# Efficient systems and renewable energies

## Technology and Energy Panel


BDH
Federation of German Heating Industry

ISH

Federal Ministry
for Economic Affairs
and Energy


Source: © Federal Government/Kugler

## Message from the patron:

*Ladies and gentlemen,*

*In the spring of 2020, the European Commission presented its proposal for an EU climate law that will, for the first time, legally bind the EU to become climate neutral by 2050. Germany has also set itself this target and will set an example for more climate protection and energy efficiency in Europe. The Energy revolution is an opportunity for the economy and society that should be taken advantage of. It sets guidelines for a modernisation strategy in all sectors of our national economy and paves the way for a safe, environmentally friendly and economically successful future – also in the heating market.*

*At the same time, the European and national climate and energy targets pose major challenges for the economy. Existing buildings come into focus, too. Energy efficiency and the supply of millions of buildings through climate-friendly technologies and energy sources must advance faster. Accelerated replacement of old heating systems with efficient, climate-friendly technologies using the highest possible share of renewable energies is an important component. The transfer of innovations and the use of smart and networked solutions are further key challenges for today's heating market and heating industry. Progress in the building sector can be achieved only through dialogue with companies in the heating and construction industries, investors, owners and tenants. New financing and business models are also needed to activate more investment in the building sector. To this end, we also need to think of possible sustainable efficiency solutions that are affordable, socially equitable and designed with the right framework conditions for the market.*

*Decarbonisation of the heating market will succeed if we leverage all potential to reduce energy consumption and, at the same time, use renewable energies. Energy sources and technologies must be measured in the market by whether they are already 2050-ready or at least have a clear path to achieving climate neutrality by 2050. This path must be compatible with the energy revolution as a whole. But it is also clear that further technological leaps are required and possible to reach success. This will be achievable if we build on the ingenuity and innovations of our economy that are highly valued worldwide.*

*The Ministry for Economic Affairs is happy to take over the patronage of the BDH Technology and Energy Panel. With a focus on green energy systems and the digitalisation of the heating market, the panel addresses key topics for a successful energy revolution in the heating market. I wish the panel all the very best at ISH Energy Digital!*

*With kind regards*
*Andreas Feicht*


## Foreword

As part of the ISH, Messe Frankfurt and the Federation of German Heating Industry (BDH) have organised the Technology and Energy Panel for the ninth time. Due to the coronavirus pandemic, the Technology and Energy Panel and ISH 2021 will take place in digital form.

**Technology and Energy Panel with 14 strong partners**
The most important industrial associations in the field of heating and energy will be working together on the Technology and Energy Panel. They stand for the dual strategy of efficiency and renewable energy, and provide concrete answers to both the international professional community and policy makers about climate policy challenges arising from the EU's Green Deal, among other things.

**ISH Energy Green Deal ready**
In November 2020, the European Council decided to make Europe climate-neutral by 2050. By 2030, the $CO_2$ emissions should drop by at least 55 % instead of 40 % as had been previously planned.

About 50 % of the energy consumption of Europe can be attributed to the heating market. Heating and domestic hot water account for roughly one third of this. The climate protection goals of the Green Deal cannot even begin to be achieved without acknowledging the enormous $CO_2$ reduction potentials in the building sector.

ISH Energy and the Technology and Energy Panel demonstrate technically commercial solutions for the heating market and for making use of its enormous $CO_2$ reduction potentials.

A good 125 million heating systems supply about 400 million Europeans with heat. However, around 60 % of the heating systems use obsolete technology. As a result, these old systems emit too much $CO_2$. Therefore, the first priority of the climate protection policy for the heating market must be to replace these existing systems with modern heating systems as soon as possible. This includes a wide range of technologies developed and manufactured by BDH member companies and presented at the ISH Digital 2021 and/or at the Technology and Energy Panel:

- The heat pump technology, which uses green electricity, as well as environmental and geothermal energy, and which has been growing rapidly in the past two years.
- Condensing technology in combination with solar thermal energy, soon to be $H_2$-ready.
- Hybrid systems, which use a combination of several energy sources with ever increasing amounts of renewable energy.
- IOT@home: intelligent networking via energy management systems and the creation of partial self-sufficiency in buildings, as well as the sector coupling between mobility and heat.
- Wood central heating systems for using $CO_2$-neutral wood energy

ISH and the Technology and Energy Panel also demonstrate the interdependence between systems engineering and energy sources. Together with its main partner, Zukunft Gas (Future of Gas), the Technology and Energy Panel focuses on the present and future of the green gases biomethane and hydrogen. With the Institute for Heat and Mobility (IWO) as the gold partner, the Technology and Energy Panel will present the research projects and pilot projects of the oil industry in the PtX sector.

The panel will also focus on the potential of green electricity and $CO_2$-free wood energy for achieving the goals of the Green Deal.

We would like to thank the Secretary of State of the Federal Ministry for Economic Affairs and Energy, Mr Andreas Feicht, for becoming the patron of the Technology and Energy Panel. Looking to the future, the two signatories of this foreword, as long-standing allies of the ISH, are looking forward to a physical event in 2023. Until then, we look forward to the digital Technology and Energy Panel with great anticipation.

Iris Jeglitza-Moshage
Senior Vice President,
Messe Frankfurt
Exhibition GmbH

Andreas Lücke
Managing Director
BDH

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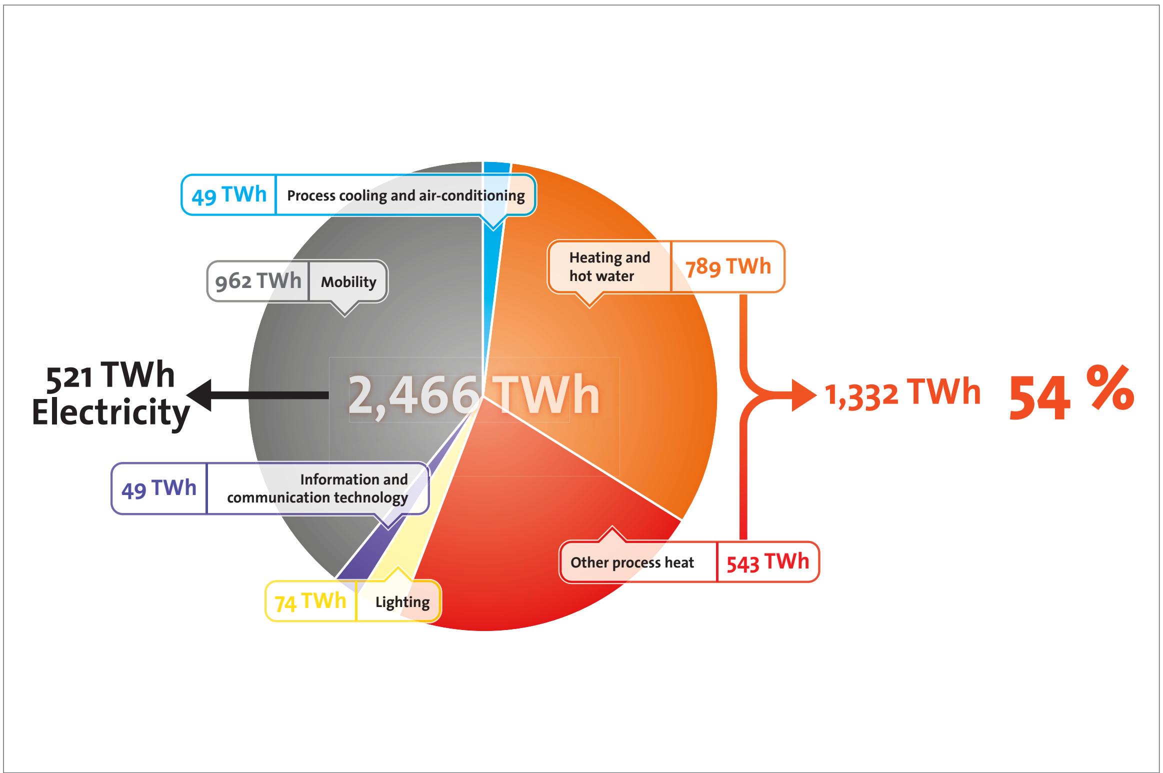



Resource: Working Group on Energy Balances (AGEB)

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

The Paris Climate Agreement of 2015 forms the climate policy basis for the EU Green Deal as announced by the President of the European Commission, Mrs Ursula von der Leyen, on 11 December 2019. The Green Deal aims to make the EU economy more sustainable, resource-friendly and efficient. It affects many sectors, such as transport, energy, agriculture and buildings, as well as the steel, cement, information technology, textile and chemical industries.

The ambitious goal of making Europe the first continent to achieve climate neutrality by 2050 is of paramount importance for the European and German heating industries. According to the decision of the European Council of 11 December 2020, the $CO_2$ emissions are to be reduced by at least 55 % by 2030 compared to the emission levels from 1990.

Anyone setting such ambitious goals cannot ignore the immense $CO_2$ reduction potential in the largest energy consumption sector in Europe and in Germany, the heating market. After all, a good third of European and German final energy consumption is attributed to heat generation in buildings. If industrial process heat is included, the heating market percentage is even well above 50 % of German final energy consumption.

In the following, this article refers to the data available for Germany, which is also representative for Europe.

For the 9th time, Messe Frankfurt and the BDH are organising the Technology and Energy Panel of ISH, this time in digital form due to the coronavirus pandemic. The following partners are participating in the Panel:

## Technology and Energy Panel: Green Deal ready

Organisation

BDH Federation of German Heating Industry

messe frankfurt

Patronage

Federal Ministry for Economic Affairs and Energy

Main partner

ZUKUNFT GAS

Gold Partner

iwo Institut für Wärme und Mobilität

Partner

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

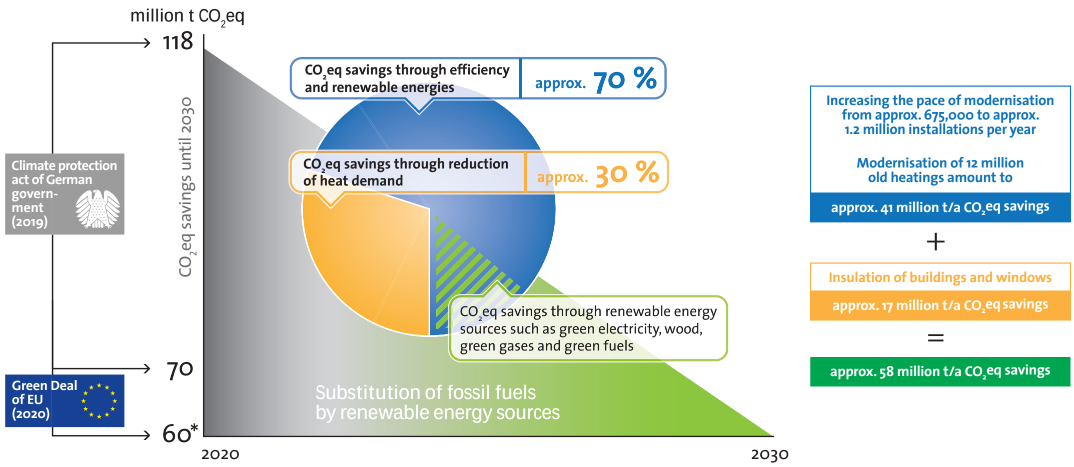
Fachverband Gebäude-Klima e.V.

geea Die Allianz für Gebäude-Energie-Effizienz

HEA Fachgemeinschaft für effiziente Energieanwendung e.V.

HKI

SMART LIVING MADE IN GERMANY




*Assumption: Reduction of only 10 million t/a $CO_2$eq through Green Deal, due to the Climate protection act already assuming a reduction in the building sector by 66 % until 2030, compared to 1990.

**Fig. 2:** Green Deal: Theoretical articles on the $CO_2$ reduction in the building sector

# Technology and Energy Panel of ISH 2021 digital:
## ISH Energy: Green Deal ready

The Technology and Energy Panel will be held under the patronage of Andreas Feicht, State Secretary of the Federal Ministry for Economic Affairs and Energy.

The organisers and partner organisers of the Technology and Energy Panel are united in the underlying belief that all technically available solutions must be considered to achieve the ambitious interim goals and the 2050 goal of the Green Deal. In particular, the tightening of the $CO_2$ reduction goal by 2030 from the previous 40 % compared to 1990 to at least 55 %, poses major challenges for all energy consumption and the $CO_2$-emitting sectors in Europe and Germany, which can, however, be solved.

The previous 40 % reduction set by the Federal Government's Climate Protection Act of 2019 was still based on the assumption that a doubling in the replacement of outdated system technology and the renovation rate of building envelope measures would render the 70 million tonne goal feasible in 2030.

The BDH assumes a scenario in which the tightening due to the Green Deal would also apply to the building sector. We assume a reduction goal for the building sector of 60 million tonnes by 2030 instead of the previous 70 million tonnes. In order for this hypothetical goal to be achieved, a three-fold strategy for the Green Deal in the building sector is required:

1. Doubling of the replacement rate for the approx. 12 million already existing heating systems through renewable hybrid technology that combines high efficiency and renewable energies. As a crucial part of the investments, this includes optimisation of the downstream hydraulics, as well as the doubling of the replacement rate from today's approx. 3 % to 6 %. In connection with system technology, there is also a need for greater electrification of the heating market. As the electricity sector already has the highest share of renewable energy, the combination with electric heat pumps offers the possibility of multiplying the use of renewable energy and to further reduce final energy consumption.

2. Reduction of heat demand by means of measures for the building envelope. In particular, this includes insulation and windows.

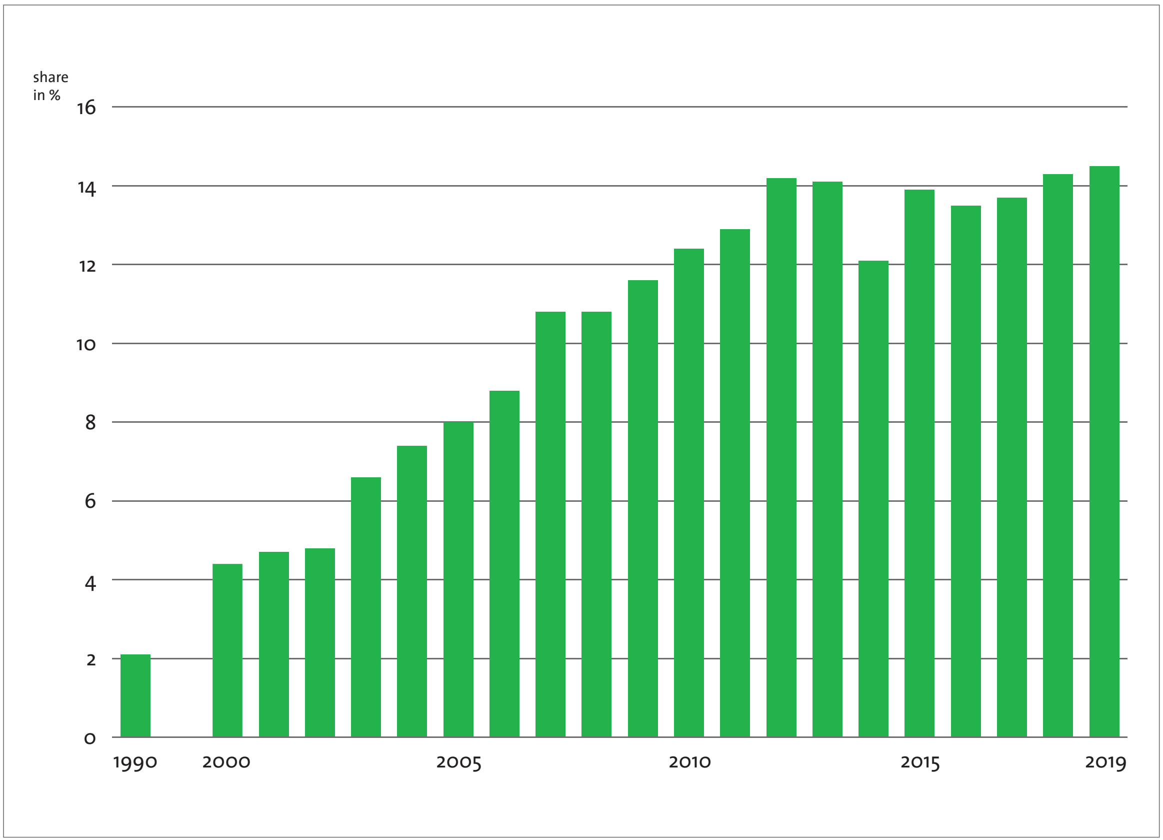



**Fig. 3: Amount of heat consumption covered by renewable energies increases**

Resource: BMWi on the basis of Working Group on Renewable Energies Statistics (AGEE-Stat), as of February 2020

3. Immediate start of changes to the energy mix in the heating market and acceleration of the expansion of low-carbon and/or carbon-free energy sources:
   - Green gases with biomethane and hydrogen
   - Green fuels with biogenic and synthetic components, such as power-to-liquid products
   - Increase in the green share of the electricity mix, coupled with increased use of heat pumps
   - Wood energy/wood heat

## Changed energy mix required in the heating market

Renewable energy contributed 14.5 % to the total heat supply in 2019. Biomass accounted for most of this. In addition to biogenic solid fuels, biogas significantly contributes to renewable heat supply. The share of green electricity should also grow disproportionately in the future. This is accompanied by an extremely dynamic increase in heat pumps that is already taking place, which, in addition to the until now partly green operating electricity, is integrating geothermal and environmental heat to generate heat. The increase in heat pumps in Germany was 40% in what otherwise remains a tough year due to the coronavirus pandemic. The mark of one million installed heat pumps in Germany was already crossed in 2020.

Obviously, green electricity finds its way to many interested buyers and sectors, all of which seek to meet their ambitious $CO_2$ goals. This also includes e-mobility, which is expected to grow to 7-10 million units in Germany by 2030. The heat pump and e-mobility – as highlighted by the Technology and Energy Panel – form a systemic unit and the sector coupling repeatedly postulated by the Federal Government. This is increasingly being implemented in owner-occupied or rental properties.

The three-fold strategy also includes a substantial increase in the share of 'green gases', i.e., biogas converted to natural gas quality or, in the case of biomethane and green hydrogen or, as a transitional technology, blue hydrogen.

Our main partner, Zukunft Gas, together with DVGW and BDH, addresses the multiple strategy for future gaseous fuels in the heating market in a corresponding article.

The energy mix in the future heating market will also include 'green fuels', which will initially become low-carbon and, eventually, carbon-free. 'Green fuels' offer an excellent technical alternative of enabling the supply security and improved load management, especially for rural regions. The Technology and Energy Panel also includes the related articles by the IWO (Institute for Heat and Mobility), in cooperation with BDH.

Wood heat, which has already been mentioned, with the highest share of renewable energies in the heating market today, could and should also substantially contribute to achieving the goal in 2030 and beyond. Domestic resources have long been used sustainably and can now be used in an eco-friendly and efficient manner using state-of-the-art technologies. The wide-ranging Wood Heat Initiative describes the wood heat resource development for Germany and the eco-friendly and efficient technologies available today.

## Digital heating, energy management systems for the energy system of the future.

The increasing electrification of the heating market and the concurrent phase-out of nuclear power and coal-fired power pose major technical and regulatory challenges for the energy system. The Technology and Energy Panel describes decentralised electricity-based systems in buildings. They enable buildings to be at least partially independent due to the supply of low-carbon or carbon-free electricity, which could, among other things, also be used for heat pumps and e-mobility. Photovoltaics, which is fairly inexpensive now, and the fuel cell heating encourage this through the decentralised supply of electricity. The smart building technology, such as energy management systems, controls and optimises the producers and consumers of the self-produced electricity.

Private home owners, as well as landlords and tenants, are turning from pure 'consumers' to 'prosumers'. Extensive independence from the purchase of expensive electricity supplied from the grid reduces operating costs considerably. At the same time, the decentralised supply systems relieve the already strained supply situation of the central electricity grid, which will have to do without nuclear energy starting from 2022 and which is facing the coal phase-out.

The planned strong increase in e-mobility by 2030 and the strong expansion in the use of heat pumps will relieve the transmission and distribution grids through the supply systems and the generation of green electricity.

# Technology and Energy Panel of ISH 2021 digital:
## ISH Energy: Green Deal ready

The rollout of smart meter gateways planned by the German government can be enabled or supported by energy management systems. They not only control the energy flows in the decentralised supply system, but also receive and use the price signals that will hopefully be available in the future in the event of supply peaks or shortages of green electricity.

Hybrid heating technology, based on the gas condensing technology and an integrated smart heat pump technology, also facilitates load management and offers the operator the advantage of using the electricity via the heat pump and storing it thermally when green electricity is readily available and electricity charges are favourable. Incidentally, these heat pumps can be designed as reversible units, i.e., in addition to the heating function, they can also be used for cooling purposes in summer. This, in turn, can replace the purely power-operated split units, which are unfavourable in terms of their $CO_2$ emissions.

### Technology and Energy Panel's response to the EU Renovation Wave Strategy

As part of the Green Deal, the European Commission published the "Renovation Wave Strategy to Improve the Energy Performance of Buildings in Europe" on 14/10/2020. This strategy is aimed at renovating up to 35 million buildings in terms of energy performance and $CO_2$ reduction by 2030, and prioritizes the following areas of action:

1. Decarbonisation of heating and cooling generation
2. Combating energy poverty
3. Measures for buildings with the lowest energy performance and renovation of public buildings

The strategy imposes stricter regulations and standards for the energy performance of building stock. For the first time, this applies not only to new buildings, but also to the already existing ones.

The analysis of the initial situation with the 125 million heat generators installed in Europe demonstrates, similar to the German scenario, that two thirds of the systems are technically obsolete.

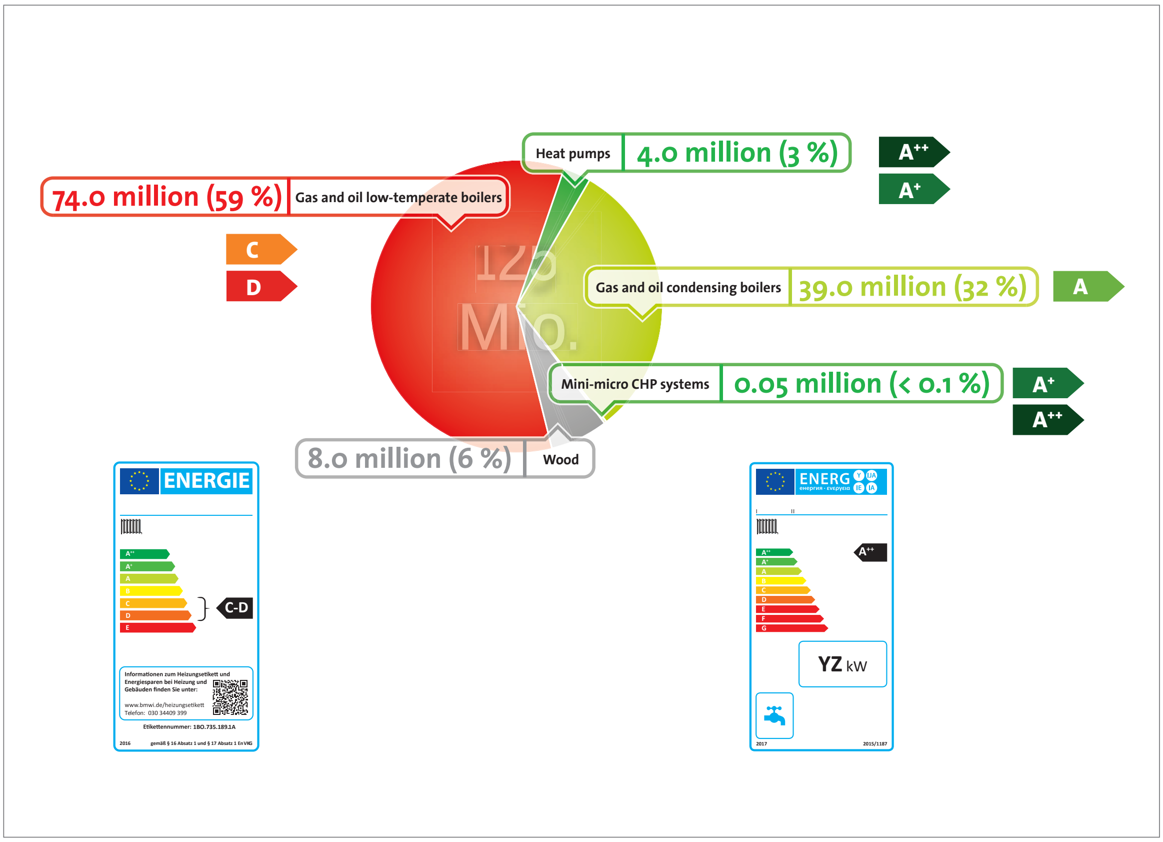



**Fig. 4: The European installations**

Resource: BDH, Association of the European Heating Industry (EHI)

The demand of the Association of the European Heating Industry (EHI), in which the industry organised in the BDH represents nearly 60 % of the market share, is as follows: Doubling of the EU's energy modernisation rate, stepping up measures implemented in the renovation sector (building envelope), and, similarly to the German climate protection strategy, rapid and intensive expansion of all available green energy resources for all sectors, including the heating market.

The win-win situation still applies to Europe and Germany.

**win 1:**
Energy efficiency and renewable energies reduce $CO_2$ emissions for climate and resource protection

**win 2:**
Energy efficiency and renewable energies conserve scarce energy resources

**win 3:**
Lower energy consumption relieves the burden on citizens by reducing costs

**win 4:**
Investments in higher efficiency and renewable energies create jobs in the European and German industries, including the trades




**Fig. 5:** Win-win situation by means of accelerated modernisation of outdated heating systems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# **Energy sources** in the heat market

- Gas: For a healthy climate
- Heating with innovative liquid energy sources
- Wood, the great renewable energy
- Geothermal energy and environmental heat: Energy from the ground and the air
- Sector coupling: Using the potential of electrical domestic heating systems
- The networking of heating systems

# Gas:
# For a healthy climate

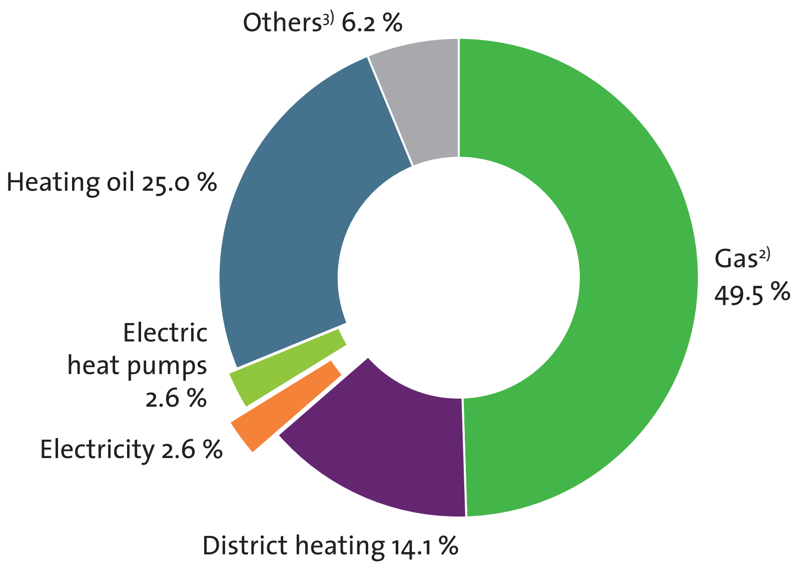
## Partner for efficient and environmentally friendly heating

Natural gas is one of the most important suppliers of energy worldwide. When it undergoes combustion, it generates almost no particulate matter and significantly less $CO_2$ emissions than other conventional energy sources. The transition to natural gas offers enormous potential for climate protection in all consumption sectors. If natural gas or methane is produced regeneratively, for example, as biogas or using the power-to-gas method, then it is even largely climate-neutral and can be combined in diverse applications with wind and solar energy, for example. This makes gas as an energy source an ideal partner for renewable energy and efficient solutions for greater climate protection – also in the heating sector.

