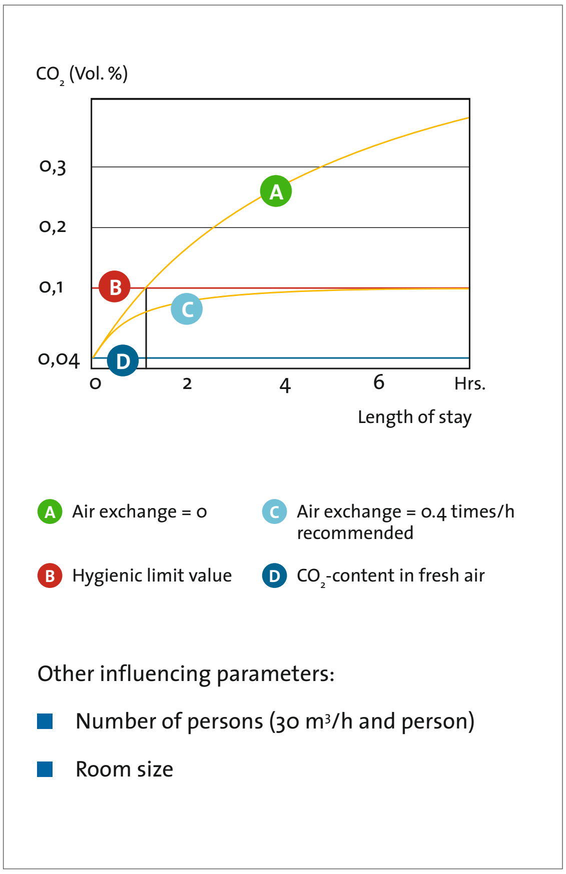
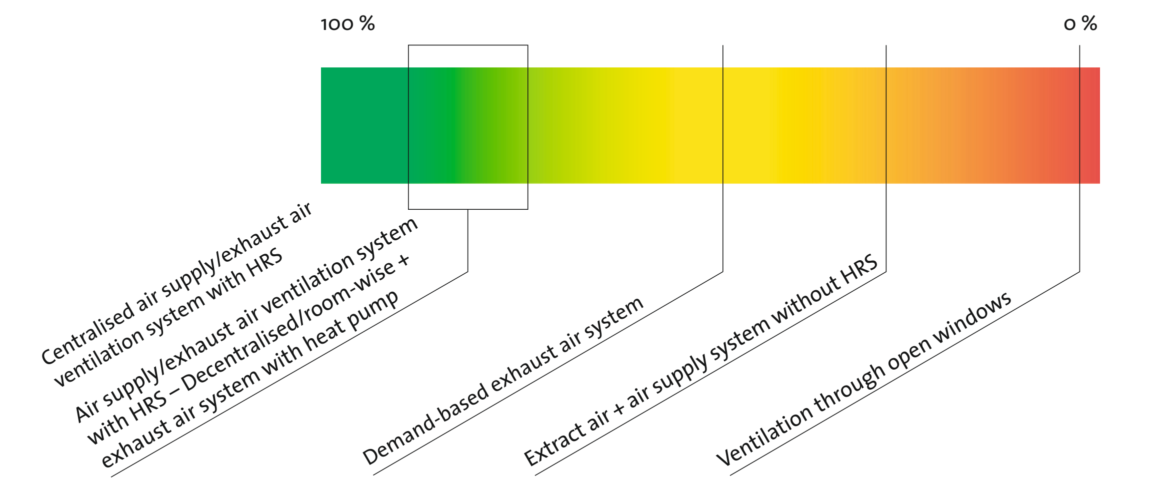


Fig. 73: Increase in the CO_2 concentration because of a resting person



* Energy-based evaluation without power consumption of the devices

Fig. 74: Reduction of ventilation thermal losses*

Residential ventilation decentralised or centralised with heat recovery (HRS)

Room-wise/decentralised ventilation system with HRS

In the corresponding fresh air rooms and extract air rooms, individual devices are installed in every room, directly in the outer wall. Thus, no air distribution system is required.

Here, two modes of operation can be selected:

- Devices which secure a parallel flow of supply and extract air in every room (continuous fresh air and extract air operation)
- Devices that alternately ensure supply of fresh or extract air (push-pull principle): For this purpose, two corresponding devices are necessary for balanced ventilation. (Fig. 72)

Both operating modes are equipped with a heat recovery of up to 90 %. An air distribution system is not necessary.

Since they are mounted in the outer wall, decentralised ventilation devices are particularly suitable for subsequent integration during the process of modernisation.

Centralised ventilation system with HRS

Centralised ventilation devices transport the air via an air distribution system. While one fan draws the outdoor air into the building, another one discharges the hot extract air from the rooms. A heat exchanger ensures that the heat from the extracted air is transferred to the outdoor air coming in. In this way, up to 90 % of the heat is recovered and used to heat the outdoor air. The effect: Up to 50 % of the heating energy can be saved. (Fig. 76)

Benefits at a glance

In addition to high energy and cost savings, users of ventilation systems can also enjoy a higher comfort level:

Modern systems ensure optimum air quality and a comfortable indoor climate with excellent sound insulation at the same time. Other advantages are thorough sanitation, pollution reduction and protection against pollen, mites and mould formation.

Plan early and save

Builders and home owners should inform themselves right at the beginning about modern and reliable ventilation systems, while planning or upgrading a building. Thus, the energy-saving potential will be optimally utilised and costs minimised.

In any case, a ventilation concept must be drawn up beforehand to check whether an air ventilation measure is required and if yes, which solution is really suitable. The market for residential ventilation systems has an appropriate solution for every need and for every application, for homes and individual flats, existing buildings or new buildings.

Fig. 75: Room-wise/ decentralised ventilation system with HRS

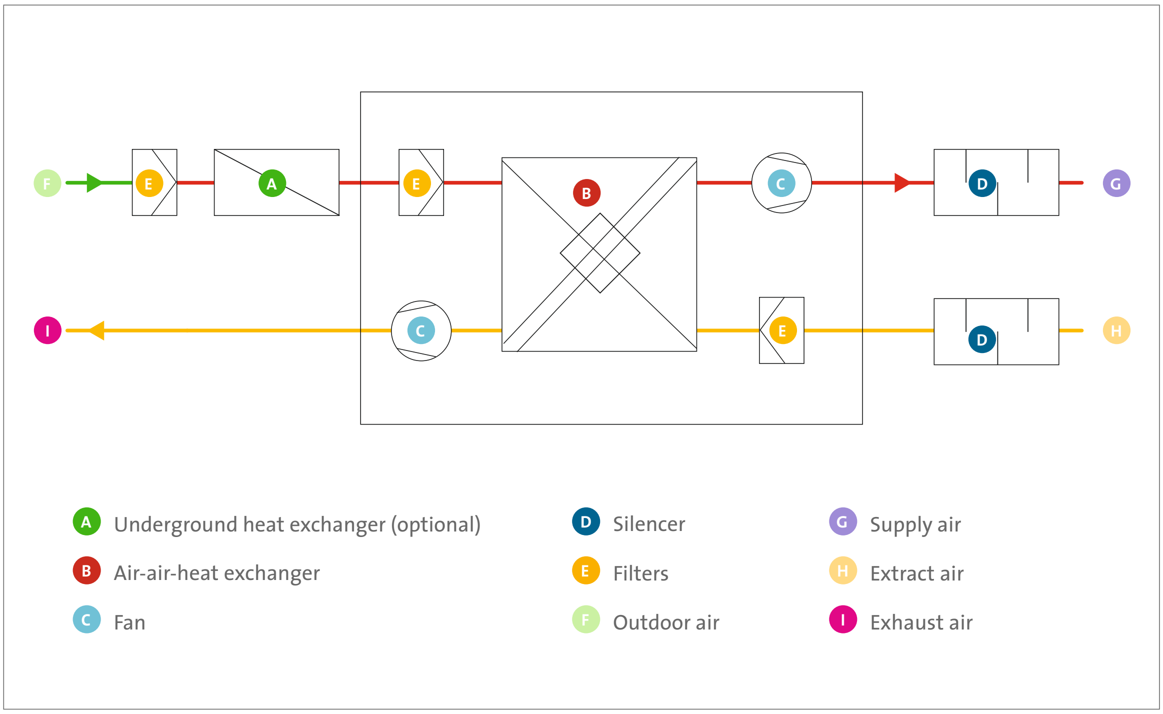


Fig. 76: Schematic diagram of the centralised ventilation system with HRS

Fig. 77: Early consideration in planning of ventilation systems

Fig. 78: Planning, installation and maintenance by a qualified technician

Storage technology

Hot water for all purposes

Domestic hot water storage tanks act as a central component of a modern heating and hot water supply system in residential and office buildings. They can perform different functions due to the great diversity of types.

Domestic hot water storage tanks heat and store domestic water, which is needed for showering, bathing or cooking. Buffer storage tanks ensure heating water supply to the heating system over a long period. This allows coupling of heat from renewable energies and CHP systems. So-called combined storage tanks combine both functions.

Modern hot water storage tanks have high energy efficiency. They are characterised by minimal thermal loss and optimised heat transfer and temperature gradient. All the hot water storage tanks on the market meet the highest standards of domestic hot water quality and sanitation.

Hot water storage tanks also play an important role in connection with cross-sector applications. Excess renewable electricity, e.g., from PV and wind power plants, can be converted into heat and stored in the form of thermal energy in hot water storage tanks (power-to-heat). The conversion usually takes place via efficient heat pumps.

Heating domestic hot water

Hot water storage tanks for domestic hot water heating store the domestic hot water required in the household or in a building, so as to make it available round-the-clock. There is a distinction between monovalent and bivalent domestic hot water heating.

In the monovalent domestic hot water heating, the domestic water in the storage tank is heated by a heat exchanger. This is supplied with heat by a centralised heat generator such as a gas or oil-fired boiler, a heat pump or alternative energies.

On the contrary, in the bivalent storage tank, the domestic hot water is heated by two heat exchangers: Heat recovered from solar energy is introduced via a heat exchanger to the lower portion of the hot water storage tank. With sufficient exposure to sunlight, the total storage volume can be heated with recovery of heat. In the upper part of the storage tank, there is a second heat exchanger, by means of which the standby part of the storage tank is maintained at a constant temperature through reheating by the centralised heat generator. This ensures the supply of domestic hot water even if the solar energy supply is insufficient.

For hygienic reasons, either standard or stainless steel tanks coated with enamel or plastic, are used for domestic hot water storage tanks.

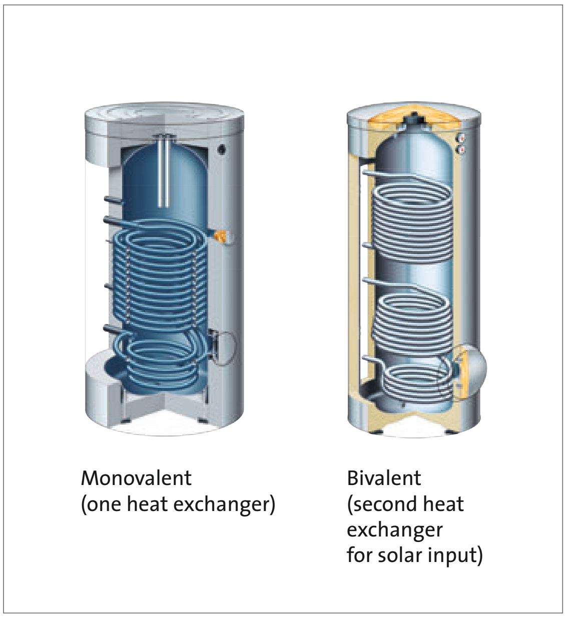


Fig. 79: Domestic hot water heating

Fig. 80: Energy storage

Internal domestic hot water storage tank (Tank-in-Tank system)

External heat exchanger (fresh water unit)

Internal domestic water heat exchanger

Fig. 81: Combined storage tank (domestic hot water heating + energy storage)

Storing thermal energy

A buffer storage tank in a heating system is a heat storage tank, which is filled with hot water for heating. It can combine heat from various sources and discharge the heat at intervals.

