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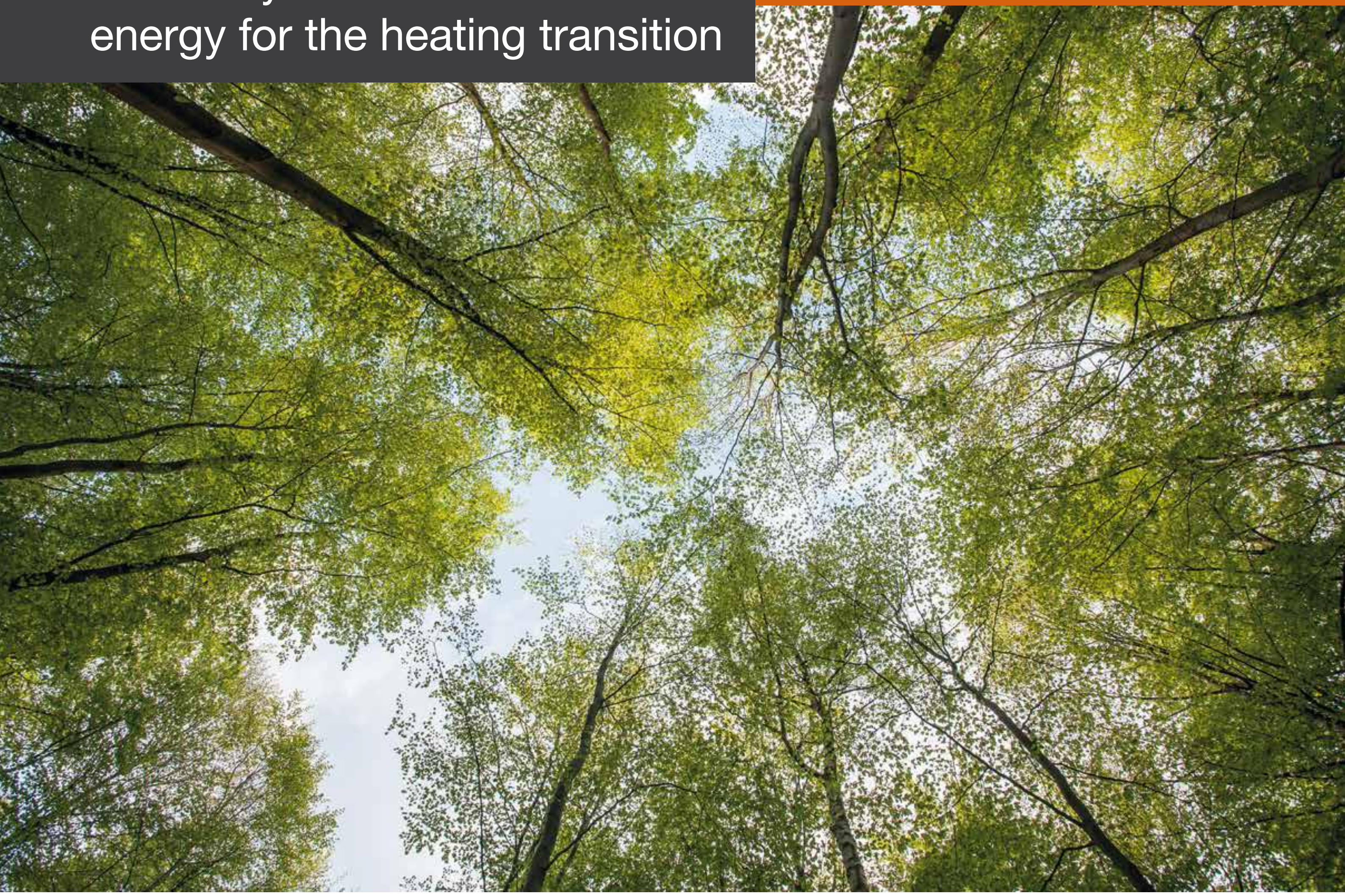
Opportunities and risks for Germany's heating industry in a competitive global environment

Efficiency and renewable energy for the heating transition



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Opportunities and risks for Germany's heating industry in a competitive global environment

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By Dr. Volker Breisig, Nicolas Deutsch, Jona Homann, Christian Linden and Josephine Neuhaus

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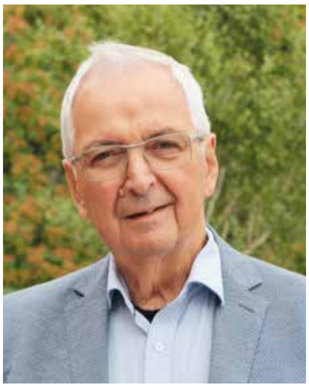
Foreword

Professor Klaus Töpfer
former Executive Director of the United Nations Environment Programme (UNEP), former Minister for the Environment, Nature Conservation and Nuclear Safety, former Director of the Institute for Advanced Sustainability Studies (IASS) in Potsdam



Professor Klaus Töpfer

We've now had three months of lockdown. Three months dominated by the COVID-19 crisis. From one day to the next, I've seen society and the economy come to a virtual standstill. It feels like there is just one topic of discussion on the radio, television, internet and in the press: the pandemic.

It seems that all of the other challenges facing politicians and society, problems that just yesterday brought thousands and thousands of protestors onto the streets, will have to take a back seat until it's all over.

But existential crises can't simply be put on hold. We can't just say "one at a time, please" while their underlying causes continue to rumble away in the background. And none more so than the climate crisis, that global risk to human existence caused by the actions of those same human beings. The urgency of that crisis has not diminished with the coronavirus crisis. There is still the same huge need for effective, strategic action to counter climate change.

The economic standstill caused by COVID-19 will usher in a recession unlike any we have experienced in Germany since the Second World War. Governments are, quite rightly, putting together rescue packages. Previously unimaginable amounts of debt – running into billions – are being taken on to protect jobs and restore confidence in the future by restabilising the economy.

There is a huge risk that other problems will be swept under the carpet, despite having consequences that will outstrip those of the coronavirus crisis in the medium to long term. Let me spell it out: a clear strategy for action on climate change must remain at the top of the agenda for society and government. The energy transition must continue to play a central role in this strategy – so from a strategic point of view, the timing of this study on the thermal energy transition is very welcome. In this crisis, the smart thing to do is to ensure that the measures we urgently need for restabilising the economy fit into an existing, robust climate policy. We must not delay the EU's Green Deal or reduce its ambitions!

During the energy transition, the thermal energy transition – which is also important for combatting climate change – must finally be accorded the prominent role it needs in state funding and policy. We need to look into the efficiency of heating systems and the demand for heat to identify areas where savings can be made and efficiency increased. We need to continue demanding measures that improve building insulation, and make them technically feasible. These measures will also help to restabilise key sectors of the economy, particularly in the construction industry.

This study goes beyond this to look at sectors which have already developed robust solutions for using renewable energy and continue to develop these further, such as the buildings sector. As part of the thermal energy transition, measures designed to combat the economic recession caused by the coronavirus crisis need to be linked to increases in state funding in the heating sector in particular.

Clear signals need to be given to companies and investors. These signals must convincingly show that politicians have taken these priorities on board and will apply them consistently when implementing the various rescue packages. The study's analysis of Germany's energy taxation system clearly demonstrates that more carbon-intensive energy sources receive more de facto subsidies than technologies that produce mostly carbon-neutral heat. These false incentives need to be completely reversed and tax incentives applied to renewable energy sources instead. Transforming the system of energy taxes and levies in this way is essential to allow the economic case to be made to prospective investors for climate-friendly heat pumps and the entire infrastructure around them. I'd also like to add that these kinds of pricing signals need to be complemented by regulatory limits on the impact of heating systems on the climate.

Participants in current debates are increasingly picking up on these ideas. This can be seen in the analysis of electricity prices, which demonstrates that electricity consumers are bearing almost all of the costs of the transition from fossil fuel-based energy sources to renewable energy via the levy under the Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz, or EEG). The hype around the debate on hydrogen confirms this trend.

It is my hope that this study will provide food for thought and solution-oriented strategies for decision-makers in all of these debates and spur them on to develop concrete action plans. We must use it to help ensure that the many billions of euros pumped into the economic stabilisation programmes make a significant positive contribution to climate policy after the COVID-19 crisis.

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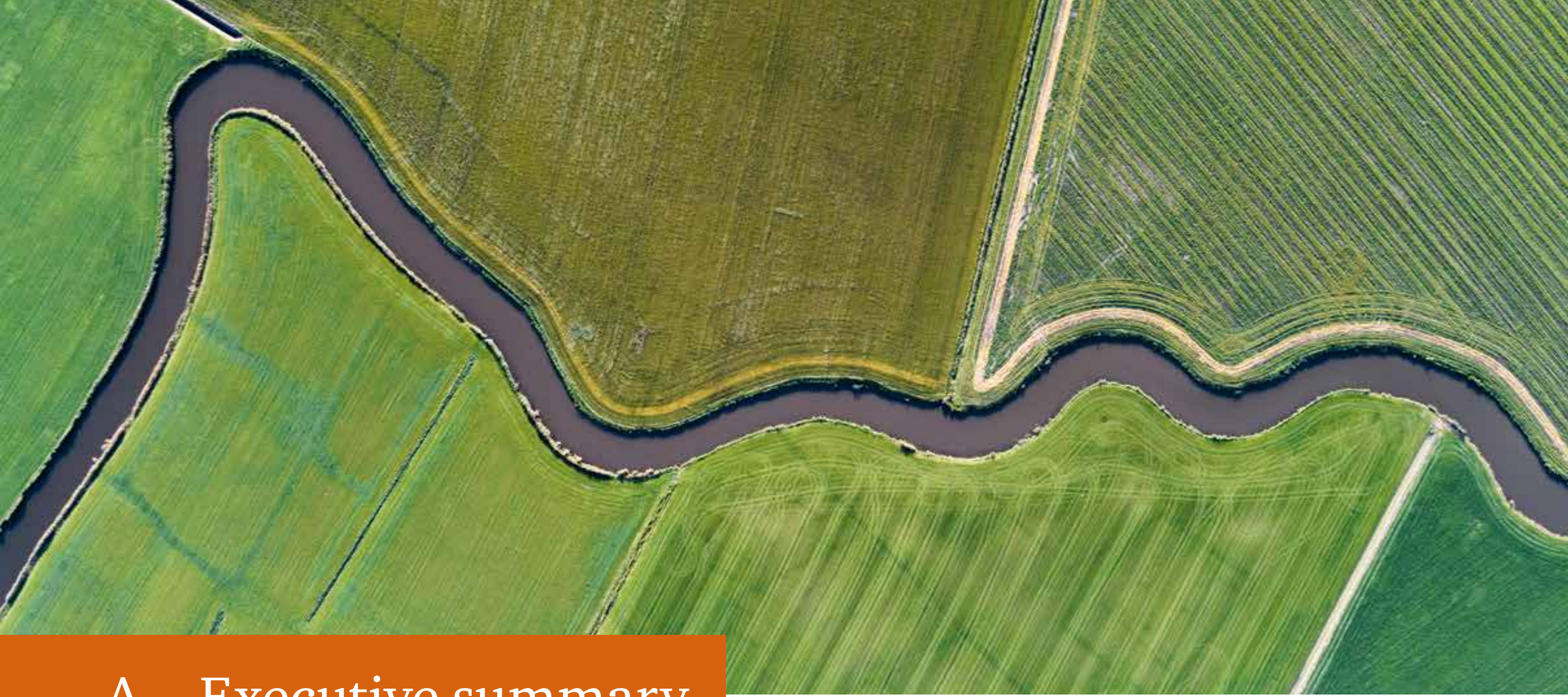


A Executive summary

The energy transition project is flagging. Rather than relying on technological solutions that still lie in the distant future, Germany needs to make better use of existing solutions and innovations. A rigorous political strategy is urgently required to institute a change in trends regarding reduction of greenhouse gas (GHG) emissions.

The European and global thermal energy markets are undergoing a transformation. In countries around the world, heat pumps are increasingly being used to supply heat as a more climate-friendly replacement for fossil fuel-based heating technologies. This study shows that Germany needs to get on board and increase its use of heat pumps, which offer a more or less immediate shortcut to a future-proof strategy for the thermal energy market. This would also increase the German heating industry's long-term resilience to international competition, allowing it to grasp opportunities on industrial policy as well as achieving environmental policy goals. This is a case where combatting climate change and driving economic growth are complementary rather than mutually exclusive. In times blighted by the global coronavirus crisis, with governments considering macroeconomic measures to support the economy, incentives for investing in sustainable heating solutions could be one way to jump-start the economy and support a transformation to an environmentally friendly economy.

The switch to heat pumps is not just driven by the global market. The reduction in greenhouse gas emissions in Germany and the measures adopted so far are not enough to achieve the country's climate goals for 2030 and 2050. More action is required, as a quick glance at the figures shows. Heating and cooling applications account for just under 60% of Germany's entire final energy demand, while renewable energy meets just 14% of demand in the heating sector.[1] A great deal has already been achieved in the electricity sector, and a 'heating transition' is now required as part of the energy transition *(Energiewende)* to drive the efficient use of electricity from renewable sources in the heating sector in particular. This would be achievable by increasing the use of heat pumps to supply building and process heat, potentially making a significant contribution towards achieving national climate goals.

[1] Cf. BDEW (2019): Entwicklung des Wärmeverbrauchs in Deutschland.

Heating and cooling account for a large proportion of total energy demand, not just in Germany but throughout the world. This means that achieving low-emission or zero-emissions heat supply requires a global approach.

Germany's heating industry is well positioned on the international markets to address these trends but needs to calibrate its response to secure jobs and continue to provide products that match the change in demand.