## Utilising climate-neutral gas via the existing gas infrastructure

Germany has an extensive nationwide network for natural gas. The transportation infrastructure available across the country consists of 540,000 km of pipelines. The integration of $CO_2$ neutral gas into the existing gas infrastructure facilitates secure and economical supply to the climate-neutral heating market in the future. In particular, the distribution network has a significant role to play here. Technically and commercially, gas distribution networks offer the ideal pre-requisites for taking up, storing, transporting and distributing climate-neutral gas. Climate-neutral gas for heating could potentially be supplied not only to corporate customers but also to every second household in Germany. In this way, a large section of the population would have a reliable energy source available for decarbonisation.

Existing residential dwellings: 42.5 million [1]
Share of energy sources used




[1] Number of apartments in buildings with living room; heating available

[2] including natural biogas and liquid gas

[3] Wood, wood pellets and other biomass, Coke/coal, other heating energy sources

As of 12/2020, provisional, partially estimated

Source: BDEW

**Fig. 6: Heating structure in residential households in Germany, 2020**

## Climate protection with efficient gas technologies

The supply of heat to buildings constitutes about 40 % of the total energy demand in Germany. 10 % of all $CO_2$ emissions are attributable to heating in private households. Around half the energy for heat generation in Germany is currently provided by natural gas. Gas heaters are particularly low-cost and climate-friendly in existing buildings. For example, an oil heater produces up to 40 % more $CO_2$ emissions. With the least emissions among conventional energy sources, natural gas is already today making a significant contribution to $CO_2$ reduction today in the heating sector. Since 1990, it has been possible to almost halve $CO_2$ emissions in Germany in the heating market. – This was also because many old heaters were converted to modern gas condensing technology.

Gas heating systems can also be operated with gas from renewable sources, for example, with biogas, bio-methane and hydrogen. With an increasing amount of climate-neutral gases, greenhouse gas emissions can be further reduced, thereby making a crucial contribution to achieving the climate goals of the building sector. The political world has also acknowledged this by means of the amendments to the Building Energy Act made at the end of 2020. Legislation has thereby created the possibility of feeding gas condensing heaters with 50 % bio-methane via the gas distribution network and that this can be offset with the mandatory quota for the use of renewable energies in the heating market.

The technical entry hurdles for these additions to the natural gas network are relatively low. The terminal devices at the customer's premises will not be impaired by this, as has already been proven. Moreover, innovative gas technologies are available in the market, such as gas hybrid heating technology or hydrogen-operated fuel cells. These can be operated with climate-neutral gases or combined with solar energy or wind energy. DVGW has developed the technical rules for “Efficiency in the heating market” especially for their deployment. They explain to experts the measures for refurbishment, optimisation and new construction in order to enhance efficiency in heating supply.

### Change in technology

| Primary energy demand of the target technology in kWh/a | Technology scenario | **Primary energy reduction** compared to LT in % | **$CO_2$ reduction** compared to LT in % |
|---|---|---|---|
| Gas condensing boiler (GBW): 41,600<br>Scenario: **Single-family house** (As of 1958) | Low temperature boiler (LT) ↓ Gas condensing boiler (GWB) | 25.3 | 25.1 |
| | Low temperature boiler (LT) ↓ Gas condensing boiler (GWB) **with 50 % natural gas and 50 % biogas** | 38.6 | 55.4 |

Graphic, section from: Primary energy and $CO_2$ reduction of various heating technologies compared to a low temperature boiler in single-family homes.

Source: TRGE

**Fig. 7: Simply exchanging the boiler for a gas condensing boiler in a single-family home results in efficiency enhancement and $CO_2$ reduction of up to 25 %**

# **Heating with innovative** liquid energy sources

## Heating oil and liquid fuels emitting reduced greenhouse gases – ideal partners for an affordable heating revolution

About one fourth of the German population (20 million people) uses heating oil today to provide safe and reliable heating. The total of 5.4 million oil heating systems are used primarily in single-family 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. This is how heating oil consumption in Germany has been more than halved in the past twenty years. Notwithstanding the fact that the number of oil heaters has remained almost the same during this period.

## Affordable entry to the heating revolution

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

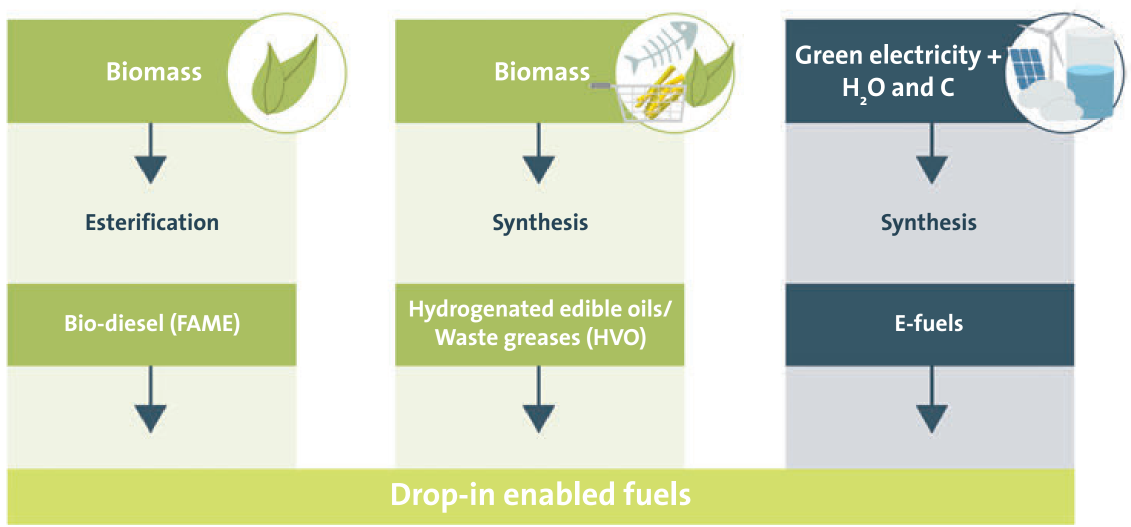



**Fig. 8: Future fuels – Manufacturing paths**

Source: IWO (Institute for Heating and Oil Technology)

## Modern fuel for efficient technology

Liquid energy sources can be stored conveniently and transported easily. In order to be able to continue utilising these benefits on a permanent basis, work is being carried out on developing marketable innovative fuels, which can supplement not only kerosene, petrol and diesel but also the heating oil in use up to now. Every litre of heating oil contains at least 10 kWh of energy. This is sufficient, for example, to heat up 200 litres of water from 10 to 55 °C. Based on this high energy content, heating oil is particularly economical. The energy density in liquid fuels is about 20 times higher than in a lithium-ion battery, for example.

Since heating oil ensures constant supply as an energy source that can be stored and is independent of power, oil heating systems are ideal as the basis for hybrid heating systems which integrate renewable energy technology.

## New fuels for the future

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

Currently, there are many different approaches being pursued to develop new fuels: From A, such as utilising algae, to X, such as XtL, which refers to the production of synthetic liquid hydrocarbons from the most varied sources of carbon, for example, from waste materials and residues. On the basis of these research projects, liquid fuels could also be usable in a climate-neutral manner in the long run. In this way, storable energy sources, combined with fluctuating renewable energy sources, will also be able to play an important role in the future energy mix.

## Research on various “paths”

In most cases, typical liquid fuels consist of carbon and hydrogen. Water ($H_2O$) and carbon dioxide ($CO_2$) are the main products formed 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 largely greenhouse-gas neutral: Carbon dioxide becomes the sustainable raw material, since the same amount is released during combustion as that extracted from the atmosphere during production.

Therefore, the research on liquid fuels with reduced greenhouse gas emissions focuses on the production of alternative liquid hydrocarbons from different renewable sources. When selecting the raw materials, any conflict of utilisation with agricultural land or food is consciously avoided. In the process, researchers speak of different “paths”: There is the biomass “path”, also called “biomass-to-liquid” or simply BtL, which investigates the production of fuels from waste materials and biogenic residues.

Another important path is “Power-to-liquid”, PtL in short (eFuels). Here, electricity from renewable sources is used for producing hydrogen, which is then combined with carbon from biomass or $CO_2$, obtained for example, from the air, to produce a synthetic liquid fuel.

The prerequisite is sufficient availability of renewable electricity. This could be done primarily in countries in which solar electricity can be produced with significantly higher hours of sunshine and solar power can be generated at lower costs.

# Wood, the great renewable energy
## Green Deal requires wood heat

Spread over 11 million hectares, forests cover one-third of the area of Germany. The wood stock continuously grows between 1-3 % per year. Wood energy amounting to 64 million m³ primarily comes from German forests, largely consisting of wood fuels that are no longer usable as well as by-products of the wood industry. This energy source offers many advantages:

- Wood is a renewable raw material and when used as an energy source, it is almost $CO_2$-neutral. Trees absorb $CO_2$ as they grow. The reduction capacity amounts to 58 million tons per year (total $CO_2$ emissions in Germany are 800 million tons per year).
- Wood energy and, particularly, the heat generated in the 11 million wood-burning stoves and 1 million wood central heating systems replace fossil fuels and thus additionally reduce $CO_2$ emissions by 36 million tons per year.

**The continent is to become $Co_2$-neutral by 2050.**
The Green Deal will fail if the immense $CO_2$ reduction potential of Germany's largest energy consumption sector, the heating market, is not exploited:

- With a consumption of almost 800 TWh, heating and domestic hot water account for one-third of the final energy consumption in Germany.
- Wood heat covers almost 10 % of the heat demand; including the industrial process heat from wood, the share of this energy resource is a good 5 % of the final energy consumption in Germany. This is roughly the same as that of wind energy.

### A strong alliance, "Initiative Holzwärme"

Initiative Holzwärme (IH / Wood Heat Initiative) started in the beginning of 2021 with nine associations and institutions from industry, trade, the energy sector and science. While the Parliamentary State Secretary in the Federal Ministry of Economics, Thomas Bareiß, took over the patronage, the BDH is responsible for the coordination of the initiative.

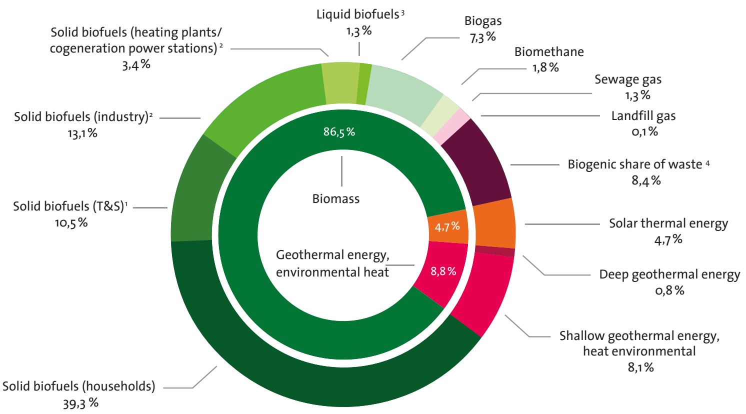
**The associations and institutions in detail:**
Initiative Holzwärme documents facts related to the topics of wood energy and wood heat. It describes the solutions that are technically feasible today for the sustainable, clean and efficient use of the local $CO_2$-free resource – wood.

### Efficient use of wood for heat generation

In almost 13 million single-family houses, around 11 million individual fireplaces partially supply wood heat to buildings. In addition, there are almost 1 million wood central heating systems, which are also used in single-family, two-family and multi-family houses as well as enterprises, especially in agriculture.

Individual stoves are heated with split logs and also increasingly with pellets. Besides these two forms of wood energy, wood chips are also used in boilers for central heating.

Waste wood is also used to generate industrial process heat and in local heating networks.




[1] T&S = trade and services; [2] incl. sewage sludge and charcoal; [3] incl. biofuel consumption for agriculture, forestry, construction and the military;
[4] Biogenic share of waste in waste incineration plants is set at 50 %

BMWi on the basis of Working Group on Renewable Energies Statistics (AGEE-Stat); as of: December 2020

**Fig. 9: Final energy consumption of renewable energies for heating and cooling in Germany in 2019 (total: 181.7 billion kilowatt hours)**

Coordination

BDH
Federation of German Heating Industry

Department Wood boilers
Department Flue gas systems

www.bdh-koeln.de

Partners

www.kachelofenwelt.de

www.bioenergie.de

www.schornsteinfeger.de

www.depv.de

www.saegeindustrie.de

www.fnr.de

Patron:

Federal Ministry for Economic Affairs and Energy

www.bmwi.de

www.hki-online.de

www.zvshk.de

Fig. 10: Partners of Initiative Holzwärme

In view of the mostly outdated individual stoves and wood boilers, Initiative Holzwärme aims to replace them with state of the art technology as quickly as possible. State of the art means:

- Closed combustion chambers
- Controlled and regulated combustion air
- Digital firing management
- Particulates collector where required

With the so-called stage 2, the 1st BImSchV (Federal Immission Protection Ordinance) defines technical requirements for usable stoves. These include:

- Heating efficiencies of 85 % and higher (old stoves have an efficiency of about 25-30 %). This means that the amount of fuel used is reduced by at least half when old stoves are replaced.
- Reduction of particulate matter emissions by 90 % and more.

## Fuels with quality

For the wood fuels pellets, wood chips and wood briquettes, the Deutsche Energieholz- und Pellet-Verband (DEPV/German Energy Wood and Pellet Association) offers a seal of quality. With regards to split logs, Initiative Holzwärme, in close alliance with the Bundesverband des Schornsteinfegerhandwerks (ZIV/Association of Chimney Sweeps), aims to intensify customer consultation with the aim of increasing fuel quality, especially with regard to residual moisture.

## No new building without chimney, retrofitting with wood fired systems for better climate protection

Heat pumps and gas-fired condensing technology are the primary sources of heat in new buildings with low heat demands (according to the Building Energy Act). Especially when using a heat pump, combining it with an individual fireplace is an ideal contribution to further $CO_2$ reduction and load management. In terms of energy policy, the latter means peak loads in the electricity grid on days of the cold dark doldrums (a time of low solar and wind power generation together with low temperatures) due to the use of heat pumps. For grid stability and for covering critical peak loads – which are intensified by the increasing electromobility – storable and $CO_2$-free wood heat can effectively make the cold dark doldrums bearable. Both in new buildings and when retrofitting existing buildings, such intelligent combinations require either a ceramic chimney or a stainless steel flue gas system.

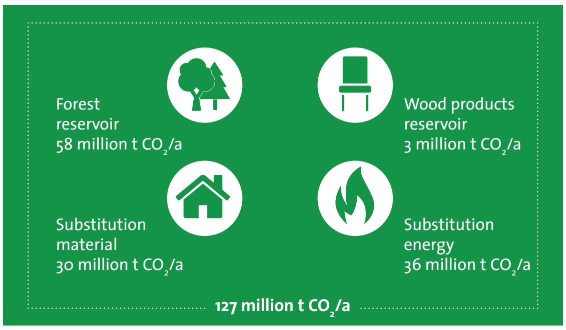



Fig. 11: Overall carbon dioxide effect of forest and wood

# Solar Energy

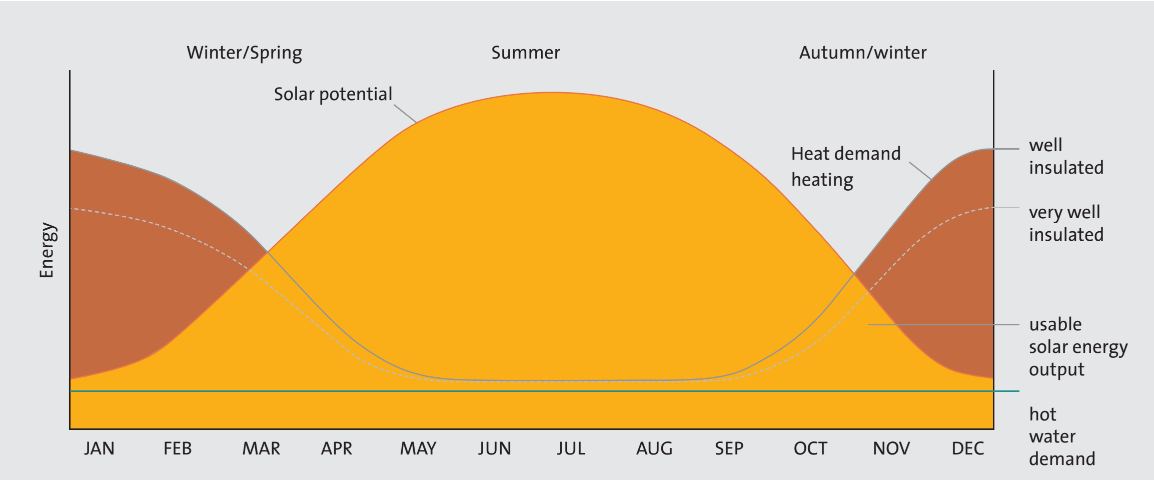



**Fig. 12: Usable solar heat of a solar thermal system in Germany during the year**

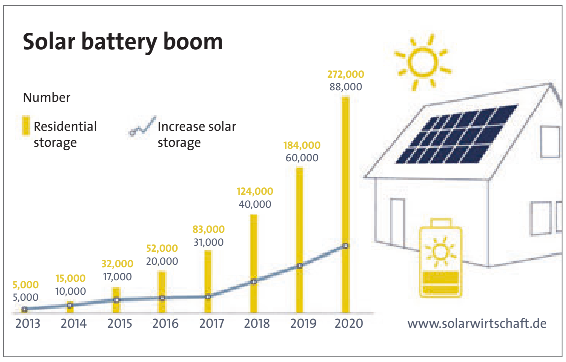
## Solar heat: ideal supplement for all heating systems

Solar thermal systems are used mainly for domestic hot water heating, auxiliary heating or for heating swimming pools. In Germany, about 60 % of the annual domestic hot water demand of a single-family home can be met by a solar thermal system of typical size. Auxiliary solar heating 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 constitutes a combination of a modern condensing boiler, an efficient heat pump or a central wood-fired boiler with a solar thermal system.

Particularly during the summer months, a modern solar thermal system can supply the entire domestic hot water demand and heat demand of a house. During this period, the heater remains 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 meet the household electricity demand proportionally. Any excess above normal consumption creates the option of generating heating energy. Using this excess electricity for heating may be more sensible than feeding it into the grid. This is all the more true since the feed-in tariff is constantly falling and, in the meantime, it has dropped to less than 8 cents for new plants up to 10 kWp in Germany. The utilisation of the excess PV electricity is particularly efficient in conjunction with a modern electric heat pump.




Source: BSW e.V., 02.2021

**Fig. 13: Development of solar electricity storage in Germany**

# Geothermal energy and environmental heat:
## Energy from the ground and the air

At both the national level in the Climate Protection Plan 2050 of the Federal Government and at the international level on climate and resource protection, application of near-surface geothermal energy and environmental heat are given serious consideration and are the key to the heating revolution. Utilisation generally takes place via brine-water, water-water or air-water heat pumps, which draw up to 80 % of the energy for heating and domestic hot water from the ground or the ambient atmosphere, and the remaining 20 % from electric drive energy. The "greener" the electricity becomes, the more environmentally friendly, i.e., more $CO_2$ free the heat pump operation. Apart from providing the required heating energy for room heating, heat pumps can also be used for domestic hot water heating and for cooling or lowering the room temperature in summer. Compared to the utilisation of wind energy and solar energy, geothermal energy has the advantage of being available round the clock.

The utilisation of near-surface geothermal energy and environmental atmospheric heat via heat pump systems can also be optimally combined with the "Power-to-Heat" concept. According to this PtH concept, the electricity generated by wind power plants and photovoltaic systems is used for thermal storage in the form of heat. The consumption of energy can be adjusted to power generation using the Smart-Grid-enabled heat pump. As systems that can be switched on and controlled, they can flatten out regional demand peaks during power generation and store the environmental energy in the form of heat. With more than 1 million systems at present, heat pumps offer great potential for use in energy management systems. Heat pumps are particularly well suited for cross-sector applications at the interface between the electricity and heating sectors.

### Heat pumps in the cold district heating network:

Heat pumps can also be used as a part of heating networks for supplying entire residential complexes. Similar to traditional district heating networks, in cold district heating networks, the buildings are provided with a domestic connection for supplying heat to the building. However, cold district heating networks operate at much lower temperatures (below 30 °C). The temperature level required for heating and domestic hot water is raised by a heat pump in the building to be supplied. The actual heating source (e.g., groundwater, heat from waste water or from industry, etc.) is at another location.

Compared to conventional district heating networks, thermal losses can be reduced here, and a high level of system efficiency can be achieved. Cold district heating networks are often used for residential complex concepts in new residential areas with a modern energy concept on the basis of renewable energies.

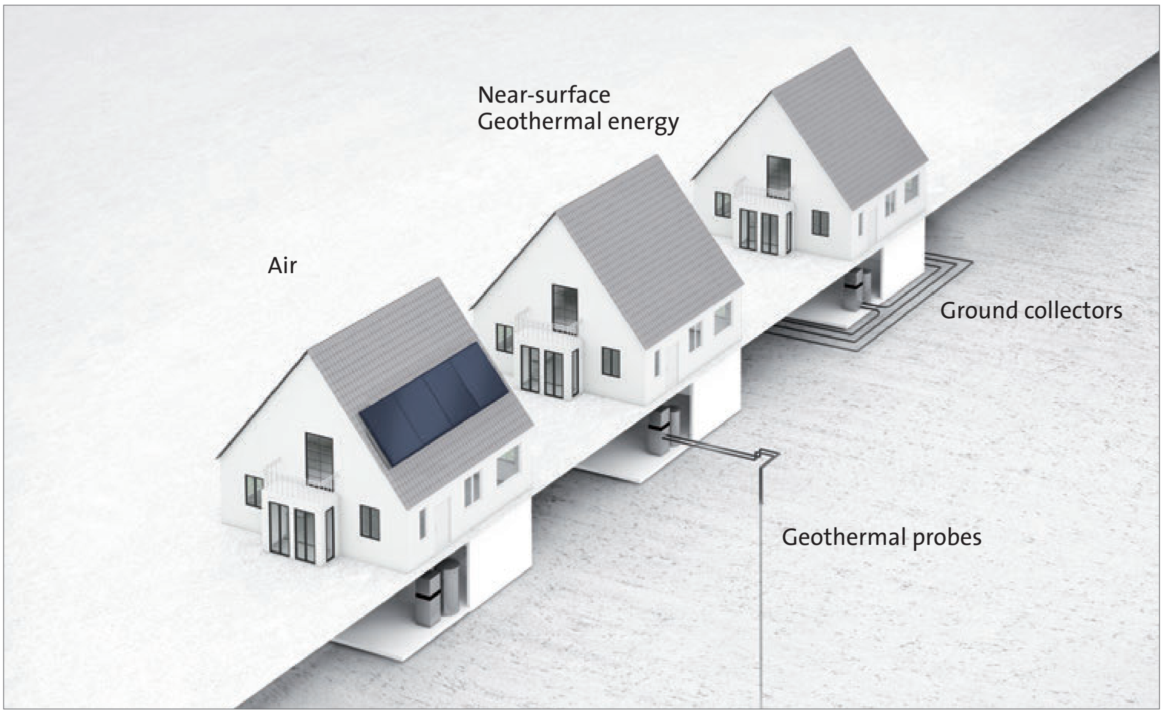



**Fig. 14: Various sources of near-surface geothermal energy and environmental heat**

# **Sector coupling: Using the potential** of electrical domestic heating systems

## Integrating renewable electricity

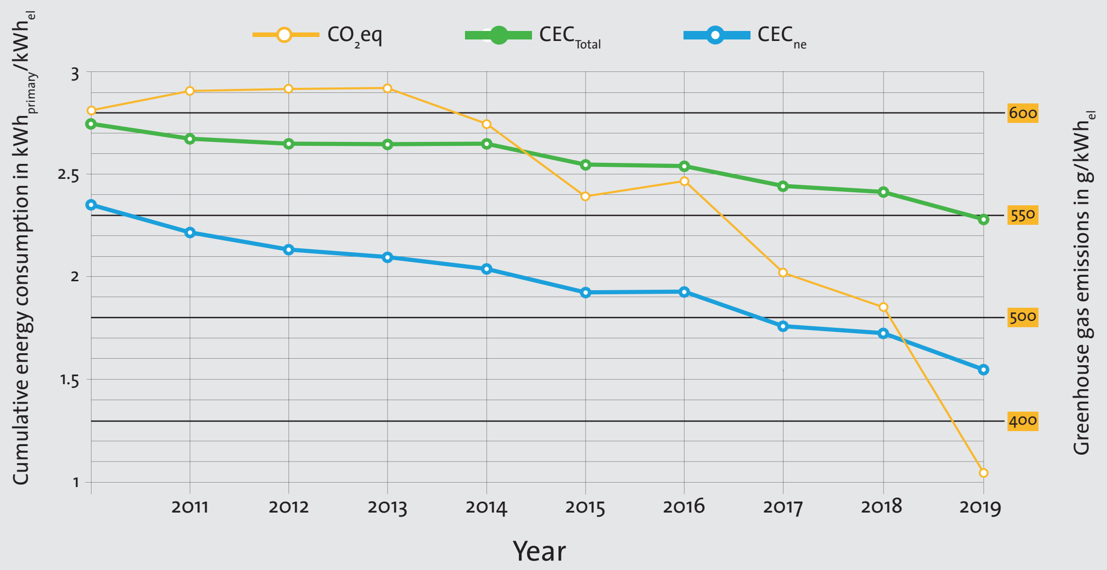
The keyword "energy revolution" is generally associated with the use of renewable energies for the generation of electricity. Nevertheless, the energy system goes well beyond the provision of electrical energy. Especially in the heating and transportation sectors, the share of renewable energy is still low at present. Fossil fuels still dominate the energy supply. An energy revolution in all sectors can be achieved only by a conversion to renewable energies in each individual sector. This can take place directly in the sector itself, for example, in buildings, by using solar thermal energy for heat generation, as well as by using renewable energy from the power generation sector.