The buffer storage tank helps compensate for differences between the amount of heat generated and consumed, and thereby, level out power fluctuations in the heating system. Thanks to this, heat generation can be operated largely independent of consumption, resulting in better operating characteristics and greater energy efficiency for many energy sources. The continuous thermal loss through the outer surface of the storage tank can be minimised by means of good thermal insulation and avoidance of thermal bridges.

Multitalent combined storage tank

Combined storage tanks allow domestic hot water heating and energy storage in a single device. With the integration of solar thermal energy, combined storage tanks are used for both heat storage for auxiliary heating and preparation and storage of domestic hot water. A difference is made between different types of domestic hot water heating.

Combined storage tank with fresh water unit

Here, the domestic hot water heating takes place via an external heat exchanger. If domestic hot water is required in the kitchen or bathroom, cold water flows through a high-performance plate heat exchanger, which is located outside of the storage tank. There, it is heated by the heating water, which is prepared in a buffer storage tank, directly to the desired hot water temperature.

Combined storage with built-in internal heat exchanger

In this model, the domestic water is heated by an internal heat exchanger: By using solar energy, the combined storage tank is charged through a heat exchanger in the lower area of the device. Optionally, a heat conduction tube is used in the stratifier lance technology. If the solar radiation is not enough for domestic hot water heating, reheating is done by the centralised heat generator in the upper region of the storage tank. If sufficient energy is available in the storage tank, the supply of the heating circuit also takes place via the storage tank. The centralised heat generator is turned on only when the temperature set for the heating circuit in the storage tank is undershot.

Tank-in-Tank system

In this system, there is a second smaller inner tank for domestic hot water inside the buffer storage tank, which holds the heating water. This means that the solar system can heat the heating water and domestic hot water in one step. The heating water in the outer jacket of the storage tank is heated by a heat exchanger using solar energy. This heat reaches the domestic hot water via the surface of the inner storage tank.

Flue gas systems – versatile systems

Refurbishing chimneys with stainless steel

The demand for heating systems with solid fuels and wood burning stoves continue to place chimneys in the focus of builders and planners. The flue gas systems of heating systems need to be optimally adapted to the type of firing. The use of stainless steel in flue gas systems is highly popular today: The material is durable, requires little space and can be used in all structural conditions. Flue gas systems made of stainless steel are suitable for both new constructions and subsequent integration, and for both the interior as well as the exterior.

Meeting all requirements

Besides high temperatures, flue gas pipes are also exposed to chemical attacks caused by the flue gases – it is especially about the acids in this case. If the dew point is undershot, these acids act aggressively on the flue gas pipes through condensation. However, contemporary stainless steel flue gas systems easily cope with the condensing operation of heating systems used today.

Suitable for every heating system

Stainless steel flue gas systems have many capabilities and are suitable for all approved fuels.
Various manufacturers offer systems that differ in the pressure and temperature range. Designs that withstand the maximum flue gas temperatures of 200 °C are suitable for oil-and gas-fuelled fireplaces. If a solid fuel system – such as a wood burning stove or a split log boiler – has to be connected, the flue gas system should be designed to withstand a flue gas temperature of at least 400 °C.
In a pellet-fired heating system, the formation of condensate inside the chimney has to be taken into account because of the low flue gas temperatures. Therefore, the flue gas system must be insensitive to moisture. If very high demands are placed on the pressure resistance due to the operation of a cogeneration of heat and power system or the connection of an emergency generator or combustion engine, there are special systems for overpressure of 5,000 Pa and flue gas temperatures of up to 600 °C.

Single-walled, double-walled and flexible

Flue gas systems made of stainless steel are available in single and double-walled designs. They are inexpensive and easy to fabricate and are often used intentionally as an architectural design feature on buildings. They are suitable for indoor and outdoor installation and, depending on the model and type of fuel used, are suitable for low or high pressure operation.

Single-walled flue gas systems made of stainless steel

Single-walled stainless steel flue gas systems are mainly installed as inner pipes to carry flue gases in existing or newly constructed shafts. In rare cases, they are installed as single-walled flue gas systems, such as, for discharging flue gases of fireplaces in the installation room in which the ceiling also forms the roof and an additional shaft is not needed for laying the pipe.

Air flue gas systems with stainless steel inner pipes for carrying the flue gases

Air flue gas systems are required for operating fireplaces independent of the air in the room. They are used for discharging the flue gas and at the same time for supplying air to connected fireplaces. They are available for installation inside or outside buildings, and also in two different types of design. As concentric or parallel air flue gas system. In the concentric system, the flue gas-carrying stainless steel inner pipe is located in an existing or newly constructed shaft. The gap between the inner pipe and shaft is used to supply the air for combustion. The parallel system consists of two shafts, one of which is needed for accommodating the flue gas carrying stainless steel inner pipe and the other for supplying air for the combustion.
Air flue gas system with stainless steel inner pipes are easy to install, modify, expand or dismantle. They also have the energy-related advantage that the cool outdoor air used for combustion flows past the warm flue gas pipes to the fireplace and gets heated in the process.
They are installed completely as so-called flue gas systems in new buildings.

Flexible stainless steel inner pipes

Flexible stainless steel pipes are used as flue gas-carrying inner pipes for renovating existing flue gas systems or chimneys with inclined sections. In rare cases, they are also used throughout vertical flue gas systems if these, for example, are rectangular in shape having oval inner pipes. Flexible piping systems are manufactured in single or double-layered design, and have a corrugated or smooth inner surface depending on the type of design. Special folding and joining techniques allow safe and yet flexible pipe runs.

Double-walled flue gas systems made of stainless steel

Double-walled flue gas systems made of stainless steel which are suitable for all types of fuels depending on the design, are called flue gas system kits. They consist of a

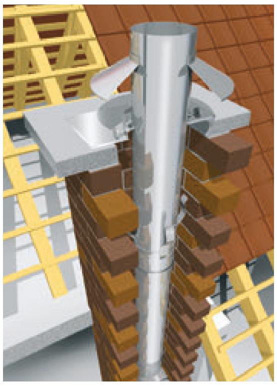


Fig. 82: Existing shafts

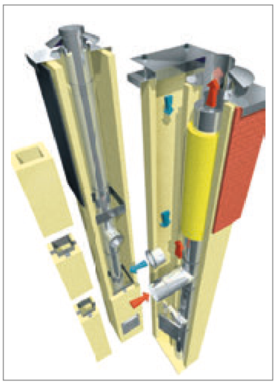


Fig. 83: Air flue gas systems

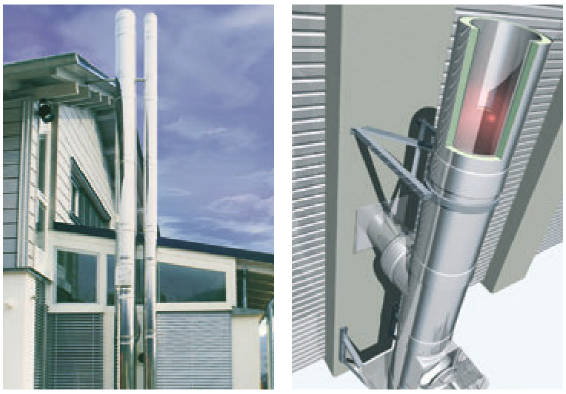


Fig. 84: Double-walled systems

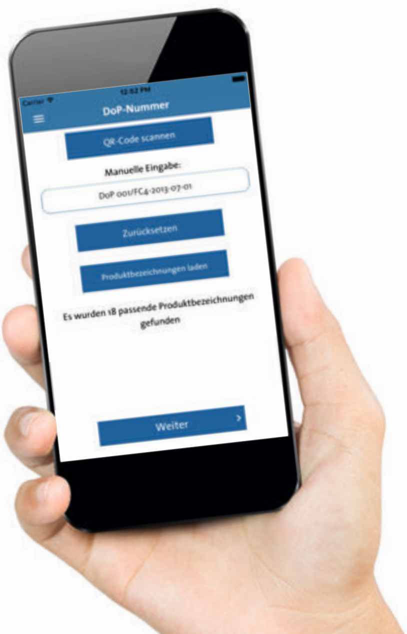
flue gas-carrying stainless steel inner pipe, a thermal insulation around it and an outer jacket, which usually also has stainless steel quality. They are used mainly for the construction of flue gas systems, where an additional jacket is not required for fire protection reasons according to building regulations, for example, when installing on exterior walls or inside buildings in halls or other fireplace-installation rooms whose ceiling forms the roof. They are also installed in buildings with several floors. Without any additional jacket if fire zones are not bypassed. Otherwise, with a jacket.

CE marking on flue gas systems indispensable

All building products, including flue gas systems may be used in conformance with the Model Building Regulation or State Building Regulations for the installation, alteration or maintenance of structural works only if these are suitable for the purpose of application. According to the European Building Products Ordinance for all products which are manufactured according to a harmonised European standard, the product specifications must be indicated in a "Declaration of Performance" by the manufacturer as proof of "suitability" and these products must bear the CE mark. This also applies to stainless steel flue gas systems which are manufactured according to a corresponding harmonised European standard. According to the provisions of the European Building Products Ordinance, the term "use" means that the flue gas systems can be commissioned.

App for determining the equipment identification of stainless steel flue gas systems

According to German building regulations, flue gas systems designed in Germany must be labelled with an equipment identification, that contains the performance characteristics which are important for the assessment of the plant. The equipment identification is of particular importance in the case of a replacement of the fireplaces. If, for example, a flue gas temperature limit of 200 °C is noted in the equipment identification (due to the given distances to combustible building materials), then no fireplace which can produce a higher flue gas temperature can be connected to this flue gas system. In this respect, a non-existent or incorrect equipment identification can be extremely problematic and lead to preventable fires or accidents.
The type of the equipment identification and the performance characteristics to be specified therein are described in DIN V 18160-1 and in Supplement 1 and the corresponding corrections. The regulation for the implementation of the system identification is found in the German building regulations, depending on the state, either in the "List of technical building regulations" or in the "Administrative guidelines of Technical building regulations (VwV TB)". They lay down the rules of application, which must be observed in the application of building products in accordance with the harmonised European standards. This also applies to the harmonised European standards for flue gas systems.
The correct specification of equipment identification is complex due to the supplements and corrections to DIN V 18160-1 to be observed. That is why the BDH has published an app for easy and simplified creation of the equipment designation for "Metallic flue gas systems". This app helps in determining the equipment identification for all "metal flue gas systems" produced and distributed by the BDH member companies.



Download the DoP app now

www.bdh-koeln.de/dop

Tank systems

Storing heating oil safely

Heating oil can be stored in different ways. Here, the personal preferences for the installation site, the individual structural conditions and economic considerations are decisive.

Modern tank systems for heating oil ensure maximum security of supply and economic independence. They form an ideal basis for an economical and environment-friendly supply of heat.