Measures to reduce emissions in the heating sector need to be guided by three principles:

1. Reducing final energy demand and heating demand in buildings and processes
2. Increasing efficiency in converting final energy to useful energy
3. Increasing the contribution of renewable energy to final energy demand for thermal energy applications

Heat pumps follow all three principles:

1. They represent a readily available, mature technology that can significantly reduce final energy demand in buildings. They therefore stand out from two megatrends – e-mobility in the transport sector and the cross-sectoral power-to-gas model – which still have neither fully-developed infrastructure nor high technical performance.
2. Heat pumps outperform all other heating technologies in terms of efficiency, measured as final energy used per kilowatt-hour (kWh) of heat delivered.
3. Heat pumps generate around 3.5kWh of thermal energy per 1kWh of electricity because they use 2.5kWh from ambient heat.[2] In practice, even more than 3.5kWh would be required when alternatively using fuel oil or gas due to efficiency losses. Even with the current power generation mix, the use of ambient heat enables huge reductions in greenhouse gas emissions. If ambient heat is used in combination with electricity generated from renewable energy sources, greenhouse gas emissions can even be avoided altogether.

[2] Generating around 3.5kWh of heat from 1kWh of electricity corresponds to a typical seasonal coefficient of performance (SCOP) of 3.5.

Heat pumps are practical, economical and ready to use, as demonstrated by their use in a wide range of areas in buildings and in industry. Using renewable energy instead of fuel oil or gas reduces Germany's dependence on imports. Heat pumps have the capacity to operate on flexible timeframes, helping to stabilise the power grid which is increasingly relying on fluctuating renewable energy sources. This just goes to show how important heat pumps can be for achieving the energy policy triad of environmental compatibility, affordability, and security of supply.

There is significant global market potential for leading heat pump technology companies. German manufacturers can unlock this market potential, but only if they have the political backing they need on the domestic market first. A successful roll-out on the domestic market will be essential to optimise the manufacturing and logistics processes needed to exploit the global market. Germany's economy simply cannot afford to lose yet another green technology of the future to foreign providers, as happened in 2012/2013 with the photovoltaic industry.

Use of heat pumps should also be viewed as part of a complete value chain that offers potential not just for the heating industry but also for the buildings and renovation sectors. Take-up in the German market is very low when compared with the potential of heat pump technology. Heat pumps account for just a tenth or so of annual sales of heat generators and make up only 5% of all existing heat generators (see also Figure 21 and Figure 22). Although they are fitted in over 40% of new buildings, they only account for 6% of new installations in existing buildings. In this study we demonstrate that these rates could be significantly increased without encountering any technical restrictions, and back this up with practical use cases. Increasing nationwide heat pump usage would have a positive impact on Germany's climate goals, and would strengthen the global market position of German manufacturers. It would also create modern jobs in industry and the trades sector.

1 Core messages of this study

1.

Secure Germany's position as an international leader in heat pump technology

Heat pumps are a booming global market. The German heating industry offers cutting-edge technology, and is a leading provider of conventional heating systems. But it risks losing its position on heat pump technology as Germany's domestic market continues to rely on fossil fuel-based heating technology.

2.

Reduce GHG emissions

As the reduction in greenhouse gas emissions starts to flag, Germany needs to make greater use of heat pumps as a tried-and-tested, ready-to-use technology. Other countries, particularly in Scandinavia, are pioneers in reducing emissions in the heating sector and are making increasing use of heat pumps to do this.

3.

Become future-proof

Heat pumps offer many other advantages besides helping to expand the renewable energy sector: for example, they can also be used for on-site cooling and to prevent air pollution on site. They are set to become an energy system of the future, fully compatible with the energy policy triad. Heat pumps are also highly adaptable, making them superior to conventional heating technologies in many respects.

4.

Decarbonise existing buildings

The current building stock is key to increasing the roll-out of heat pumps, as these buildings provide the greatest leverage for emissions savings. But fossil fuel heating technologies are still frequently installed when old appliances are replaced. Heating systems have a very long service life, so continuing to install fossil fuel-based appliances means Germany will increasingly fail to meet its climate goals in the heating sector. Establishing heat pumps as the standard technology in the sector, however, can help to achieve these goals.

5.

Optimise the operating environment

There are many ways for industrial policy, energy policy and climate policy to support the roll-out of heat pumps in Germany. In particular, relief on electricity prices and setting an ambitious upward trajectory for the CO_2 emissions trading scheme could advance the roll-out. And improving the way the numerous opportunities for using heat pumps are communicated could also help to chip away at the uncertainties felt by business decision-makers, end customers and other key stakeholders such as tradespeople.

B The heating transition is marching on: how is Germany positioning itself?

1 Trends in the global heating sector

In these times of population growth and increasing expectations around quality of life, global heating demand is rising. Most energy is required for heating, not just in Germany: supplying heat to households and industry is responsible for around 50% of total final energy demand – worldwide. Industry accounts for over half of this, mainly process heat and hot water; the rest is for domestic heating and hot water for buildings.[3]

Meanwhile, protecting the climate is one of the major challenges of our time. The international community aims to combat climate change by significantly reducing emissions from electricity and heat generation, transport and industry. Whereas significant progress has been achieved worldwide on electricity generation, and renewable energy already meets a quarter of global demand for electricity, just 10% of heat came from renewable energy in 2017.[4]

50% of global energy consumption is for heating.

2 Global heating industry is increasingly focusing on heat pumps

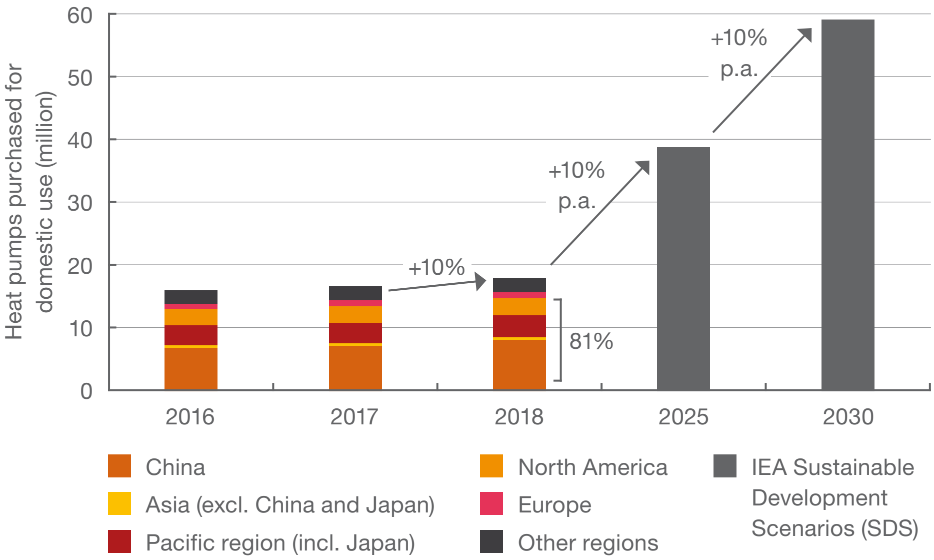
Heat pumps provide a technological solution to meet both the demand for heat and increasing requirements for combatting climate change in heat generation. As heat pumps are an efficient, clean technology for generating heat, the market is booming: global demand for heat pumps rose by just under 10% in 2018. The global market volume in 2017 was already $48bn, and it is expected to rise to $94bn by 2023.[5]

[3] Cf. IEA (2019b): Renewables 2018.
[4] Cf. REN21 (2019): Renewables 2019 – Global Status Report; IEA (2019b): Renewables 2018.
[5] Cf. IEA (2019a): Heat pumps – Tracking Clean Energy Progress; Markets and Markets (2018): Heat Pump Market – Global Forecast to 2023.

The target of reducing GHG emissions is the most important driver of the rise in heat pump sales. The International Energy Agency (IEA) expects the number of heat pumps sold to rise to 38 million in 2025 and almost 60 million in 2030 to achieve the relevant climate goals. This forecast is based on the Sustainable Development Scenario (SDS) developed by the IEA, which can be used to achieve the energy-related sub-goals for the UN's Sustainable Development Goals. By way of comparison: in 2018, just under 18 million households bought a heat pump.[6]

The IEA estimates that electric heat pumps could offer a lower-emission solution for over 90% of global needs for domestic heating and hot water for buildings. As a result, one of the assumptions behind the forecast that heat pump sales will increase across all regions is that heat pumps can help to achieve the climate goals agreed internationally in the Paris Climate Agreement (Figure 1; IEA 2019a).

Fig. 1 Sales and potential of heat pumps in selected markets



Source: IEA (2019a). ('SDS' in the key for Figure 1 refers to the Sustainable Development Scenario developed by the IEA, which can be used to achieve the energy-related sub-goals for the UN's Sustainable Development Goals. Figure 1 is based on heat pump sales for 2018 as stated in the text of IEA (2019).)

[6] Cf. IEA (2019a): Heat pumps – Tracking Clean Energy Progress.

More widespread use of heat pumps is not only relevant to the climate but also offers huge potential for the German heating industry. As heat pumps are needed within the new energy system that will be required to achieve the 2050 climate goals, they could become a dynamic growth industry for the European Union (EU). The forecasts also raise the question of which countries will be able to drive this technology of the future forward and benefit from the growing global demand.

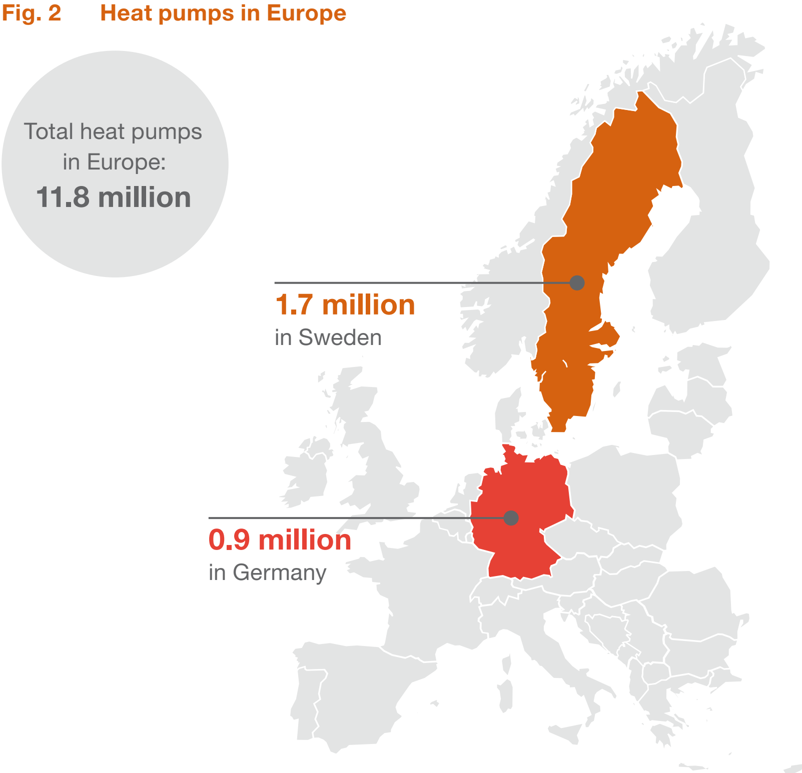
As well as the industrial policy aspects, this study also reveals how heat pumps can be used to realise the 'heating transition' in Germany and what obstacles are currently preventing this from happening. We will be examining the extent to which the German heating industry can benefit from this trend and which obstacles German manufacturers face, particularly in terms of the political and legal frameworks.

3 Asia, the US and Scandinavia are overtaking Germany

The trend towards heat pumps is mainly being driven forward in Asia and the US: over 80% of new heat pumps installed in 2017 were in households in China, Japan and the United States (Figure 1). In China in particular, measures including government grants for replacing old coal-fired boilers led to approximately 8.1 million households buying a heat pump. Government support, such as in the form of an energy saving plan, also increased the roll-out of heat pumps in Japan. Growth is also strong in North America: around 2.7 million households in the US and Canada bought heat pumps in 2017.[7] There, too, regulatory measures such as tax rebates for energy-efficient technologies, combined with government initiatives for funding heat pumps, have ensured the spread of this environmentally friendly technology.[8]

7 Cf. IEA (2019a): Heat pumps – Tracking Clean Energy Progress.
8 Cf. Global Market Insights (2018a): Water Source Heat Pump Market Size, Industry Analysis Report; Global Market Insights (2018b): Air Source Heat Pump Market Size By Product.

Fig. 2 Heat pumps in Europe



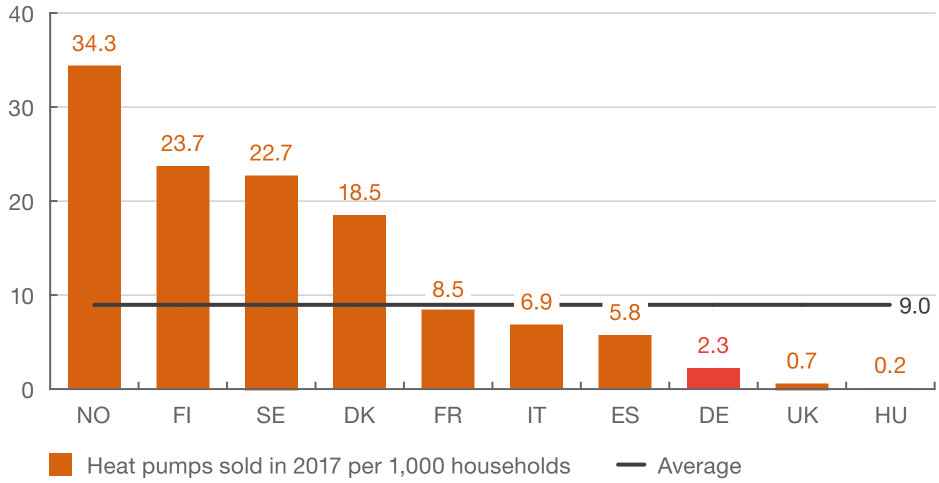
Source: EHPA (2019).