Electricity is already being generated at present in Germany to a large extent from renewable energy sources, with the share of the gross German domestic electricity generation being about 45 % in 2020. By 2030, the share is expected to be around 65 %. This means that electrical energy will develop into "green energy" in the next few decades. A recent study on behalf of the HEA expert group illustrates the impact for the year 2019. Both the cumulative energy consumption (CEC) and the greenhouse gas emissions for generating an average kilowatt hour of electricity ($CO_2$ equivalent) are on the decline. In the process, the researchers tracked a comprehensive balance sheet. To determine the CEC, the environmental effects, among other things, of generating electricity based on "life cycle data" for energy, material and transportation systems were taken into account. The "CEC result", i.e., the inclusion of upstream losses up to 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 fuel sources in the heating market, and they are significant for selecting heating systems in the market.

A holistic approach to the energy revolution is needed for the integration of volatile renewable energy sources. Only a systemic approach will open up the potential solutions that would be difficult to develop as long as industrial sectors are considered in isolation. This means that the energy potential of one sector can be used in another sector.

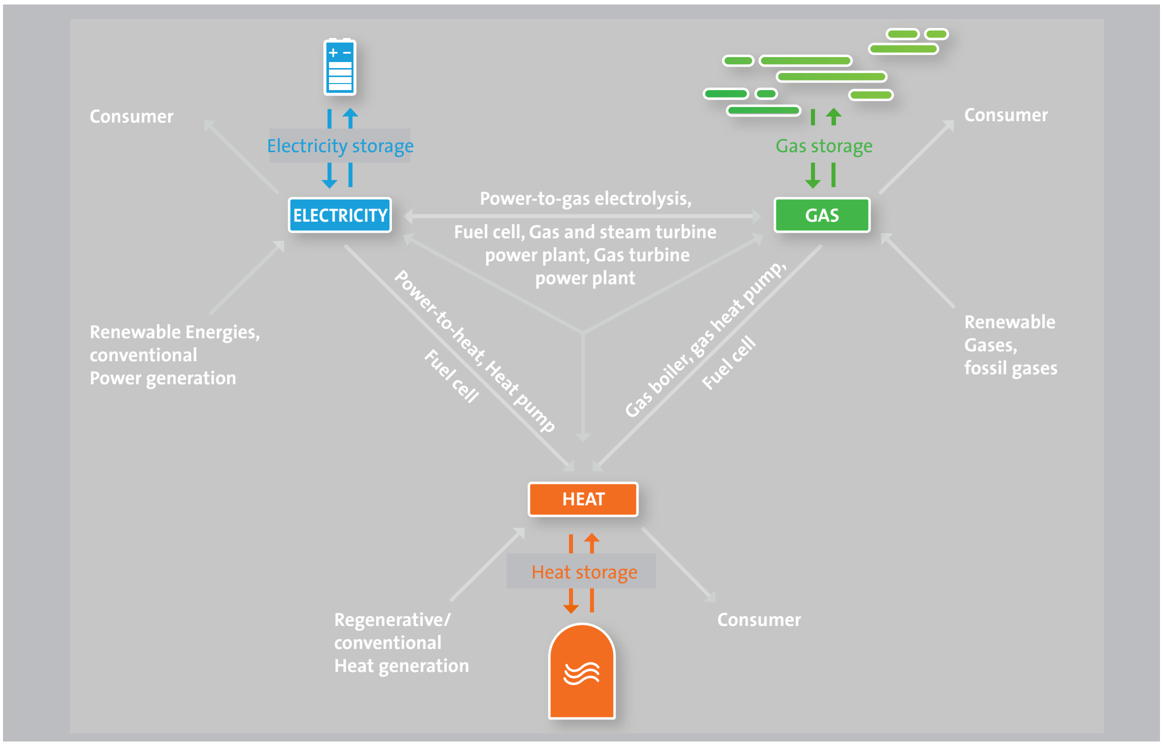
### Energy consumption and emissions during electricity generation continue to sink

The results illustrate that both cumulative energy consumption ($CEC_{ne}$) and the greenhouse gas emissions for generating an average kilowatt hour of electricity in the Federal mix in 2019 has reduced considerably




Source: Brief study by IINAS in 2020 for electricity generation in Germany

**Fig. 15: Energy consumption and emissions during electricity generation continue to sink**




Source: BDEW/DVGW 2018

**Fig. 16: Representation of a $CO_2$-reducing energy system**

## 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 be stored only to a limited extent compared to fossil fuels. Sector coupling extends the range of potential conversions beyond conventional storage by involving other sectors. The flexible use of electrical energy in the heating market is a good example for this purpose. Electricity can be converted to heat in buildings by means of heat pumps, electronic flow heaters or direct electric heating systems. The latter may also be used as a component in hybrid heating systems. In this way, a condensing boiler, for example, can be expanded using an electric heating element in thermal storage, which is operated using self-generated PV electricity.

Even the use of existing storage heaters is a good option for storing electricity from renewable energy to help the system to store electricity and then to use it as needed. There are about 1 million storage heating systems installed in Germany, which represents substantial storage potential. The storage systems are usually charged at night, and the stored heat is again released the next day at different times as needed by the user. Older systems can be fitted with modern charging controllers, among other things, in conjunction with an on-line weather forecast, and can thus be operated significantly more efficiently. At present, pilot projects by equipment manufacturers and energy companies are being executed where the conventional, fixed charging at night is superseded by 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.

## Power-to-Heat as a building-independent solution

Harnessing electrical energy in the heating sector, also known as Power-to-Heat (PtH), can also be deployed beyond the limits of buildings and even in urban quarters. Electrode boilers or heat pumps can be used to convert large amounts of electricity of up to several megawatts for the provision of a heat supply. Heating networks play an important role in bridging any spatial gaps present between the heat source (e.g., in the PtH boiler) and heat sinks (e.g., in private households or commercial facilities). The integration of "green electricity" increases the share of renewable energy sources (RES) in supplying heat to existing buildings in urban areas. The share of renewable energies in district heating in Germany has increased continuously since 2010 (7.8 %). With almost 18 % share in renewable energies (2020), district heating contributes significantly to the urban heating revolution.

# The networking of heating systems

Our energy system is on the brink of a revolution, which is leading to a veritable paradigm shift. Previously, electricity was generated in centralised power plants primarily from fossil fuel sources. Since electricity cannot be stored easily, it was always necessary to establish a balance between generation and consumption. To do this, the power plants were regulated based on the momentary consumption of all end customers.

In future, electricity will be produced from renewable sources, whose yield is volatile and can be controlled only to a limited extent. As a result, generation can no longer be aligned easily to demand. In addition to this, there is the increasing number of decentralised generation systems, which sometimes belong to the end customer and are controlled by them. The end customer is then no longer merely a consumer of energy, but becomes a prosumer who themselves consume a part of the electricity generated and sell the rest or feed it into the grid.

This development takes place against the backdrop of sector coupling, which provides electrification to at least a part of heat generation and transportation, and, as a result, causes an overall significant rise in the demand for electricity.

Under these circumstances, and with diverse interests, it is necessary to find new mechanisms in order to ensure the balance between generation and consumption. Since it is considerably more difficult to control generation as compared to previously, this leads to the necessity of controlling the consumption – i. e. load management. Moreover, the electricity grids have to be expanded in order to transport larger quantities of energy. This is associated not only with high costs, but is also time-consuming and threatens the pace of the electrification of transportation especially. In order to minimise this effect, it is necessary to achieve the most optimal grid utilisation possible. Here, too, load management is one approach to arriving at a solution.

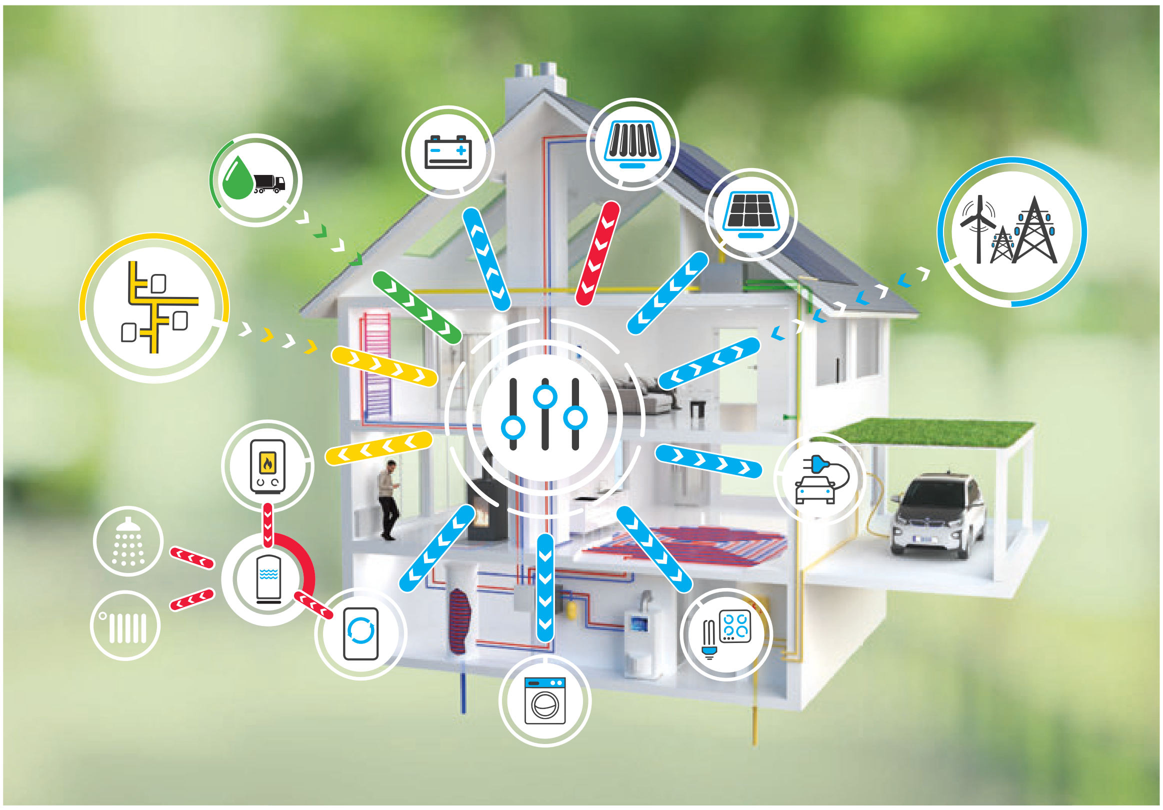


**Fig. 17: Networking of energy-related products with an intelligent energy management system (EMS)**

## What is load management?

Load management is the temporal offset in electricity consumption depending on various parameters. In doing so, it is possible to consider the amount of renewable energy available or the grid utilisation at the moment. However, this requires communication between generators, consumers and electricity grids in real time. In most cases today, this is not yet possible at all since there is no appropriate communication link in place. This is where digitalisation of the energy revolution comes into play, and the foundation stone for this is being laid with step-by-step implementation of the smart meter roll-out nationally. The reason is that smart meters are not only intelligent electricity meters: they also provide a safe and secure communication platform that enables the elements of the energy system to be adjusted and aligned with one another. That is the shift to the networked energy system.

The energetically networked building then receives the conditions in real time from the electricity grid and responds to it, for example, by adjusting the building energy consumption with respect to time to the availability of regenerative electricity. An energy management system in the building translates the requirements to an optimisation of the internal energy-related processes for the various devices or appliances. This includes local generators (such as photovoltaic systems or fuel cells), electrical and thermal storage facilities, as well as consumers. In this case, heat generation has a very special significance due to the high share of the energy demand for the building and the potential for storing thermal energy.

## Networking in the building

The energy-related role of the building changes. It increasingly becomes a place of generation and also a flexible storage facility of energy. The change in role leads to two very favourable resulting effects. On the one hand, it enhances the degree of building self-reliance, the building literally becomes more independent. As a result of this, demand on the electricity grids is lowered and the energy revolution receives a crucial impetus. On the other hand, coordinated control of the energy flows in the building provides flexibility that can be used to serve the grid and the system – against remuneration for the customers.

The requirement for this is not only that the building is networked with the energy system but that the energy-related components of the building are also networked to one another. Energetic networking within the building means that energy can flow from one system to another, for example, from the photovoltaic system to the heat pump or to the electric car. However, it also means that these systems can communicate with one another in order to coordinate and agree with optimal utilisation of the energy. Of course, in the process, the needs of the residents are also of significance. In this way, photovoltaic systems, heat pump and storage facilities can be coordinated so that the energy currently generated by the PV system is not used immediately by the heat pump, but is stored for the electric car which will soon be arriving home. Such processes are referred to as energy management. They are controlled by an energy management system (EMS).

The energetic networking is considerably different from smart home systems which do not focus on energy-related aspects, but instead on multimedia, lights or shading, for example. Frequently, products from the consumer goods sector are integrated into smart home systems, whereas in energy-related networking, long-life investment goods, such as heating systems, photovoltaic systems or electric cars, are involved.

The connection between energy management and smart home leads to a new type of comfortable control and visualisation of the energy-related processes within the building to a central control unit. In this way, you can promote customer awareness and an interest in matters concerning energy efficiency.

## Interoperability between products

An important prerequisite for networking products is interoperability. All the generators, storages and consumers in the house will not necessarily be from the same manufacturer. The desire to connect all the energy-related devices to one another, in order to implement the maximum possible benefit for the end customer, necessarily means that a technical basis has to be established for manufacturer-independent and even industry-independent interoperability across devices and appliances.

This subject is treated in detail in the chapter “Smart Heating and energy management systems”.


COMFORT
-20
-10
DIGITAL
EFFICIENCY
RENEWABLES

# **Modern**
# Heat Generators

- Efficient heating systems
- Gas-fired hybrid heating systems
- Oil-fired condensing technology and hybrid systems
- Heat pumps
- Heat from wood
- CHP and fuel cell

# **Efficient**
# heating systems

## Building planning and system selection

Buildings (both old buildings and new buildings) must be regarded as integral structures. Here, all components (building envelope, windows and system equipment) must be optimally adjusted to the functions to be met (heating, cooling, domestic hot water, as well as ventilation and air conditioning). For the system equipment, this means that maximum efficiency can be achieved only in the system. Moreover, both coupling with other sectors and digitalisation must be taken into consideration. In order that the efficiency achieved is sustained across the technical service life, it is recommended to carry out an annual inspection and requirement-based maintenance of the components. In addition, for larger properties, system monitoring or building monitoring can also contribute to maintaining efficiency as well.


Fig. 18: The system concept has priority

The correct system ultimately depends on the framework conditions: Apart from legal requirements, it is also necessary to pay particular attention 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, the corresponding cooling load has to be calculated. The systems presented in this brochure for the supply of heat to buildings, as well as for domestic hot water and residential ventilation, are regarded internationally as being state of the art. They convert energy sources such as gas, oil, wood and electricity very efficiently into heat and, in the process, also use renewable energies (e.g., solar thermal energy).


Fig. 19: Interaction between heat generation and storage

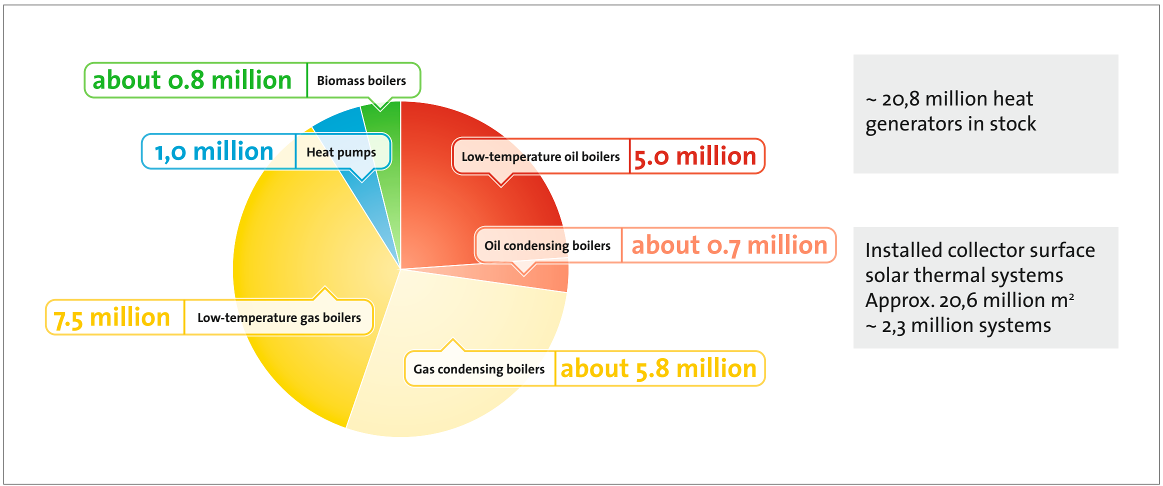
## The system concept is always of priority

All the components of the heating system must be perfectly matched and compatible with one another so that the energy savings potential of the system equipment can be implemented optimally. This is why heat generation, storage, distribution and transfer as well as the exhaust gas system – if required – must always be considered as a holistic system.

## Heat generation and heat storage

Heat generation is the starting point for operation of the heating system: In a centralised heat generator, the energy sources used (gas, oil, wood or electricity) are converted into heat. This is then used for central heating and for domestic hot water heating. In the process, renewable energies such as environmental heat, geothermal energy, renewable electricity, wood and gaseous and liquid biomass are integrated. In addition, solar thermal energy can be coupled as renewable energy with all systems.


Fig. 20: Factors influencing efficient heat distribution




Source: Statistics of the association of chimney sweeps for 2019 and BDH estimation

**Fig. 21: Total number of centralised heat generators in Germany (2019)**

Systems with cogeneration of heat and power (CHP) form a peculiarity here: They generate heat and electricity simultaneously. The area of application of this technology ranges from small single-family homes (micro-CHP systems, up to 2 $kW_{el}$) to apartment houses and medium-sized commercial facilities (mini-CHP plants up to 50 $kW_{el}$) and right up to the industrial sector. An overall efficiency of over 90 % can be achieved by deploying such systems.

Installing a domestic hot water storage tank is particularly important as the heat provided by the heat generator is not always immediately utilised fully. Today, domestic hot water storage tanks form a central component of the heating system and domestic hot water supply system in residential and office buildings. Thanks to the large diversity of types, they can perform various functions:

- Domestic hot water storage tanks store the heated domestic hot water which is needed in the household, e.g., for showering, bathing or cooking.
- Buffer storage tanks ensure that the heating system is reliably supplied with domestic hot water over a long period of time. In this way, they enable the coupling of heat from renewable energies and CHP systems.
- Combination storage tanks combine both functions with one another.

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, storage tanks enable reliable supply of domestic hot water and heat at varying times of demand and supply. Apart from the individual heat generators described, a combination of two or more heat generators is being planned increasingly (so-called "hybrid systems"). In this way, the strengths of individual products are employed by optimised interaction for greater operational efficiency.

## Heat distribution

Heat distribution forms the link between heat generation/storage and heat transfer. In addition to the pipelines, the heat distribution system includes heat circulating pumps, forward and return flow of the hydraulic heating system, as well as the fittings and control devices.

Efficient distribution of heat in the heating system also depends on the insulation of the forward and return flow, as well as hydraulic balancing of the entire heating system. On the one hand, modern thermostatic valves, equipped with pre-adjustable valve bodies, and thermostat sensors characterised by good control quality, are suitable for optimum regulation of the ambient temperature. 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 enables the reduction of system and indoor air temperatures, as well as high controllability of the system.

In the meantime, digitalisation has also arrived in the field of heating technology, and the controllers described can also be controlled externally, for example, using a smartphone. This not only permits customised control of the heating system, but can also lead to energy savings when operated optimally.

## Heat transfer

Heat transfer is the link between heat distribution and the user. Either a surface heating system or a radiator is available as a heat transfer system. They can be combined and installed if desired.

# **Modern** heating systems

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. Properly designed heat transfer systems ensure this. Simultaneously, they enhance the comfort in the room and can make radiators visually attractive.


**Fig. 22: Influencing factors for efficient heat transfer**

## Other components of an efficient heating system

Modern flue gas systems ensure safe discharge of the flue gases and permit low flue gas temperatures, as well as condensate drainage.

For the operation of an oil-fired heating system, the most diverse variants of modern oil tank systems are nowadays available to consumers. At present, double-walled tank systems made of plastic are the state of the art. Even solar thermal energy can be used with all types of heating systems as a support for heating domestic hot water and for central heating.

Regardless of the heating system, facilities for controlled (centralised or decentralised) residential ventilation with heat recovery reduce the energy demand of the building considerably and, at the same time, ensure the required hygienic air conditions.

Smart control and communication facilities enable optimum interaction of all components. The heating system can be remotely controlled or diagnosed via mobile radio or on-line access. This makes operation extremely convenient.

However, the optimised use of modern heating systems should always be considered in coordination with the energy-related quality of the building envelope.

Energy-related examples of modern renovation are listed on pages 76–81 based on a typically partially refurbished single-family house constructed in 1970. The examples must be understood as an approximation with respect to improving the quality of energy in the heating system. In the next step, an energy consultant and/or a heating specialist company should be consulted. The following energy-related modernisation measures are taken into consideration:

| Pages 76–79 | Examples of modernisation (without renovation of building envelope) |
|---|---|
| | Renovation variant – gas/oil condensing technology with solar thermal system |
| | Renovation variant – gas/oil condensing technology with solar thermal energy and wood burning stove/ pellet furnace with collection basin |
| | Renovation variant – pellet/split log boiler |
| | Renovation variant – micro CHP system |
| | Renovation variant – Air-water heat pump |
| | Renovation variant – Brine-water heat pump |

| Pages 80–81 | Examples of modernisation (renovation according to KfW Efficiency House 55 standard) |
|---|---|
| | Renovation variant – Air-water heat pump, controlled residential ventilation |
| | Renovation variant – gas/oil condensing technology (20 % Bio-methane) with solar thermal system, controlled residential ventilation |
| | Renovation variant – Brine-water heat pump and PV system with electric storage, controlled residential ventilation |


**Fig. 23:**
**Efficient Heating Systems**

# Gas-fired hybrid heating systems

## 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. Gas-fired heating technologies can be best operated with electric heat pumps on the one hand and in combination with solar thermal systems on the other.

## Solar thermal energy for heat generation

As against photovoltaic systems, which generate electricity using solar energy, solar thermal energy is used for 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 2.5 million solar thermal systems are installed in Germany. Since 2006, their number has increased by more than double. For new buildings, gas-fired condensing technology based on solar thermal energy is one of the most favourable heating options for homeowners, considering both the investment and heating costs.

The preparation of 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-fired condensing technology bridges this gap efficiently. The system operates even more efficiently if the solar thermal energy is also used for auxiliary heating. When a solar thermal system generates at least 25 % of the heating requirement, the heating is classified as gas-fired hybrid heating in the funding schemes of the Federal Office for Economics and Export Control (BAFA) – and for this there is state funding of 30 % of the investment costs.

## Seven tips for modernisation

**1. Ensure the best possible orientation of the roof**
A southward orientation of the roof is ideal. The slope of the roof should deviate from this by a maximum of ten degrees and the inclination should be between 40 and 45 degrees. Shading is not advisable. On flat roofs, the collectors can be positioned correctly using stands. A static inspection should always take place.

**2. A question of efficiency**
You can choose between vacuum tube collectors and flat plate collectors. The latter are cheaper, but also less efficient than vacuum tube collectors.

**3. Consumption-dependent**
The size of the drinking water storage tank and the collector area is determined by the consumption of the supplied household. Solar thermal energy can be used for domestic hot water, but also for additional auxiliary heating. In low-energy houses, solar auxiliary heating, including domestic hot water, can save up to 40 % of heating energy according to the Federation of German Heating Industry (BDH).

**4. Short distances**

The shorter the connection between the collector and the hot water storage tank, the lower the energy losses when transporting solar energy. An ideal solution, for example, is the installation of a natural gas heating system with connected solar drinking water storage tank in the attic. This means that the circuit paths are short and the flue gas can also be easily discharged into the atmosphere through the roof. If the collectors and storage tanks lie some distance apart (roof – cellar), the joint use of existing supply shafts or the use of an inoperative chimney is a good way of connecting them.

**5. The right heating system**

Given the weather conditions in Germany, solar heat covers around 60 % of the heat demand for domestic hot water. Additional heating technology, such as an economical gas heating system, is the perfect addition, for example, when renovating an old building.

**6. The right energy source**

While solar energy generates heat in an inexpensive and climate-neutral way, this is only partially the case with additional energy sources. Natural gas is a good choice due to its low price, high availability and low $CO_2$ emissions during combustion. When using bio-natural gas, even a completely renewable energy supply is possible.

**7. Good funding**

The installation or expansion of solar collector systems for thermal use is funded by the BAFA if they are used mainly for domestic hot water and/or space heating, cooling or the supply of heat/cold to a heating or cooling network. The funding for new and existing buildings is up to 30 % of the eligible costs.



Source: Max Weishaupt GmbH

**Fig. 24: Gas-fired condensing technology can be used well in combination with solar thermal energy.**

# Oil-fired condensing technology
and hybrid systems

## Efficient heating with oil-fired 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 heaters a relatively cost-effective entry into the energy revolution – and for new buildings.

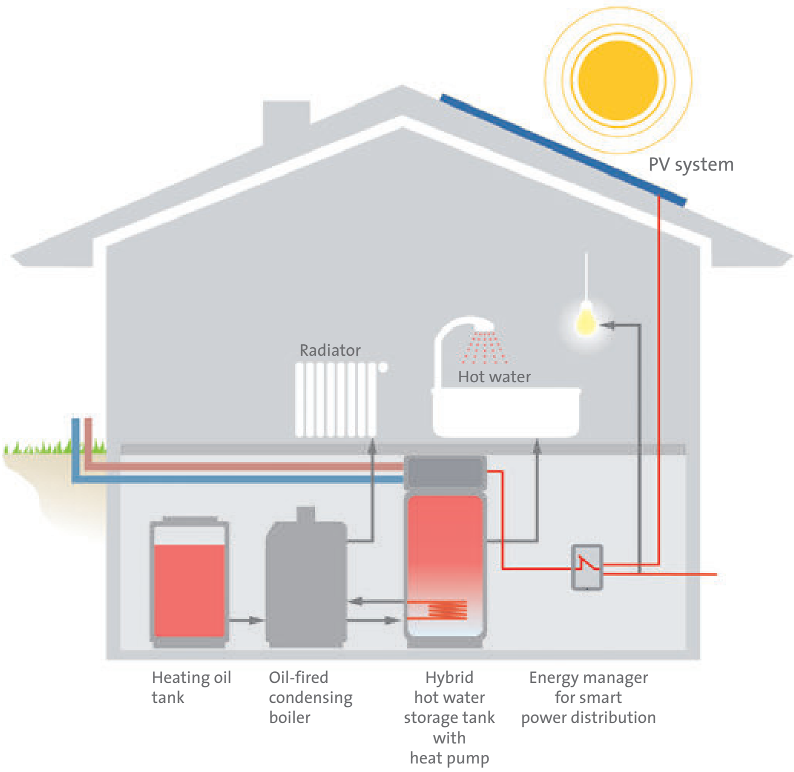
## Same principle, same efficiency

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. Oil-fired condensing boilers are high-tech devices, which use the fuel with the maximum technically feasible efficiency.

## 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: Whenever renewable energies are available, they are used. Nevertheless, the oil heater automatically and reliably pitches in when the sun does not shine or the wind does not blow. This way, a hybrid heating system always combines 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 the energy revolution. And they are outstanding at this: 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 share than all other energy sources put together. 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 supplementing the efficient oil-fired condensing technology offers the ideal heating for 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.