The separate tank offers operators of oil heating systems the free choice of suppliers and the option of making a reasonable purchase, because the consumer is free to decide the time of delivery and is also able to safely store a larger stock of fuel.

Modern heating oil tanks, according to the state of the art, are double-walled tank systems that do not require more collection space. The factory production and testing ensures an extremely safe tank system that guarantees the secondary protection required by law for storing heating oil for decades. In old single-wall tanks, often the secondary protection by the on-site collection trough is no longer ensured.

Unfortunately, most of the operators of an oil heating system are not aware that **they** are fully responsible for proper and safe operation and are even personally liable in the event of any damage. Environmental damage can quickly lead to unpleasant amounts of total damage for the operator. An oil tank insurance also will usually not pay for damages, if the system does not correspond with the state of the art.

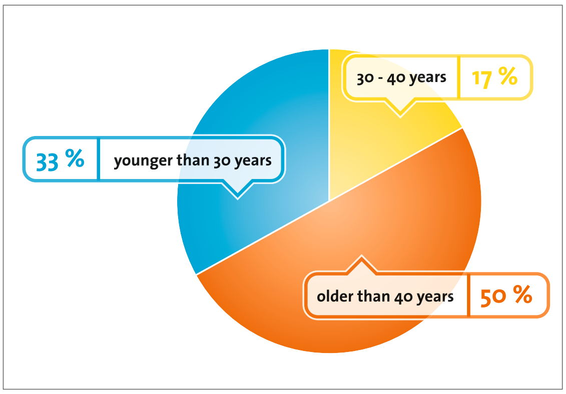


Fig. 85: Ageing structure of the plastic storage tank in the market since 1970

Fig. 86: Modern single- and double-walled safety tanks

Requirements

Heating oil can be stored either underground or aboveground. An oil storage tank is considered to be underground, if it is completely or partially embedded in the ground. Storage tanks that are usually set up in closed rooms are considered aboveground, even though the cellar is below the ground level.

Outdoor storage of heating oil in an underground double-walled steel tank is rather rare in the private sector. Aboveground storage in the basement is common. Formerly, there used to be a separate heating oil storage chamber (walled collection space); today the storage facility is mostly in the boiler room itself. Basically, the legal requirement of secondary protection that is achieved by the double-walled characteristic of the tank system with an additional leak detector or leak detection system applies here.

The previously common, single-walled tanks made of metal or plastic, which require a collection chamber for secondary protection, are still found in the old stock of many cellars. However, this collection chamber is regarded as an acceptable secondary protection only if the sealing surface is made of approved materials. Moreover, the masonry should be sufficiently stable, there should not be any damages and the collection chamber should be maintained leak-proof permanently.

For more than 40 years, plastic storage tanks have been used for storing heating oil. They are mainly installed in the cellar or boiler room. Today, as per the statistics of the association of chimney sweeps, Germany has approx. 5.8 million oil heating systems and a corresponding number of heating oil storage tanks (2-3 tanks per system on an average) in the cellars of German one-family houses and apartment houses.

From 1970 to 1990, single-walled plastic storage tanks, which were mounted in walled collection troughs (collection space) as secondary protection, were sold for the storage of heating oil. Since 1990, factory-made, double-walled and odour-proof tanks have established themselves in the market and completely replaced the old single-walled tank in sales.

The replacement of the single-containers after 30 years of service life is strongly recommended by experts and expert agencies, since the safety and the functional capability of the tank system as well as the collection space can no longer be ensured.

Investigations of the TÜV in Bavaria and Hesse have proven: More than 80 % of the tested collection troughs did not show the required secondary protection any more.
Besides, a modernisation backlog can be seen today in the heating oil tanks: Around 45 % of all plastic storage tanks are 25 years old or even older.

By buying a modern double-walled heating oil tank, consumers are investing in a high-quality product that guarantees the easy and safe supply of fuel even in the future. This modernisation measure is usually even associated with significant space saving through the simplified installation in the boiler room that is possible now.

Mounting on double-walled safety tanks

The principle of double safety applies to storage of heating oil. Thus, a collection space is required by law for single-walled tanks: It prevents release of oil in the water in case of any leakage. This collection space must be oil-tight, have an approved intact coating and be accessible for inspection. Moreover, the masonry should be structurally sufficiently stable in the case of a leak. The single-walled tanks should be mounted at a sufficiently large distance from the walls to allow inspection.

In contrast, double-walled heating oil tanks come with the capability of absorbing oil spills completely, already delivered ex-factory. Moreover, they save a great deal of space when installed: clear advantages which are of great importance to the consumer. Double-walled heating oil tanks are available in different models – versions with inner and outer tank made of plastic, or with the facility of translucent leak detection,or as metal-cased plastic tanks with optical leak detection.

Fig. 87: The Öltankschau app

All double-walled tank systems have a long service life and provide maximum safety without any maintenance cost, which is unavoidable in walled collection areas. Practice has proved that collection areas often lose their protective properties after approximately 20 years of use. Therefore, double-walled tank systems clearly provide security.
The fuel tank systems department at BDH has launched the ÖLTANKSCHAU app which is a digital tool for quickly assessing a heating oil consumption system. With this app, the heating company can inform the customer on-site about the status of his heating oil consumption system and make suggestions. More information is also available at: www.oeltankschau.de

Small dimensions, high flexibility

Modern insulation and increasingly efficient heating systems ensure continuous reduction in fuel demand in a lot of buildings. This also reduces the storage quantities of heating oil.

New tank systems require less space, home owners gain valuable space. Thanks to the compact dimensions of double-walled tank systems, subsequent integration is also possible. Besides, modern tanks are also approved for low-sulphur heating oil and for oil with biological additives under construction and water law. The tank systems are equipped with limit switches and partly with other safety equipment to prevent an overfill when refuelling.
Several automatic monitoring devices ensure easy and safe control. The heating oil storage can be controlled at all times with the level indicator.

Smart Heating:
More comfort and energy efficiency

Smart Heating as a key component of energy management and Smart home

The digital heating technology is a key component in the networking of building services. Almost every smart home solution now allows the heat supply to be optimised using schedules, room sensors and other automatic features. The systems that are particularly efficient are the ones that control not only the heat transfer but the heat generator itself to adapt the heating demand because they control not only the room heating, but can flexibly control the energy consumption as well.

Here, the heater cannot be considered as an isolated system. As part of the energy revolution, consumers will increasingly use electricity generated from renewable sources. The existing electrical building services will then compete with electrically operated heat pumps and electric cars that are charged at house wall terminals.

The integration of equipment and systems, which generate electricity, heat and mobility is described as “linking of sectors”. Heating and electric mobility have to be adapted to the other electrical systems through the use of the available electricity. Since electricity from renewable sources is limited and going to be increasingly volatile in the wake of the energy revolution, the discussion about the optimal use between the major electricity producers and consumers is becoming more and more important.

EEBUS provides a common language for energy

The prerequisite for this communication is a common language,which can be used by the equipment and systems to communicate the energy supply, demand and capacity beyond the limits of industry and manufacturer. To this end, the leading communication standard across manufacturers and industries is EEBUS. With the standard networking protocol SPINE (Smart Premises Interoperable Neutral Message Exchange), EEBUS provides the prerequisites for ensuring that all energy-related equipment and systems of a building can exchange information about their energy demands and their flexibility in energy consumption. In the EEBUS initiative, over 70 international companies from all areas of electrical, heating, power systems and electric mobility develop the communication specifications together for energy-related equipment and systems in buildings.

The goal is to integrate “new” electricity consumers such as heat pumps or electric car charging stations in a flexible manner and without mutual interference. Illustrative example: If an electric car is connected to the wall terminal and a heat pump is running at full capacity at the same time, it has to be ensured that the safety circuit in the house does not trip. If the systems support the EEBUS application “Overload Protection” then they adapt their loads: To start the charging process, the heater slightly reduces its capacity and then adapts its overall capacity to that of the building grid.

Communication relieves the network – and your wallet

Along with an energy management system (HEMS), further EEBUS applications are planned. Thus an energy manager can operate the heat pump such that it consumes maximum electricity from an in-house photovoltaic system. In the noon time, the hot water tank is heated to the maximum using inexpensive solar power generated by the roof-installed batteries – instead of using it in the evening when the heat is required.

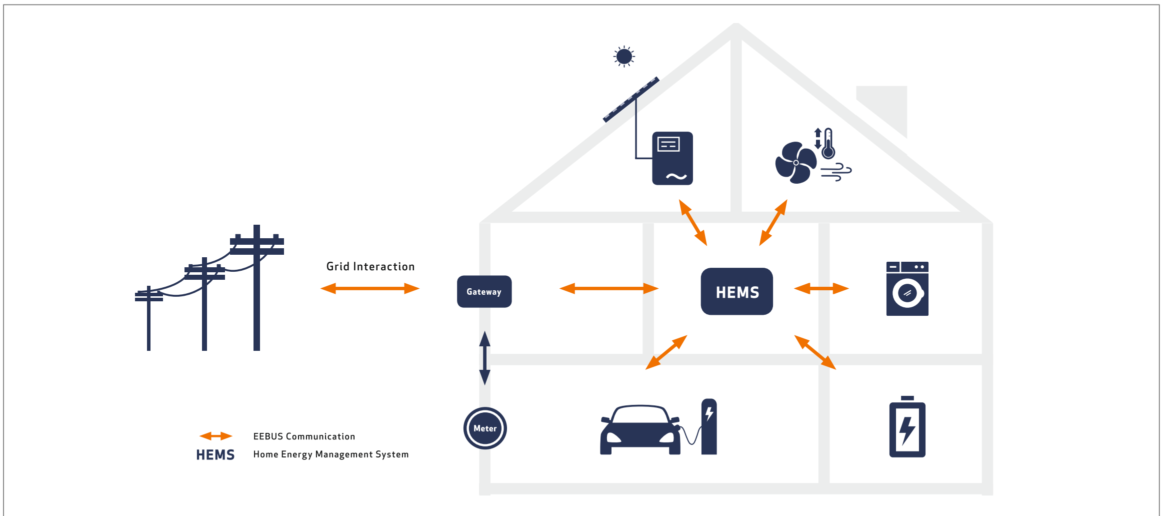


Fig. 88; EEBUS provides a common language for energy

In addition to cost benefits, this also takes the load off the public power grid: At the time of peak power generation, less solar power is supplied and, on the whole, the output of the existing solar power or wind power systems need to be curtailed later. Ultimately, large quantities of energy generated by renewable sources on windy and sunny days are curtailed or sold too cheaply to other countries today. Even electric cars can be charged in a flexible manner that is network conducive using the standardised EEBUS communication between HEMS, PV system, heating and electric car charging station.

Heating and e-mobility use excess electricity from the power grid:

Together with a smart measuring system, the EEBUS communication also supports the power grid. The HEMS can offer the flexibility of the building in the grid or take up the tariff of the local energy supplier via an interface to the distribution network. The heat pump then heats its water storage favourably at noon when surplus electricity is available in the grid. Using the same technique, supply shortages can be managed, when many people connect their electric cars into a wall box for charging at the same time when they get back from work. The EEBUS communication can thereby offset consumption peaks by prioritising the charging and coordinating the distribution throughout the night time. The additional grid load is as low as possible.

Working group HVAC: EEBUS and BDH are connected for success

BDH and its member companies have been participating in the working group "Heating, ventilation, air conditioning" (HVAC) of the EEBUS initiative since 2016. In addition, the manufacturers involved also cooperate with the leading companies in the energy management and e-mobility sector in order to link the sector internally and to the Smart grid interface in an efficient and transparent manner.