The European market is lagging behind Asia and North America, despite around 1.1 million heat pumps being installed in Europe in 2017. The relatively low number is mainly due to the fact that the market share of heat pumps has only been just over 10% for each of the last few years.[9] In Europe, the Scandinavian countries have been largely responsible for driving the trend. A total of around 11.8 million units had been installed in Europe by the end of 2018,[10] but the potential of heat pumps is far greater than in North America and China: based on the example of Norway, the European Heat Pump Association estimates potential annual sales of 6.8 million units and a potential total stock of 89.9 million heat pumps for Europe.[11]

Growth in Germany, however, has so far been sluggish, even compared to other European countries (Figure 2). Measured against the number of heat generators installed, heat pump growth in Germany is still too low to make use of the technology's climate-friendly potential. The market share of heat pumps in new buildings (currently 43%) is rising, but the main leverage lies in existing buildings, in which heat pumps account for just 6% of new heating systems. This means that any strategy for climate-friendly growth in the German buildings and heating sector needs to focus on the current building stock to succeed. And the pressure to act is rising.

[9] Cf. EHPA (2017): European Heat Pump Market and Statistics – Report 2018.
[10] Cf. EPHA (2019b): EHPA Stats – The heat pump stock of 11.8m units in 2018 contributed.
[11] Cf. EPHA (2019a): Heat pump sales overview.

Fig. 3 Comparison of heat pump sales across Europe



Source: EHPA (2017).

Norway, Finland and Sweden have been making the switch to heat pumps successfully: over 20 heat pumps are sold per 1,000 households every year in these countries. In France, Italy and Spain, sales figures relative to the number of households are also three to four times higher than in Germany; current sales in Germany are just two heat pumps per 1,000 households. Extrapolating the trend in Scandinavia to the German market shows huge untapped potential for emissions savings on heating.

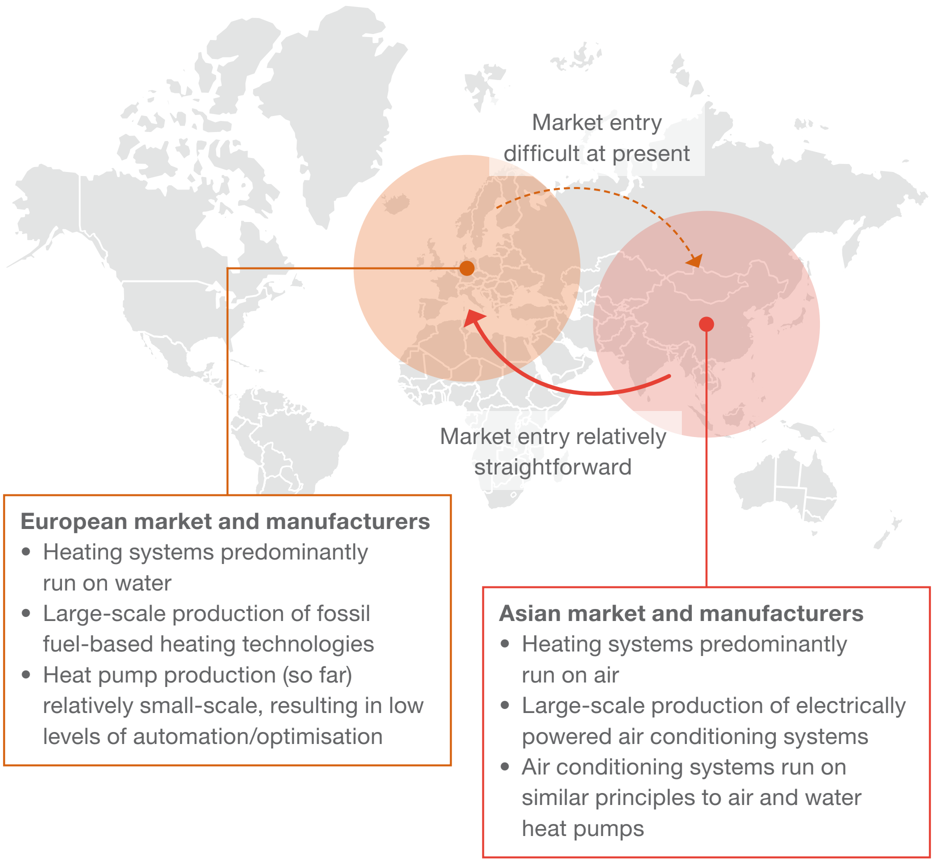
4 German domestic market key for global success of the heating industry

But where do the heat pumps installed around the world come from and which industry is behind them? Germany's expertise in conventional heating systems, particularly gas-fired condensing boilers and low-temperature boilers, continues to enjoy high international demand. Germany's heating industry produces cutting-edge technology and is a global leader in sales of fossil fuel-based heating systems. But German manufacturers are only minor players in the current growth in the heat pump market: very few of the world's largest manufacturers of heat pumps are German. In fact, the leading heat pump manufacturers are all from outside Germany: Daikin (Japan), United Technologies (US), Midea (China), NIBE (Sweden), Ingersoll Rand (Ireland) and Dimplex (Ireland).

Heating systems provide heat either using hot air or hot water. Different types of heat pumps are needed to generate thermal energy depending on the system. Germany mostly has pumped hot water heating systems, which can move large quantities of water. Air heating systems are more usual in Asia, although water-based heating systems represent a considerable segment of their own due to the absolute market size.

This technical difference is one of the reasons why the German heat pump market has tended to be populated by companies with production facilities in Germany. Global competitors, on the other hand, have the advantage of existing production lines set up for large production runs at low unit prices. Because of this, and because the refrigerant circuit principles involved apply equally to air and water heating systems, entry into the European and German market is not a particularly big step for these companies. In this context, German heat pump manufacturers need a clear, reliable and long-term political operating environment if they are to align their business strategies and production lines with the growing heat pump market. This, together with progress on efficiency and expertise, is essential for them to deal successfully with this technological transformation.

Fig. 4 European vs. Asian markets



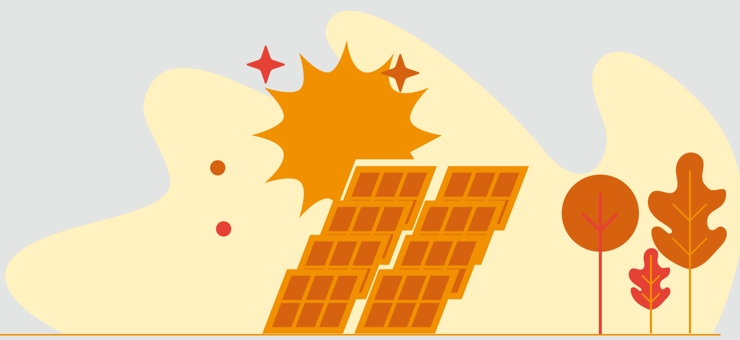
The untapped potential in the German market is a major headache for the German heating industry. It is limiting manufacturers' future capacity for innovation, but the manufacturers need scalable technology and must roll out production to maintain their position on the global market. In the long term, this could lead not only to German heat pump manufacturers losing ground, but also to the entire German heating sector losing its strong position to the world's leading providers of heat pump technology. Manufacturers from other countries, particularly from Asia and the US, have been dominant in this technology so far. Starting from a leading market position, they can make use of their expertise and position themselves on the European market to the detriment of the German and European heat pump industry.

The heat pump market is set to grow significantly in Germany, too, mainly to help combat climate change. The German Government's Climate Action Programme 2030 was a game changer for the buildings sector. So far, however, the measures have been limited to increasing the attractiveness of subsidies for renewable heating. Market actors are still unclear as to how the roll-out of heat pumps can actually go ahead without a reform of energy prices. The announcement that carbon pricing will apply from 2021 is just the first step. The political and legal framework has so far worked against the roll-out of heat pumps that is required. The constant delays have created uncertainty among manufacturers, potential customers and other stakeholders alike. This is a major disadvantage compared with international competitors who are already producing on a large scale, particularly for Asia.

In detail: development of the solar power industry in Germany

Economic policy measures such as the German Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz, or EEG) have been responsible for reliable feed-in tariffs in Germany and have led to a large number of new photovoltaic systems being installed. However, they did not include measures to expand German manufacturing and maintain its competitiveness. This is in stark contrast to Asia, particularly China, where targeted conditions for investment and loan terms attracted billions in inward investment, resulting in the roll-out of production lines that are still highly scalable and give a competitive edge.

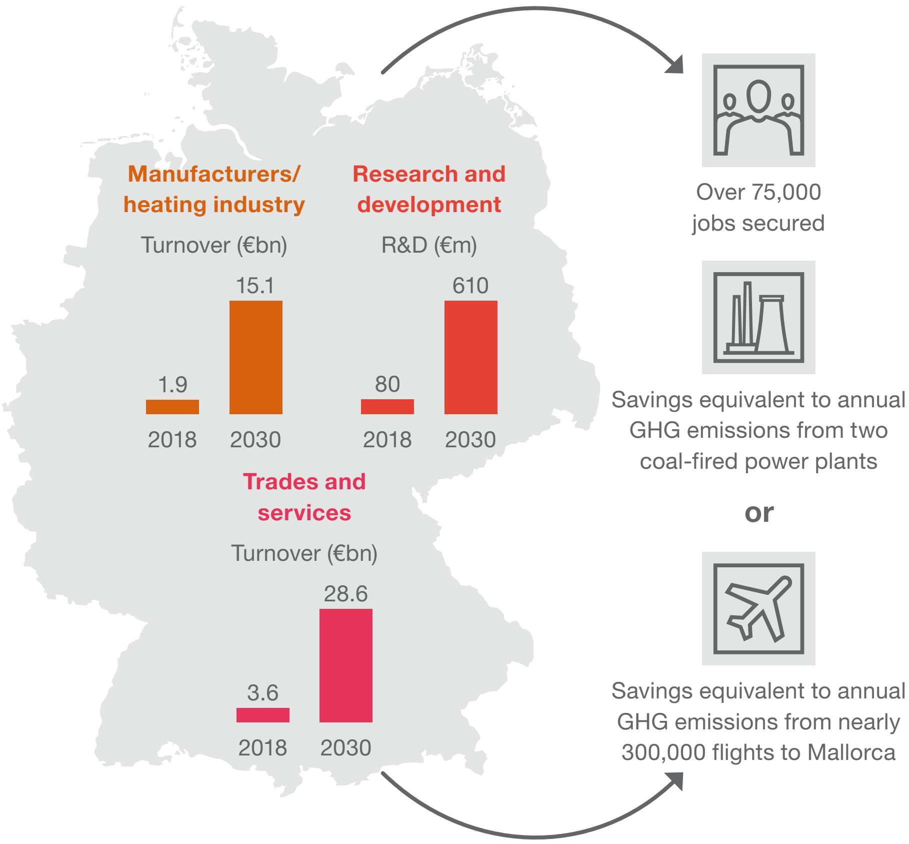
Meanwhile, German manufacturers saw a dramatic decline in their market share, with huge job cuts: up to 114,000 people were employed in the solar power industry in 2012, but by 2016 this had fallen to 36,000.



A greater focus on heat pumps in the domestic market is essential for the German heating industry to expand its role on the global market. Around 75,000 people are employed in the heating sector, and their jobs are at risk without a functioning domestic market. It should also be noted that the sector is mainly composed of mid-sized companies, most of which are located in rural and sometimes deprived areas where they provide employment and local value creation. If the competition were to take charge of the market, Germany would not only sacrifice jobs but would also lose a segment that is important for research and development: the heating sector is a major driver of innovation, with annual investments of €680 million.[12]

Experience from the Nordic countries shows the economic potential: extrapolating the annual heat pump sales in Sweden – approximately 25 heat pumps per 1,000 households – to the German heating market suggests that the 75,000 jobs in the industry could be secured and expanded by 2030 (Figure 5). Germany needs to avoid the kind of losses it suffered in the solar power industry (see box) if it is to position itself as an innovative pioneer of key technologies in the global energy transition.[13]

Fig. 5 Potential for heat pumps up to 2030, based on Swedish market share extrapolated to Germany



Sources: atmosfair (2019), BDH (2019a), BDH (2019c), DG Haustechnik (2019), Fraunhofer ISE (2019), GWS (2018), HBS (2016), ZVSHK (2019).

[12] Cf. BDH (2019): Press release “Heizungsindustrie zieht Jahresbilanz: Wärmewende? Fehlanzeige”.
[13] Cf. BSW Solar (2018): Statistische Zahlen der deutschen Solarstrombranche (Photovoltaik).

A rigorous strategy on heat pumps would also offer other advantages for Germany: widespread use of heat pumps could help alleviate the backlog of refurbishment going back several years and increase the share of renewable energy in the heating market. In view of current economic conditions created by the coronavirus crisis, it could also be used to send a positive signal to companies and tradespeople working on building renovations, an industry with around 540,000 employees.[14]

At the same time, many owners of solar panel systems are affected by the phasing out of EEG funding and are on the lookout for alternative uses for the electricity they generate: using locally generated electricity to operate a heat pump, for example, is more attractive than feeding into the grid, as the feed-in tariff is being reduced. In the medium term, too, heat pumps make it easier to come up with systemic solutions to achieve and control sector coupling – heat pumps would then help to bring about digitalisation in the energy transition.

5 Pressure on German policymakers to act

Despite the increase in funding for renewable heating systems, the current regulatory framework continues to create incentives for inefficient fossil fuel-based technologies. The energy pricing system, in particular, is not sufficiently steering the sector towards climate-friendlier technologies. Considerable potential in the heating sector is also going untapped because government policies designed to increase investment in sustainable buildings do not go far enough.