Source: IWO (Institute for Heating and Oil Technology)

**Fig. 25:**
**PV hybrid system with solar-driven hot water heat pump**



## Power-to-heat: Sector coupling of electricity and heating market

Heating-oil-based hybrid systems offer a good opportunity to also use electricity from wind power and photovoltaic systems for heating purposes, which would otherwise be down-regulated – in keeping with the sector coupling of electricity and heating 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 using power-to-heat and used for the heat supply. Legal intervention is required for this solution to become suitable on a mass scale, because a reduction in levies and charges on otherwise regulated electricity is an important prerequisite.

Even today, renewable electricity from an in-house photovoltaic system can be used for heating water using an electrical heating element in the hot water storage tank or a domestic hot water heat pump. Self-used photovoltaic electricity is therefore a concrete option in reducing greenhouse gas emissions caused by electricity and heat supply quickly, sustainably and affordably.

# Heat pumps:
# Energy from air, water and the ground

## Using free environmental energy

The regenerative energy stored in the air, in groundwater or in the ground can be harnessed with the help of a heat pump, and be used for cooling or heating buildings.

The principle of operation of a heat pump is equivalent to that of a refrigerator. While a refrigerator extracts the heat and dissipates it outside, the heat pump uses the heat from each heat source and delivers it as heating energy to the building.

In the cooling circuit of the heat pump, while absorbing the heat from the environment, a refrigerant is evaporated and then the refrigerant vapour is compressed in a compressor. As a result of this, both the pressure in the cooling circuit and the temperature of the refrigerant rise. This heat is now released at a usable temperature level to the heating water. In the process, the refrigerant condenses and then expands in the expansion valve, and the cycle repeats itself.

Electric heat pumps use electricity as the drive energy and work very efficiently. Depending on the type of heat source, whether air, ground or water, one heat pump can generate between three and more than five kilowatt hours of heat from one kilowatt hour of drive electricity. In order for the heat pump to actually achieve this efficiency in day-to-day operation, the heat pump must be designed to meet the custom heat demand.

## Heating, cooling and ventilation

The higher the temperature of the source, the more efficiently heat pumps work. Therefore, it is worthwhile to use a heat source at as high and as constant a temperature as possible. State-of-the-art heat pumps heat up domestic hot water as required, and can also be used to ventilate or cool a building. If the heat pump obtains its power from renewable sources such as wind power or photovoltaic systems and, in the best case directly at the building, it works completely emission-free and contributes still more to climate protection. Several power utility companies also offer special tariffs for operating heat pumps.

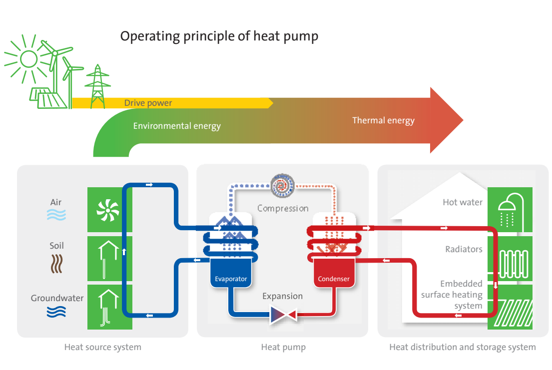



**Fig. 26: Principle of operation of an electrically driven heat pump**

## The commercially available variants of heat pumps

**Brine-water heat pumps**
Heat from the ground can be harnessed as a heat source by using the brine-water heat pump. There are primarily two ways of using geothermal energy near the surface: Geothermal probes (Fig. 27) and ground collectors.

Geothermal probes are inserted into the ground through drilled holes of up to 200 meters (in most cases up to 100 m) and use the average ground temperature of about 10 °C. Approval has to be obtained from the water authorities for probe holes drilled up to 100 m and from the mining authorities for greater depths. If the plot of land is large enough or if drilling holes is not possible, the geothermal energy can also be tapped using a flat plate collector at a depth of 1.5 to 2 m or ground cages placed at a depth of about 1 to 4 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 geothermal probes or in the flat plate collector.

The heat extracted from the ground is transferred to the 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 various designs, with and without integrated domestic hot water storage tank.

**Water-water heat pumps**
The water-water heat pump extracts the heat 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 via an injection well. An annual coefficient of performance of over 5.0 can be achieved since the water-to-water heat pump uses the 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.

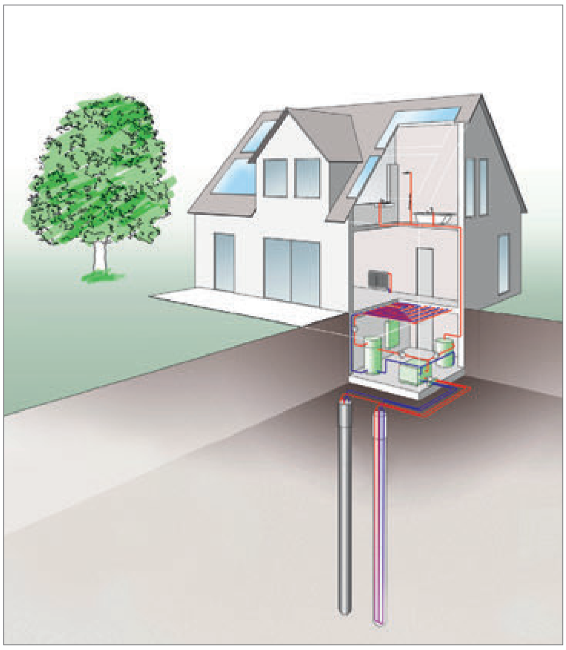


Fig. 27: Brine-water heat pump with ground probe

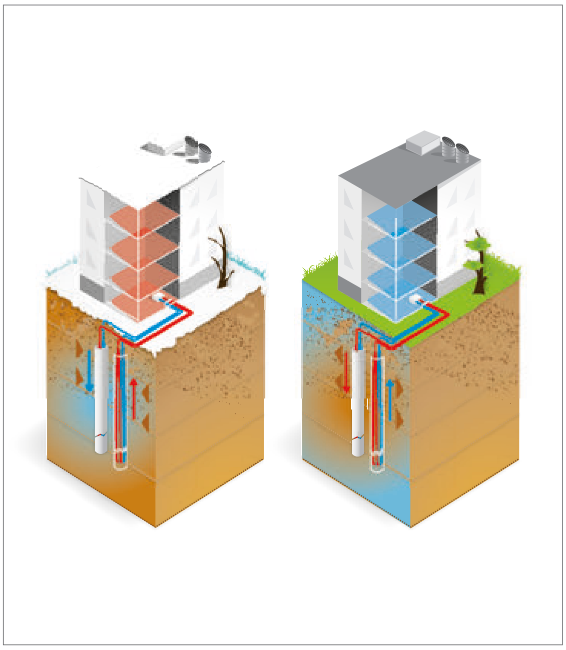


Fig. 30: Illustration of heating or cooling distribution of a heat pump in heating mode (left) and in cooling mode (right)

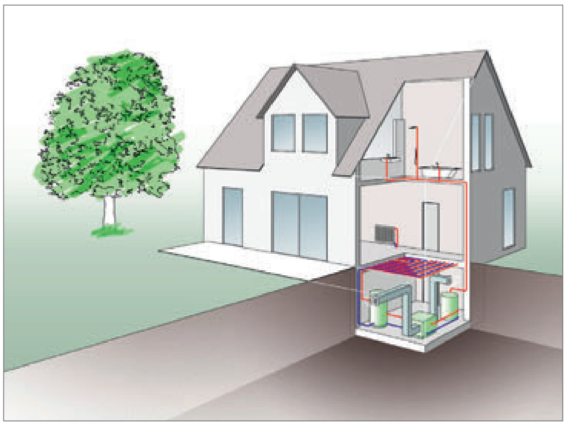


Fig. 28: Indoor air-water heat pump/mono-block

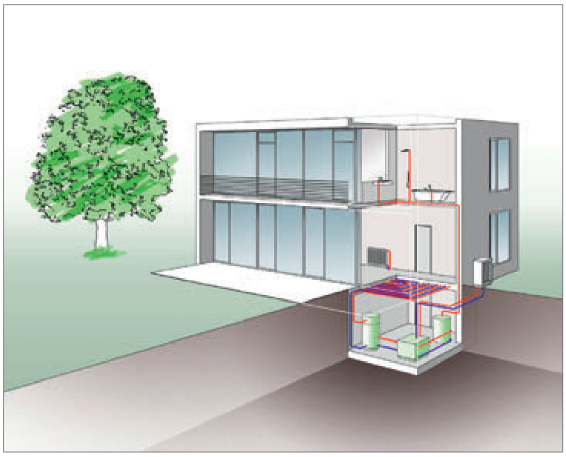


Fig. 29: Outdoor air-water heat pump/Split system

**Air-water heat pumps**

Air-water heat pumps extract heat from the ambient air. They are able to extract energy from the outdoor air even if its temperature has fallen to -20 °C or less. The investment costs of an air-water heat pump are lower because tapping the heat source is not required. However, due to fluctuating ambient air temperatures that are also low during the heating period, a reduction in efficiency must be expected. Since the heat source temperatures fluctuate, and often is lower than for other types of heat pumps, air-water heat pumps achieve a somewhat lower annual coefficient of performance between 3.0 and 4.0.

## Cooling with the heat pump

A heat pump with a cooling feature can also cool down indoor rooms with higher outdoor temperatures: The heat is extracted from the indoor rooms via the heating surfaces, and discharged to the outdoor air or the ground depending on the type of the heat pump. The direction of the cooling circuit is reversed in the heat pump for this purpose. Apart from active cooling with driven compressors, it is also possible to achieve passive cooling with the help of ground probes. In the process, the compressor of the heat pump is not in operation, and does not therefore require an electrical drive (Fig. 30).

# **Hybrid** heat pump

## Optimum combination of two heat generators for optimised heating

A hybrid heat pump is a combination of an electrically operated heat pump and a fossil heat generator (e.g., gas, oil or wood boiler) that communicate with each other via a smart control unit (Fig. 31)

Hybrid heat pumps are used as compact devices in single-family and two-family houses or are assembled together from individual components (heat pump, condensing boiler, storage tank) as bivalent systems and individually planned and installed for multi-family houses as well.

## There are a number of reasons for deciding to use hybrid heat pumps:

**Heating output and flow temperature for heating and domestic hot water**
If the heat pump is unable to provide the heating output or the required flow temperature throughout the year on its own, or if the efficiency is too low at cold outdoor temperatures, the second heat generator switches on.

**Temperature of the heat source:**
If the heat source temperature falls below the permissible minimum, e.g., when an air-water heat pump is used in colder regions, the hybrid heat pump balances out the temperature difference.

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

**Minimisation of $CO_2$ emissions:**
To minimise the environmental burden, the hybrid heat pump independently decides – depending upon the expected $CO_2$ emissions – which heat generator features minimum environmental burden at the current operating point.

**Long-term perspective due to gradual renovation:**
An option for a gradual energetic modernisation is the extension of an existing fossil heating system with a heat pump in the first renovation phase. The existing heat distribution and heat transfer system and chimney can still be used. By subsequent renovation of the building envelope in the next renovation phase, the heat load of the building is reduced and the heat pump takes over the supply of the building. The existing fossil boiler can be put out of operation.

## Modes of operation for heat generation in the hybrid heat pump (Fig. 32):

- Bivalent parallel operation:
  Above the bivalence point, the heat is provided exclusively via the heat pump. Below the bivalence point, the second heat generator is operated simultaneously 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, only the second heat generator is used, which provides the entire thermal heat.

## A variable system with a wide range of applications

- Whether in new buildings, renovations or simply when replacing condensing boilers, a hybrid heat pump is a solution for many special applications. It is particularly suitable for existing buildings where large heating output and high system temperatures are required for the preparation of domestic hot water.
- It guarantees that the building is heated at the most favourable prices at any given point in time because it can easily react to any fluctuations in the energy price by using the second heat generator. This function is generally integrated in the controls of most of the hybrid heat pumps.

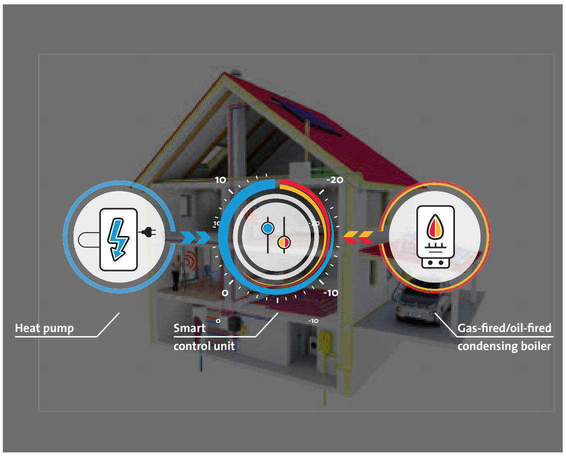



**Fig. 31: A hybrid heat pumps combines various energy sources using a smart control unit.**

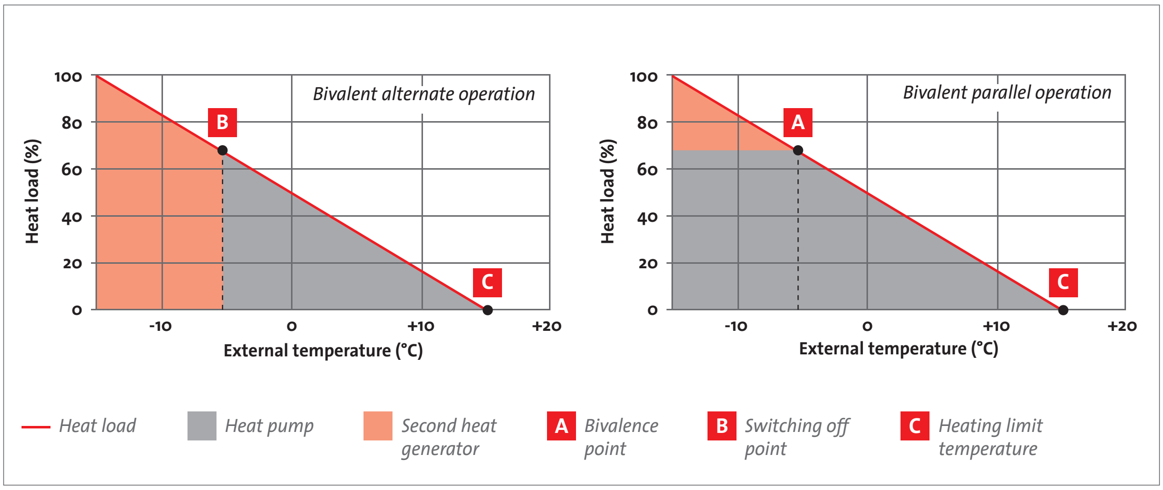



**Fig. 32: Illustration of common operating modes for hybrid heat pump systems**


**Fig. 33: Control unit selects the desired mode of operation**

By introducing flexible electricity tariffs, the variability of the hybrid heat pump can be used even better.

In principle, hybrid heat pumps contribute significantly to resolving the existing modernisation backlog, and reduce the power requirement and the grid load during periods of low availability of renewable electricity. Hybrid systems become "renewable energy heating systems" when high quantities of electricity from renewable energy sources and high amounts of green gas and green fuel are used.


**Fig. 34: Hybrid heat pump with split outdoor unit**

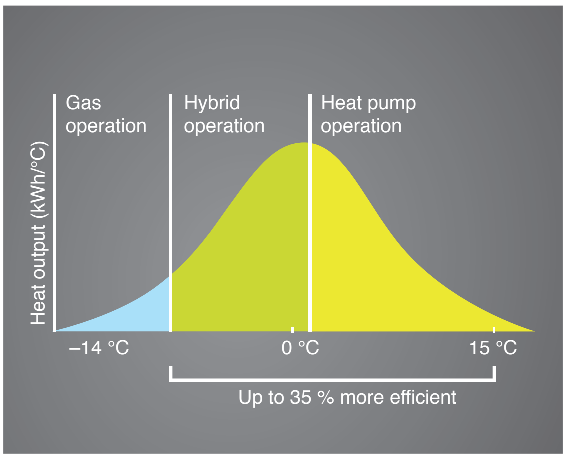



**Fig. 35: The hybrid heat pump system automatically selects the most efficient mode of operation**

# **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.

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.

If living room devices with a collection basin have to be used for the 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 proof its unique strengths during the appropriate season and completely replace the central heating system in the passive house.

Source: HKI – Nordpeis

**Fig. 36: Domestic fireplaces provide sustainable and low-cost heat**

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

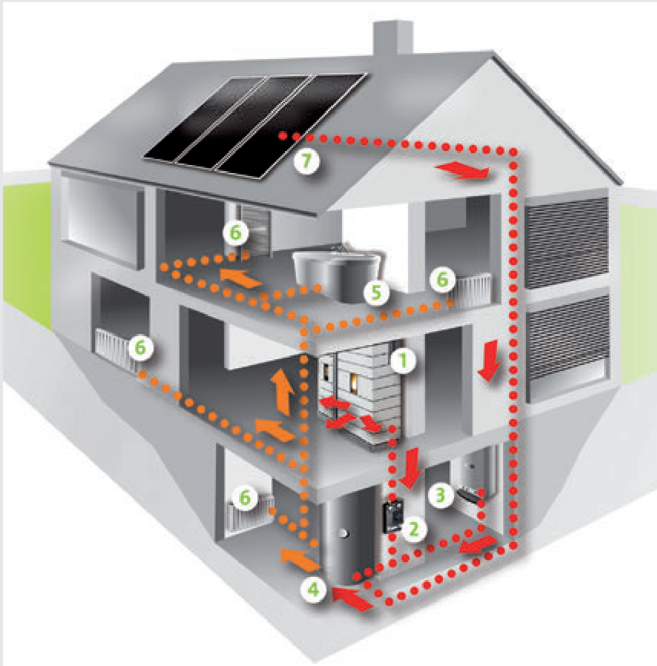


Fig. 37: Pellet stoves and split log stoves with a collection basin can be integrated into the heating system



## Ideal supplement for the heat pump

Wood firing, in particular, can bring benefits as a supplement to the heat pump. If the efficiency of air-water heat pumps drops on cold days, more electricity is required for the desired heating output – hence increasing the costs. This peak load can be accommodated by a supplementary fireplace with a collection basin, thus reducing costs for the operator.

Source: HKI

Fig. 38: Split logs as $CO_2$-neutral fuel

## 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.

Interested parties can choose from a large selection of models in different designs, sizes and price classes. 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 permits its use in modern buildings with controlled residential ventilation, such as low-energy and passive houses.

# Heat
# from Wood

## Wood-based central heating systems

From a single-family or multi-family house to commercial enterprises and right up to the local heating grid: Modern wood-fired central heating systems provide heat to buildings of all sizes. The big advantage: By using wood as renewable fuel, heat generation is climate-friendly since it is almost $CO_2$-neutral. Attractive government subsidy programmes, low fuel prices, and the favourable evaluation in the Building Energy Act (GEG) are other plus points. Apart from automatic wood-based central heating systems for wood chips and pellets, there are also manually loaded split log boilers. A common factor is the sophisticated technology and the efficient and low-emission combustion associated with it. 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 gasifier boilers. This efficient technology ensures a high degree of efficiency, low exhaust gas temperatures and low level of emissions. It is important that the heat exchange surfaces of the boiler are adequately dimensioned. The suction blower and combustion air duct are responsible for correct and adequate air supply. While the primary air duct ensures optimum wood gasification and, with it, the output, the secondary air supply ensures complete combustion of the wood gases, thereby ensuring low emission levels.

A suitably dimensioned buffer storage tank is not only prescribed by law, but also technically necessary, because current split log boilers operate intermittently. In the process, the boiler is filled and then the fuel is burnt completely over a period of several hours, before it is refilled. The buffer storage tanks permit replenishment intervals of once to twice daily – even in winter. This ensures noticeably greater 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 area to the heating boiler – often with a screw conveyor or similar equipment. A microprocessor-controlled regulator continuously controls the combustion in order to achieve high system efficiency. When controlled in such a way, even varying fuels do not have a decisive impact on the combustion values, and it is possible to adjust the power to approx. 30 % of the nominal heat output.

The output for wood chip based central heating systems ranges from about 20 kW to several megawatts. Since the viability of a wood chip based heating system increases with its size, it is often used in multi-family homes, restaurants and in large residential or commercial complexes. Wood-processing and agricultural companies very often use wood chip based heating systems, because the short transport distance of the fuel enhances the benefits of the system.

**Fig. 39:** An automatically loaded wood chips heating system with spring core space discharge and screw conveyor for transporting the fuel

**Fig. 40: An automatic pellet heating systems is illustrated here without a discharge system**

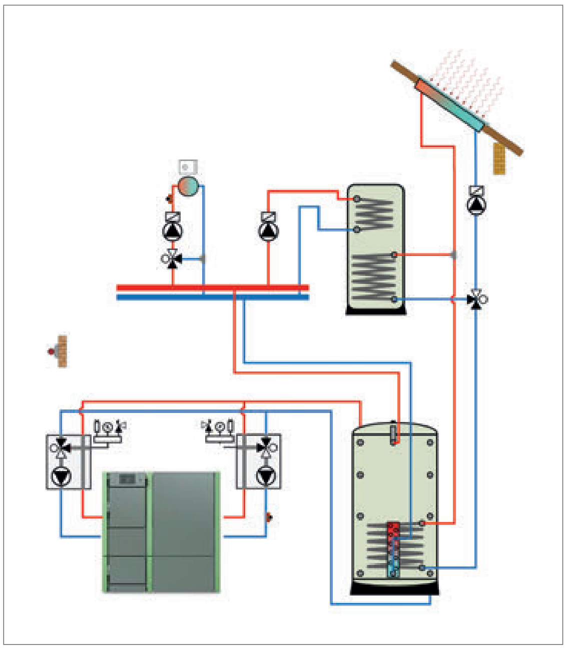


**Fig. 41: Schematic representation of a combination boiler (split logs/pellet) with system storage tank, domestic hot water storage tank and integrated solar thermal system**

## Pellet boilers

Pellet-based central heating systems are a particularly convenient method of generating heat from wood. Generally, the wood pellets come from the storage area 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. In this way, pellet heating systems are 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-based condensing boilers achieve efficiency levels 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-based central heating systems can easily be combined with solar thermal systems, making them even more climate-friendly. If both the systems are used together, the wood heating system is used as the primary heat source. If space heating is not required, e.g., in the summer months, the wood-based heating system remains switched off and the solar system supplies hot water. Even during winter and in the transitional seasons, the solar thermal system can support the wood boilers significantly. In doing so, one buffer storage is adequate for both systems. This accepts energy from both the solar 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 and an automatic pellet, oil or gas-fired heating system, which serves as a "backup" or is used 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.

# CHP and fuel cell – The power-generating heating system

## The heating system generates electricity as well as heat

Conventional heating systems work according to a clear principle: The used energy source is converted into heat. With cogeneration of heat and power, the heating system generates electricity in addition to heat. Very high efficiency rates of more than 90 % can be achieved with the simultaneous production of electricity and heat. Losses due to waste heat, occuring in separate power generation in power plants, are avoided. Overall, this is therefore a high-efficiency principle!

CHP systems and fuel cell heating systems work according to this principle. In addition to the high level of efficiency, which leads to reduced costs for the customer, they also have several other benefits. Considering the continuously rising prices of electricity, it is becoming increasingly attractive for many consumers to generate their own electricity, regardless of weather conditions. Particularly in high-quality new buildings and with the energetic renovation of large old buildings, such systems therefore represent an attractive option. They also conserve the environment since, with the simultaneous and decentralised generation of electricity and heat, they make an important contribution to reducing the load of energy systems and electricity grids. Thanks to their low $CO_2$ emissions, they contribute sustainably to the energy revolution and therefore to climate protection.

## Fields of application and advantages

The potential fields of application of the CHP technology are huge:

- For single and two-family houses, there are so-called “micro-CHP systems”, as well as fuel cell heating systems with an output range of up to approximately 2 kW of electrical power.
- In apartment houses, as well as in small and medium-sized commercial premises, “mini-CHP systems” with a power output up to 50 $kW_{el}$ are used.
- CHP systems with more than 50 $kW_{el}$ are also used in the industrial sector and for large residential complexes.

Micro-CHP and mini-CHP systems, as well as fuel cell heating systems, are generally operated in conjunction with a second heat generator for peak loads. The systems can be easily integrated into existing heating systems.

## Differentiation between systems with the CHP technology

Systems are currently available from a wide range of manufacturers. They can be distinguished by

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

## Fuel cell heating system

At present, fuel cell heating systems are generally operated using natural gas, which is converted into hydrogen. In the future, green gases might also be used directly. In the fuel cell heating systems operated using natural gas, the natural gas is not burnt. Rather, an electrochemical reaction takes place, which enables significantly higher levels of efficiency compared to engine-based or combustion-based systems. In addition, $CO_2$ emissions are significantly lower during the low-noise, low-vibration and low-maintenance operation. Especially in typical single and two-family homes, there is huge potential for the technology, since natural gas heating systems already have a large market share in existing buildings. Currently, however, every one in two of these heating systems is outdated, which means that they are often no longer economical to operate. This results in an unnecessary burden for the wallet and the climate. Therefore, it is advisable to modernise the system, for example with a high-efficiency fuel cell heating system.

But in new buildings as well, there are opportunities for deploying fuel cell heating systems. In addition to compact heaters with integrated buffer storage, freely combinable kits consisting of the fuel cell, with integrated or supplemented heat generator and buffer storage are also possible. It also makes sense here to combine the system with a heat pump. Moreover, high capacity models are also available that are specifically designed for use in commercial or non-residential buildings.


**Fig. 42: Components of a fuel cell system**

## System-friendly features

Generally, the fuel cell heating system is already operated at present using hydrogen, which is converted from natural gas. In the energy systems of the future, green hydrogen will play an important role as a source of energy, and both CHP and fuel cell heating systems are ideal for using hydrogen for the decentralised generation of heat and electricity. In this case, not being dependent on the weather is system-friendly.

As described in the chapter on networking heating systems, we are in the process of migrating to networked energy systems in which new mechanisms have to be found in order to ensure that a balance between electricity generation and consumption is maintained. The CHP technology becomes particularly important against this background. CHP systems for single family and two-family homes, as well as fuel cell heating systems, can be controlled flexibly in the energetically networked building, and can adapt to the electricity supply in a system-friendly manner. In this way, the systems can contribute towards intercepting peak loads. Similarly, grid bottlenecks can be eliminated by using electricity generated locally. 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.

In this way, CHP systems and fuel cell heating systems contribute directly to the energy revolution. This is why decentralised CHP is particularly encouraged in many countries. Generally, self-generated electricity is subsidised. Moreover, there are investment subsidies for installation, incentives when paying taxes on energy, as well as separate tax depreciation options.