A series of heating systems and their controllers already support the EEBUS communication, as well as growing number of energy management systems. The first networked electric car charging stations with EEBUS will be launched in 2019.

In developing its communication specifications, the EEBUS Initiative, being an European association with German roots, focuses on open systems, democratic decision making processes as well as free availability of the final standard. This is also to be seen as an alternative to the closed communication platforms in the "Internet of Things", which some big companies put on the market with force.

EEBUS heating applications

To enable open communication, all the information that needs to be exchanged between a heating and domestic hot water system in the networked building for its optimal operation with other equipment, are defined in the EEBUS specifications. This includes the operating condition (on, off, auto, eco) or a required room temperature, but also complex data sets like schedules or the expected heating demand.

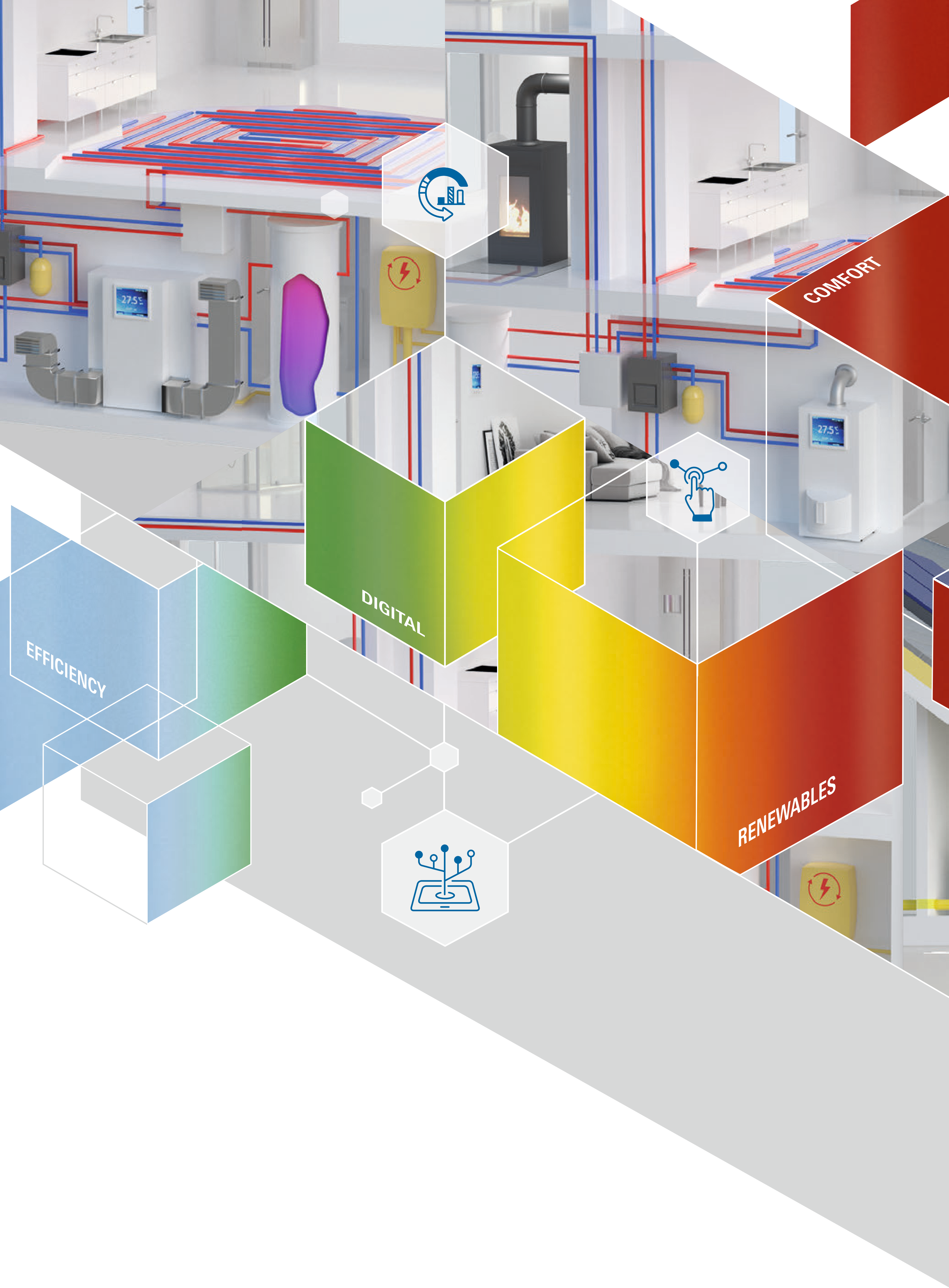
In the first step, the EEBUS specification defines HVAC-specific control data in order to operate heating systems, e.g., via smart home systems. These application scenarios provide for convenient, cross-industry operation of the heating system, without being restricted by proprietary protocols of individual smart home platforms.

In the area of "Energy management", the information with which the heating system can be integrated into an energy network is defined. The application scenario "Consumption forecast" roughly shows how the forecasted heating energy needs are reported to an energy management system (HEMS). The HEMS can then control the heater such that the power consumption of a solar system is optimised or surplus power is drawn from the grid.

Each manufacturer has the control over their device functions

The use cases are defined, translated into technical specifications and tested jointly by the participating member companies of BDH and EEBUS. The functions within the heating system are still left to the discretion of the manufacturer. In this manner, the EEBUS standard provides a shared communication basis on the one hand and on the other hand, allows manufactures all options of differentiation within their product series. The interlinking of systems via the EEBUS communication is carried out locally via Ethernet or Wi-Fi in the building via plug and play using a secure encrypted, standardised data protocol.

The EEBUS standard is defined today for the solar, household appliance, heating system and e-mobility applications and the connection to the smart grid. The specifications are developed further based on new applications. In the process, all market players are invited to collaborate by joining the EEBUS initiative and actively participating in its working groups. The major focus thereby is on the practical needs: Standardisation takes place at the request of the BDH and EEBUS members, rather than based on the technical platform specifications.


COMFORT
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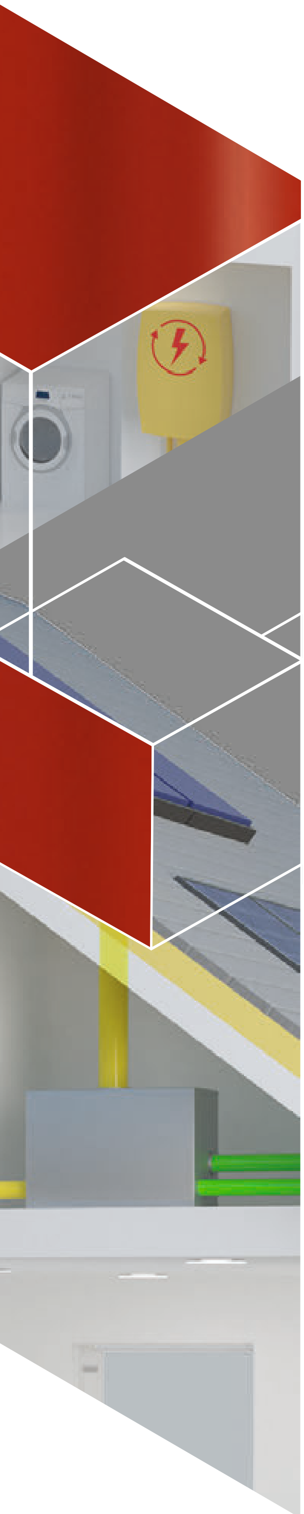
RENEWABLES

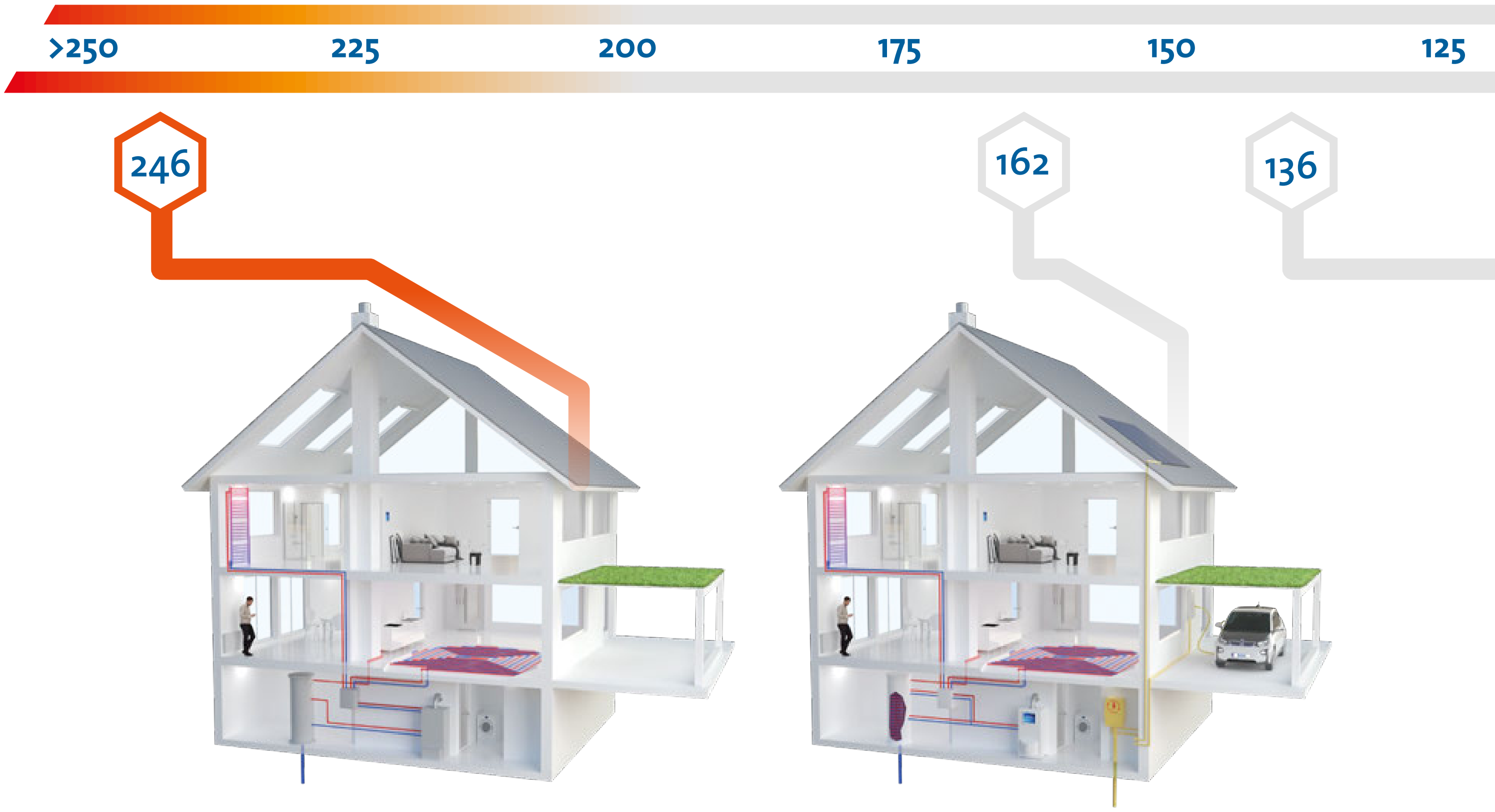


Examples
of modernisation

- Examples of modernisation
  Variants with gas/oil condensing boilers
- Examples of modernisation
  Variants with heat pumps
- Examples of modernisation
  Variants with wood burning systems/CHP systems

Examples of modernisation

Variants with gas/oil condensing boilers



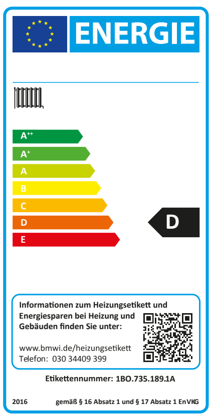
House before the renovation

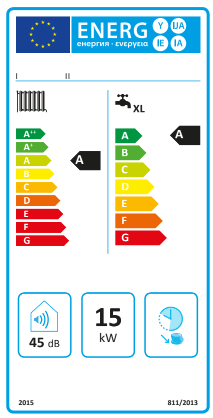
Partially renovated detached single-family house, year of construction 1970, usable floor space 150 m², solid construction/plastered, standard boiler – oil/gas, with indirectly heated domestic hot water storage tank, unregulated circulation pump.