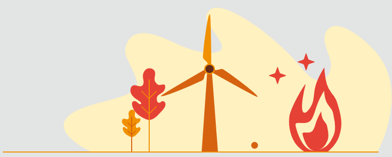
Increasing take-up of heat pumps is one way out of this situation. The industrialised countries of China, Japan, the US and Scandinavia have realised this, while heating systems in Germany are still mostly fossil fuel-based. This is holding back not only the heating transition in Germany, but also the German heating industry, which needs exports and innovations. The decline in Germany's solar power industry, which was once a leading, dynamic sector, is a scenario hanging over the heating industry, and one that Germany – the pioneer of the energy transition – must not repeat.

Now in particular, when important changes to the political and economic course are being taken due to the coronavirus crisis, political solutions are needed that will promote the spread of future-proof, clean technologies and also benefit the heating industry in Germany. Putting in place the right regulatory framework and driving the heating transition forward in Germany can ensure or even increase the industry's competitiveness on the international market. The following chapters show the characteristics of the heat pump that explain the demand for the technology, and the potential the heat pump has in Germany – not only for the climate, but also for the heating industry.

[14] Cf. www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2019-06-13_uib_02-2019_indikatoren-energieeffizienz.pdf.

C What is driving the trend towards heat pumps?

Heat pumps deliver
around 3.5kWh
of heat from 1kWh of electricity.



1 Mature technology that can be deployed in many use cases, using renewable energy and reducing emissions

The increasing spread of heat pumps is mainly due to the efficient, climate-friendly technology they use to generate heat. This is particularly important in the context of achieving critical climate goals.

Heat pumps require a relatively low electricity input and are based on a simple physical principle: energy contained in the air, ground or water is harnessed to evaporate a refrigerant. The physical properties of the refrigerant mean it can work at very low temperatures, so a supply of heat is assured even in winter.[15] The refrigerant is then compressed. This raises its temperature, allowing heat to be transferred from the relatively hot refrigerant to the relatively cool heating circulation system.

This system, unlike others which first have to be fired up to around 1,000°C, is deliberately designed to raise the available source temperature (in the air, ground or water) to the required ambient temperature of 24°C. Using ambient energy means that no greenhouse gases are released, and – much like the sun's rays, as used for solar power – ambient energy is available free of charge. Heat pumps are already being deployed to replace conventional gas-fired or oil-fired heating, eliminating the need to use fossil fuels and giving long-term emissions savings.

[15] Generating around 3.5kWh of heat from 1kWh of electricity corresponds to a typical seasonal coefficient of performance (SCOP) of 3.5.

The heat sources are as varied as the settings in which the systems are used. Besides fresh air and geothermal energy, waste water and groundwater can also be tapped to provide renewable heat sources, even in dense metropolitan areas. Heat pumps are already widely used in single-family and two-family houses, and they are increasingly being used in larger properties such as apartment buildings and commercial buildings. The heat can even be fed into heat networks; this is also already being implemented. The starting point is always the same: which free energy source – the air, the ground or water – can best be used at the site in question, and how much is available? Heat pumps thus combine renewable energy and energy efficiency.[16]

In detail: types of heat pump

Air-to-air heat pump
Air-to-air heat pumps use air as a heat source, extracting the heat and emitting it directly into the ambient air (without water-filled heaters). Both fresh air and waste air can be used as the heat source. In the latter case, the pump may also be called a ventilation heat pump.

Air-to-water heat pump
These heat pumps extract heat from fresh air and emit it to the ambient air via a hot water circulation system.

Brine-to-water heat pump or geothermal heat pump
Geothermal heat pumps use shallow geothermal energy. Brine-filled ground collectors or geothermal probes extract heat from the ground. Waste water can also be used as the heat source for brine-to-water heat pumps; in this case, heat exchangers extract the heat from the waste water.

Water-to-water heat pump
Groundwater is the main heat source for these pumps: for example, groundwater might be transported from an extraction well to the heat exchanger where it transfers its heat to the refrigerant. The cooler groundwater is then injected back into the aquifer via a soakaway.

[16] Although we sometimes use typical values for Germany to quantify the benefits of heat pumps covered in the sections below, the benefits generally apply globally. The precise form that the benefits take will vary depending on local weather conditions and the energy mix used to generate electricity.

2 Highly efficient heat supply

Heat pumps are the most energy-efficient heating system, as measured by energy used to generate a given amount of ambient heat. The ecodesign requirements introduced in 2015 have made it possible to compare the primary energy efficiency (or fuel efficiency) of a wide range of technologies. This involves calculating an annual heating efficiency ratio that states how well the heating system converts primary energy to heat. If the efficiency is 100% or more, this shows that renewable energy sources are being used. Heat pumps use renewable energy and so they are in the highest energy efficiency classes. Before the introduction of the ecodesign requirements, heat pumps in Germany were rated by their seasonal coefficient of performance (SCOP). The SCOP measures the ratio of heat generated to electricity used over an entire year. Heating systems with a higher SCOP are more efficient.

Fig. 6 Classification of heating systems (composite systems) by energy efficiency classes

n_s[1] (%)	Efficiency classes	Heat pump	Natural gas	Fuel oil
150	A+++	Brine-to-water heat pump Water-to-water heat pump		
125	A++	Air-to-water heat pump		
98	A+		Condensing boiler + solar/CHP/ gas heat pump	Brennwertkessel + Solar
90	A		Condensing boiler	Condensing boiler
82	B			Low-temperature boiler
75	C		Low-temperature boiler	
36	D			

[1] Energy efficiency of room heating, seasonally adjusted. All room heating appliances work in combination with class VIII temperature regulators.

Sources: Interdomo (2020), UBA (2020).

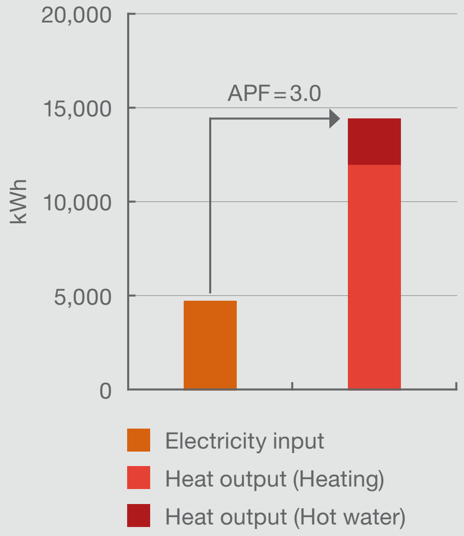
On average, heat pumps in new buildings or existing building stock achieve a SCOP of between 3 and 4. Geothermal heat pumps tend to have higher SCOPs than air heat pumps. As a general principle, reducing the difference in temperature between the heat source and heat sink will make a heat pump operate more efficiently.

Examples of heat pump use, focusing on energy efficiency

Example 1: air-to-water heat pump[17]
An air-to-water heat pump is used in a detached house built in 1956 and completely renovated in 2015. The house has a heated floor space of 91m^2 and a heating demand of 133kWh/(m^2·a), making it roughly equivalent to current building stock.

A 4kW air-to-water heat pump is used in combination with an electric heating element. The heat produced by the heat pump is emitted into the building via underfloor heating (average temperature of heating circuit: 38°C).

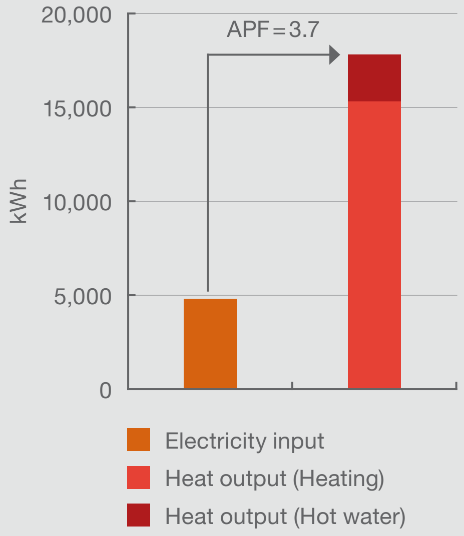
In 2018, this arrangement supplied 12,000kWh of energy for heating and 2,500kWh of hot water with an electricity input of 4,800kWh. This corresponds to a SCOP of 3. The electric heating element only accounted for about 250kWh – 5% of the total electricity input.



Example 2: ground-source heat pump[18]
A ground-source heat pump was installed in an end-terrace house built in 1973 with 170m^2 of heated floor space and a heating demand of 96kWh/(m^2·a). This is typical for a single-family house upgraded to modern energy efficiency standards.

The building is supplied with heating and hot water by an 11kW heat pump that uses geothermal energy as the heat source. The heat is emitted using conventional radiators (average temperature of heating circuit: 42°C).

In 2018, the house had a heating demand of 15,500kWh and a hot water demand of 2,500kWh. Just under 5,000kWh of electricity was required to supply this heat, which corresponds to a SCOP of 3.7. The electric heating element installed to cover peak loads was not used at all in 2018.



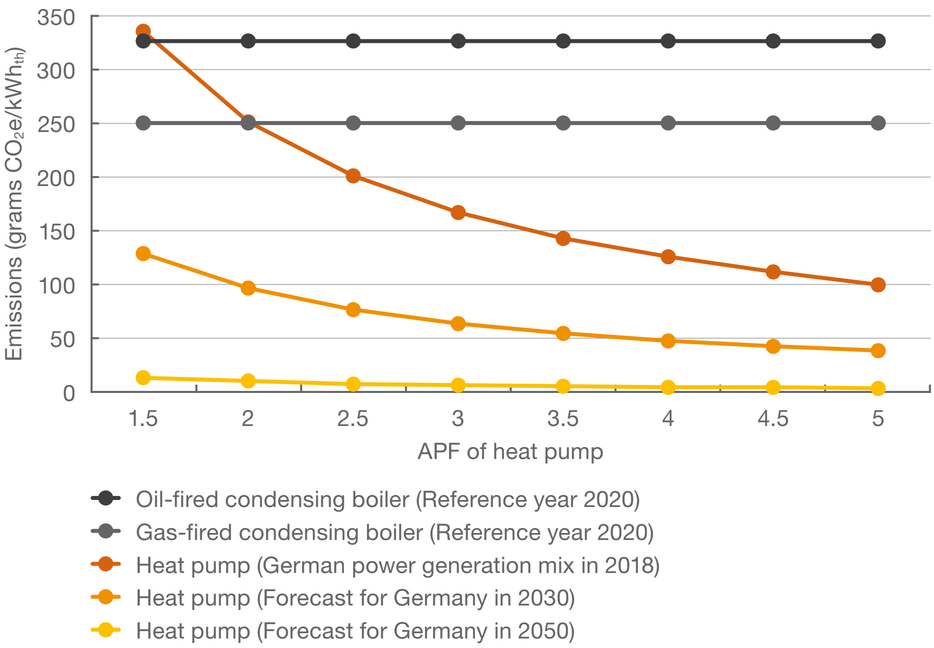
[17] Cf. Fraunhofer ISE (2019b): WP smart im Bestand – Demo 78.
[18] Cf. Fraunhofer ISE (2019c): WP smart im Bestand – Demo 63.

3 Replacing fuel oil and natural gas for zero-GHG heating and carbon-neutral building stock

Instead of burning fuel oil and natural gas, heat pumps use freely available renewable energy from the ground, air, water or waste water (ambient heat), along with a small amount of electricity. The impact of a heat pump on GHG emissions can be assessed based on the emissions intensity measured in grams of CO_2 equivalent (CO_2e) per kWh of heat, including the emissions from electricity generation. With the current power generation mix in Germany, heat pumps effectively save between 110 and 230 grams of CO_2e per kWh of heat compared with an oil-fired or gas-fired boiler (Figure 7). These figures apply for a specific SCOP (3.5) and a specific power generation mix used to operate the heat pump (Germany power generation mix in 2018).

The emissions intensity of heat pumps will decrease further in future, as the proportion of electricity generated from renewable sources is increasingly steadily.[19] Ongoing research and development in the heat pump sector is also increasing system efficiency as defined by SCOP.[20] The GHG emissions of heat pumps will therefore continue to fall for both new installations and existing systems, unlike the GHG emissions of oil-fired and gas-fired heating systems, which will remain constant.[21]

Fig. 7 GHG emissions intensity of various heating systems as function of SCOP and power generation mix



Sources: BDEW (2017), IINAS (2019).

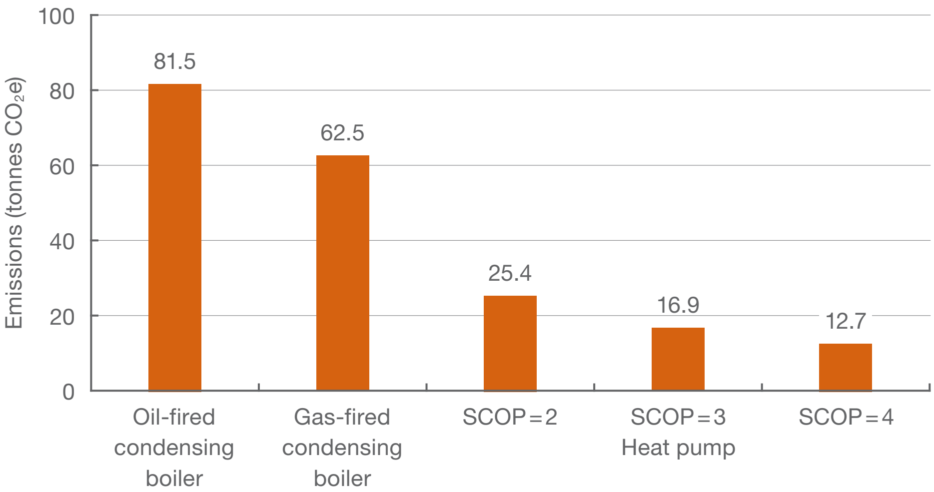
19 This change corresponds to a downward movement on the vertical axis on the graph.
20 This change corresponds to a movement along the curves towards the (bottom) right of the graph.
21 No further significant efficiency gains are expected for condensing boiler technology, so the emissions intensity of fossil fuel-based heating systems can only be reduced by supplementing them with renewable fuels such as biogas or synthetic energy sources (power-to-gas/power-to-liquid).