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 continuation of government funding, strengthening the perception of technology among the public and politicians, as well as continuation of standardisation activities. The initiative is supported by the Federation of German Heating Industry (BDH) and the industry initiative Future of GAS. The heating appliances industry, as well as numerous gas supply companies, support the IBZ as a valuable partner.***

# Solar thermal systems

Solar thermal systems for domestic hot water heating and room heating are currently used mainly in residential buildings, primarily single family and two-family homes. They are also used in apartment buildings, hospitals, hotels and sports facilities. 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.

Due to the targets of climate protection, the energy-related requirements worldwide are being made more stringent in newly constructed and existing buildings. 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 plants) and domestic hot water heaters, the integration of solar thermal energy enhances the energy efficiency class of the original equipment.

Almost all the technical systems in the heating market can be usefully 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.

## Application in the system

In solar thermal energy, the solar energy is used to extract heat. Solar thermal systems are usually operated on a bivalent basis in combination with another heat generator. In doing so, all the components of the overall system must be aligned and compatible with one another. The reason for this is that, ultimately, the desired savings can be achieved only with an overall system that is optimised with respect to its control and hydraulic system.

## 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.

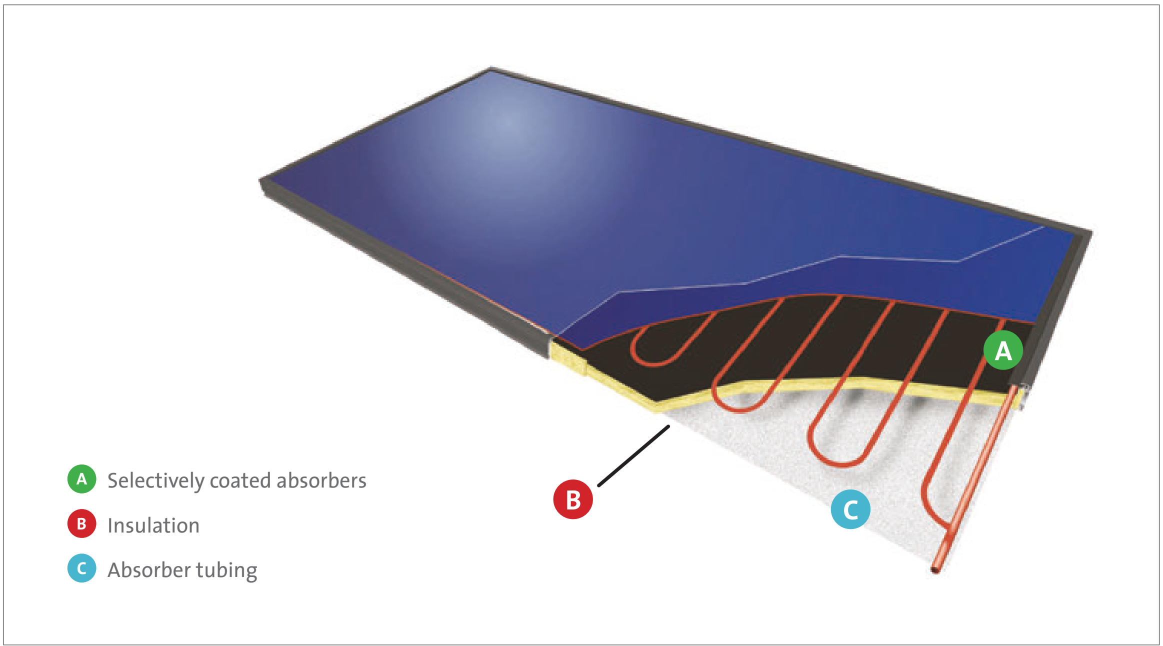



**Fig. 43: Installation of a flat plate collector**

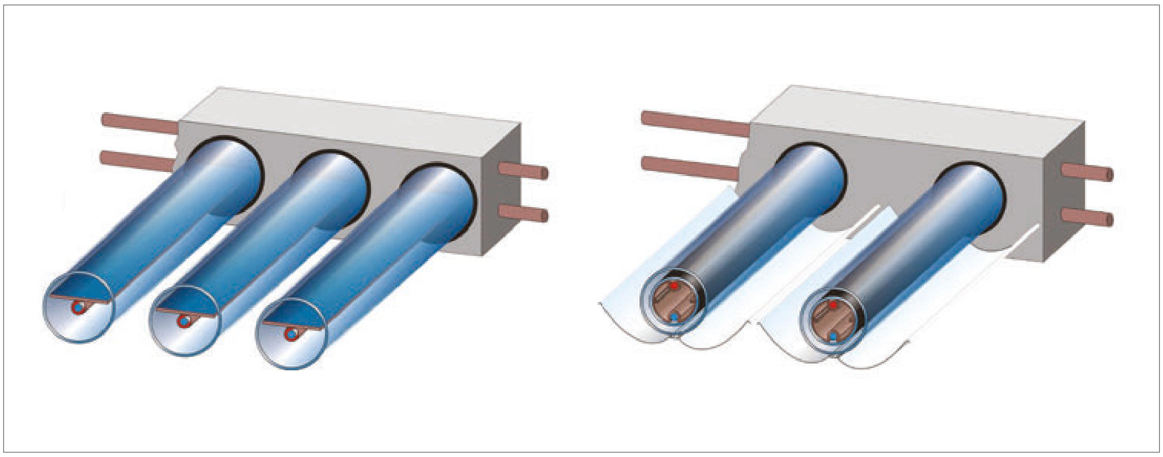


Fig. 44: Vacuum tube without and with an external reflector

## 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 regulator for controlling 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 home.

## 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 home, up to 30 % of the heat demand can be met depending on the design and insulation of the building. With low-energy buildings, you savings of up to 50 % and more become possible.

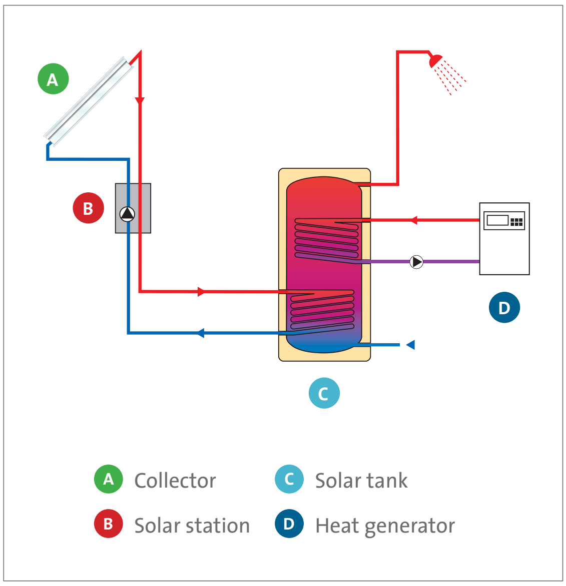



Fig. 45: Thermal solar system for domestic hot water heating in a single family house

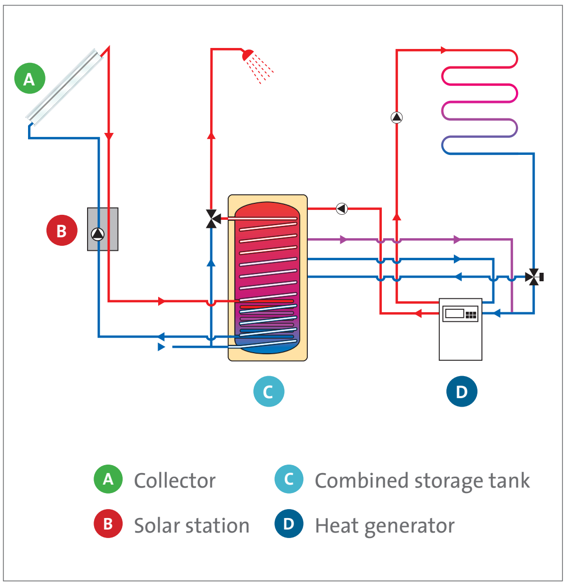



Fig. 46: Thermal solar system for supporting space heating and domestic hot water heating in a single family house (combined system)

# Solar thermal systems

Fig. 47: System example – Flat plate collector

Fig. 48: System example – Vacuum tube collector

## Solar thermal systems for local and district heating

With solar thermal energy-based local and district heating systems, a differentiation can be made between rural thermal networks and urban district heating systems. While solar thermal energy has been used in rural thermal networks in Germany for years, solar thermal energy is also beginning to gain a foothold in standard urban district heating. Urban utility companies and other direct heating operators are becoming increasingly involved with solar district heating. Examples of execution for both variants are described below.

## Solar-based heating networks for rural areas

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 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 centre 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 these networks, centralised wood-fired boilers, biogas CHP plants or heat pumps are used quite often.

Fig. 49 illustrates a solar-supported heating network using the example of the bio-energy village Buesingen in the district of Constance. Using vacuum tube collectors with a gross collector area of 1,090 m², 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 wood chip boilers.

Fig. 49: Solar-supported heating network for a village using the example of Buesingen

Photo www.solarcomplex.de

## Solar urban district heating

The largest solar thermal system in Germany was put into operation in 2016 in Senftenberg, Lusatia. The district heating, which for decades was based on lignite, has been supplied since then by the solar thermal system and with the help of natural gas. Using vacuum tube collectors with a gross collector area of 8,300 m², the solar thermal system produces an average annual heat output of 4 GWh (approx. 4 % of the entire heat quantity of the network). The specific annual output is about 482 kWh/(m²a). The maximum continuous power is 5 MW. The system was erected on a floor area of 20,000 m²

The heat is fed from the decentralised solar thermal system into the district heating network. As an option, it is possible to switch between solar forward flow supply and increased return flow. The majority of the time, the system is operated with forward flow supply. During phases of low irradiation – for example, in the mornings when the system starts up or in the evenings before sundown – the system switches to increased return flow. An increase in return flow is also more common in winter. The system works without a heat storage tank. The solar thermal system is designed in such a way that only during a few summer periods does it produce more power than the grid requires. At these times, the grid itself is used as a buffer. The solar heat can flow through the entire network through a bypass in the centralised driver pumps.



**Fig. 50: Solar district heating using the example of Senftenberg utility company**


COMFORT
DIGITAL
EFFICIENCY
RENEWABLES

## **Modern**
## System Components

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

# Heat distribution

## Components

Heat distribution ensures that the required amount of energy is transported from the point of heat generation to the heat transfer system. In addition to the pipelines, the (line) control valves and the pumps are primarily used for heat distribution in a hydraulic heating system.

## Line routing

For laying the pipelines of the heating system, there are various ways of routing 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 takes place as a single or dual pipe system within the insulation layer of the screed or in a suspended ceiling below the structural slab.

## Pipe network calculation

A pipe network calculation must be carried out in the course of system planning and design to dimension the line cross-sections in such a way that heat transfer to the specified volume of heating water takes place. Excessively high flow rates should not be used for the calculation so that no undesirable noises occur during operation and the pressure losses are minimised. The result is used as a set value for the control valves.

**Fig. 52: Radiator thermostatic valve**

## Insulation of pipelines

For the energy-efficient installation of the heat distribution system, requirements for the thermal insulation of pipes and fittings are defined in the Building Energy Act (GEG). It specifies the insulation thickness to be maintained for the specific values of inner pipe diameter. A proper design for avoiding thermal bridges is of crucial importance. In order to prevent transmission of structure-borne sound between the building structure and the pipeline, the pipelines must be provided with an elastic enclosure. When subsequently plastering the duct openings, it must be ensured that no acoustic bridges are formed.

**Fig. 51: Control valves**

**Fig. 53: Valve with pre-settable valve insert for adjusting the flow rates to the required heat load**

Fig. 54: Electronic radiator valve

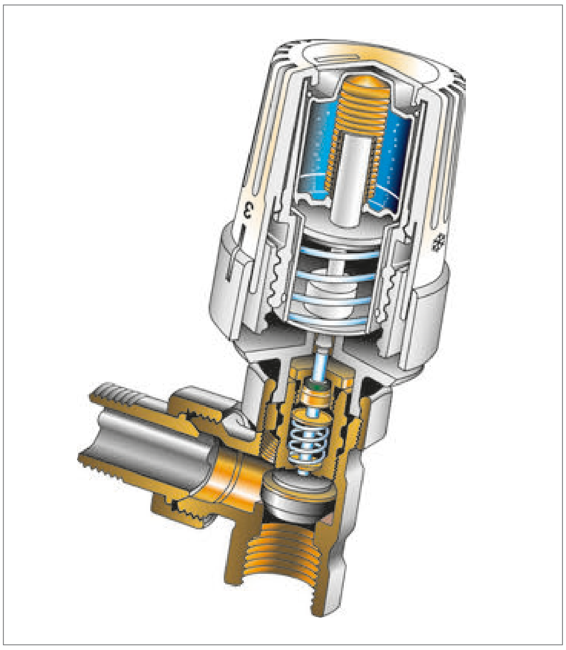


Fig. 56: Sectional model of a radiator valve


Fig. 55: Factors influencing efficient heat distribution

## Control valves

Valves are used for shutting off pipelines or controlling the flow rate or pressure. Differential pressure or mixing valves, as well as line control valves, are used in the heat distribution system. Differential pressure valves are necessary in order to ensure optimum pressure conditions in the heat distribution system. Depending on the system size, the differential pressure control can be carried out centrally or in a decentralised manner. Mixing valves are required to mix hot water of different temperatures, so that the desired system temperature can be achieved. Two typical products are three-way or four-way mixers.

In individual distribution pipes/lines of a heating system, line control valves are used to optimally balance the volume flow rates as needed. As a result, equal pressure losses can be adjusted throughout the entire pipe network, which supports hydraulic balancing and ensures efficient distribution of the heating water. This is the prerequisite for efficient use of heating pumps.

# Hydraulic balancing
and high-efficiency pumps

## Hydraulic balancing enables comfort and saves costs

Hydraulic balancing is an effective means of saving heating energy. Here, the aim is to ensure the determined target water volume flow rate for individual system components and heat transfer installations so that an adequate amount of heat gets to where it is required. In order to perform hydraulic balancing, suitable fittings such as thermostatic valves, differential pressure regulators or circuit control valves can be used. Hydraulic balancing with corresponding declaration can be carried out according to DIN EN 14336 or VDI 2073 Sheet 2, for example. In addition, there are various software products available on the market that facilitate hydraulic balancing, especially in larger systems.

## The path of least resistance

With hydraulic balancing, it is possible to achieve uniform heat distribution in a building. Here, the dimensions and settings of the heating system are established in such a way that the system – made up of pipes, pumps, fittings, heat transfer installations, as well as any other components, such as heat meters or separators/filters – offers the least 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 could offset this, but the price would be (too) high, since it would instead result in an oversupply to the closer rooms and disturbing flow noises. Furthermore, this would needlessly increase energy consumption. 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 absent 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: The system can be operated with optimum system pressure and a lower volume flow rate. This reduces the energy and operating costs: Savings of up to 15 % of the heating energy costs are possible.

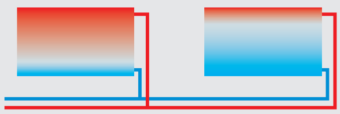
## GEG (Buildings Energy Act), VOB (German Construction Contract Procedures) & Co.

The GEG (Buildings Energy Act) requires that technicians confirm in writing, as part of the subcontractor declaration, that their services comply with the legal requirements, and that the hydraulic balancing has also been executed, if 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. It is also funded as part of the Federal Funding for Efficient Buildings and through a percentage deduction of expenses from tax liability.

## Calculating the heat load, adjusting the heat output

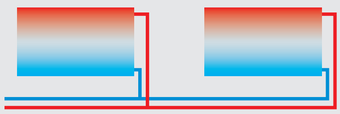
For hydraulic balancing, it is first necessary to calculate the heat load for every room in the building, taking into account the external surfaces, walls, ceilings, windows and doors. According to the calculated heat load, the heating surface with the required heating output is selected. Additionally, 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 fittings or balancing devices are derived from all these parameters.

Imbalanced heat output in systems **without hydraulic balancing**



Without hydraulic balancing
✗ unnecessarily high energy consumption
✗ overheated or undercooled rooms
✗ poor condensing boiler efficiency
✗ flow noise at thermostatic valves
✗ oversizing or incorrect setting of the heating pump

Optimised heat output in systems **with hydraulic balancing**



With hydraulic balancing
✓ Energy saving
✓ Optimum room temperatures
✓ good system efficiency (optimised condensing boiler efficiency)
✓ no flow noise at thermostatic valves
✓ ideal controllability of the system

**Fig. 57: Hydraulic balancing**

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 are a support for 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 performed 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 energy savings.

**Fig. 58: High-efficiency pumps in accordance with the Eco-design Directive**

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

## High-efficiency pumps: Efficient and controlled depending on 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 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 require much less energy.

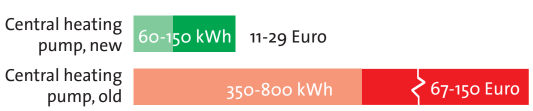
Circulating pumps in heating systems can be operated in different ways. Here, a distinction is made between unregulated and electronically regulated pumps. Unregulated pumps do not adapt to the constantly changing operating conditions (so-called partial load range) of the heating system and therefore require an unnecessarily large amount of electrical energy. Due to legal and/or regulatory requirements, unregulated pumps are practically no longer allowed in new buildings and are therefore predominantly found only in older buildings.

Electronically regulated pumps or high-efficiency pumps adapt their output to the needs of the heating system. This improves operating behaviour and saves energy. Most modern high-efficiency pumps also have different control types, such as the so-called “constant pressure control” or “proportional pressure control”. As a result, the circulating pump can be exactly adapted to the hydraulic requirement and energy consumption can be reduced to a minimum.

A high-efficiency pump allows efficient control of both the heating circuit and the drinking water circulation. The pump reacts automatically and quickly to the changes in the volume flow rate 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 greater 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 the changing performance requirements of the system continuously. This means that they not only save electrical driving power in the full load state, but also in the partial load state of the heating system. Compared to conventional pumps they use 80 % less electricity.

**The heating pump: from energy waster to energy saver**




Typical power consumption of a single-family (3 person) house – Data from Stiftung Warentest (leading German consumer safety group) 09/2007

**Fig. 59: Savings potential of pumps**

# Embedded surface heating and cooling system

## Heating and cooling in one system

In the case of new buildings, the embedded surface heating and cooling 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 south-facing window areas and summer heat waves, 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 particularly in office and administrative buildings or halls. Also, as a rule, the service life of the embedded surface heating and cooling system is to be equated with the economic life of the building, so that it represents a sustainable, efficient and convenient solution.


**Fig. 60: The dual function of "Heating and Cooling" of an embedded surface heating and cooling system**

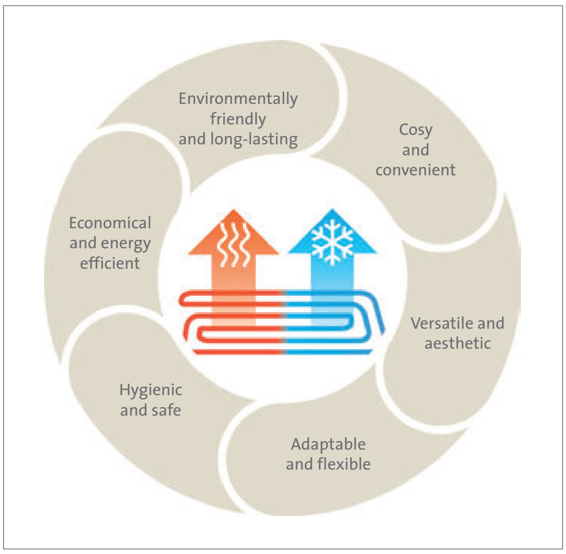



**Fig. 61: The features of a embedded surface heating and cooling system with the dual "Heating and Cooling" function**

## Wide range of solutions also for old buildings

For old buildings, suitable systems are available for subsequent integration into floors, walls or ceilings with only minor structural modifications. The versatility of wet systems (screed or plaster), dry systems, and special thin-layer systems provides 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.

## Practically unlimited range of application

In addition to the field of residential buildings already described, the embedded surface heating and cooling system can also be used in office and administrative buildings or halls. Here too, the embedded surface heating and cooling system ensures a pleasant atmosphere throughout the year, as well as energy efficiency. As a low-temperature system, it is particularly suitable for the integration of renewable energies.

## More comfort, less costs

In embedded surface heating systems, only low system temperatures are generally required (35 °C flow temperature/28 °C return temperature). This enables their energy-efficient combination with any type of heat generator and solar thermal system. 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, which can be both wired and wireless. Last but not least, the invisible embedded surface heating and cooling system in the floors, walls and ceilings has the advantage of giving the residents free rein in designing their living space.

## 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 ceiling 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

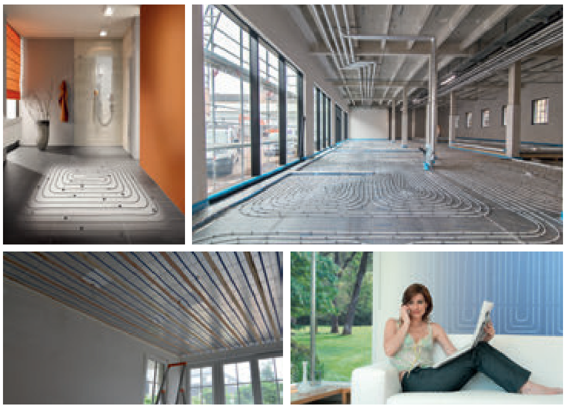


Fig. 62: Freedom for interior decoration even in non-residential buildings thanks to an embedded heating system (floor, wall and ceiling).

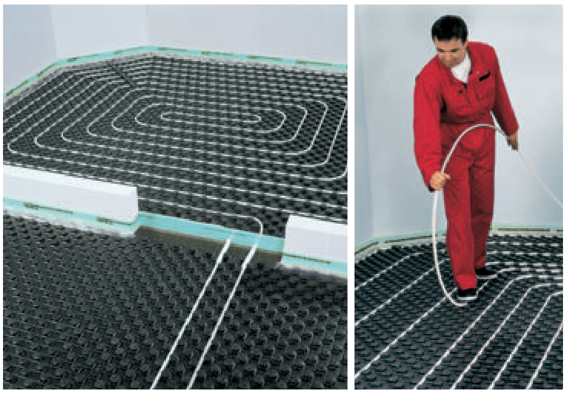


Fig. 63: Easy installation of an embedded surface heating and cooling system using the example of a floor heating

Fig. 64: Controlling the heating circuit distributor via a remote controlled single-room control

Source: Values based on DIN EN 1264 and DIN ISO 7730

| | Surface temperature $\vartheta_F$ on component in °C | | Heat transfer coefficient α on component in W/m²·K | | Max. specific output $q_H$ in W/m² | |
|---|---|---|---|---|---|---|
| | Maximum during heating | Minimum during cooling | Heating | Cooling | Heating at $\vartheta_i$ 20 °C | Cooling at $\vartheta_i$ 26 °C |
| Floor | 29 | 19 | 10.8 | 6.5 | approx. 100 | approx. 45 |
| Wall | 40 | 18 | 8 | 8 | approx. 160 | approx. 65 |
| Ceiling | 29 | 18 | 6.5 | 10.8 | approx. 60 | approx. 85 |

Table 1: Typical thermal values of an embedded surface heating and cooling system

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. The typical thermal values of the different embedded surface heating and cooling system variants have been compiled in Table 1. Due to these temperature differences between the coolant and ambient 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.

## 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.

## Remote-controlled room temperature control

The options provided by the control technology for embedded surface heating and cooling systems can be fully utilised only in combination with state-of-the-art communication technology. This means that the embedded surface heating and cooling system can be controlled wirelessly or via app from home through WLAN, or 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 both create and modify individual heating profiles for every room, define or adjust a basic temperature, 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 embedded surface heating and cooling system offers the dual advantage of "heating in winter" and "cooling in summer". This means that the ambient temperature can be set to a comfortable range throughout the year – in apartments, office and administrative buildings, as well as in halls.

# Radiator

## Efficient, comfortable and sustainable

Modern radiators can be used flexibly and integrated into any heating system in a reliable, sustainable and future-proof manner regardless of the energy source. For sustainable benefits, heating surfaces that can react quickly to changes in heat demand are required. For this purpose, there are modern radiators with small installation depths, low water content and high transmission areas. There is a wide spectrum of solutions available for new buildings and renovation projects, ranging from products for low temperature ranges, such as when using a heat pump right up to those suitable for remote heating systems. In the process, residents or building owners can choose from the most diverse designs, and thanks to the supplementary functions and optimum equipment, the room temperature can be quickly adjusted by using maximum radiated heat, thereby providing cosiness and comfort with energy savings all at the same time.

## Quality, efficiency and design

However, the quality is determined not only by the output of a radiator: The heat can be delivered optimally only if the radiator is mounted in the right place. The classic space below the window is still recommended. Positioning from the energy perspective, combined with the design requirements of the room, provides the optimum customised solution. For efficient heat dissipation, the radiator should not be blocked or hidden behind curtains.

Various designs and an almost unlimited choice of colours provide additional accents in the room.

## Comfortable temperature setting to the exact degree

Thermostatic valves that keep the heat in the room at a constantly desired temperature, play an important role in efficient heat transfer. To do this, they depend on the correct differential pressure in the radiator, which is achieved by hydraulic balancing.

In order to achieve maximum heat dissipation even with reduced water flow rate, modern thermostatic valves and fittings for hydraulic balancing support a heating system by adjusting the individual "comfortable" temperature accurately even at different heating times. Timer-controlled thermostatic valves specify the time at which the radiator should start with the heating – accurate to the degree, including automatic shut-down.

## Beautiful design and intelligent features

The diverse variations in shape, colour and design facilitate an attractive, customised interior and create new interior design options for the residents, since the radiators fit seamlessly into the architectural ambience. New radiators are available in several colours – even chrome versions are possible. If you want something unusual, the radiator, for example, can be powder-coated with a matt finish or it can be given a stainless steel finish. Additional features and smart accessories such as hand towel rods, mirrors or

**Fig. 65: Modern radiators for customised living comfort**

**Fig. 66: Numerous design options and smart accessories**

racks, hooks and lighting create feel-good accents. Often, radiators are also used as design objects, which are adapted to the ambience and match the colour and design of the room.

## Between modernisation and comfort

Radiators are subject to wear and tear, which primarily affects their quality and functionality. This is why the increase in service life is often accompanied by higher energy consumption, enhanced wear and tear of heating components, as well as loss of comfort. Therefore, the aim of modernising existing equipment is to increase efficiency by energy-saving operation and optimum heat transfer using modern radiators.

When planning the modernisation of heating systems, owners particularly weigh costs against benefits. The reason for this is that renovations, potential impairment, dirt and noise cannot be avoided 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 powerful models is no longer a problem in practice. Simple and quick installation of the radiators is the rule: drain them out, unscrew, screw and fill. Ready to go! Detailed information is available at www.heizkoerpertausch.de.

**Fig. 67: Fitting accuracy at the time of modernising radiators**

**Fig. 68: Easy replacement**

# Residential ventilation systems
with heat recovery (HRS)

## Comfort without limitations

Good and hygienic air is crucial for our well-being indoors. Ventilation systems with heat recovery ensure the air quality and thus the well-being of residents. They also ensure the required minimum air exchange as specified under the GEG (Building Energy Act) and reduce the energy demand for heating.