Renovation variant – gas/oil condensing technology

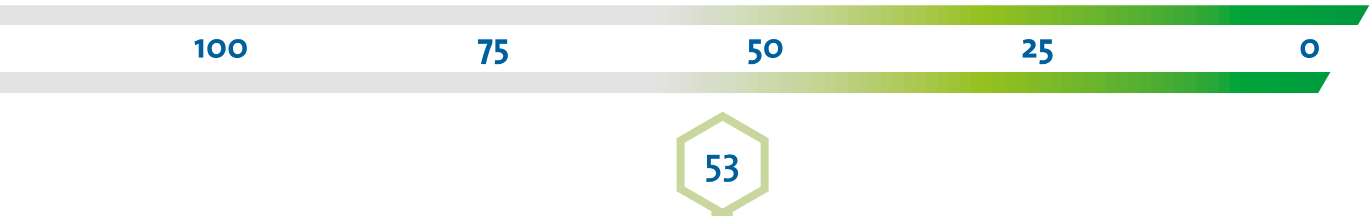
Modern condensing boiler (oil/gas) and indirectly heated domestic hot water storage tank, adaptation of the heating surfaces, high-performance pumps, new thermostat valves, insulation of the distribution pipes, hydraulic balancing, modern flue gas system.

	House before the renovation	Renovation variant
Annual oil consumption	3,263 litres	2,126 litres
Annual gas consumption	3,263 m³	2,126 m³
Annual saving of oil	–	1,137 Litres
Annual saving of gas	–	1,137 m³
Primary energy saving	–	83 kWh/(m²a)
Energy efficiency class for space heating	D	A
Energy efficiency class for domestic hot water heating	–	A





Primary energy demand in kWh/(m²a)



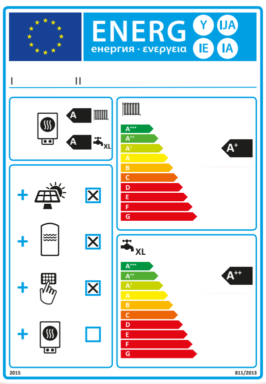
Renovation variant – gas/oil condensing technology with solar thermal system

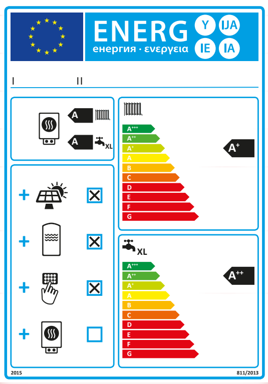
Modern condensing boiler (oil/gas), solar thermal system for domestic hot water and auxiliary heating, adaptation of the heating surfaces, high-performance pumps, new thermostat valves, insulation of the distribution pipes, hydraulic balancing, modern flue gas system.

Renovation variant – gas/oil condensing technology with solar thermal system, controlled residential ventilation and renovation of the building envelope

Modern condensing boiler (oil/gas), solar thermal system for domestic hot water and auxiliary heating, adaptation of the heating surfaces, high-performance pumps, new thermostat valves, insulation of the distribution pipes, hydraulic balancing, modern flue gas system, additionally controlled residential ventilation with heat recovery and renovation of the building shell in conformance with KfW-Efficiency House-70 standard.

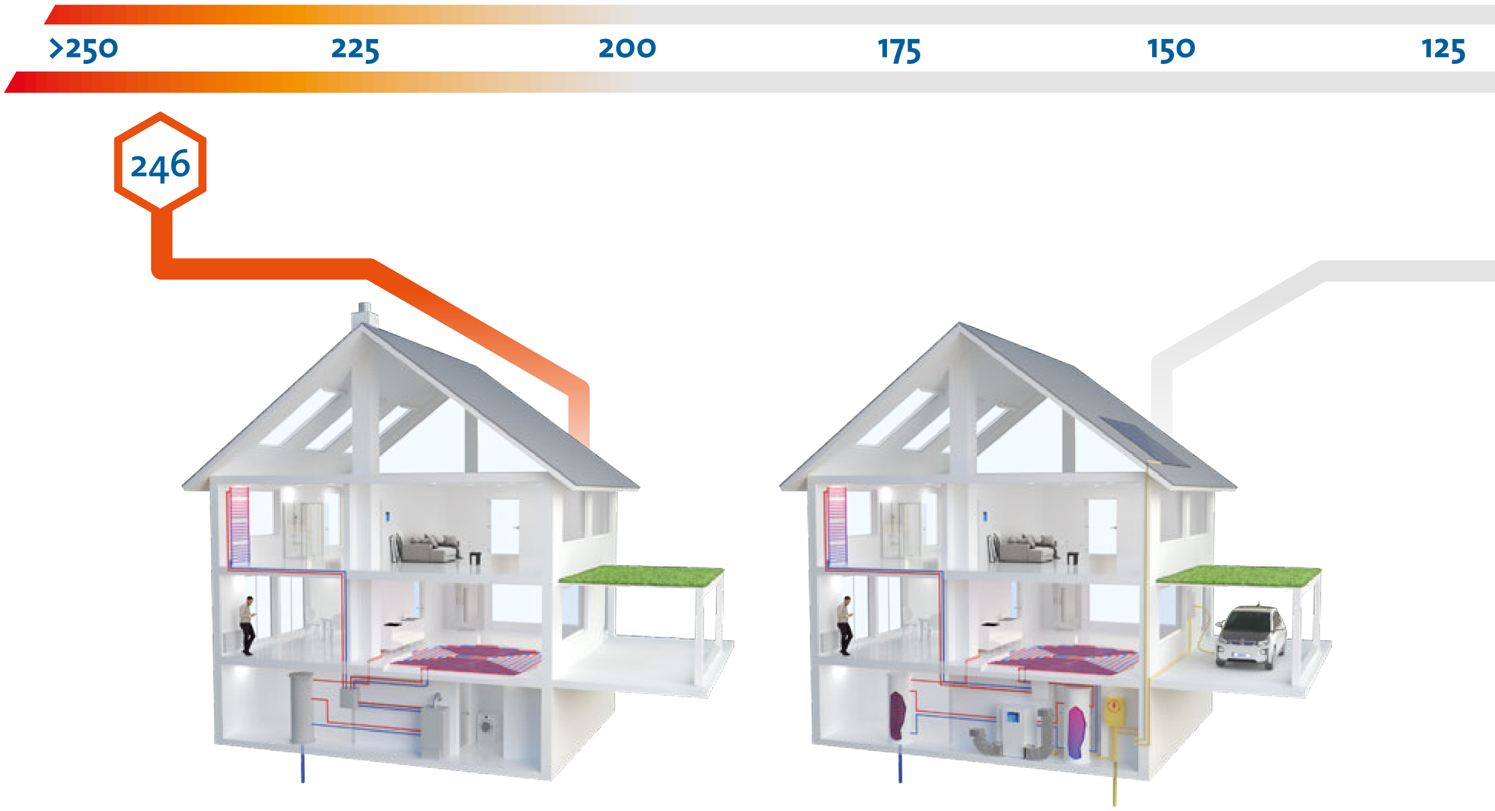
1,775 litres	602 litres
1,775 m³	602 m³
1,488 litres	2,661 litres
1,488 m³	2,661 m³
109 kWh/(m²a)	193 kWh/(m²a)
A+	A+
A++	A++





Examples of modernisation

Variants with heat pumps



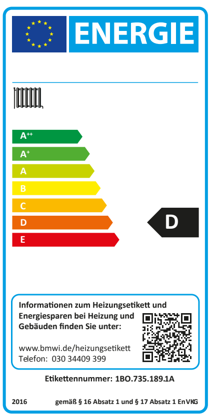
House before the renovation

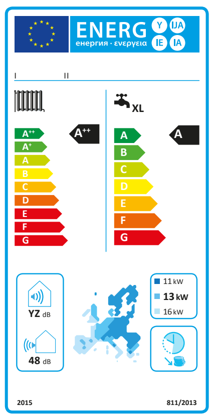
Partially renovated detached single-family house, year of construction 1970, usable floor space 150 m2, solid construction/plastered, standard boiler – oil/gas, with indirectly heated domestic hot water storage tank, unregulated circulation pump.

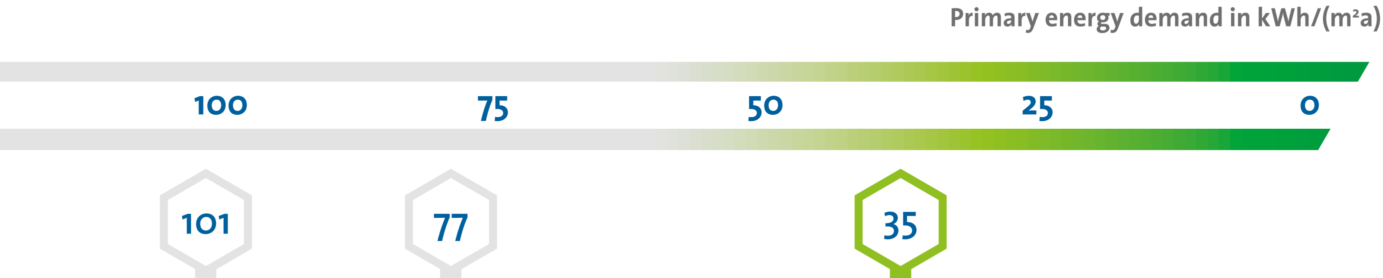
Renovation variant – Air-water heat pump

Air-water heat pump, buffer storage and domestic hot water storage tank, adaptation of the heating surfaces, high-performance pumps, new thermostat valves, insulation of the distribution pipes, hydraulic balancing.

	House before the renovation	Renovation variant – Air-water heat pump
Annual oil consumption	3,263 litres	–
Annual gas consumption	3,263 m³	–
Annual electricity demand	–	8,100 kWh
Primary energy saving	–	145 kWh/(m²a)
Energy efficiency class for space heating	D	A++
Energy efficiency class for domestic hot water heating	–	A







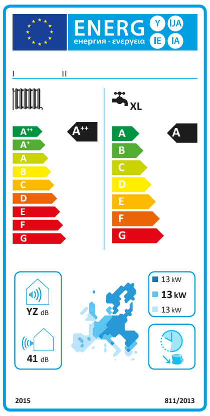
Renovation variant – Brine-water heat pump

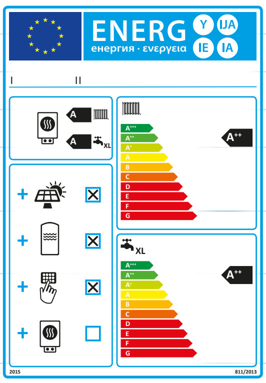
Brine-water heat pump, buffer storage and domestic hot water storage tank, adaptation of the heating surfaces, high-performance pumps, new thermostat valves, insulation of the distribution pipes, hydraulic balancing.