A key consideration here is that the electricity for heat pumps, particularly in large-scale projects, can be also be produced on-site – using photovoltaic systems, for example, possibly with batteries for interim storage – or purchased at green electricity rates. Astonishingly, this continues to be overlooked,[22] even in Germany's energy saving legislation.

It is also clear that even heat pumps with a relatively low SCOP will reduce GHG emissions over their service life. While a heat pump system with a SCOP of 2 (Figure 7) was only level with a natural gas-fired condensing boiler in 2018, the projected power generation mix will make the very same system more climate-friendly than the condensing boiler as soon as 2020; this benefit will continue to increase over its operating life: a heat pump installed in 2020 with a SCOP of 2 will still reduce GHG emissions over its service life to 31% or 41% of its rivals, depending on which fossil fuel is measured.

Figure 8 shows the GHG emissions intensity per kWh of heat supplied extrapolated to the entire service lives of heating systems.[23] This includes the steady increase in green electricity in Germany. It is clear that heat pumps can significantly reduce the GHG emissions of heating systems. In the example labelled SCOP = 3, the GHG emissions are reduced to 21% of the value for an oil-fired condensing boiler, or 27% of the value for a gas-fired condensing boiler.

Fig. 8 GHG emissions intensity per kWh of heat produced from heating systems over their service lives



Sources: BDEW (2017), IINAS (2019).

[22] Section 5 of the Energy Savings Regulation (Energieeinsparverordnung, or EnEV) classes electricity from renewable energy as eligible for offset provided it is generated in the immediate vicinity of the building, is predominantly for use in the building, and only surpluses are fed into the grid. However, energy savings legislation does not class the reduction in a heat pump's ecological footprint by using green electricity supplied by utlitiy companies as an eligible benefit.

[23] Assumptions: heating systems installed in 2020 supplying 10,000kWh of heat per year and with a service life of 25 years.

A comparison with the transport sector gives an idea of the scale of GHG savings. The CO_2 emissions of a typical diesel car are around 145 grams per kilometre. If the vehicle is driven 15,000 km per year, the CO_2 emissions will be 2.2 tonnes per year. So the GHG savings made by using a heat pump are equivalent to the annual CO_2 emissions of a normal car. And the savings made will be cost-relevant once the carbon pricing scheme announced by the German Government comes into force.

4 No particulates and no nitrogen oxides (NO_x)

Alongside GHG emissions, particulates and nitrogen oxides (NO_x) have also gained significance in public debates. Diesel bans have been imposed in several cities in Germany to ensure compliance with NO_x limits.[24] High density of vehicles and use of small combustion plants for heating are leading to poor air quality and damaging the health of the population in large cities all around the world.

Installing a heat pump can replace all of a household's combustion processes. Its most direct impact is to reduce air pollution in the vicinity and improve living conditions generally. It also does away with the need for a chimney or flue to discharge smoke or for a chimney sweep to maintain a combustion-based system, thus reducing ongoing costs.

5 Flexible technology: heat pumps can also be used for cooling

As well as an increase in extreme weather, climate change means that temperatures are rising. This is particularly noticeable in urban areas where there is less circulation of air than in rural areas. Extremely hot years have become more frequent since the 1990s, a trend evinced by 2014 and 2018, the hottest years on record.[25] After several summers of above-average heat, demand for cooling systems in the private and commercial sectors is rising in Germany.[26] This means that air conditioning technology is becoming increasingly important for making living conditions more comfortable in residential buildings, improving employee productivity in office buildings, improving occupancy rates in hotels; in hospitals and retirement homes it is even essential for maintaining health. Compared with separate heating and cooling systems, heat pumps are more efficient since they combine both functions – in fact, this ability to both cool and warm buildings is one of the heat pump's USPs. Having a heat pump available for cooling enhances a property's functionality, driving up its value.

[24] Cf. ADAC (2019): Dieselfahrverbot: Alle Fragen und Antworten.
[25] Cf. UBA (2019d): Mittlere Tagesmitteltemperatur im Frühling in Deutschland 1881 bis 2018.
[26] Cf. ZVEI (2019): Elektro-Hausgeräte: Wachstum bei Kleingeräten, leichter Rückgang bei Großgeräten in 2018.

There are basically two different types of cooling using heat pumps. Active cooling uses the heat pump's compressor. Passive cooling uses a circulation pump to transfer surplus heat out of the building into the cooler ground, or in some cases into waste water as well. In a best-case scenario, this stores some of the summertime thermal energy underground so that it can be used to heat the building the following winter.[27] For active cooling, the heat pump needs a reversible refrigeration circuit, which is possible with any heat source.

Cooling heat pumps can be efficiently run on electricity from photovoltaic systems in the summer months when the electricity output is particularly high. This is often attractive for operators, since feed-in payments for electricity from renewable energy are decreasing, making self-consumption of regenerative electricity a more interesting prospect. As a result, it often makes more sense to use electricity produced from photovoltaic cells to operate heat pumps (reducing consumption of electricity from the grid) than it does to feed the power generated into the grid.

This situation is particularly common in Germany, where the feed-in tariff for electricity from (small-scale) photovoltaic systems is around 10 cents/kWh, while the price of electricity for households is around 30 cents/kWh. On-site self-consumption is becoming increasingly important in other countries, too, as renewable energy systems are introduced into the conventional market where revenues are essentially limited to the wholesale electricity price. This contrasts with an electricity supply price that comprises not just the wholesale price but also network charges, taxes, fees and levies.

6 Potential for use in industry and manufacturing outside 'traditional' uses in buildings

But heat pumps are not just for use in the buildings sector. In addition to the goals on avoiding GHG emissions from buildings, the manufacturing or industry sector – which now account for 22% of Germany's total GHG emissions (2017 figures) – also needs to make changes. The Climate Change Act (Klimaschutzgesetz) requires industrial emissions, which were around 200 million tonnes of CO_2e in 2017, to be reduced to 140 million tonnes of CO_2e by 2030.[28] Widespread use of heat pumps to supply low-temperature heat could reduce emissions by around 18 million tonnes of CO_2e, almost a third of the entire reduction required (60 million tonnes of CO_2e; see Chapter E).

[27] Underground thermal energy storage (UTES) is used for seasonal heat and cold storage. An outstanding example of this is the Reichstag building in Berlin, which has a hot and cold aquifer thermal energy storage (ATES) system installed. Heat is fed into the hot ATES in the summer and recovered in the winter; the cold ATES is charged in winter using the lower external temperatures and used for cooling in summer. Another version of a UTES is a borehole thermal energy storage (BTES) system like the one used in the Drake Landing Solar Community, a residential area in Canada.

[28] Cf. UBA (2019b): Nationale Trendtabellen für die deutsche Berichterstattung atmosphärischer Emissionen 1990–2017 – Endstand zur Berichterstattung 2019.

The cooling aspect of heat pumps is also of interest in industry and manufacturing in addition to the conventional use of heat pumps to supply heat, since these companies are often in great need of heat and refrigeration (for example, numerous steps in processes in the food industry: slaughter, butchery, drying, roasting, refrigerating and portioning). Heat pumps can provide both heating and refrigeration; this means that companies do not need to install separate systems, which generates potential savings on energy costs. Heat pumps can also be used to improve use of waste heat and can be used in combination with other systems such as geothermal energy, waste heat, solar heat or bioenergy.

The three examples of heat pump use below are taken from industrial and manufacturing practice and provide an illustration of the many possibilities:

- The server rooms at a bank branch (6,200m^2 plot with 22,300m^3 of interior space) require continuous cooling, while the offices and meeting rooms are heated or cooled depending on the season. Three large-scale brine-to-water heat pumps and 25 geothermal probes at depths of 100m to 150m can each supply 180kW of heating and cooling output for this purpose. The heat pump system reduces both the bank's operating costs and GHG emissions.[29]
- Deutsche Bahn's carbon-neutral ICE maintenance depot in Nippes, Cologne, (22,250m^2) combines several climate-friendly technologies. A 300kW photovoltaic system and a 100kW solar heating system on the roof generate electricity and heat for hot water respectively. Some of the electricity is used to run three large-scale water-to-water heat pumps, which are fed from 10 groundwater wells and can supply 4.9MW of heat output. Overall, the systems save more than 1,000 tonnes of CO_2 emissions a year and reduce the depot's operating costs.[30]
- A hotel in an historic building on the Moselle river uses a 24kW brine-to-water heat pump to harness geothermal energy and supply underfloor heating. The ground has a relatively high constant temperature of 10°C to 12°C and the underfloor heating uses a low flow temperature, so the heat pump operates at a SCOP of 4.7 – i.e. it supplies almost 5kWh of heat per 1kWh of electricity. The heat pump system can be used to cool the building in summer.[31]

[29] Cf. Project 3 in BWP (2019b): Gewerbeobjekte und Industrieanlagen mit Wärmepumpe – Überblick, Anregungen, Referenzobjekte.
[30] Cf. Project 10 in BWP (2019b): Gewerbeobjekte und Industrieanlagen mit Wärmepumpe – Überblick, Anregungen, Referenzobjekte.
[31] Cf. Project 7 in BWP (2019b): Gewerbeobjekte und Industrieanlagen mit Wärmepumpe – Überblick, Anregungen, Referenzobjekte.

7 Use of local renewable electricity generation for the heating sector (sector coupling)

Energy generation is shifting from centralised to decentralised (distributed) systems as part of Germany's energy transition and the global transformation to sustainable energy supply.[32] So far, this shift has applied mainly to the electricity sector: large-scale coal-fired power plants are replaced by smaller-scale photovoltaic systems and wind farms. However, if the use of natural gas and fuel oil is restricted as requirements for climate action increase and resources become more limited, a rethink will inevitably take place in the heating sector as well.

Heat pumps allow distributed electricity generation to be used to supply heat, too. Heat pumps are powered by electricity, which means they can use electricity generated locally from renewable energy (such as solar power) to generate heat. This makes heat pumps a key component in any sustainable, local energy supply system and provides a major step towards sector coupling.

For Germany in particular, heat pumps can be used to help with the integration of renewable energy systems as required by the EEG. Statutory funding for these systems comes to an end after 20 years, even though many of them will still be fit for purpose. After the funding period ends, feed-in to the grid will usually not be a very attractive option if more electricity is generated than can be consumed, as the tariff will be very low (see above).

Converting from a fossil fuel-operated heating system to a heat pump largely dispenses with the need to source energy from fuel oil or natural gas; some of the electricity required can be provided by a renewable energy system such as a photovoltaic plant. This increases the proportion of self-generated electricity used for self-consumption relative to total energy input.

The outlook on the electricity market of the future and the options for its flexibilization reveils another advantage: the volatile – or intermittent – nature of electricity supplied from solar panels and wind turbines means that long-term, dynamic tariff models will be required for end customers. When supply is plentiful, electricity will be provided at lower prices than during periods when the amount of electricity available is small.

Because of their buffer function, heat pumps can benefit from lower prices at various times throughout the day. Since heat can be stored in the heating circuit (particularly in relatively slow-to-respond underfloor heating systems) as well as in the building itself, a heat pump can heat a building during periods when large quantities of wind and solar power are available. The heat saved is then released into the building at periods of lower supply and higher prices. This flexible use of heat pumps is perfectly suited to the fluctuating supply of electricity from renewable energy sources.

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[32] The reason behind this shift is that renewable energy such as solar radiation, wind power or biomass is not as locally concentrated as coal, oil and gas: the energy density of renewables is lower than that of fossil fuels. This means that energy is no longer generated centrally and then distributed; the renewable energy available needs to be tapped locally.

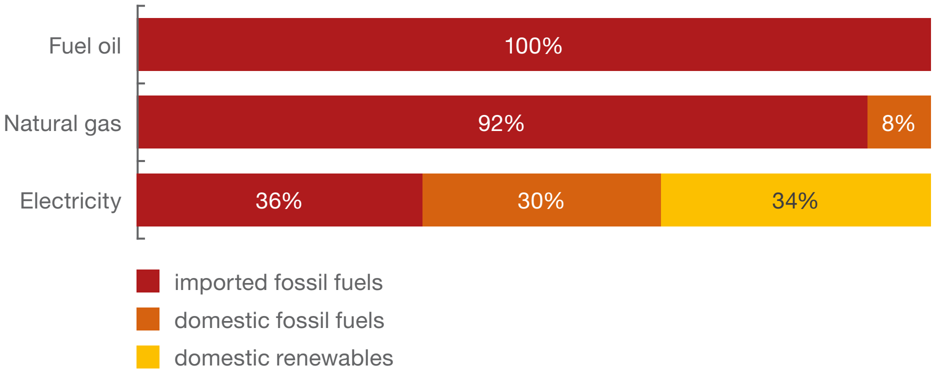
8 Support for the energy policy triad

Most of the arguments so far set out in favour of heat pumps have been presented from the user's perspective, i.e. they address the question of what benefits a heat pump provides for individual users or companies. The following section extends our analysis of heat pump usage to include a higher-level energy policy or macroeconomic perspective. The key issue here is how heat pumps fit into the energy system envisaged by government policy.