Daily use of indoor spaces gives rise to carbon dioxide ($CO_2$) and water vapour. To properly control and discharge these outside, the rooms must be sufficiently ventilated (Fig. 70).

Ventilation systems with heat recovery are capable of doing this independently. They prevent ventilation thermal losses and help to save heating energy by means of heat recovery (Fig. 72).

- 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 also protected against structural damage. Accumulated moisture in the air, e.g., caused by showering, cooking or drying clothes, is reliably dissipated to the outside. This prevents the breeding ground for ventilation-induced mould growth.

If desired, the outdoor air can be cleaned additionally by a pollen filter, which provides extra protection against particulates, soot particles and pollen. This largely minimises the exposure to pollen and allergens.

Controlled residential ventilation systems offer numerous opportunities to find a customised solution for each individual requirement and each individual installation situation.

## Systems with heat recovery – HRS

Ventilation is necessary. However, normal ventilation with open windows is associated with high thermal loss because the inside air heated by the heating 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.

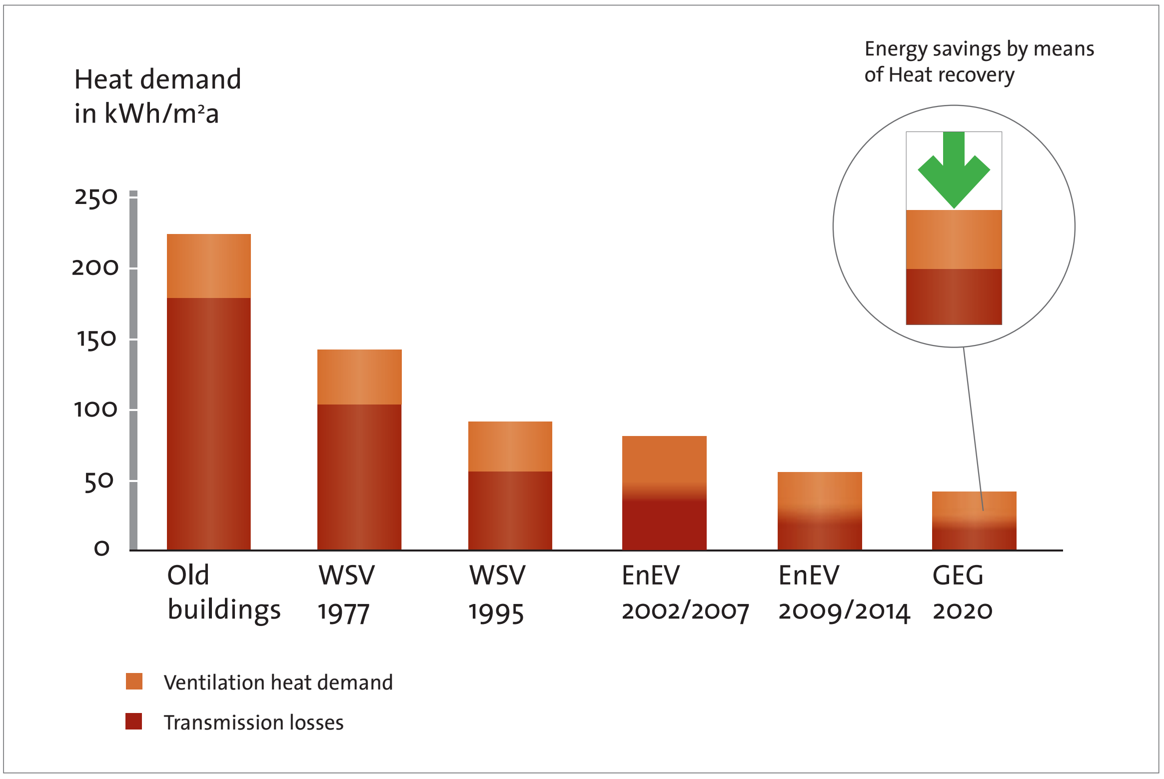



**Fig. 69: Relative proportion of ventilation with respect to the total heat demand**

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. Due to the growing energetic requirements on the building envelope with increasing legal minimum insulation standards, transmission thermal losses could be reduced further, which means that the ventilation thermal losses continue to be the dominating factor. In modern buildings, up to 50 % of the heat demand is required to heat the necessary fresh air supply (Fig. 69).

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) by using a heat exchanger. Modern systems are able to recover up to 90 % of the heat present in the extract air.

## Day-to-day life with Corona: distancing, hygiene, masks and VENTILATION

As a purely outdoor air system, controlled residential ventilation provides a dilution effect in the respective rooms thanks to the permanent supply of fresh air. This reduces the specific exposure per cubic meter to any viruses that may be present in the room.

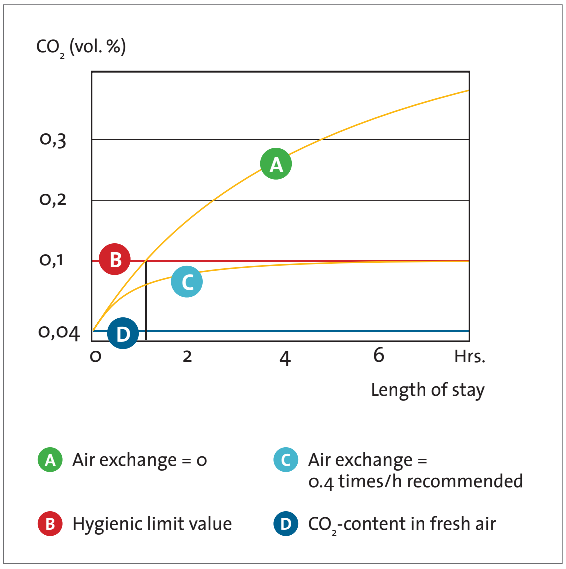



**Fig. 70: Correlation between $CO_2$ concentration, length of stay and air exchange**

**Fig. 71: Ventilation lowers the risk of infection**

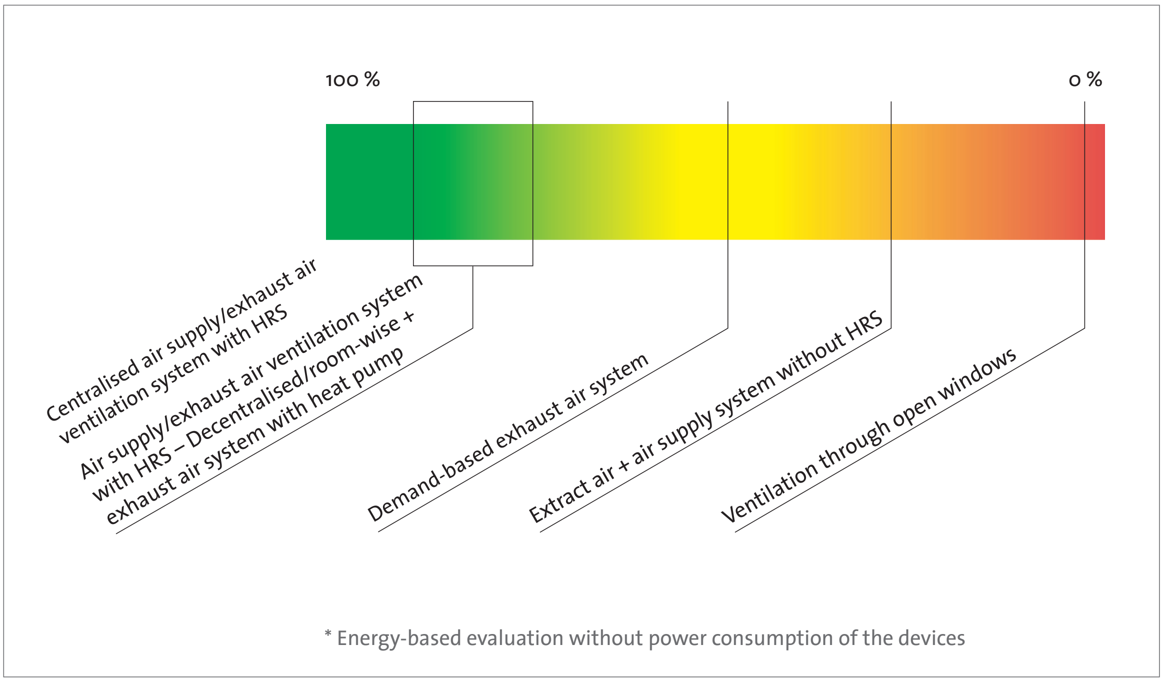



**Fig. 72: Reduction of ventilation thermal losses**

# **Residential ventilation decentralised or centralised** with heat recovery (HRS)

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

## 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)
- Swing blowers that alternately ensure a supply of fresh or extract air (push-pull principle). For balanced ventilation, two corresponding devices are required.

Both operating modes are equipped with a heat recovery of up to 90 %.

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 supply air and extract air systems 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.

A summer bypass allows the apartment to be cooled on warm summer nights even without opening windows. Here, the heat exchanger is bypassed depending on the room and the outdoor temperature, so that the fresh and cool outdoor air flows directly into the apartment (Fig. 74).

## 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.

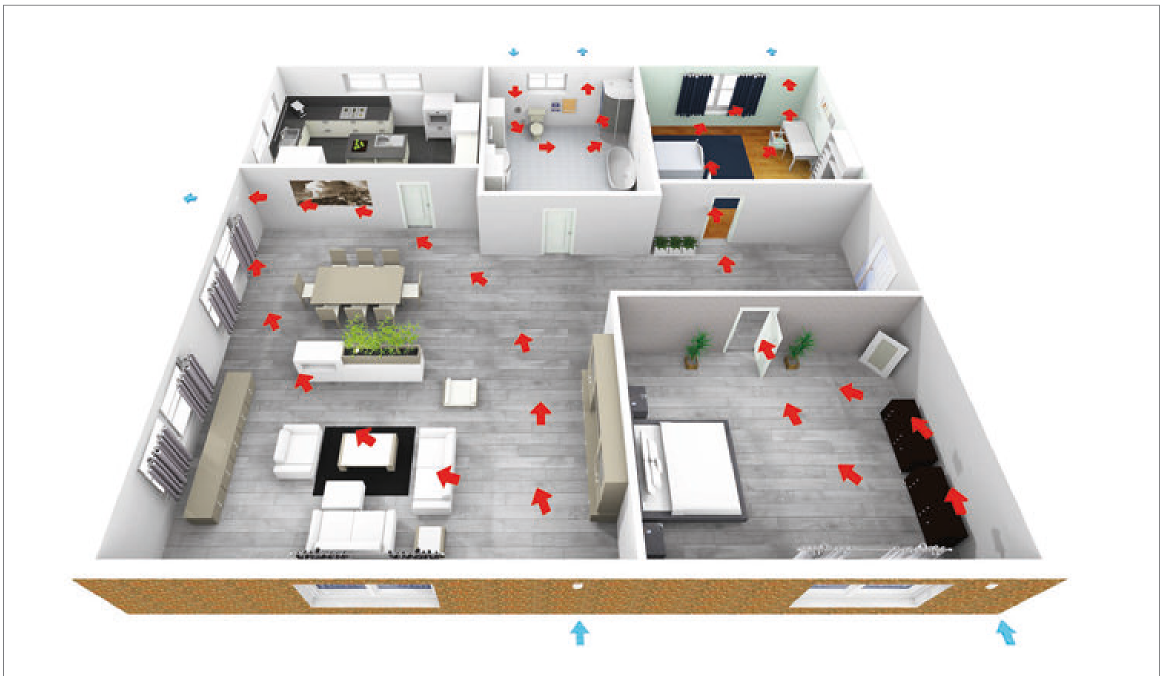
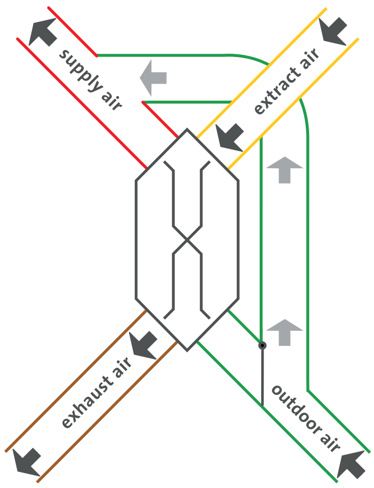


**Fig. 73: Airflow with room-wise/ decentralised ventilation units**




The **outdoor air** from the surroundings flows to the ventilation unit or is suctioned via a fan.

The air flows through the heat exchanger and is released into the rooms as **supply air**.
In summer, the heat exchanger can be circumvented using a bypass.

The air that flows from the room to the ventilation unit or is suctioned by it is called **extract air.**

The air that flows from the ventilation unit into the open is the **exhaust air.**

**Fig. 74: Heat recovery with summer bypass**

**Fig. 75: Planning, installation and maintenance by a qualified technician**

## 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 single-family, two-family and multi-family houses, individual flats, existing buildings or new buildings.

**Fig. 76: Decentralised residential ventilation unit with push-pull principle**

# Storage Technology

## Hot water for all purposes

Hot water storage tanks act as a core component of modern heating and hot water supply systems in residential and office buildings. They can perform various functions due to the large 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 of time. This enables coupling of heat from renewable energy sources and CHP plants. So-called combined storage tanks combine both functions.

Modern hot water storage tanks have high energy efficiency. They are characterised by minimum thermal loss and optimised heat exchange and temperature gradient. All the hot water storage tanks in the market meet the highest standards of domestic hot water quality and hygiene.

Hot water storage tanks also play an important role in connection with cross-sector applications. Excess renewable electricity, e.g., from photvoltaic 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 with the help of efficient heat pumps.

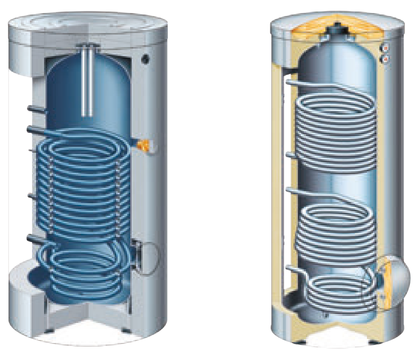
## Heating domestic water

Hot water storage tanks for domestic hot water heating store the domestic hot water required in the household or in a building, in order to make it available round-the-clock. In this case, a distinction is made between monovalent and bivalent domestic hot water heating.

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

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

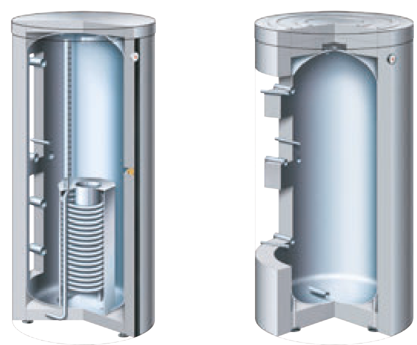
Either standard steel or stainless steel tanks coated with enamel or plastic are used for domestic hot water storage tanks for the sake of hygiene.



monovalent
(one heat exchanger)

bivalent
(second heat exchanger
for solar input)

Fig. 77: Domestic hot water heating



Buffer storage tank

Fig. 78: Energy storage

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

External heat exchanger (Fresh water unit)

Internal domestic water heat exchanger

**Fig. 79: Combined storage tank (domestic hot water heating + energy storage)**

## Storing thermal energy

A buffer storage tank keeps hot water in a heating system, which is transported to the radiators or hot surfaces in the case of heat demand. It can combine heat from various sources and discharge it again at different intervals.

In the process, the buffer storage tank helps compensate for differences between the amount of heat generated and consumed, and thus smooth out output fluctuations in the heating system. Thanks to this, heat can be generated independently of consumption to a large extent, resulting in better operating behaviour and greater energy efficiency for several energy sources. The continuous thermal loss resulting from the outer surface of the storage tank can be minimised by means of good thermal insulation and avoiding thermal bridges.

## Multi-talent combined storage tank

Combined storage tanks enable 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, as well as preparation and storage of domestic hot water. A distinction is made between various types of domestic hot water heating.

## Combined storage tanks 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 via a high-power plate heat exchanger, which is placed 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 tank with integrated internal heat exchanger

In this variant, the domestic water is heated up by an internal heat exchanger: By utilising solar energy, the combined storage tank is charged by a heat exchanger in the lower section of the device. Optionally, a heat conduction tube is used in the stratifier lance technology. If the solar radiation is not sufficient for domestic hot water heating, reheating is performed by the centralised heat generator in the upper section of the storage tank. If sufficient energy is available in the storage tank, the heating circuit also receives its supply from the storage tank. The centralised heat generator is turned on only if the set-point temperature 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 up the heating water and domestic hot water in one operation. 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

The demand for heating systems with solid fuels and wood burning and pellet stoves continue to place chimneys in the focus of builders and planners. Anyone constructing a new building should always think about the value of their building and plan the option of connecting a wood fireplace through a chimney in as central a location as possible. In new buildings and during renovations, flue gas systems are also used to dissipate flue gases from oil and gas-fuelled fireplaces. The flue gas systems of heating systems have to be optimally adapted to the type of firing. Flue gas systems as chimneys or for gas and oil boilers are usually made of stainless steel or ceramic inner pipes. Plastic is additionally used in gas-fired or oil-fired condensing boilers.

## Suitable for every heating system

Stainless steel and ceramic flue gas systems have many capabilities and are suitable for all approved fuels. Various manufacturers provide 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 wood 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, and even in wood-fired condensing boilers, the formation of condensate inside the chimney must 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.

## Stainless steel flue gas systems

Flue gas systems made of stainless steel are available in single and double-walled designs. They are easy to manufacture and are often used intentionally as an architectural design feature on buildings. They are suitable for interior and exterior installation.

**Single-walled stainless steel flue gas systems** are installed primarily as inner pipes to transport flue gases in existing or newly constructed shafts. In rare cases, they are installed as single-walled flue gas systems, such as when discharging flue gases from 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 flue gas-carrying stainless steel inner pipes** 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 combustion 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 combustion air. 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 combustion air.

**Flexible stainless steel inner 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, requiring oval inner pipes. Flexible piping systems are manufactured in a 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,** which are suitable for all types of fuels depending on the design, are called flue gas systems. They consist of a 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.

## Flue gas systems with ceramic inner pipes

Ceramic chimneys usually have a two or three-shell structure. The core element is always a high-temperature resistant ceramic pipe. Due to the almost unlimited range of applications with all heating systems and fuels, the ceramic chimney is often also used in combination with different pipe diameters. While smaller diameters of up to 14 cm are more likely to be connected to a central heating system with gas-fired/oil-fired condensing technology or to a pellet heating system or a pellet stove, the larger diameters from 16 to 20 cm – and even larger if necessary – are used for wood or tiled stoves, as well as for larger fireplaces.

Fig. 80: Stainless steel inner pipe in an existing shaft

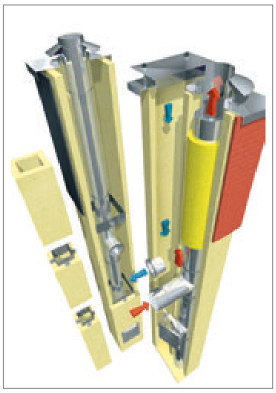


Fig. 81: Air flue gas systems (stainless steel)

Fig. 82: Double-walled system (stainless steel)

Ceramic building materials in general, as well as ceramic chimneys, have always been particularly durable due to their high resistance to heat (including soot fire) and corrosion attack. According to EN 1457, ceramic pipes have a service life of up to 100 years. As a rule, they meet the highest requirement class W3 for moisture insensitivity and G for soot fire resistance (W3G). The first choice, however, should always be an air flue gas chimney system, which, in addition to the exhaust function, also safely supplies the required combustion air to the fireplace. Two proven versions can be used for this purpose.

## Concentric air flue gas system

The chimney assembly consists of a lightweight concrete/brick modular chimney block with an insulated, ceramic inner pipe. The air gap between the inside of the modular chimney block and the insulated ceramic pipe is used to guide the combustion air through the building.

## Air flue gas system with adjacent draught

Here, a separate shaft is formed on the lightweight concrete/brick modular chimney block with an insulated ceramic inner pipe. This takes over the air supply from the chimney outlet to the fireplace.

Source: IPS in the BDH

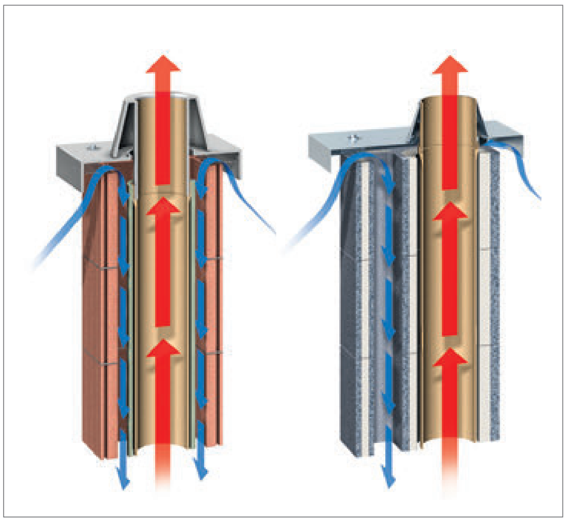


Fig. 83: air flue gas system with ceramic inner pipe and adjacent draught

Source: IPS in the BDH

Fig. 84: Ceramic chimney in a single-family house

# 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 environmentally 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 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. 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 damage, if the system does not correspond with the state of the art.

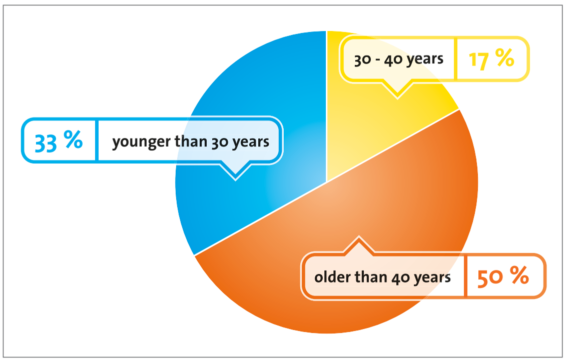



Fig. 85: Ageing structure of the plastic storage tank in the market since 1970

Fig. 86: Modern 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 if the cellar is below 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 cellar is common. Previously, there used to be a separate heating oil storage chamber (walled collection chamber). 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 cellars of many old buildings. 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 damage and the collection chamber should be maintained permanently leak-proof.

For more than 40 years, plastic storage tanks have been used for storing heating oil. They are installed mainly in the cellar or boiler room. Today, on the basis of the statistics of the association of chimney sweeps, Germany has approx. 5.5 million oil heating systems and a correspondingly high 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 chamber) 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-walled tanks 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 of the collection chamber, can no longer be ensured.

Investigations by the TÜV in Bavaria and Hesse have proven: More than 80 % of the tested collection troughs no longer showed the required secondary protection.

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 in the future, too. This modernisation measure is usually also associated with significant space saving as a result of simplified installation in the boiler room that is now possible.

## Relying on double-walled safety tanks

The principle of double safety applies to storage of heating oil. Therefore, a collection chamber is required by law for single-walled tanks: It prevents the release of oil into the water in the event of any leakage. This collection chamber must be oil-tight, have an approved intact coating, and be accessible for inspection. Moreover, the masonry should be structurally sufficiently stable in the event 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.

All double-walled tank systems have a long service life and provide maximum safety without any maintenance costs, which is unavoidable in walled collection chambers.

**Fig. 87: The Öltankschau app**

Practice has proven that collection chambers often lose their protective properties after approximately 20 years of use. Therefore, double-walled tank systems clearly provide safety.

The Department Fuel Tank Systems at BDH has launched an ÖLTANKSCHAU app which is a digital tool for quickly assessing a heating oil consumer system. With this app, both the chimney sweep and the heating company can inform the customer on-site about the status of their heating oil consumer system and make suggestions. More information is also available at:

- www.oeltankschau.de
- https://www.schornsteinfeger.de/oeltankschau.aspx
- https://www.zvshk.de/technik/topthemen/heizungs-klima-lueftungstechnik/

## Small dimensions, high flexibility

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

New tank systems require less space and home owners gain valuable space. Thanks to the compact dimensions of double-walled tank systems, subsequent integration is also possible. Moreover, 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 refueling.

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 and energy management systems: Comfort and climate protection

The chapter on "The Networking of Heating Systems" described how the shift to networked energy systems has begun. However, this networking affects not only power plants and electricity grids, but also involves the end customer's building and even energy-related products. In this context, the digital heating system plays an absolutely crucial role.

## Smart Heating as a key component of the energy networked building

Almost every smart home solution now enables optimisation of the heat supply using schedules, room sensors and other automatic systems. The systems that are particularly efficient are the ones that, in addition to heat transfer, also control the heat generator itself so as to adapt to the heating demand. This is because they control not only the room heating, but can also configure energy consumption in a flexible manner.

However, that is only a first step in networking the heating system. The energetically networked building opens up a considerably wide range of opportunities.

This development is driven by the fact that in the course of the energy revolution, the availability of electricity is being determined increasingly by volatile renewable energy sources. At the same time, the demand for electricity is growing as a result of electric mobility and heat generation. This is when the communication regarding optimal energy utilisation between generators and consumers becomes increasingly important. In the building, energy management systems (EMS) organise the interaction of all energy-related devices, ranging from electrical home automation right up to heat pumps and electric cars.

## The energy management system (EMS)

The job of energy management systems is to analyse the energy-related framework conditions continuously and to convert them for every individual product in order to organise optimal energetic control for the building. However, what "optimum" means is very different from case to case. Grid information such as variable electricity costs, grid tariffs or power restrictions is taken into consideration. Just as relevant is data from other energy-related products in the building such as photovoltaic systems and fuel cells as electricity generators, storage facilities for electricity or heat, as well as energy consumers such as home automation, electric cars and heating systems. It is not enough to consider merely the current situation. Forecasts must be evaluated and a "roadmap" for the energetic control must then be compiled. Of course, all this must satisfy the needs and priorities of the customer. For this purpose, energy management must understand the individual preferences and also the flexibility limits of the residents. What temperature drop is acceptable in the living room when the electric car needs to be charged quickly? How much convenience are cost advantages over variable electricity costs worth to me? It is at this juncture at the latest that AI methods come into play in order to learn about customer needs during operation which are still difficult to measure at the time of installation.

To put it briefly: Energy management systems optimise the energy-related processes in the building from the customer's perspective, taking costs, comfort and security of supply into consideration.

Moreover, energy management systems are absolutely necessary from the broader social point of view in order to control the building – and with it, electric mobility and heat generation – so that it is grid-friendly and system-friendly. In this way, the spread of energy management systems will become an important and necessary step towards the energy revolution.

## Energy management systems in BDH

The BDH and its member companies are aware of this development and also that, in addition to electro-mobility, the heating system plays a crucial role in the process. Networking of the digital heating systems with energy management systems is therefore a core issue in the heating systems sector.

This is why BDH established the new department Energy Management Systems in 2020. Apart from political, technical and market-related framework conditions in connection with energy management systems, networking applications also remain in the focus of the work. For these applications, manufacturer-independent and industry-independent products generally work together. For devices consuming electricity such as multimedia, lighting or shadowing systems, the spread of networking has slowed down at present due to the large number of different systems that are often not interoperable. Based on considerations of climate protection alone, a similar development must be prevented from occurring with regard to energy-related networking. This is why BDH is promoting industry-independent exchange and the common definition of applications and standards for energetic networking. For this reason, the department Energy Management Systems is entering into dialogue with other sectors. At the same time, the cooperation between technology and platform providers is being intensified, as, for example, with the EEBUS initiative, which defines an industry-independent language for energy-related networking.