Renovation variant – Air-water heat pump with solar thermal energy, controlled residential ventilation and renovation of the building shell

Air-water heat pump, buffer storage and domestic hot water storage tank, adaptation of the heating surfaces, high-performance pumps, new thermostat valves, insulation of the distribution pipes, hydraulic balancing, additional solar domestic hot water system, controlled residential ventilation with heat recovery and renovation of the building shell in conformance with the KfW-Efficiency House-70 standard.

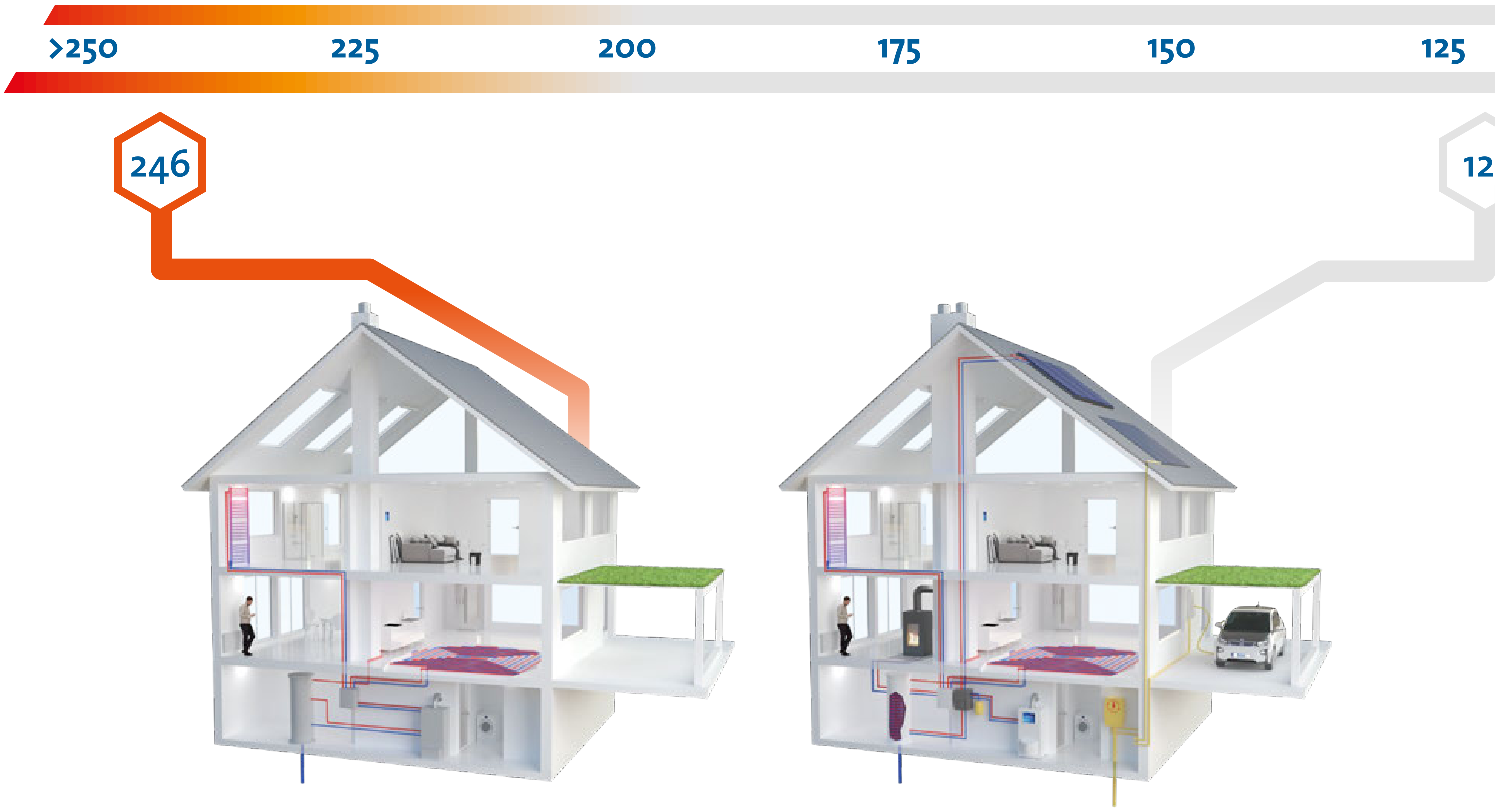
–	–
–	–
5,850 kWh	2,250 kWh
169 kWh/(m²a)	211 kWh/(m²a)
A++	A++
A	A++





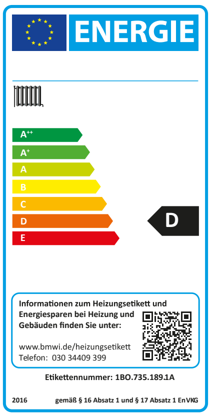
Examples of modernisation

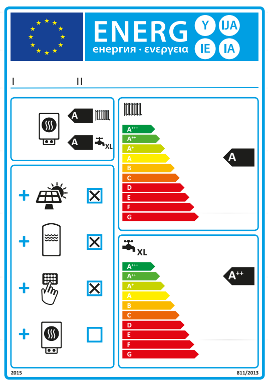
Variants with wood burning systems/CHP systems

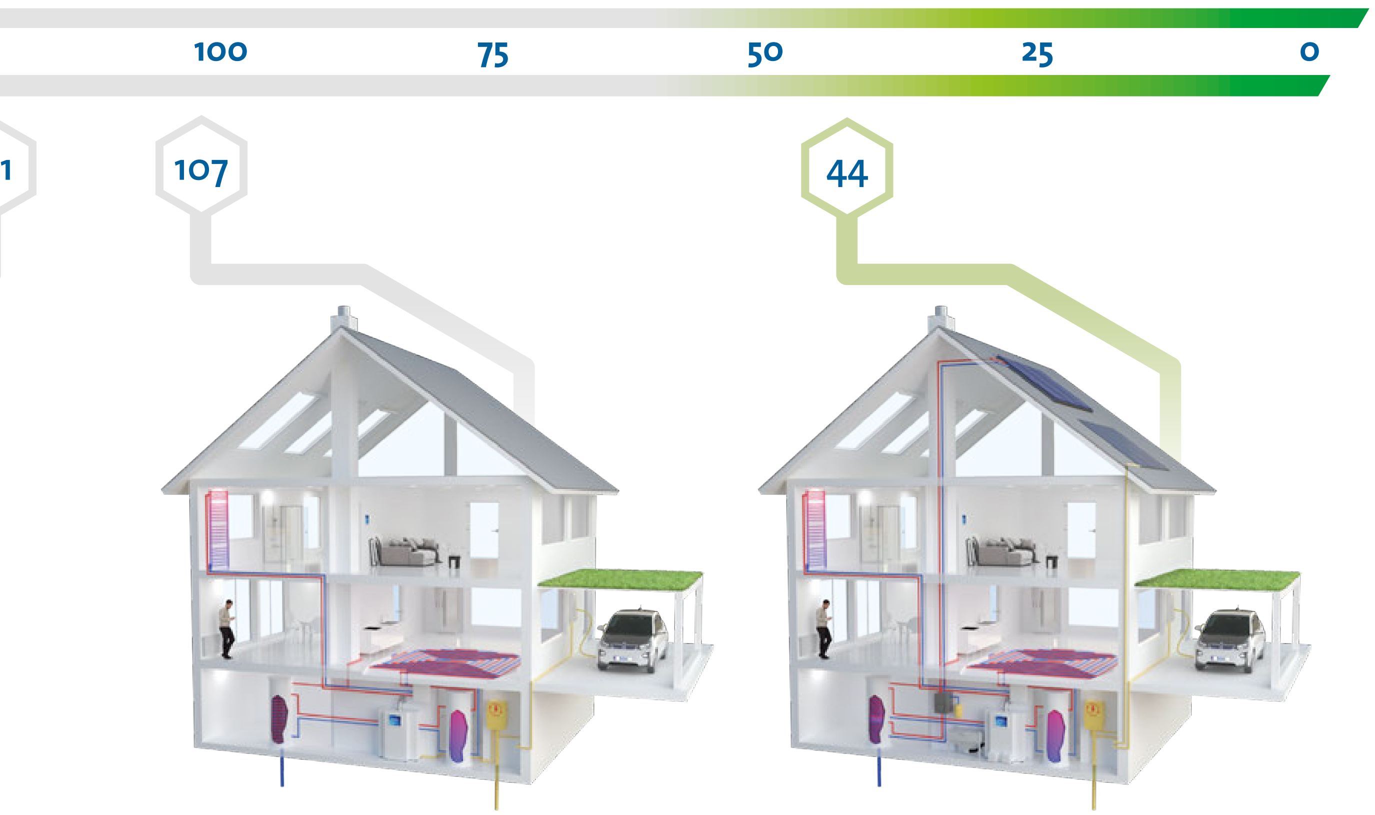


House before the renovation	Renovation variant – gas/oil condensing technology with solar thermal energy and wood burning stove/pellet furnace with collection basin
Partially renovated detached single-family house, year of construction 1970, usable floor space 150 m2, solid construction/plastered, standard boiler – oil/gas, with indirectly heated domestic hot water storage tank, unregulated circulation pump.	Modern condensing boiler (oil/gas), solar domestic hot water system, pellet furnace/wood burning stove with built-in collection basin, adaptation of the heating surfaces, high-performance pumps, new thermostat valves, insulation of the distribution pipes, hydraulic balancing, renovation of the flue gas system.

	House before the renovation	Renovation variant
Annual oil consumption	3,263 litres	1,352 litres
Annual gas consumption	3,263 m³	1,352 m³
Annual pellet/split logs demand	–	2,0 t/5,0 stère
Amount of electricity produced annually		–
Primary energy saving	–	124 kWh/(m²a)
Energy-efficiency class for space heating	D	A
Energy-efficiency class for domestic hot water heating	–	A++





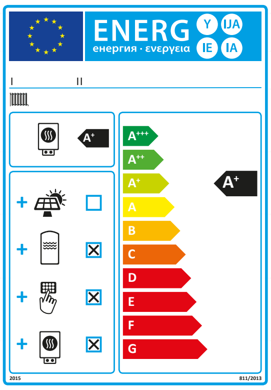
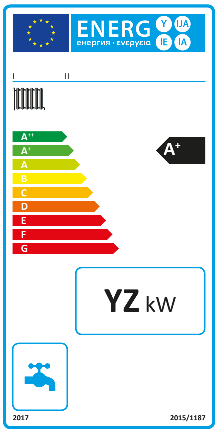


Renovation variant – micro CHP system

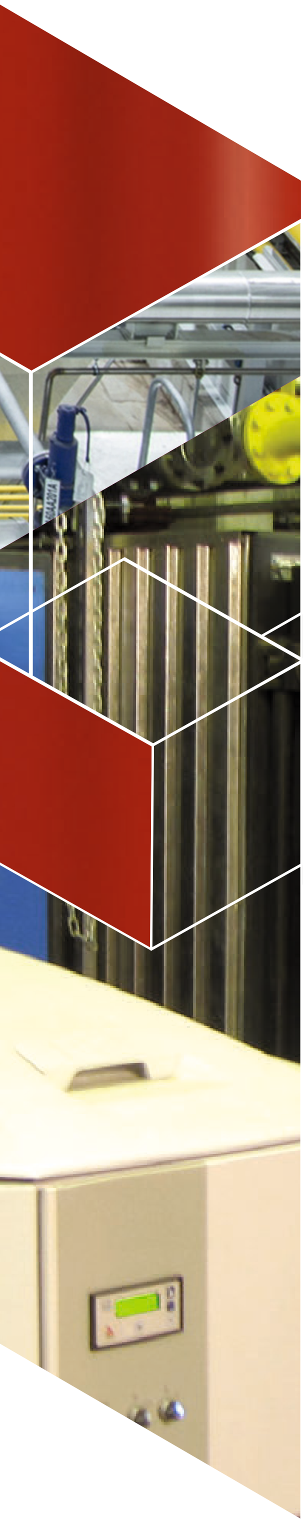
Renovation variant – pellet/split log boiler

Micro CHP system with modern gas condensing boiler, buffer storage tank and domestic hot water storage tank, adaptation of the heating surfaces, high-performance pumps, new thermostat valves, insulation of the distribution pipes, hydraulic balancing, renovation of the flue gas system.