The energy policy triad summarises the requirements for electricity and heat supply in a modern energy system. It comprises security of supply, affordability and environmental compatibility.[33]

Availability of the energy sources used (reliable amounts of energy) and stability of the infrastructure (reliable energy capacity) are key to current and future **security of supply**. Conventional heating systems use fuel oil and natural gas, almost all of which have to be imported. Various technologies are used to produce electricity, with only some of the conventional power plants operating on imported energy sources. In addition, the proportion of electricity generated from renewable energy sources – which pose no risk of dependence on imports – is increasing (Figure 9).

Fig. 9 Dependence on imports of energy sources in the heating sector



Sources: BNetzA (2019), UBA (2019c).

[33] The energy policy triad is to be found, for example, in Section 1(1) of the Energy Industry Act (Energiewirtschaftsgesetz, or EnWG): "The Act aims at ensuring the public supply of electricity and gas, which should be as safe, inexpensive, consumer-friendly, efficient and environmentally compatible as possible and increasingly be based on renewable energy."

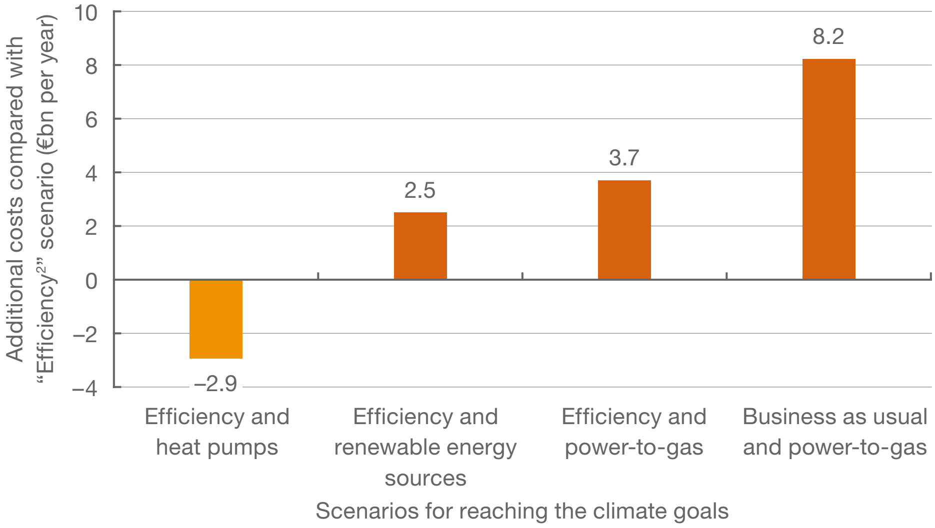
Heat pumps also contribute to security of supply in terms of reliable energy capacity. They do not have to be operated continuously and have long been used – as "taxable consumer facilities" as defined in Section 14a of the EnWG – by grid operators to stabilise the electricity grid by adjusting their supply to the load on the grid. Heat pumps are smart grid-ready, i.e. they are ready for smarter communications between grid operators and system operators based on smart meters when these are phased in. The heating circuits in buildings and the mass of the buildings themselves act as heat reservoirs that can be charged up with heat during periods of plentiful electricity supply and gradually discharged when supply is low. These storage processes are operated at strictly delimited temperature intervals that have no impact on the building user but still offer significant potential for load displacement. Flexible heat generation with heat pumps thus increases sector coupling and grid stability.

In terms of **affordability**, low conversion losses and total system costs score highly. A number of studies have shown that heat pumps require lower final energy inputs associated with GHG emissions than other heating technologies. Studies by Agora show that this also provides benefits for the national economy.[34] The authors simulate a number of sets of measures, each of which enable German climate goals to be met. An "Efficiency^2" scenario is used as a basis on which the costs or savings of other scenarios that focus on specific climate action can be calculated. When the scenarios are run, focusing on heat pumps turns out to be less expensive than the baseline scenario, while focusing on other measures involves additional costs (Figure 10).

Electrification of households also offers new opportunities for smart energy management – 'smart homes'. After integrating photovoltaic systems, electric cars and home battery storage, adding heat pumps into smart systems can be the next step on the way to consistent, systemic solutions for the energy transition.

[34] Cf. Agora (2018a): Wert der Energieeffizienz in Zeiten der Sektorenkopplung.

Fig. 10 Comparison of costs of reaching Germany's climate goals



Source: Agora (2018a).

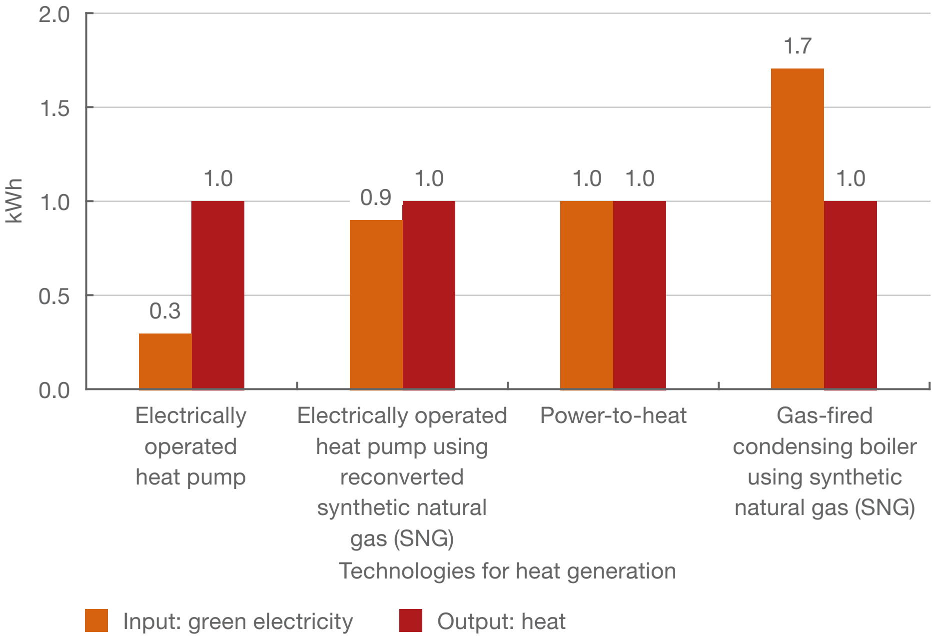
As regards **environmental compatibility**, increased use of heat pumps is already reducing GHG emissions compared with using fuel oil and natural gas for heating (see above), and the heat pumps GHG balance will continue to fall in future. Unlike other technologies used to supply renewable heat, heat pumps do not have to overcome problems such as low power density (solar heat), limited overall potential (biomass) or relatively high-risk development (deep geothermal energy, with potential environmental impacts as well as economic risks of project failure), and can be scaled up exactly as required. This makes heat pumps the go-to technology for generating heat quickly and at scale on a renewable, climate-friendly platform. Besides the climate considerations, heat pumps do not emit any flue gases, reducing atmospheric pollution.

9 Heat pumps and power-to-gas

Storing and transporting regenerative energy is becoming increasingly important as a result of the fluctuations in electricity inputs from wind and solar power. Power-to-gas systems are used to convert electricity into (mostly) hydrogen and methane, which can then be used as synthetic gas over the medium to long term. There has been strong demand for these CO_2-free fuels from many sectors of the economy in recent years. The German Government's hydrogen strategy includes, among other sectors, heavy industry, freight transport, peak-load electricity generation plants and the buildings sector as future targets for expansion.

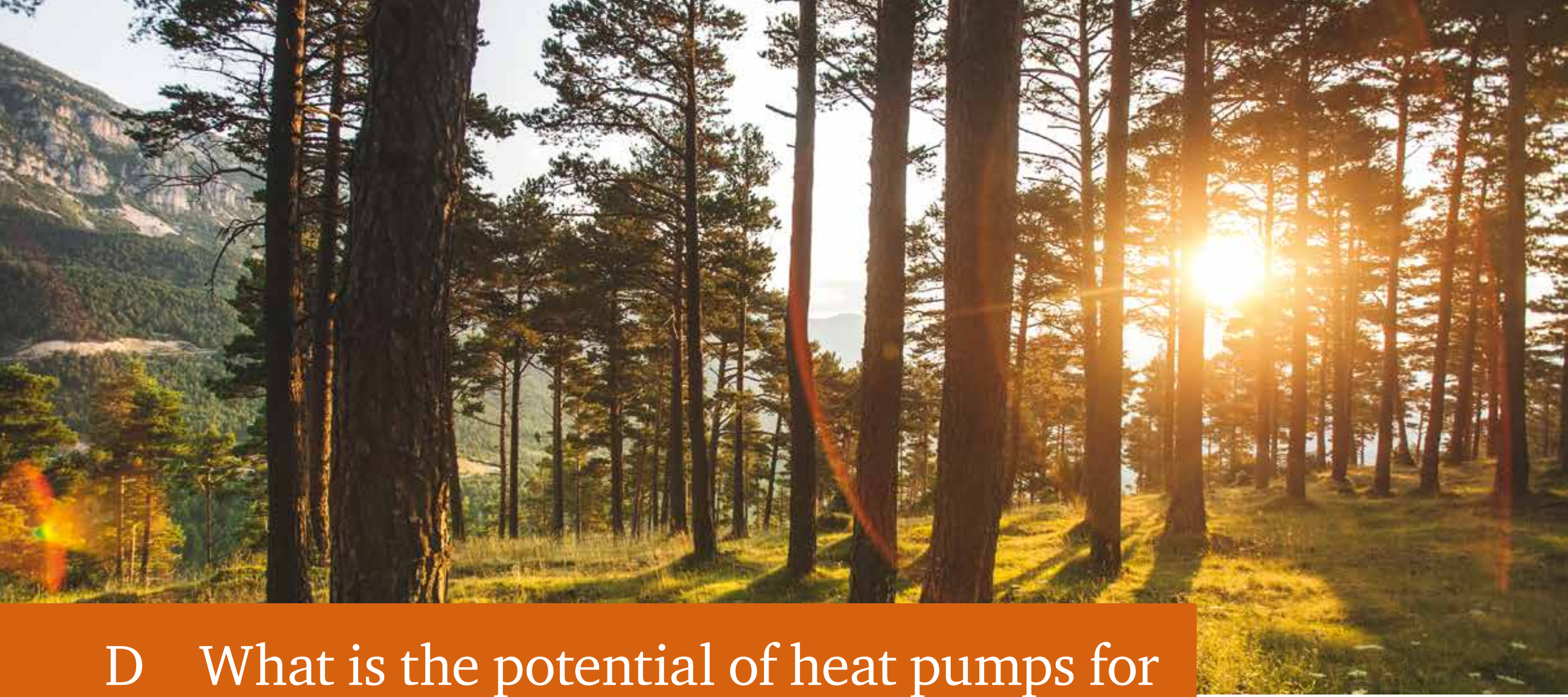
But heat pumps and power-to-gas should not be seen as rivals. Even after power-to-gas has been rolled out, synthetic gas will not be available in sufficient quantities for the foreseeable future. Given the demand for hydrogen from so many sectors, it must be remembered that supplying heat using heat pump-based systems requires a far lower electricity input than a supply system where synthetic gas has to be produced before it is converted into heat in boilers. Figure 11 shows the conversion efficiency of these processes, i.e. how much renewable electricity is needed by each solution to produce one kWh of useful heat.

Fig. 11 Comparison of conversion efficiency in heat supply



Source: in-house calculation based on FENES (2015).

As a result, power-to-gas should in fact be seen as a useful complement to heat pumps. And this is clearly shown from the use case where the synthetic gas generated from power-to-gas is stored, reconverted to electricity as required, and then efficiently used in heat pumps.



D What is the potential of heat pumps for achieving Germany's climate goals?

We noted in previous chapters that heat pumps offer huge international growth potential and that there are many reasons behind their rise in importance. We will now take a look at where we are in Germany on the path towards the energy transition and the extent to which we are on course to meeting our climate goals, particularly in the heating sector.

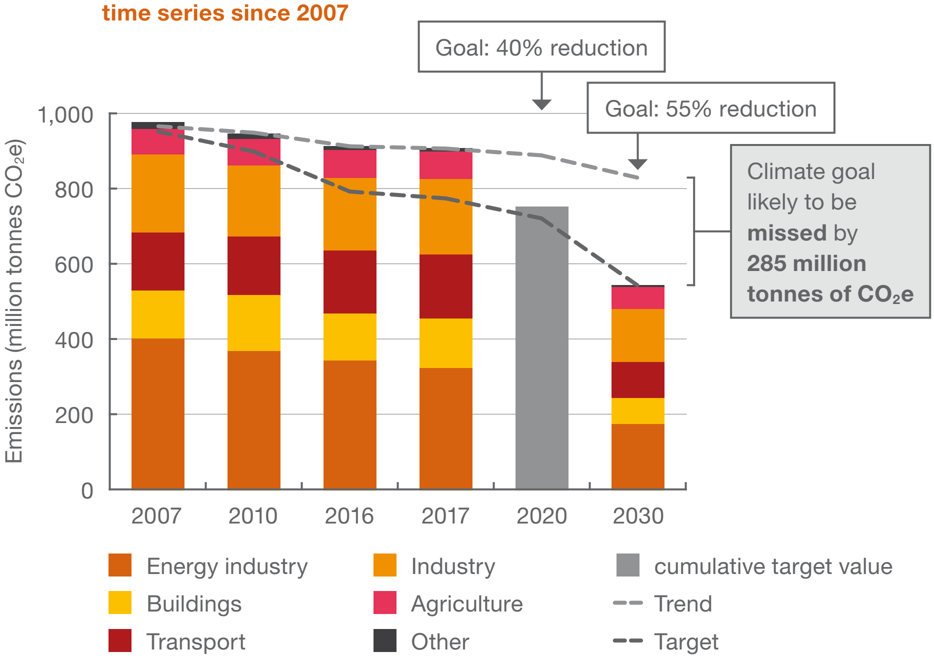
1 Energy transition flagging and climate goals missed

Germany has set itself ambitious climate goals which it has repeatedly reaffirmed, including in international treaties. It seems likely that the 40% target for reducing GHG emissions will be met in 2020, but only just, and principally due to growth in electricity generation from renewable sources and a number of unsustainable effects (weather conditions, coronavirus pandemic). That makes 2030 the next milestone, with a goal of a 55% reduction compared with 1990 levels. Trend extrapolations, as well as the German Government's latest assessment that already includes the new measures in its climate package,[35] suggest that this goal will not be met unless politicians decide on tougher measures to institute a change in trends.