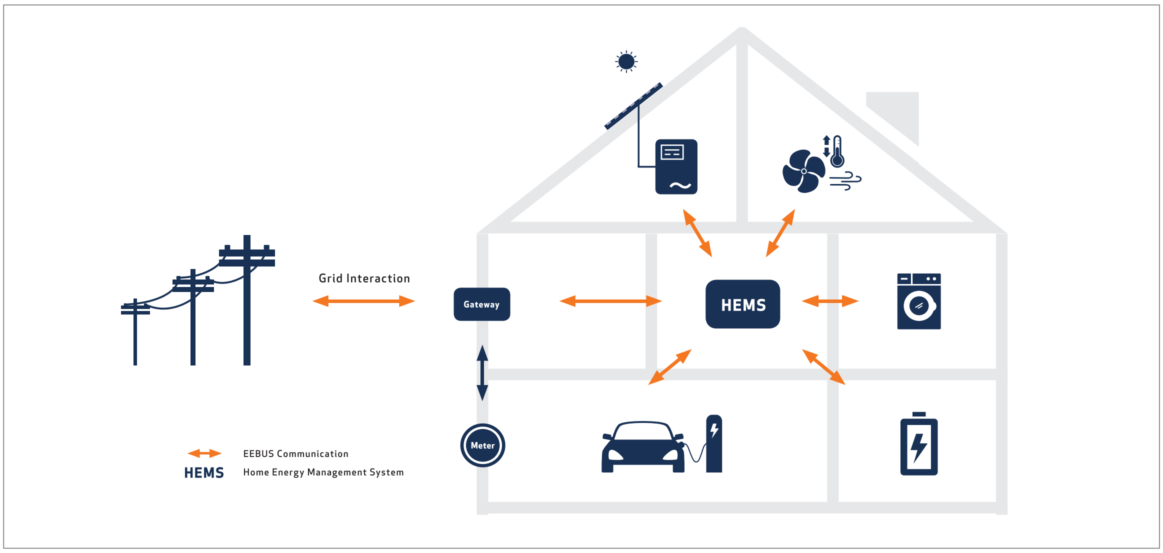



**Fig. 88: EEBUS provides a common language for energy**

## EEBUS provides a common language for applications of energetic networking

The prerequisite for networking is a common language, in which the devices and systems can communicate beyond sector and manufacturer limits about the energy provided, as well as demand and capacity. The EEBUS is the leading communication standard across all manufacturers and sectors. In the EEBUS initiative, over 50 international companies from all areas of electrical, heating and power systems, as well as from electric mobility, are jointly developing the communication specifications for energy-related equipment and systems in buildings.

In the process, a number of applications have been developed, for example, "Overload Protection". If an electric car is connected to a wall terminal and a heat pump is running at full capacity at the same time, it must be ensured that the safety circuit in the building does not trip. At the start of the charging process, the heater slightly reduces its output and then adapts its overall output to that of the building network.

Other EEBUS applications are envisaged along with an energy management system (EMS). This means that an energy manager can operate the heat pump so that it uses maximum electricity from an in-house photovoltaic system. When the sun is shining during the day, the hot water tank is heated to the maximum using inexpensive electricity from the roof – instead of only in the evenings when the heat is required.

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

Moreover, EEBUS also facilitates communication to the smart meter gateway, in order to obtain information from it regarding the electricity prices or restrictions on power from the grid.

## Standardisation of EEBUS

When developing its communication specifications, the EEBUS Initiative, as a European association with German roots, relies on open systems, democratic decision-making processes, as well as the free availability of the final standard. This is also to be regarded as an alternative to the closed communication platforms in the "Internet of Things", which some large companies are eager to launch on the market.

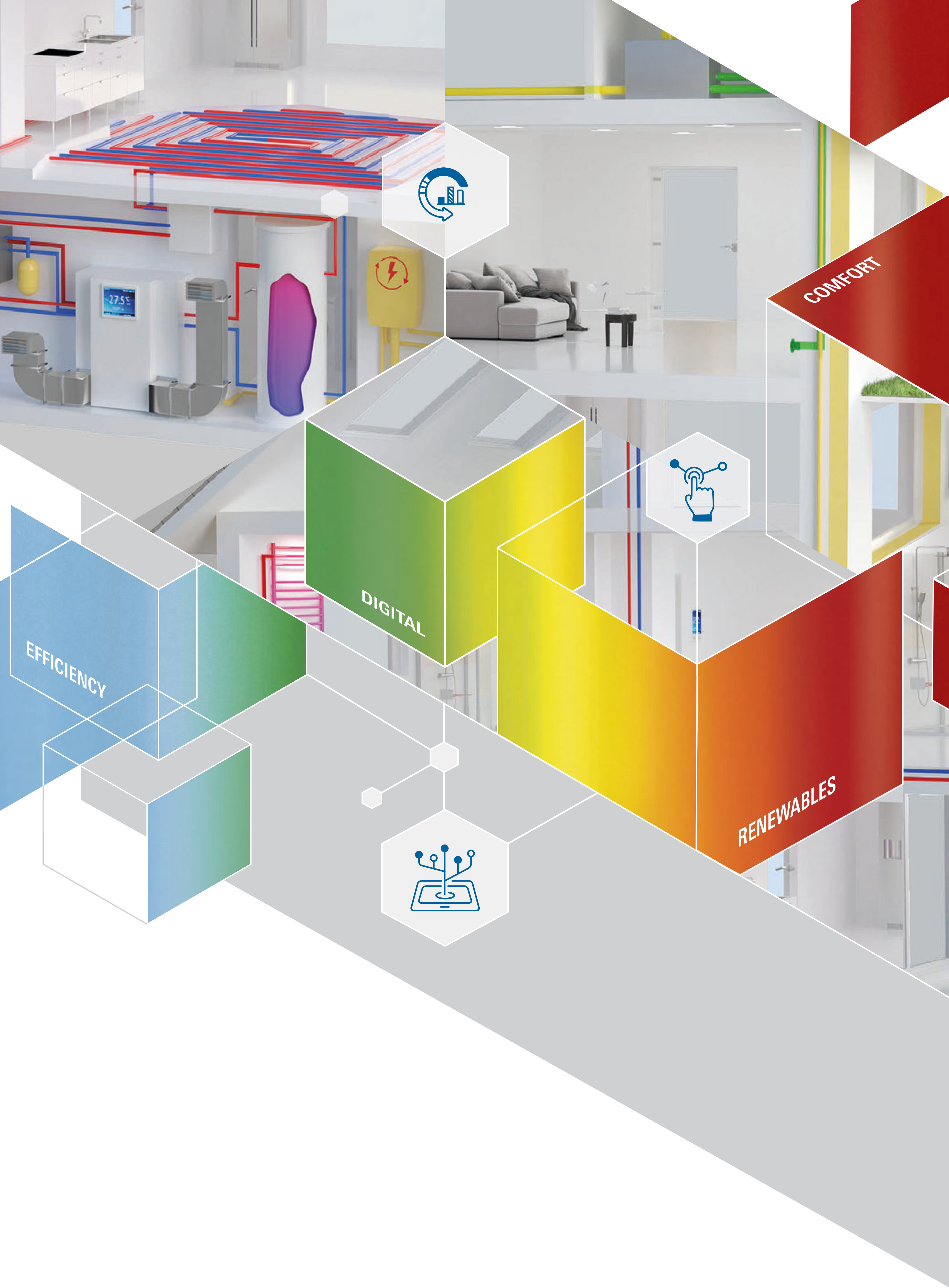
Currently, parts of the EEBUS specifications have already been transferred to DKE application rules, in order to promote general availability and spread.

The functions within the heating system continue to remain with the manufacturer. In this way, the EEBUS standard achieves a common basis of communication on the one hand and, on the other hand, it permits manufacturers all differentiation options within their range of products.

## Cross-industry cooperation

Just as the EEBUS initiative commits itself in the BDH department Energy Management Systems, BDH and its member companies have also been participating in the work group "Heating, Ventilation and Air Conditioning" (HVAC) of the EEBUS initiative since 2016.

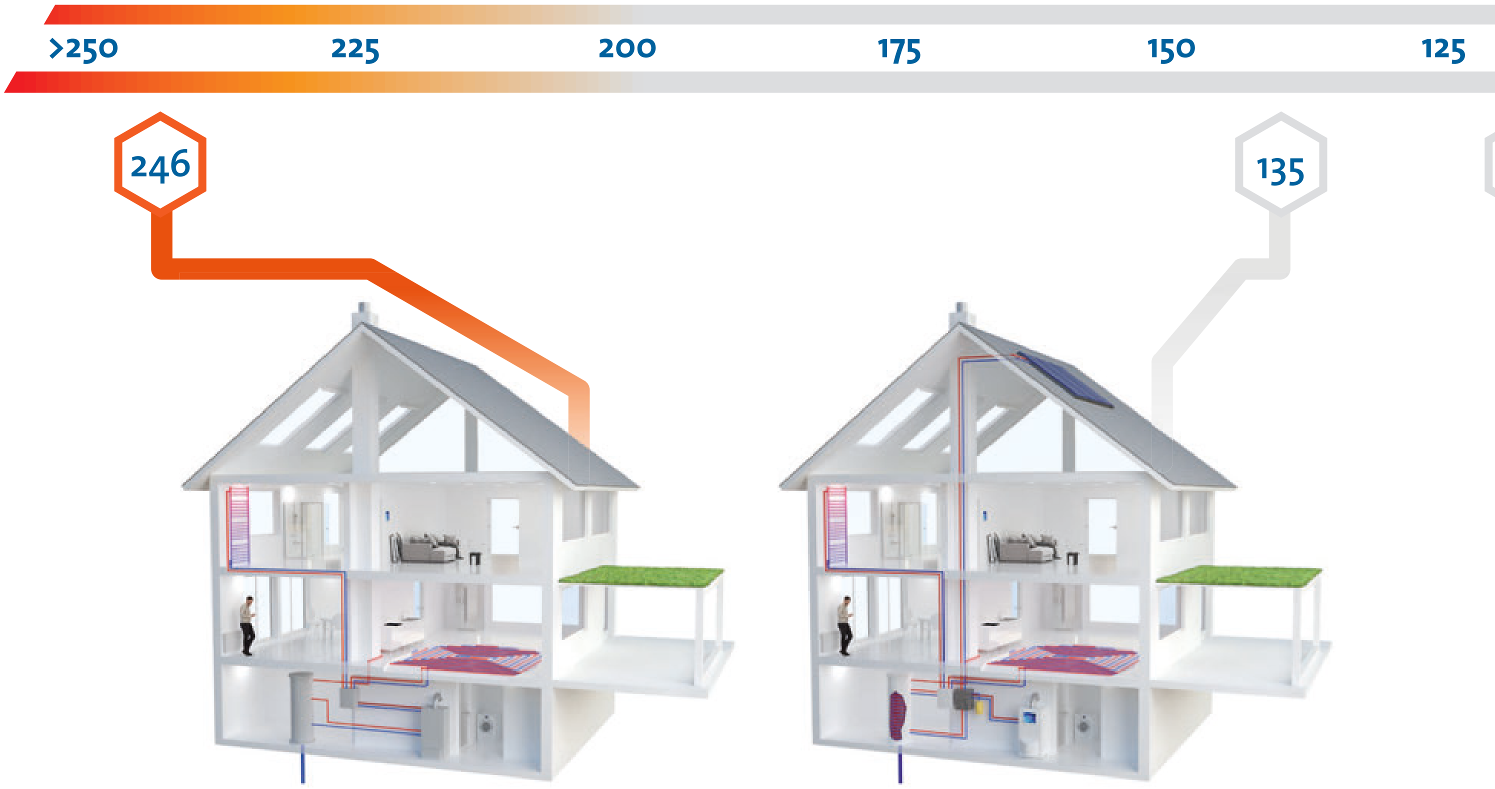
Based on this example, the BDH department Energy Management Systems is pleased with the exchange and cooperation with other sectors and players in the energy management division.


COMFORT
DIGITAL
EFFICIENCY
RENEWABLES

# **Examples**
# of modernisation

- Examples of modernisation (without renovation of building envelope)
- Examples of modernisation (renovation according to KfW Efficiency House 55 standard)

# Examples of modernisation
(without renovation of building envelope)



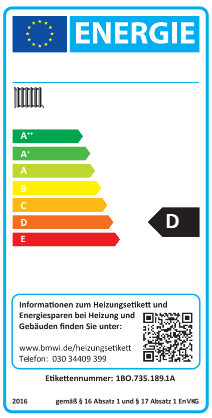

## House before the renovation

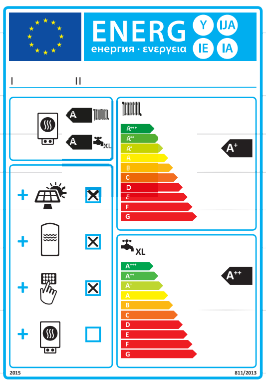
Partially renovated, detached single-family house, built in 1970, usable floor space 150 m², solid/plastered construction, standard oil/gas boiler with indirectly heated domestic hot water tank, uncontrolled circulation pump.

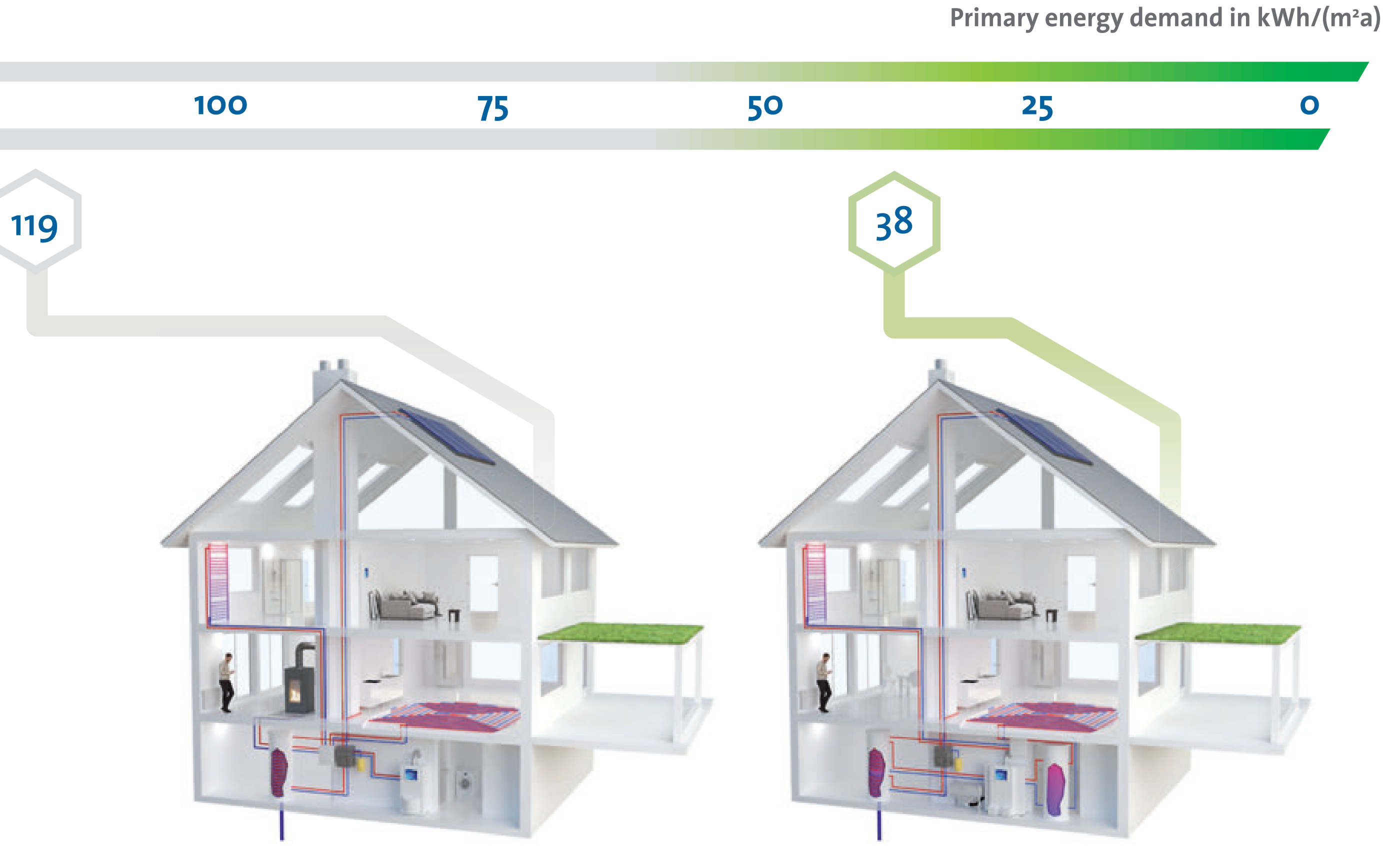
## Renovation variant – gas/oil condensing technology with solar thermal system

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

| | | |
|---|---|---|
| **Annual oil consumption** | 3.251 litres | 1.769 litres |
| **Annual gas consumption** | 3.251 m³ | 1.769 m³ |
| **Annual electricity demand** | – | – |
| **Annual pellet/split logs demand** | – | – |
| **Electricity produced annually** | – | – |
| **Annual saving of oil** | – | 1.482 litres |
| **Annual saving of gas** | – | 1.482 m³ |
| **Primary energy saving** | – | 111 kWh/(m²a) |
| **Energy efficiency class for space heating** | D | A+ |
| **Energy efficiency class for domestic hot water heating** | – | A++ |





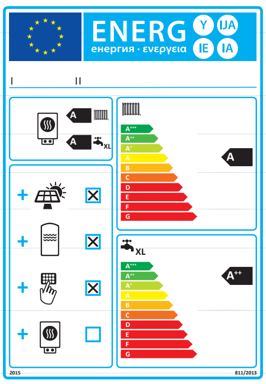

## Renovation variant – gas/oil condensing technology with solar thermal energy and wood burning stove/pellet furnace with water pocket

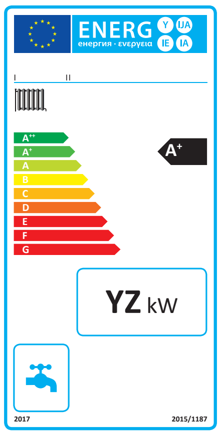
Modern condensing boiler (oil/gas), solar domestic hot water heating, pellet/wood burning stove with integrated water pocket, adaptation of the heating surfaces, high-efficiency pumps, new thermostatic valves, insulation of the distribution pipes, hydraulic balancing, renovation of the flue gas system.

## Renovation variant – pellet/split log boiler

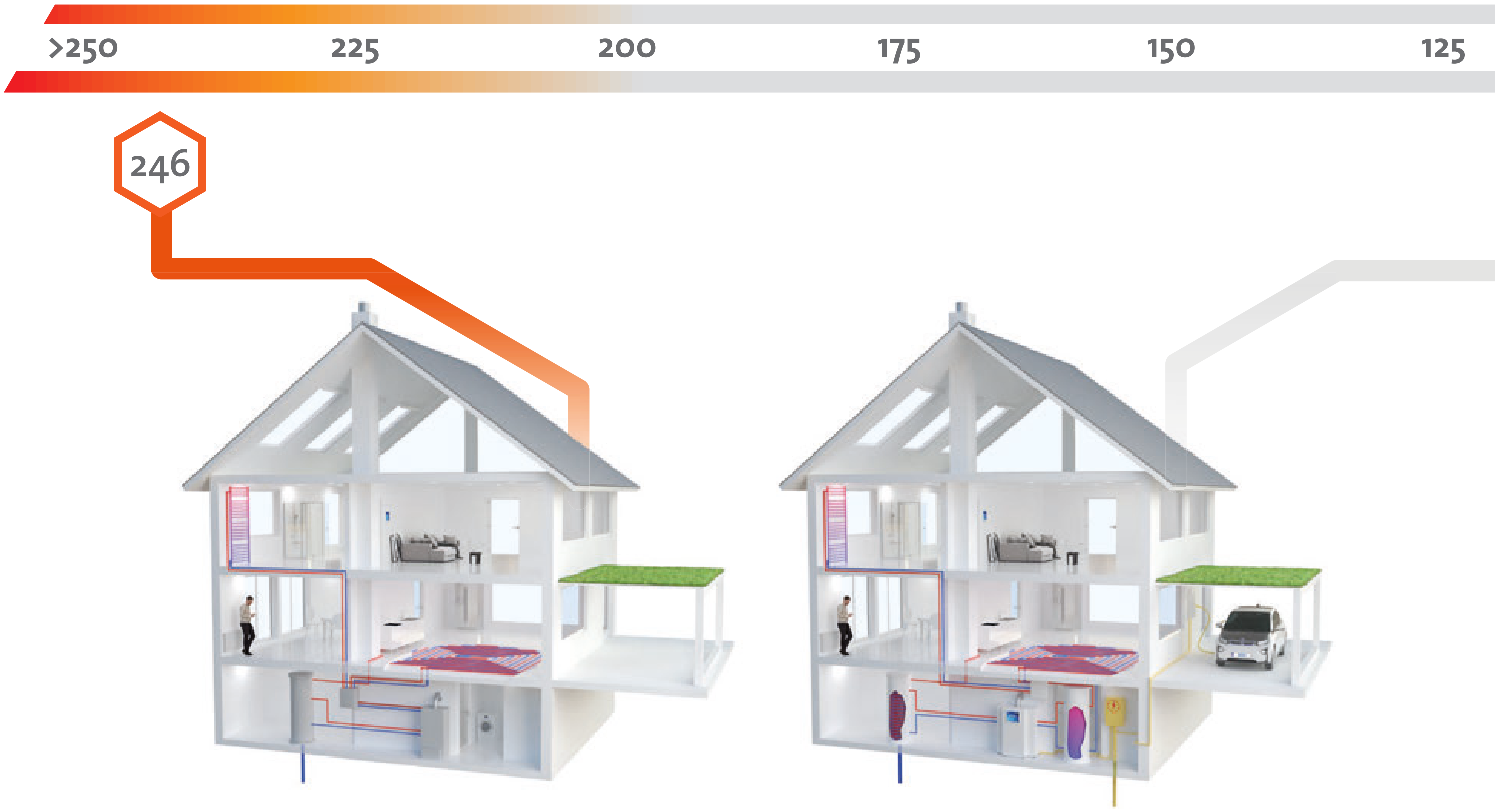
Wood pellet/split log boiler and solar domestic hot water system, adaptation of the heating surfaces, regulated pumps, new thermostat valves, insulation of the distribution pipes, hydraulic balancing, renovation of the flue gas system.

| | |
|---|---|
| 1.352 litres | – |
| 1.352 m³ | – |
| – | – |
| 2,0 t/5,0 stère | 4,9 t/13 stère |
| – | – |
| 1.899 litres | – |
| 1.899 m³ | – |
| 127 kWh/(m²a) | 208 kWh/(m²a) |
| A | A+ |
| A++ | – |



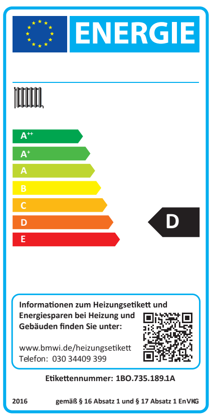



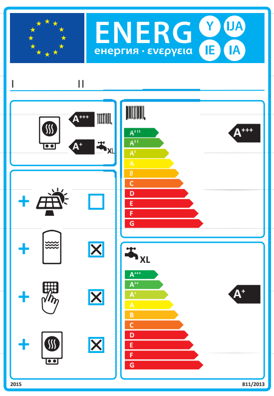
# Examples of modernisation
## (without renovation of building envelope)



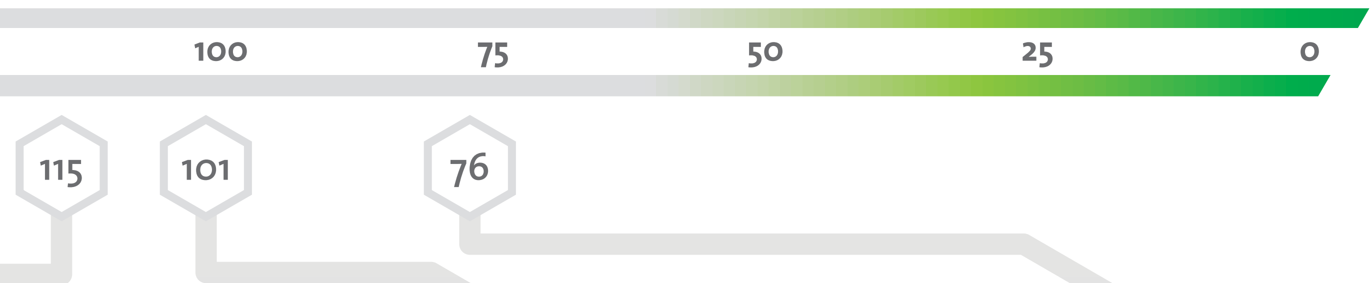

| House before the renovation | Renovation variant – micro CHP system |
|---|---|
| Partially renovated, detached single-family house, built in 1970, usable floor space 150 m², solid/plastered construction, standard oil/gas boiler with indirectly heated domestic hot water tank, uncontrolled circulation pump. | Fuel cell with modern gas condensing boiler, buffer and domestic hot water tank, adaptation of the heating surfaces, high-efficiency pumps, new thermostatic valves, insulation of the distribution pipes, hydraulic balancing, renovation of the flue gas system. |

| | | |
|---|---|---|
| **Annual oil consumption** | 3.251 litres | – |
| **Annual gas consumption** | 3.251 m³ | 2.927 m³ |
| **Annual electricity demand** | – | – |
| **Annual pellet/split logs demand** | – | – |
| **Electricity produced annually** | – | 5.503 kWh |
| **Annual saving of oil** | – | – |
| **Annual saving of gas** | – | – |
| **Primary energy saving** | – | 131 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)



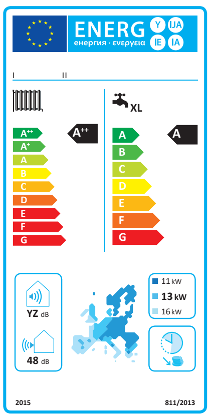

Renovation variant – Air-water heat pump

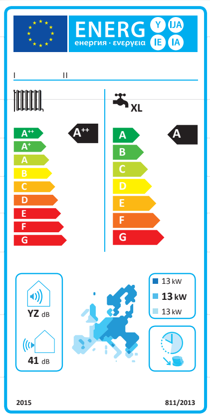
Renovation variant – Brine-water heat pump