Wood pellet/split log boiler and solar domestic hot water system, adaptation of the heating surfaces, regulated pumps, new thermostat valves, insulation of the distribution pipes, hydraulic balancing, renovation of the flue gas system.

Micro CHP system		Pellet/split log boiler	
–		–	
3,017 m³		–	
–		4,8 t/12 stère	
6,353 kWh		–	
139 kWh/(m²a)		202 kWh/(m²a)	
A+		A+	
–		–	


COMFORT
DIGITAL
EFFICIENCY
RENEWABLES



Industrial heat supply/
Standardisation

- Large firing systems
- Standardisation in Heating and Ventilation and Air-Conditioning Technology
- BDH Members

Large firing systems

The energy efficiency initiative of BDH with dena: Efficient heat supply systems reduce costs and emissions

The energy and cost-intensive production of large amounts of process heat for many technical processes and procedures in the industry and manufacturing sectors can be significantly reduced by optimising the heat supply system – by an average of at least 15 %. These kinds of energy efficiency measures are highly profitable and the costs associated with them are generally recouped within one to four years.

However, the emissions of these firing systems are also drastically reduced in the same step due to lower energy consumption and the use of modern technology.

High energy consumption of process heat

Depending on the application, process heat is required at very different temperature levels. It is produced from various energy sources, e.g., with electricity, oil and/or gas, and transported in various ways by warm or hot water as steam or hot air.

To supply thermal processes, a total of about 400 TWh of final energy is used each year in Germany. The economic energy savings potential in the industrial sector* is at least 30 TWh per year (i.e., 7.5 %) for thermal processes. An additional 96 TWh (i.e., 24 %) can be saved every year by increasing the energy efficiency in the provision of space heating. Of course, the emission loads of the firing systems are also reduced.

Steam and hot water production

The most widespread processes for process heat generation include steam and hot water boilers with a share of around 30 %. However, 80 % of these industrial heat and steam generation plants in Germany are now older than ten years and do not correspond to the current state of the art. If these old plants were refurbished to be state of the art, an annual energy saving of 9.6 TWh could be achieved. Let us be clear that this adds up to 2 % of the total energy consumption of process heat in Germany. On average, energy consumption in steam and hot water generation, including heat recovery, could be reduced by 15 %.

Analysis of potential savings

It can be assumed that nearly 300,000 heating systems in the power range between 100 and 36,000 kW are used in larger commercial buildings and in the industrial sector of the German thermal market. This is the result of in-depth research by the chimney sweep trade (ZIV), the inspection bodies of the TÜV and the sales of BDH members. 80 % of the installations in the heating market, approx. 250,000 systems, no longer correspond to the state of the art.

The following calculations were made on the basis of the above stock figures and provide the following high potential savings:

* The distribution between 2008 and 2016 is almost identical as specified by the BMWi .

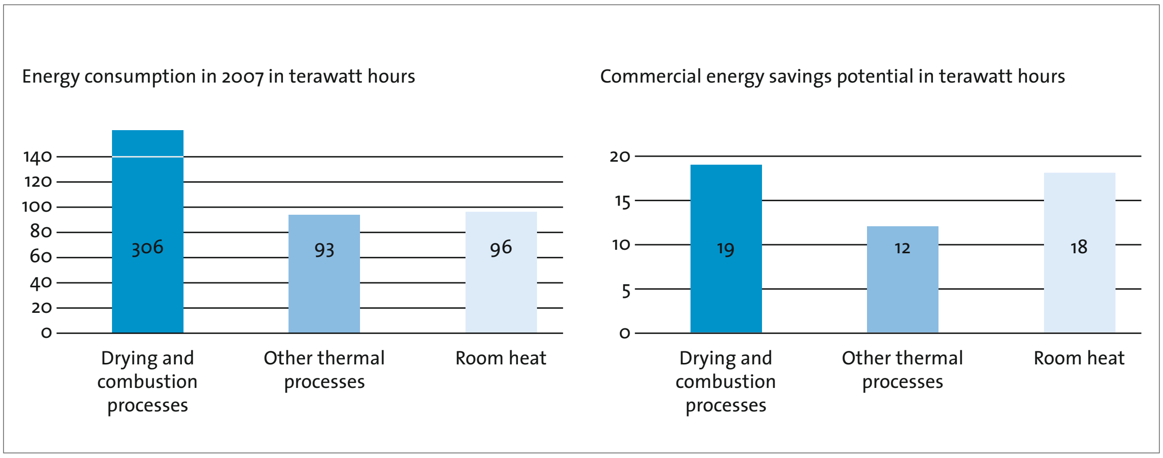


Fig. 89: Energy consumption and potential energy savings in industrial process heat applications

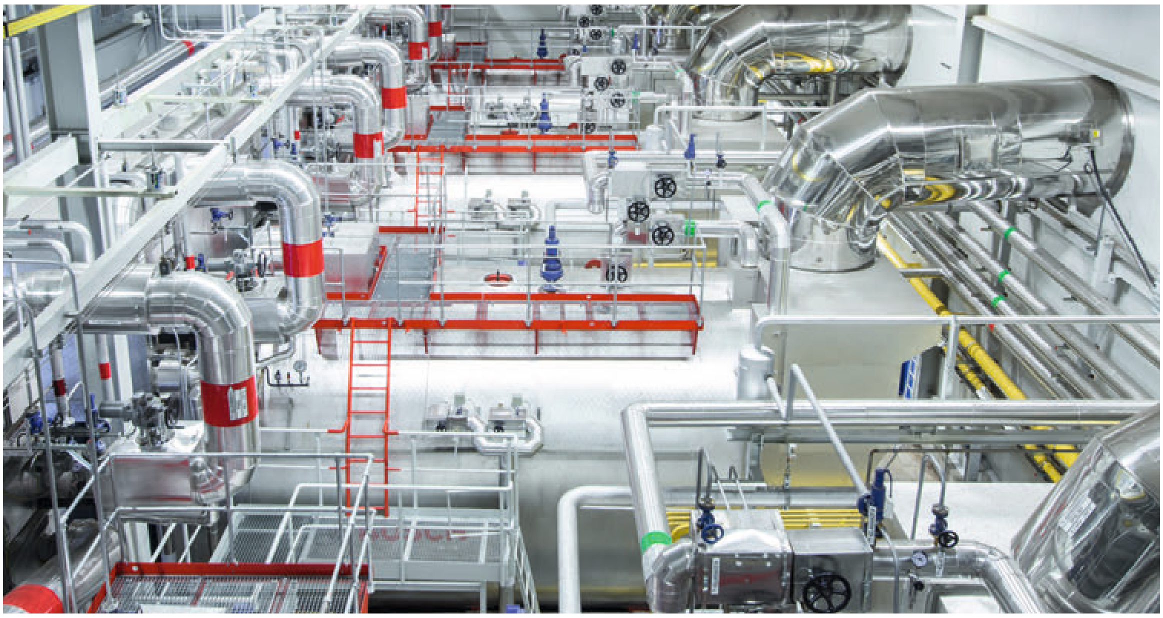


Fig. 90:
By far the largest energy demand in industry and manufacturing is attributable to the generation of heat for technical processes

- Reduction in annual consumption of heating oil: 810,000 t/a
- Reduction in annual consumption of natural gas: 4.43 billion m³
- Reduction in CO_2 emissions: 16.3 million t/a
- Reduction in nitrogen oxide emissions (NO_x): 34,885 t/a
- Reduction in the installed power output: 398 MW

Using 2008 as a basis, this constitutes a possible reduction in heating oil consumption of 3.3 % and a reduction in natural gas consumption of 4.6 %. In total, the use of efficient technology in the largest technical combustion systems can lead to annual final energy savings of 175 PJ. However, the potential reduction in CO_2 and NOx emissions is also highly significant.

It should be emphasised that the highest energy and cost reductions are achieved if the heat supply system is holistically optimised by adapting and coordinating all of the components. Only the optimum combination of all components of a firing system ensures a potential savings of 15 % on average, taking heat recovery into account.

Procedure for system optimisation

Measures to enhance energy efficiency within the heat supply system should always be considered as elements of optimising the overall system. Energy efficiency can be improved only by matching all the components with each other and optimising the system regulation and control.

All of the facts come to light by a detailed state analysis of the system's energy consumption, the heat demand and the individual system components. Additional savings can be achieved by optimising the control and regulation of the individual firing systems and any other firing systems connected.

Whenever constructing new systems, even the preliminary plans should take care to ensure energy efficiency of the components and the overall system.

Sensible use of waste heat by heat recovery

Around 40 % of the energy used for generating process heat in the industries is lost as waste heat today. Measures targeted at heat recovery maximise the efficiency of the overall system and therefore the system's energy efficiency.

In the event that upstream measures to reduce thermal loss have been exhausted, it is certainly worthwhile to exploit the waste heat by means of heat recovery. Generally, the following applies: Heat recovery is all the more sensible, the greater the difference between waste heat temperature and the required temperature. It is helpful in this context to create a heat circuit diagram, presenting all temperatures and the heat volumes transported and transferred within the process.

Large firing systems

A pinch analysis can then be used to determine the most efficient method for exploiting the waste heat available in every case. Thermal potential should be used locally and as directly as possible. For instance, waste heat can be used to heat industrial or process water, for preparing domestic hot water, to preheat combustion and drying air, or as room heat. It is also worthwhile to use an economiser, for example, to preheat the feed water.

In condensing technology, an additional heat exchanger is fitted downstream from the economiser, which cools the flue gases to below the condensation temperature of water. This means that the condensation heat of the water contained in the flue gas can also be exploited.

Optimising the overall system

Measures to minimise the heat demand and losses should first be implemented before optimising the individual components of a heat supply system. Keep one thing in mind: Electrical energy has a higher value than steam, which in turn has a higher value than hot water. Therefore, the supply medium with the lowest possible value should be selected in each of the respective process stages, depending on the requirements.

By using hot water instead of steam, the efficiency of the firing system can be increased by 10 to 15 %. In many cases, a reduction in the temperature of the supply medium enables the use of heat recovery and the cogeneration of heat and power for further reduction of the energy demand of the entire system.

In order to minimise losses, the heat insulation on the heat generators, the pipes and also the heat storage should be analysed and improved wherever necessary.

Use energy efficient components

Equally, the target in using energy efficient components should always be the optimisation of the overall system. This is achieved by effectively streamlining all new and existing components.