The data since 2007 reveal the shortfall: if GHG emissions follow the trend of the past ten years, Germany's GHG emissions will be approximately 828 million tonnes of CO_2e in 2030, around 285 million tonnes of CO_2e short of the climate goal (Figure 12).[36]

[35] Cf. Tagesschau (2020): Klimapaket spart nicht genug CO_2 ein.
[36] The chart shows the overall GHG emissions target for 2020 and sector-by-sector targets for 2030 under the Climate Change Act (Klimaschutzgesetz). The sector-by-sector targets under the Climate Change Act correspond to the lower sectoral targets in the previous 2050 Climate Action Plan.

Fig. 12 Change in German GHG emissions and emissions targets over time – time series since 2007



Sources: BMU (2016), Öko-Institut (2017), UBA (2019b).

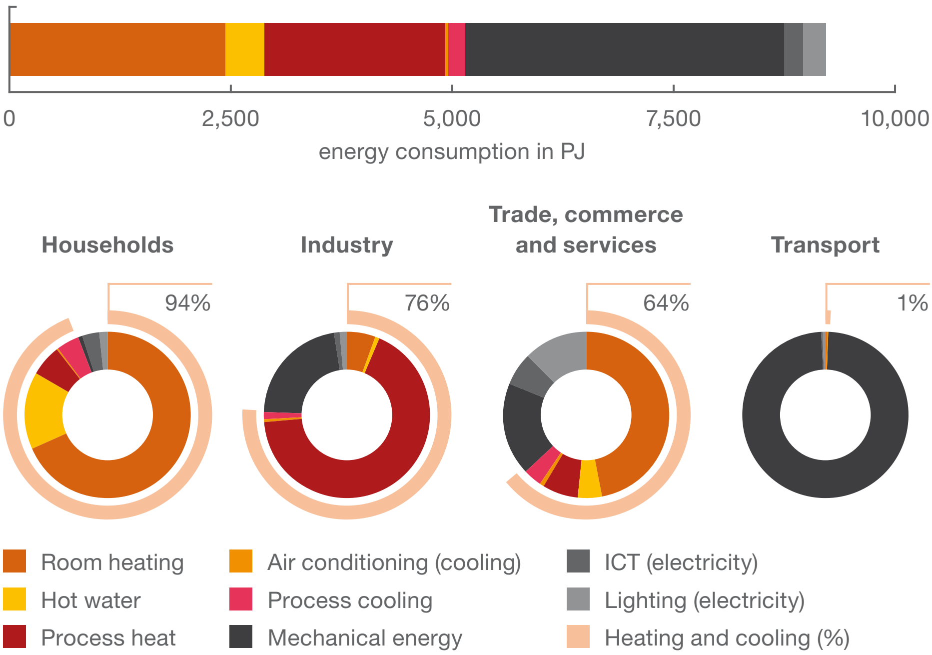
Missing the climate goals also matters because Germany has made a legally binding commitment under EU law to reduce GHG emissions. If Germany misses its goals outside the EU Emissions Trading Scheme (the non-ETS sector), it will have to buy emission allowances from other EU member states to make up the shortfall. Agora Energiewende estimates that failure to meet climate goals from 2021 to 2030 will result in a cumulative shortfall of around 620 million tonnes of CO_2e in the non-ETS sector, at a cost to the Government of between €30bn and €60bn depending on the price of emission allowances.[37]

[37] Cf. Agora (2018b): Die Kosten von unterlassenem Klimaschutz für den Bundeshaushalt – Die Klimaschutzverpflichtungen Deutschlands bei Verkehr, Gebäuden und Landwirtschaft nach der EU-Effort-Sharing-Entscheidung und der EU-Climate-Action-Verordnung.

57% of Germany's final energy demand is related to heating and cooling.

Focusing on final energy demand and its components may help to identify ways of reducing Germany's GHG emissions.[38] Heating and cooling account for around 57% of Germany's final energy demand. In other words, the heating sector's share of final energy consumption is almost twice that of the entire transport sector (around 30%).[39] And heating accounts for a large proportion of final energy demand across all areas of consumption, too (apart from the transport sector). While demand in the industrial sector is mainly for process heat, the trade, commerce and services sector and households mainly require room heating (Figure 13).[40]

Fig. 13 Final energy demand in Germany in 2017 by area of application



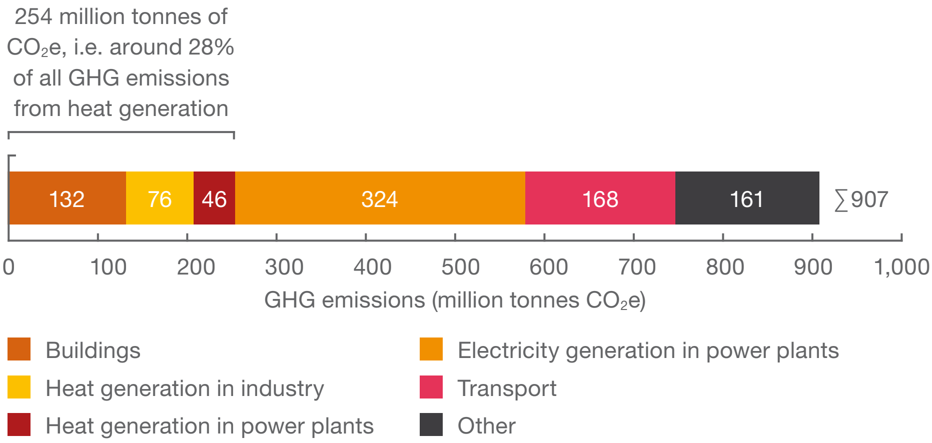
Source: BMWi (2019b).

This energy consumption pattern is by no means unique to Germany. In other European countries, as in the world's other major industrialised nations, heating applications form a central component of final energy consumption. Since countries all around the world have committed themselves to climate goals, innovative solutions on more climate-friendly design and decarbonisation are becoming increasingly important. This gives manufacturers an incentive to become leading exponents of climate-friendly, highly efficient heat pump technology.

[38] Around 85% of Germany's GHG emissions originate in the energy sector. This includes burning of fuel both for direct energy use in transport, buildings and industry, and for generating electricity and district heat. The remaining GHG emissions are mainly process-related emissions from the industrial sector and emissions from agriculture.
[39] Cf. AGEB (2019): Auswertungstabellen zur Energiebilanz Deutschland.
[40] Note: households and the trade, commerce and services sector are grouped under "buildings" in the sectoral goals in the 2050 Climate Action Plan.

Converting energy consumption into GHG emissions shows that 254 million tonnes of CO_2e, or 28% of Germany's GHG emissions, come from generation and use of heat (Figure 14).[41] This makes the heating sector – behind electricity production but ahead of the transport sector – one of the largest GHG-emitting sectors that must be addressed by any effective climate strategy. Alongside the buildings sector, which is particularly relevant here and currently accounts for at least 52% of heating sector emissions, we also need to look at the demand development for process heat in industry, which is responsible for at least 30% of these GHG emissions. GHG emissions from heat produced in power plants are classed under the buildings sector (district heat supplied by power plants in the energy sector) and the industrial sector (process heat generated in industrial power plants).

Fig. 14 Heat-related GHG emissions as percentage of total GHG emissions for Germany in 2017



Sources: Öko-Institut (2017); UBA (2019b).

Since electricity only accounts for around 20% of final energy consumption, it is not enough to switch to renewable energy for electricity alone.[42] Given the huge importance of the heating sector, a holistic energy transition will only work if the heating sector also makes a transition – the heating transition.

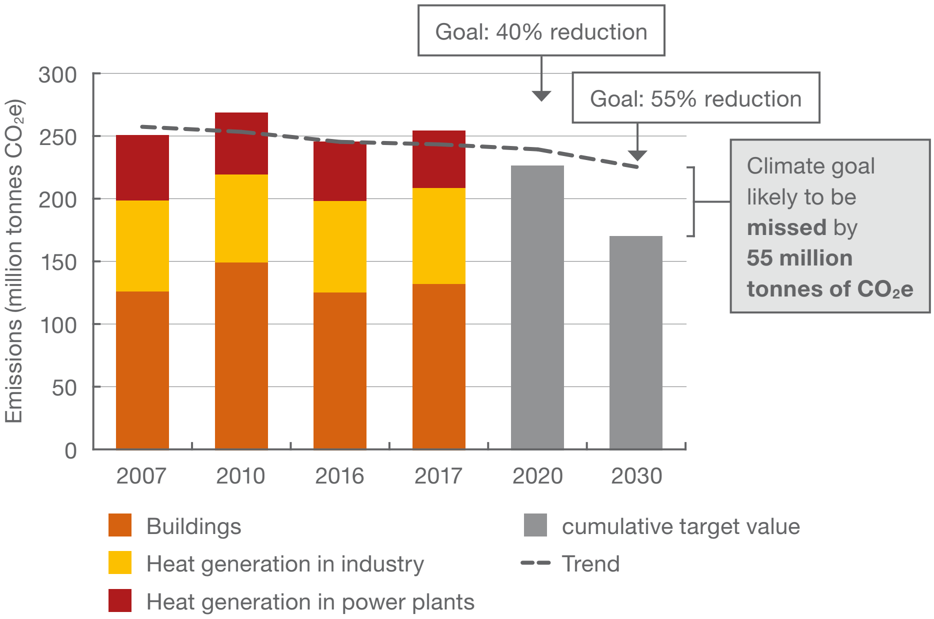
[41] In this analysis, emissions from the building sector (CRF categories 1.A.4 a, 1.A.4 b, 1.A.5) and some of the combustion-related emissions from the energy sector (CRF category 1.A.1) and industry (CRF category 1.A.2) are classed as heat-related GHG emissions. This classification of some emissions from the energy sector and industry is based on the ratios provided for 2015 in "Sektorale Abgrenzung der deutschen Treibhausgasemissionen mit einem Schwerpunkt auf die verbrennungsbedingten CO_2-Emissionen" (Öko-Institut, 2017). The approach ensures that only emissions stemming from heat generation and extraction into local or district heating grids are classified as heat-related. Emissions from the generation of thermal energy and its subsequent conversion to electricity are not included.

[42] Cf. AGEB (2019): Auswertungstabellen zur Energiebilanz Deutschland.

2 Heating transition not yet on the right path

Generating heat contributes significantly to Germany's overall GHG emissions; this would be tolerable if heat-related emissions would steadily decrease in absolute terms. But, as the chart below clearly shows, GHG emissions caused by the heating sector have not been reduced to any significant extent in recent years. Without political action to reverse this trend, the heating sector's contribution to national climate action will be negligible.[43]

Fig. 15 German GHG emissions trends and goals – time series since 2007, focusing on the heating sector



Sources: Öko-Institut (2017), UBA (2019b).

In terms of GHG emissions, therefore, the energy transition in the heating sector can hardly be classed as a success. The buildings sector largely determines GHG emissions in the heating sector, and there are three major factors that influence the sector's GHG emissions:

1. Heat demand of the buildings sector
2. Energy efficiency of the heat generators used
3. Energy sources used

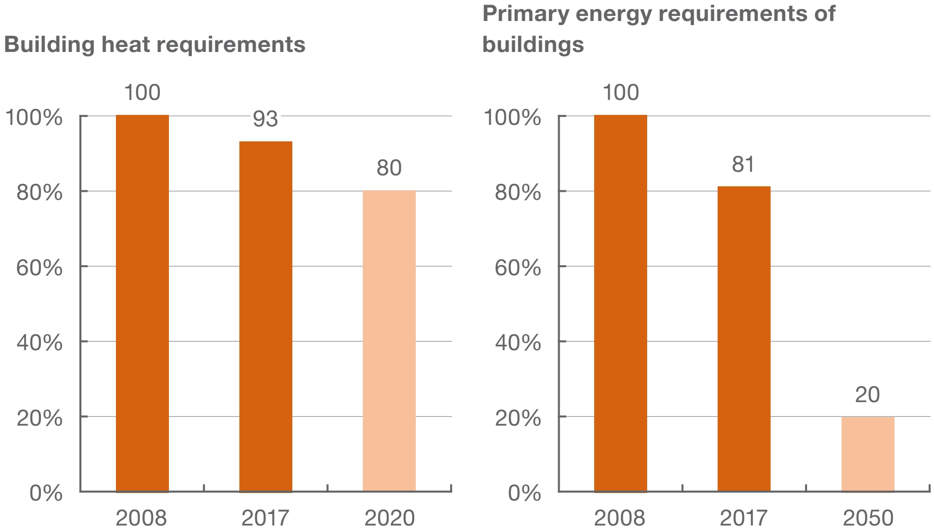
[43] There are national GHG emission targets for the energy sector, buildings sector, transport sector, industry, agricultural sector and others, but none for the heating sector. The figures for 2020 and 2030 in the chart are therefore based on the assumption that emissions reductions in the heating sector should be in line with the overall target of 40% by 2020 and 55% by 2030 (relative to 1990 levels in both cases).