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

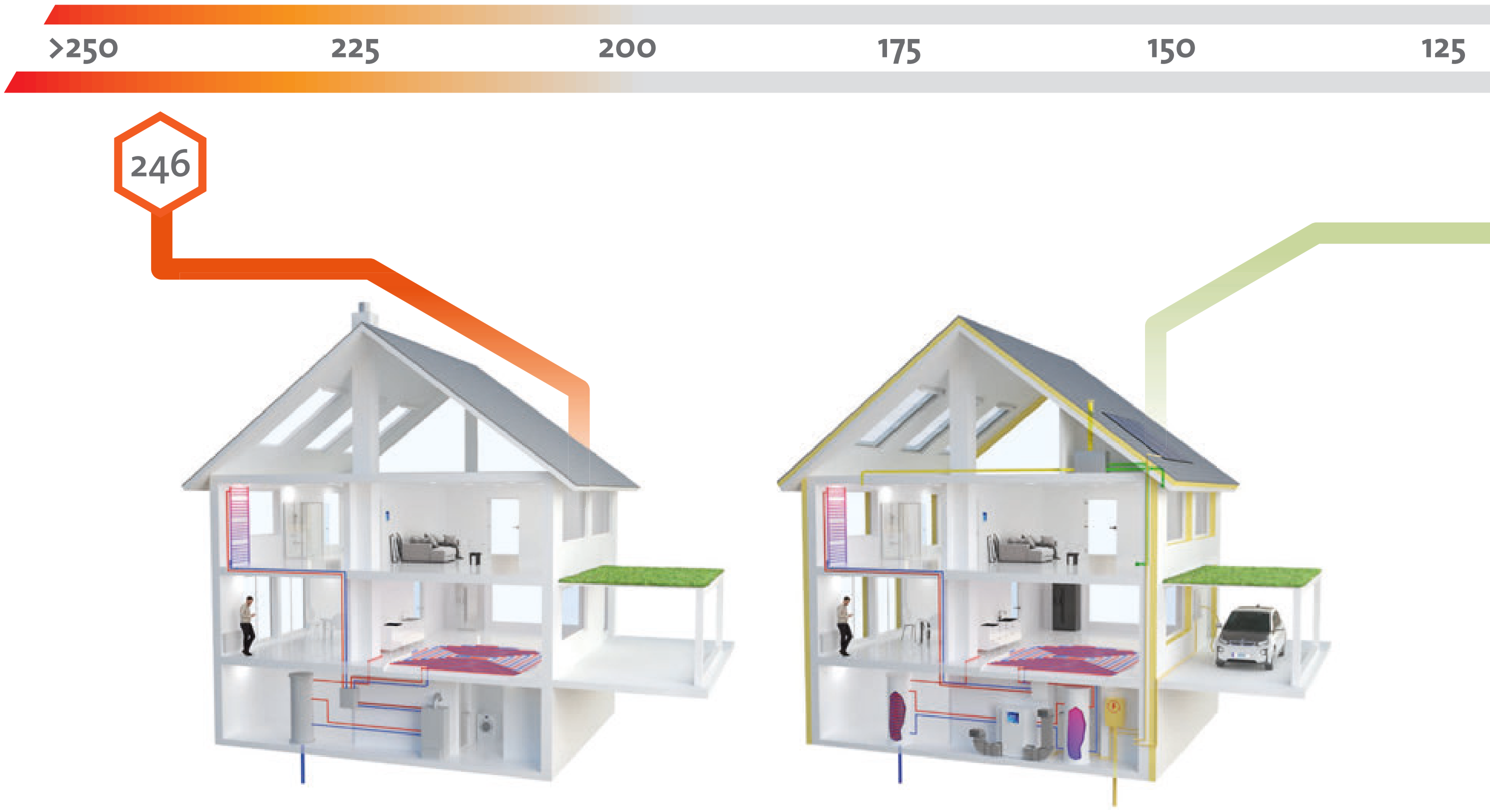
Brine-water heat pump, buffer and domestic hot water tank, adaptation of the heating surfaces, high-efficiency pumps, new thermostatic valves, insulation of the distribution pipes, hydraulic balancing.

| | |
|---|---|
| – | – |
| – | – |
| 8.100 kWh | 5.885 kWh |
| – | – |
| – | – |
| – | – |
| – | – |
| 145 kWh/(m²a) | 170 kWh/(m²a) |
| A++ | A++ |
| A | A |



# Examples of modernisation
## (renovation according to KfW Efficiency House 55 standard)



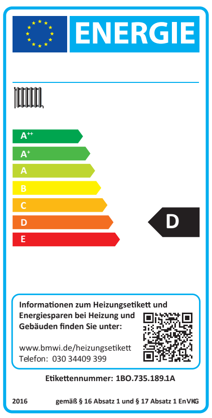

### House before the renovation

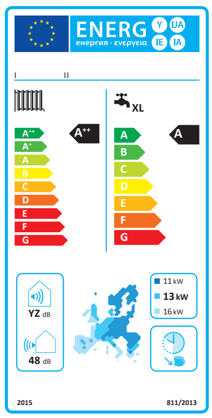
Partially renovated, detached single-family house, built in 1970, usable floor space 150 m², solid/plastered construction, standard oil/gas boiler with indirectly heated domestic hot water tank, uncontrolled circulation pump.

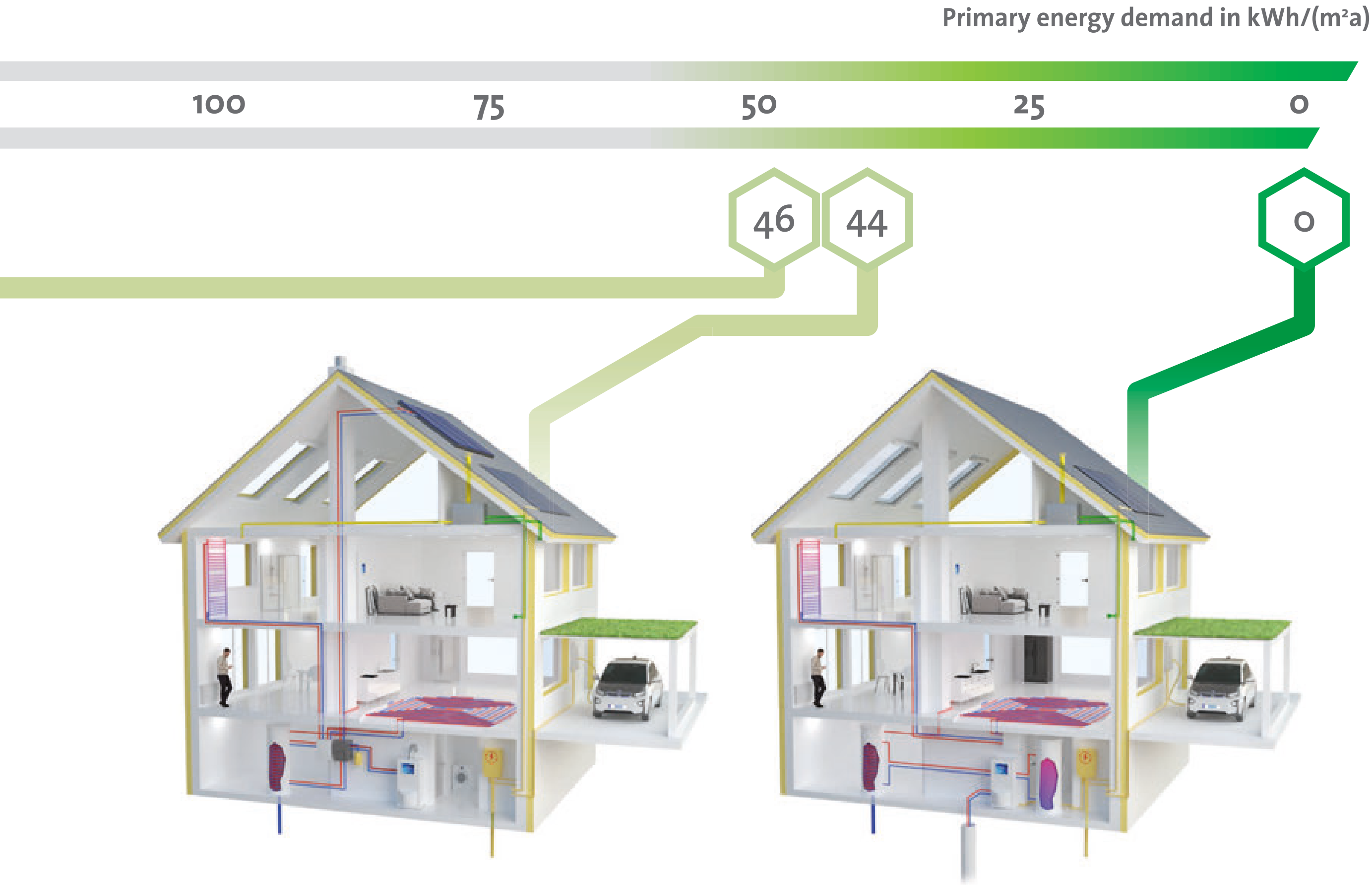
### Renovation variant – Air-water heat pump, controlled residential ventilation

Air-water heat pump, buffer and domestic hot water storage tank, adaptation of the heating surfaces, high-efficiency pumps, new thermostatic valves, insulation of the distribution pipes, hydraulic balancing, additional controlled residential ventilation with heat recovery and renovation of the building envelope.

| | | |
|---|---|---|
| **Annual oil consumption** | 3.251 litres | – |
| **Annual gas consumption** | 3.251 m³ | – |
| **Annual electricity demand** | – | 3.627 kWh |
| **Annual pellet/split logs demand** | – | – |
| **Electricity produced annually** | – | – |
| **Annual saving of oil** | – | – |
| **Annual saving of gas** | – | – |
| **Primary energy saving** | – | 200 kWh/(m²a) |
| **Energy efficiency class for space heating** | D | A++ |
| **Energy efficiency class for domestic hot water heating** | – | A |





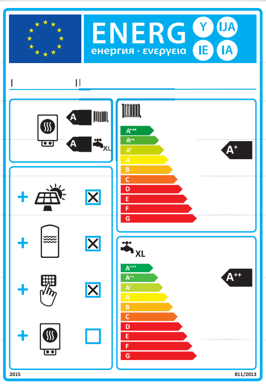

## Renovation variant – gas/oil condensing technology (20 % bio-methane) with solar thermal system, controlled residential ventilation

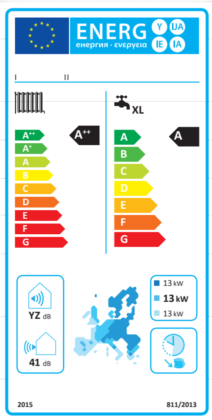
Modern condensing boiler (gas), solar domestic hot water heating and auxiliary heating, adaptation of the heating surfaces, high-efficiency pumps, new thermostatic valves, insulation of the distribution pipes, hydraulic balancing, modern flue gas system, additional controlled residential ventilation with heat recovery and renovation of the building envelope.

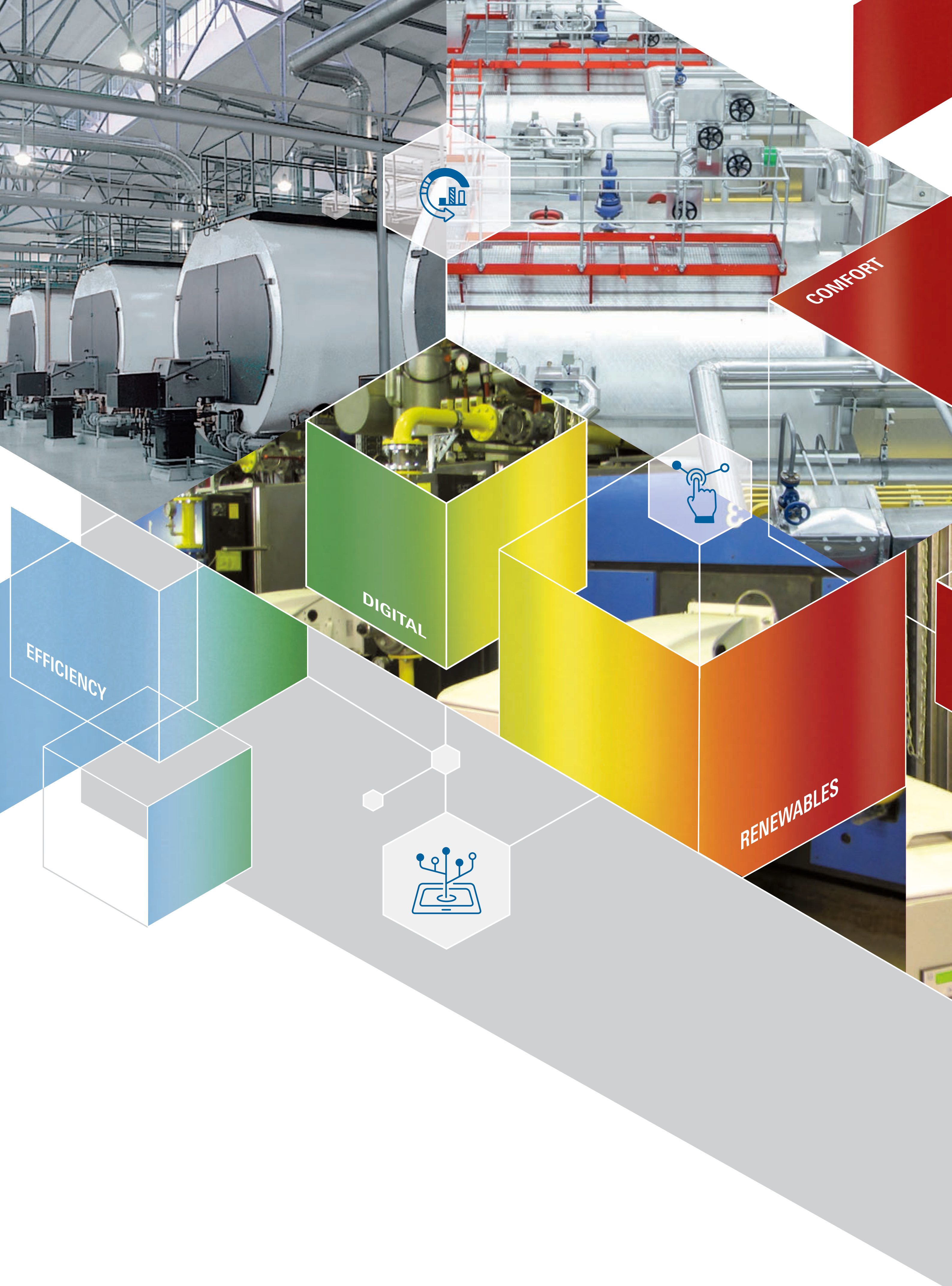
## Renovation variant – Brine-water heat pump and PV system with electric storage, controlled residential ventilation

Brine-water heat pump, buffer and domestic hot water tank, adaptation of the heating surfaces, high-efficiency pumps, new thermostatic valves, insulation of the distribution lines, hydraulic balancing. PV system with 7.3 $KW_{el}$, additional controlled residential ventilation with heat recovery and renovation of the building envelope.

| | |
|---|---|
| – | – |
| 536 m³ | – |
| – | 2.840 kWh |
| – | – |
| – | 5.521 kWh |
| – | – |
| 2.715 m³ | – |
| 202 kWh/(m²a) | 246 kWh/(m²a) |
| A+ | A++ |
| A++ | A |




COMFORT
DIGITAL
EFFICIENCY
RENEWABLES

# **Industrial heat supply/** Standardisation

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

# **Large** firing systems

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

The energy and high-cost 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 %. Such energy efficiency measures are highly profitable and the costs associated with them are generally amortised 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 room heat. 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 heating market. This is the result of in-depth research obtained from the association of chimney sweeps (ZIV), the inspection bodies of the TÜV and the BDH members' sales figures. 80 % of the systems in the heating market, i.e., approx. 250,000 systems, no longer correspond to the current state of development.

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

* The distributions between 2008 and 2016 are almost identical as specified by the BMWi.

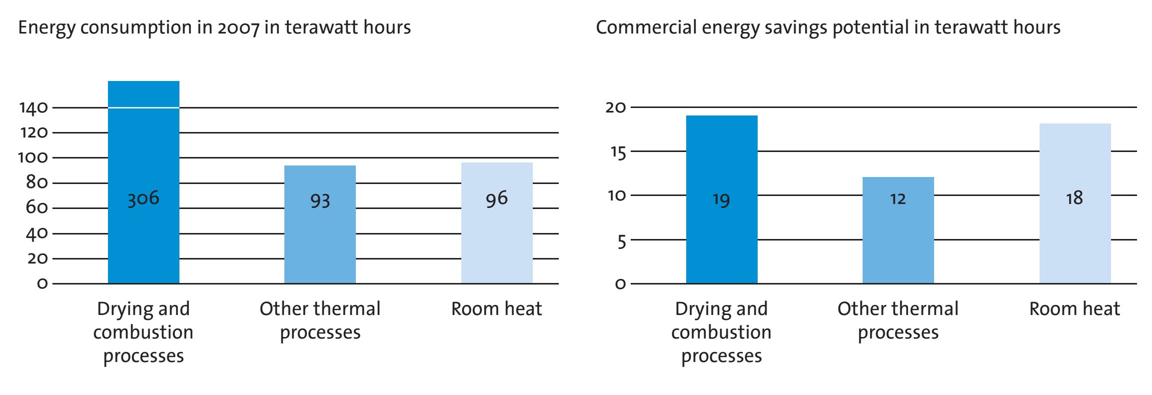



**Fig. 89: Energy consumption and potential energy savings in industrial process heat applications**

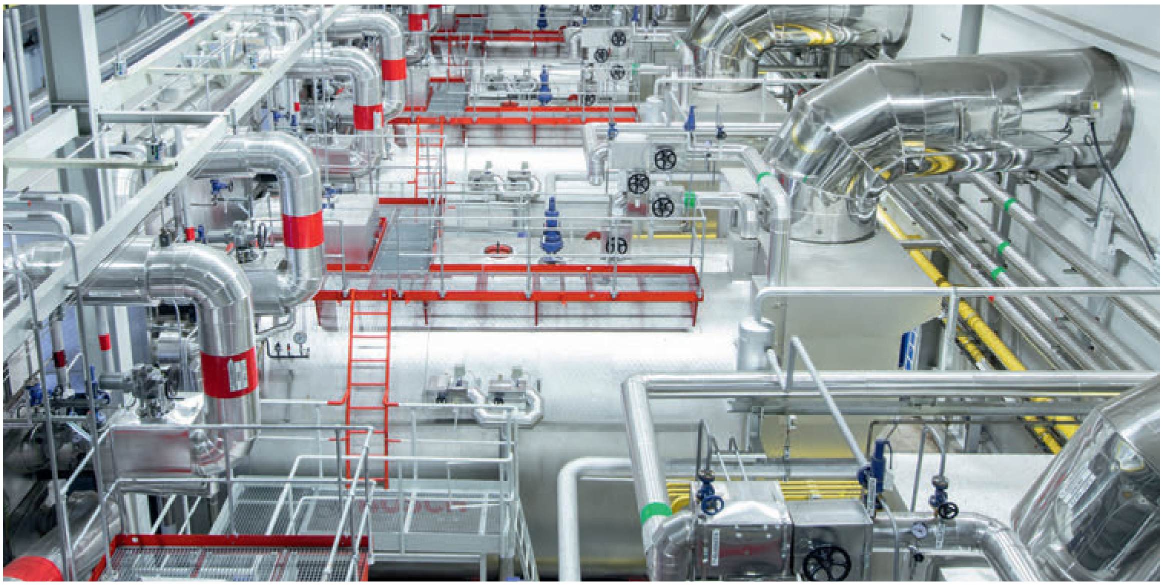


**Fig. 90: By far the largest energy demand in the industry and manufacturing sectors is attributable to the generation of heat for technical processes**

- Reduction in annual consumption of heating oil: 810,000 t/a
- Reduction in annual consumption of natural gas: 4.43 billion $m^3$
- Reduction in $CO_2$ emissions: 16.3 million t/a
- Reduction in nitrogen oxide emissions (NOx): 34,885 t/a
- Reduction in the installed electrical 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 heating 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 components with each other. Only the optimum combination of all components of a firing system ensures a potential saving 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 coordinating all 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 increase the system's energy efficiency.

In the event that upstream measures to reduce thermal loss have been exhausted, it is worthwhile to exploit 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.

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 domestic hot

# **Large** firing systems

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 overall 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 of 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 coordinating all new and existing components with each other.

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.

## Optimising regulation and control

Large firing 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.

**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**

Controlling and regulating 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 (up to 20 MW) and the TA-Luft (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, existing plants have to comply with the European emissions limits as well.

Within the framework of national laws, this European requirement is implemented by:

- The new **44th BImSchV** – ordinance introducing the ordinance on medium-sized firing plants, gas turbine plants and combustion engines

as well as by the thus necessary:

- Amendment of the **1st BImSchV** – ordinance on small and medium-sized firing plants
- Revised version of the **4th BImSchV** – ordinance on installations requiring a permit
- Revised version of the **TA-Luft** – the First General Administrative Regulation pertaining to the Federal Pollution Control Act (Technical Instructions on Air Quality Control)

The requirements are also 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 Pollution Control Act (BImSchG) are retained as they already partly 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.

For an overview of the above amendments and of all you need to know about $NO_x$ emissions, visit:

- https://www.bdh-koeln.de/fileadmin/user_upload/Publikationen/Infoblaetter/Infoblatt_Nr_66_NOx-Emission_Feuerungsanlagen_022020.pdf

**Fig. 92: 167 tonnes of superheated 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 to manufacturers, planners, 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's 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:

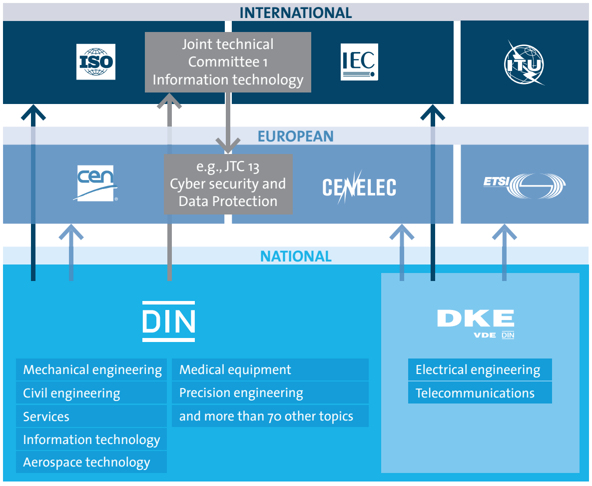
- Division 1 – heating technology
- Division 2 – ventilation and air-conditioning technology
- Division 3 – ICE for heating, ventilation and air-conditioning technology
- Division 4 – facility management
- Division 5 – overall energy performance of buildings – system standardisation

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 funds from its own returns, obtained from the products and services it offers. At NHRS, the share of DIN is roughly 43 %. A somewhat greater contribution, about 45 % at present, comes from industry project funds. The remaining funds are obtained via public funding.
The standardisation work in the NHRS is also being sponsored directly 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**




| | |
|---|---|
| **ISO:** | International Standards Organization |
| **IEC:** | International Electrotechnical Commission |
| **ITU:** | International Telecommunication Union |
| **CEN:** | European Committee for Standardization |
| **CENELEC:** | European Committee for Electrotechnical Standardization |
| **ETSI:** | European Telecommunications Standards Institute |
| **DIN:** | German Institute for Standardisation e. V. |
| **DKE:** | German Commission for Electrical, Electronic & Information Technologies in DIN and VDE |

DIN and DKE represent national interests in European and international standardisation.

**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 requirements for heating, cooling, ventilation, domestic hot water and lighting.

The pre-standard series DIN V 18599 was approved by the responsible joint working committee for the “Energy assessment of buildings” of the DIN standards committee “Civil Engineering” (NABau), “Heating, ventilation and air-condition technology and their safety” (NHRS) and “Lighting technology” (FNL) and subsequently published by Beuth Verlag. The documents were updated and adapted to the technological developments.
The calculations permit the assessment of all quantities of energy which are necessary for heating, domestic hot water, air-conditioning and the lighting of buildings. In the process, DIN V 18599 also takes into consideration the mutual influence of energy streams and the resulting consequences for design plans. Apart from the calculation methods, utilisation-related boundary conditions for unbiased assessment of the energy demand are also specified (regardless of individual user behaviour and local climate data). The pre-standard series is used to determine the long-term energy demand for buildings or even sections of buildings and for estimating the potential application of renewable energies for buildings. The normatively documented algorithms are applicable for energy balancing of:

- Residential and non-residential buildings
- New 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 a change in temperature can lead to the pressure being increased considerably even with a slight rise in temperature. Without additional measures, such as expansion tanks, this increase in pressure may lead 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 as to how diaphragm pressure relief vessels must be designed and enables them to be dimensioned correctly. Without proper dimensioning, there is a risk of pipe break. Dimensioning according to DIN EN 12828 provides confidence to both the user and the designer: Ultimately, any diaphragm pressure relief vessel properly designed according to DIN EN 12828 can be regarded as 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 in such a way that they reach the internal design temperature required. DIN EN 12831-1 provides a uniformly applicable method that enables equivalence of different systems. To put it simply, DIN EN 12831-1 thus ensures that the heating system is able to heat the flat and apartment house to a comfortable temperature in winter.

# BDH Members

ait-deutschland GmbH
Angerer Baustoffwerke GmbH
Arbonia Riesa GmbH
ATAG Heizungstechnik GmbH
ATEC GmbH & Co. KG
Austria Email AG
BASF Polyurethanes GmbH
BDR Thermea
- August Brötje GmbH
- Remeha GmbH
- SenerTec GmbH

Bomat Heiztechnik GmbH
Bosch Thermotechnik GmbH
- BOSCH
- Buderus

BTD Behälter- und Speichertechnik
Dettenhausen GmbH
BWT Wassertechnik GmbH
Carl Capito Heiztechnik GmbH
DAIKIN Heiztechnik
Danfoss GmbH
DEHOUST GmbH
De Jong hot water tanks
Walter Dreizler GmbH Wärmetechnik
Karl Dungs GmbH & Co. KG
ebm-papst Landshut GmbH
eka - edelstahlkamine gmbh
ELCO GmbH
Enbi Germany GmbH
Enertech GmbH Division Giersch
ERLUS AG
ETA Heiztechnik GmbH
Federal-Mogul Ignition GmbH
Flamco Group
Freudenberg FST GmbH
Frey & Sohn Kaminwerk GmbH
Fröling Heizkessel- und Behälterbau Ges. mbH

getAir GmbH & Co. KG
Glen Dimplex Deutschland GmbH
Greiner PURtec GmbH
GRUNDFOS GmbH
Guntamatic GmbH
Hager Electro GmbH & Co. KG
HARGASSNER Ges mbH
Hart Keramik AG
Hautec GmbH
HDG Bavaria GmbH
Heizomat Gerätebau- Energiesysteme GmbH
Herrmann GmbH & Co. KG
HERZ Energietechnik GmbH
Hoval GmbH
hpa ag
Huch GmbH Behälterbau
IMI Hydronic Engineering Deutschland GmbH
IVT GmbH & Co. KG
IWO - Institut für Wärme und Mobilität e.V.
Jeremias Abgastechnik GmbH
Kermi GmbH
KLB Klimaleichtblock GmbH
KOF Abgastechnik GmbH
KORADO a.s.
KSB SE & Co. KGaA
Kutzner & Weber GmbH
KWB - Kraft und Wärme aus Biomasse GmbH
MAGONTEC GmbH
MARANI G. S.p.A.
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