Modulating (controllable) burners can be operated in many partial load ranges and are far more efficient than burners that have to be fired up and shut down individually.

Flue gas temperatures and energy consumption can be reduced using boilers with large heat exchange surfaces.

It is sensible to use energy efficient condensing boilers in hot water systems, as their deployment leads to significantly lower flue gas temperatures. Furthermore, their efficiency is substantially higher. Speed controlled drive motors for forced air burners and pumps also permit pronounced savings in energy consumption.

Fig. 91: Five gas-operated high-pressure steam generators, each of which produce 16 tonnes of steam per hour at an operating pressure of 10 bars

Optimising regulation and control

Large combustion systems should always be tailored to suit the actual heat demand. For example, a multi-boiler control ensures that only the actually required number of boilers is switched on at all times. Installation of flue gas sensor control ensures continuous measurement of the flue gas composition. Air intake control takes place in line with the best possible oxygen ratio in the flue gas at any given time (O_2 ratio). Simply cutting the O_2 ratio by just one percentage point leads to increased efficiency, by 0.5 to 1 %, depending on the age of the system.

Controlling and managing other combustion parameters such as CO content, flue gas temperature, soot figure or combustion chamber pressure and the installation of automatic flue gas or combustion flaps can cut the energy consumption still further.

Reducing emissions at the same time

The efficiency measures described not only reduce fuel consumption, but also the emission of anthropogenic emissions. In particular, the CO_2 and NO_x emissions generated during combustion can be reduced to a minimum by the use of modern and optimised firing systems.

In addition to existing national requirements from the 1st BImSchV (German Federal Immission Protection Ordinance – up to 20 MW) and the TA-Luft (Technical Instructions on Air Quality Control – 20-50 MW), existing systems (old plants) have to meet the requirements of the European Directive (EU) 2015/2193 of the European Parliament and of the Council dated 25 November 2015 in the future to limit emissions of certain pollutants from medium-sized firing systems. From a deadline depending on specific capacity, even existing plants have to comply with the European emissions limits.

These European requirements will be implemented by the 44th BImSchV – ordinance for introducing the regulation on medium-size firing, gas turbine and combustion systems, and for amending the regulation on small and medium firing systems.

The requirements are grouped together into a single regulation and adapted to the state of the art. For new systems in the future, only the requirements of the 44th BImSchV shall apply in Germany. The requirements for systems already installed under the scope of the existing TA-Luft and 1st BImSchV and other regulations under the Federal Immission Control Act (BImSchG) are retained as they already exceed the requirements of the Directive (EU) 2015/2193. From 2025, the existing systems will have to meet the requirements of the 44th BImSchV in general. Timely planning of a measure for retrofitting, conversion or new construction of the firing system is therefore recommended.

Fig. 92:
167 tonnes of hot steam per hour can be supplied by the boiler for the propulsion of the steam turbine and supporting the district heating supply

Standardisation in Heating and Ventilation and Air-Conditioning Technology

Questions and answers

Standardisation in the field of heating and ventilation and air-conditioning technology is carried out by the DIN Standards Committee for heating and ventilation and air-conditioning technology and their safety (NHRS). The NHRS processes all standardisation applications in the field of heating and indoor air-conditioning systems and their components (including the control, protection and safety devices). Some of the fundamental questions will be addressed in the following, because the topic of standardisation can lead to uncertainty or misunderstanding in many users.

Fundamental purpose

By means of standardisation, technical standards are defined and made available for everyone. This allows a large group of users to have access to the same know-how (for example, dimensions and tolerances, or testing and safety requirements).

Why participation in standardisation work is worthwhile

Active participation in standardisation work provides many advantages to users and final consumers, as well as manufacturers, designers, executors and authorities. Besides the information advantage over future technical regulations, which contributes significantly to the planning security, the following points are listed:

- Monitoring trends in the industry
- Good basis for implementing the company technologies in the market
- Shaping the technical regulations of the future
- Prerequisite for access to the global market

The liability of standards

Standards do not have any legal liability as such. Therefore, the standards are applied at first for everyone on a voluntary basis. However, the user can be confident of acting in a technically proper manner when observing the standards. A standard is always mandatory only if it is bindingly cited or included in, for example, laws, ordinances, administrative regulations or contracts.

The tasks of the NHRS

The work of the NHRS is classified under five divisions:

- Division 1 – heating technology
- Division 2 – ventilation and air-conditioning technology
- Division 3 – ICA for heating and ventilation and air-conditioning technology
- Division 4 – facility management
- Division 5 – overall energy performance of buildings – system standardisation

Each of the five divisions is composed of several working committees, where the actual standardisation work is done. A detailed list can be found on the NHRS website (www.din.de/go/nhrs). Anyone, who wants to participate can send an application for participation at any time to the respective working committee.

Besides small- and medium-scale enterprises, it is mostly industry and trade associations that are committed to standardisation. One of them is the Bundesverband der Deutschen Heizungsindustrie e.V. (BDH) (Federation of German Heating Industry), which contributes a broad spectrum of views and experience to the standardisation work.

Financing

The DIN group (DIN e. V., Beuth Verlag GmbH, DIN Software GmbH) receives 70 % of the funds from its own returns, obtained from the products and services it offers. At NHRS, the ratio of DIN is roughly 43 %. A slightly larger proportion, currently approx. 45 %, comes from industry project funds. The remaining funds are obtained via public funding.

The standardisation work in the NHRS is also being directly sponsored by associations and companies. Therefore, the non-profit “voluntary foundation to promote standardisation work of the NHRS” (VF NHRS) was founded. It undertakes the promotion of science and research in the field of heating and ventilation and air-conditioning tech-

Fig. 93: The development process of standards at DIN

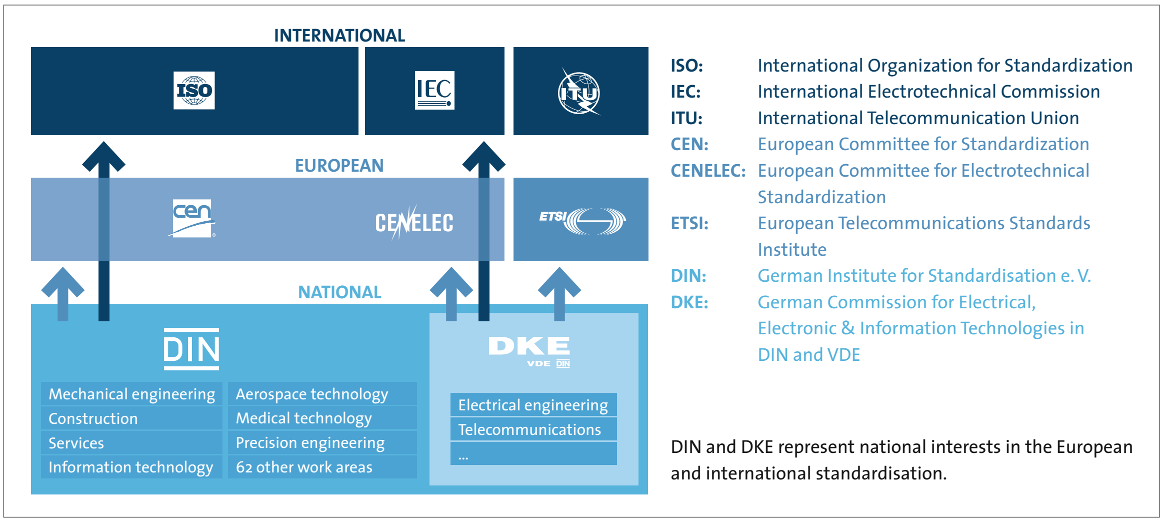


Fig. 94: Representation of national interests by DIN at European and international level

nology, as well as their safety and the financial support of the NHRS. The BDH is a member of VF NHRS.

Benefits

In the following, with reference to some industry-specific examples, the benefits of standardisation are shown.

DIN V 18599: Energy efficiency of buildings – Calculation of the demand of useful energy, delivered energy and primary energy for heating, cooling, ventilation, domestic hot water and lighting.

The pre-standard series DIN V 18599 was revised in September 2018 by the responsible joint working group for the "Energy assessment of buildings" of the DIN standards committee "Construction" (NABau), "Heating and ventilation and air-condition technology and their safety" (NHRS) and "Lighting technology" (FNL) for a revised republication. The documents were updated and adapted to the technological developments. Furthermore, the new edition replaced the versions of 2016.
The calculations allow the assessment of all quantities of energy which are necessary for heating, domestic hot water, air-conditioning and the lighting of buildings. While doing so, DIN V 18599 also takes into consideration the mutual influence of energy streams and the resulting consequences for design plans. Besides calculation methods, usage-related boundary conditions are also specified for a neutral assessment to determine the energy demand (independent of individual user behaviour and local climate data). The pre-standard series serves the purpose of determining the long-term energy demand for buildings or even sections of buildings and for assessing the possible application of renewable energies for buildings. The normatively documented algorithms are applicable for energy balancing of:

- Residential and non-residential buildings
- New buildings and existing buildings

DIN EN 12828: Heating systems in buildings – design of domestic hot water heating systems

Due to the low expansion capacity of pipes, the change in volume of the water caused by change in the temperature may lead to the fact that the pressure is increased greatly even with slight temperature increase. Without additional measures, such as expansion tanks, this increase in pressure leads to the destruction of pipelines and pressure vessels. Diaphragm pressure relief vessels help to compensate for these changes in volume of water in piping systems.
DIN EN 12828 gives clear indications how diaphragm pressure relief vessels must be designed and allows correct dimensioning. Without a correct dimensioning, there is a danger of pipe break. Dimensioning according to EN 12828 provides confidence to both the user and the designer: Finally, any diaphragm pressure relief vessel properly designed according to DIN EN 12828 can be considered technically reliable.

DIN EN 12831-1: Heating systems in buildings – Method for calculation of the design heat load

The heat load calculation, based on the layout of each heating system is carried out today according to the method accepted by DIN EN 12831-1. In this way, DIN EN 12831-1 contributes significantly to the fact that heating systems are designed so that they reach the design internal temperature required. EN 12831-1 provides a uniform applicable method that allows the comparison of different systems. Simply put, this means that EN 12831-1 ensures that the heating system is able to heat the flat and apartment house to a comfortable temperature in winter.

BDH Members

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Ademco 2 GmbH
ait-deutschland GmbH
Arbonia Riesa GmbH
ATAG Heizungstechnik GmbH
ATEC GmbH & Co. KG
Austria Email AG
BASF Polyurethanes GmbH
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BTD Behälter- und Speichertechnik Dettenhausen GmbH
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DL Radiators SpA
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Hautec GmbH
HDG Bavaria GmbH
Heizomat Gerätebau- Energiesysteme GmbH
Herrmann GmbH & Co. KG
Hoval GmbH
Huch GmbH Behälterbau
IMI Hydronic Engineering Deutschland GmbH
IVT GmbH & Co. KG
IWO - Institut für Wärme und Oeltechnik e. V.
jeremias GmbH
Kermi GmbH
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Federal Ministry for Economic Affairs and Energy
BDH Federation of German Heating Industry
Energieeffiziente Gebäude BDI initiativ
BSW German Solar Association
bwp German Heat Pump Association
DEPV Deutscher Energieholz- und Pellet-Verband e.V.
DIN NHRS
DVGW
EEBUS
Fachverband Gebäude-Klima e.V.
geea Die Allianz für Gebäude-Energie-Effizienz
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