None of these three factors is moving in the right direction, as the figures below demonstrate.

1. Energy consumption in the buildings sector is not falling rapidly enough.
The required target rate of 2% per year for upgrading buildings to the latest energy efficiency standards is regularly missed.[44] The latest rate (2017) was less than 1%.[45]

Heat demand in buildings is still well above the 2020 target, and the primary energy demand of buildings also needs to be significantly reduced by 2050 (Figure 16).

Fig. 16 Heat demand development to date and targets for 2020 and 2050 in the buildings sector



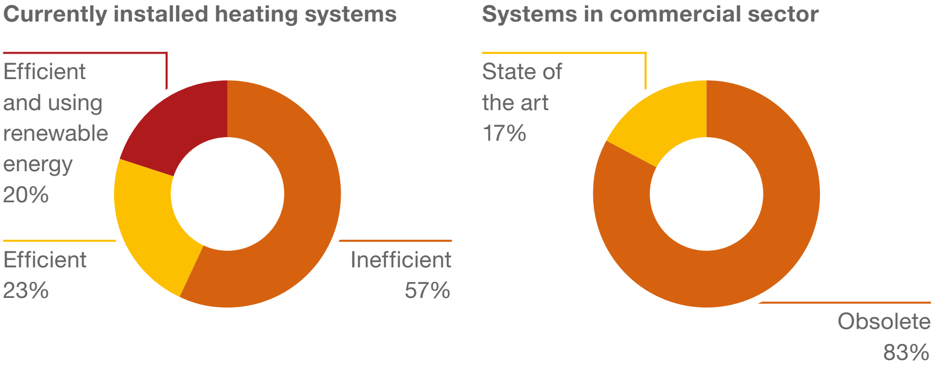
Sources: BMWi (2010), BMWi (2019c).

44 This target was first articulated in the "Energiekonzept für eine umweltschonende, zuverlässige und bezahlbare Energieversorgung" published by the BMWi (Federal Ministry for Economic Affairs and Energy) and the BMU (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety) in 2010. But targets for this rate are mired in statistical complexity, since there is no standardised definition of the rate that applies across databases, nor is there any source that currently publishes a rate on an annual basis. Cf. BBSR (2016): Datenbasis zum Gebäudebestand – Zur Notwendigkeit eines besseren Informationsstandes über die Wohn- und Nichtwohngebäude in Deutschland.

45 Depending on the method of calculation employed, the modernization rate for 2005 to 2008 is 0.6% or 0.8%, and the rate for 2010 to 2016 is 0.9% or 1.0%. Cf. Singal/Stede (2019): Wärmemonitor 2018: Steigender Heizenergiebedarf, Sanierungsrate sollte höher sein, in: DIW Wochenbericht 36/2019.

2. Too many of the heat generators currently in use are inefficient.
The majority of heating systems used in both the private and the commercial sectors are obsolete or inefficient (Figure 17).

Fig. 17 Efficiency of German heating systems and heat generators



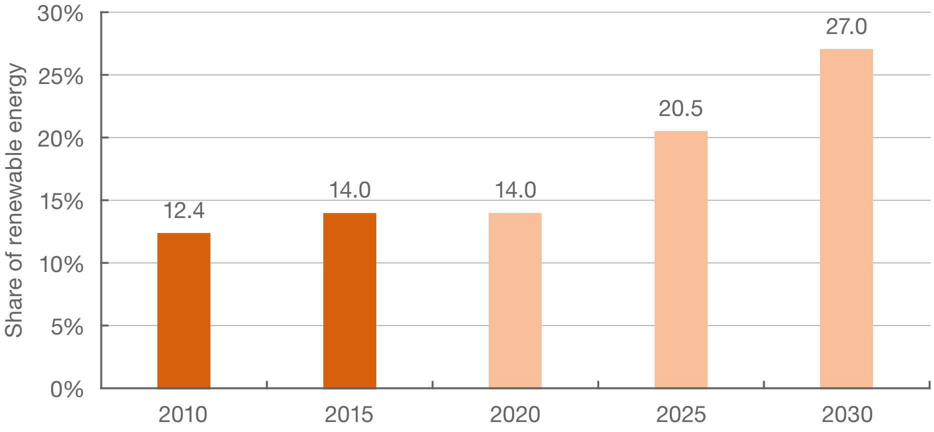
Sources: BDH (2019b), BDH (2019d).

However, even if all heat generators were upgraded and operated at maximum technical efficiency, there would still be potential to further increase efficiency. That's because heat pumps achieve levels of efficiency that simply cannot be reached by conventional fossil fuel-based heat generators (see also Figure 6).[46] Rolling out more heat pumps could unlock more potential.

3. There is too little renewable energy in the heating market.
If energy consumption remains the same, Germany needs to commit to increasing its use of renewable energy to reach the climate goals it envisages. But here again there has been stagnation since around 2012. The short-term goal may well be reached in 2020, but the draft of Germany's Integrated National Energy and Climate Plan (part of the amended Renewal Energy Directive (RED II)) requires a 27% share of renewable energy in the heating sector by 2030. This is double its current share (Figure 18).

[46] Combined heat and power plants (CHP) can also be given the highest energy label of A^{+++} under the EU framework. Under the framework, a factor is applied to electricity generated by CHP plants that can result in them achieving values above 100%. CHP plants are not classed as conventional heat generators for these purposes.

Fig. 18 Share of renewable energy in the heating sector and targets for 2020, 2025 and 2030



Sources: BMU (2007), BMWi (2019a), BMWi (2019d).

In summary, the heating sector offers huge potential for GHG emissions reductions since it accounts for a large percentage of final energy consumption. But so far this potential has barely been realised, with little or no progress on the relevant aspects (reductions in final energy and heat demand, efficiency in conversion to useful energy, renewable energy for heating applications).

Meanwhile, heat pumps are a readily available, mature technological solution that can unlock the heating sector's potential relatively quickly. Heat pumps do not need the vast expenditure required for the energy transition in the transport sector, with its huge investments in rolling out e-mobility in the private and public sectors. The major challenges of increasing efficiency and using renewable energy can be addressed right away with relatively little cost (Figure 19).[47] For the purposes of economic analysis, Figure 19 presents the additional investments required without state funding.

[47] The chart excludes any form of state funding, in order to present the options with as little distortion as possible. In practice, all three options attract state funding, albeit of different kinds: heat pumps are eligible for investment grants, photovoltaic systems are eligible for legally guaranteed feed-in tariffs, and electric cars are eligible for investment grants and tax benefits.

Fig. 19 Comparison of potential climate measures open to private individuals

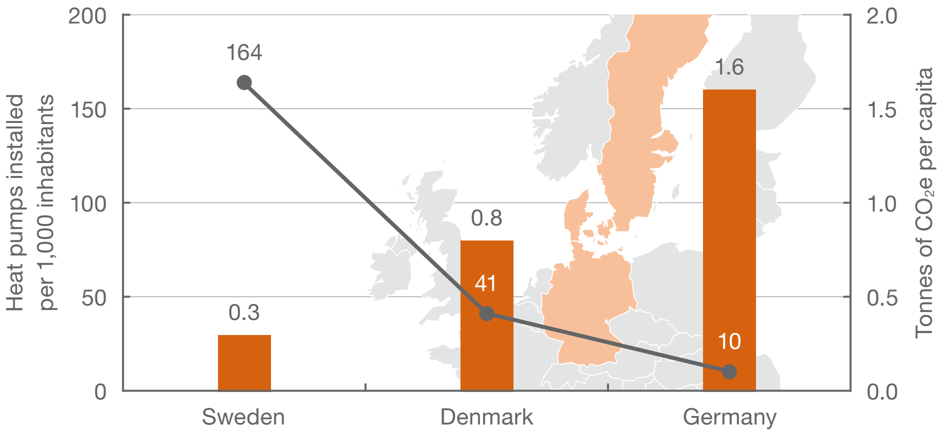
Options for private households to help the climate

	Installing a heat pump instead of an oil-fired boiler	Replace German energy mix with photovoltaic system	Buying an electric car instead of a diesel car
Additional investment	+€6,100	+€13,300	+€7,395
Emissions savings over service life	137 tonnes CO_2e	96 tonnes CO_2e	22 tonnes CO_2e
Cost of saving one tonne of CO_2	€45	€139	€330

Sources: BDEW (2018a), BDEW (2018b), IINAS (2019), VW (2019).

In countries where heat pumps meet a large proportion of the demand for heat, emissions for the building sector tend to be well below those in Germany (Figure 20). Sweden and Denmark lead the way on heat pumps, and emissions in the buildings sector per head of population are just a fifth (Sweden) or half (Denmark) of German levels. This is all the more impressive since the climate in these countries creates a much higher demand for heat. The progress made by these countries suggests Germany would do well to emulate them.

Fig. 20 Key performance indicators for sustainability in the buildings sector in selected EU states



Sources: EHPA (2019b), EUA (2019), Eurostat (2019).

3 Measures in the 2019 climate package are not enough

There are various plans and laws designed to advance action on climate change in Germany. However, the political decisions taken by the 'climate cabinet' in 2019 are likely to fall short of their goal of acting as a stimulus to installing heat pumps, particularly in existing building stock. This is only too clear if we consider performance with respect to the Buildings Energy Act (Gebäudeenergiegesetz, or GEG), the 2030 Climate Action Programme and the 2050 Energy Efficiency Strategy.

Buildings Energy Act

The explicit goal of a "carbon-neutral building stock", which was a key component of the first cabinet draft in 2017, was removed in the 2019 draft law. For new buildings, the level of energy efficiency in the 2016 Energy Savings Regulation (Energieeinsparverordnung, or EnEV), was declared as "nearly zero-energy building". These requirements are not due for increase until 2023 at the earliest. All this, while more energy-efficient designs are usually cost-efficient, particularly because the introduction of carbon pricing represents a major change. Therefore, significant progress on efficiency in new buildings was most likely not achieved.

2030 Climate Action Programme

The compromise of the arbitration panel between federal and state level regarding the 2030 Climate Action Programme is a step in the right direction that should have a particular impact on upgrading current building stock. Although the planned carbon pricing scheme does not reflect the real costs of fossil fuels, the initial CO_2 price of €25/tonne does mean, for example, that the price of natural gas will increase by 0.51 cents/kWh. However, this adds just €51 to an annual gas bill for 10,000kWh, and is still hardly an incentive to switch to a more climate-friendly heating system.

So we will have to wait and see what the amendments to the market incentives programme due on 1 January 2020, or the federal funding scheme for energy-efficient buildings (Bundesförderung für effiziente Gebäude, or BEG) look like and how they will work in tandem with the energy pricing system. Expansion and simplification of the funding programmes could become a key factor affecting the rate of energy efficiency upgrades. The replacement incentive scheme for oil-fired heating systems is a welcome development, although not introducing the ban on new oil-fired systems until 2026 means these climate-damaging systems will continue to be installed for another five years, and will then remain in the building stock for another 20 to 25 years.

2050 Energy Efficiency Strategy

Some parts of the Climate Action Programme have been picked up on in the cabinet decision of 18 December 2019 on the German Government's 2050 Energy Efficiency Strategy. This reaffirms the important role of heat pumps in the energy system of the future, on the grounds that they can be used in "new builds and rebuilds of heat infrastructure to climate-friendly infrastructure integrating renewable energy" as well as "replacing as many fossil fuels as possible with as little electricity as possible" (through sector coupling). The strategy also recognises that heat pumps make for particularly efficient sector coupling in this regard, as can be seen from Figure 11.

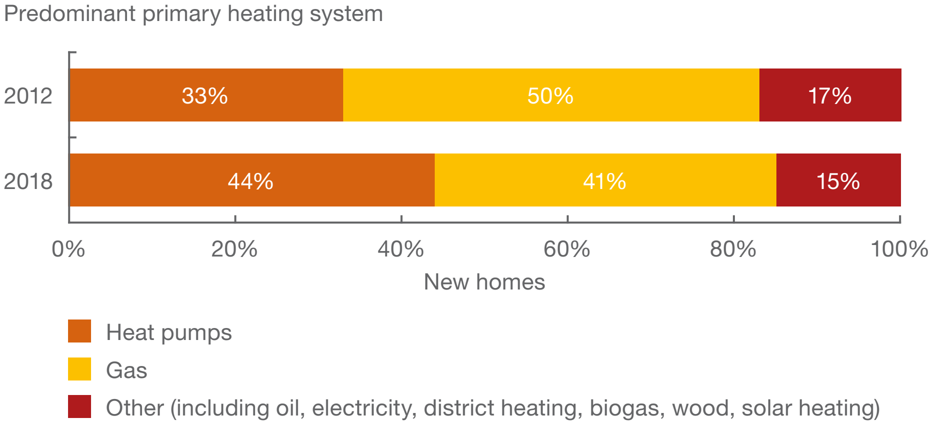
Despite the recognition that GHG emissions in the heating sector have barely decreased over the past ten years and that heat pumps are an attractive solution to this problem, the political changes introduced so far are still rather hesitant and, as a whole, inadequate. This situation is inexplicable, given that other European countries have already managed to put their own heating transitions into practice and the required technical capacity is there. The next chapter therefore looks at the status quo and the opportunities for rolling out heat pumps across Germany, before identifying the obstacles preventing this from happening.

E What potential do heat pumps offer for upgrading existing buildings?

1 Potential of heat pumps in modernising buildings

Heat pump technology has already proved its worth in the new-build sector, with heat pumps included in more planning approvals for new housing than conventional gas heating since 2017 (Figure 21). Raising the requirements for new buildings to the 'KfW Efficiency House 55' standard would almost certainly increase the share of renewable heat generators even more.[48]

Fig. 21 Heating systems in new homes in Germany, 2012 to 2018

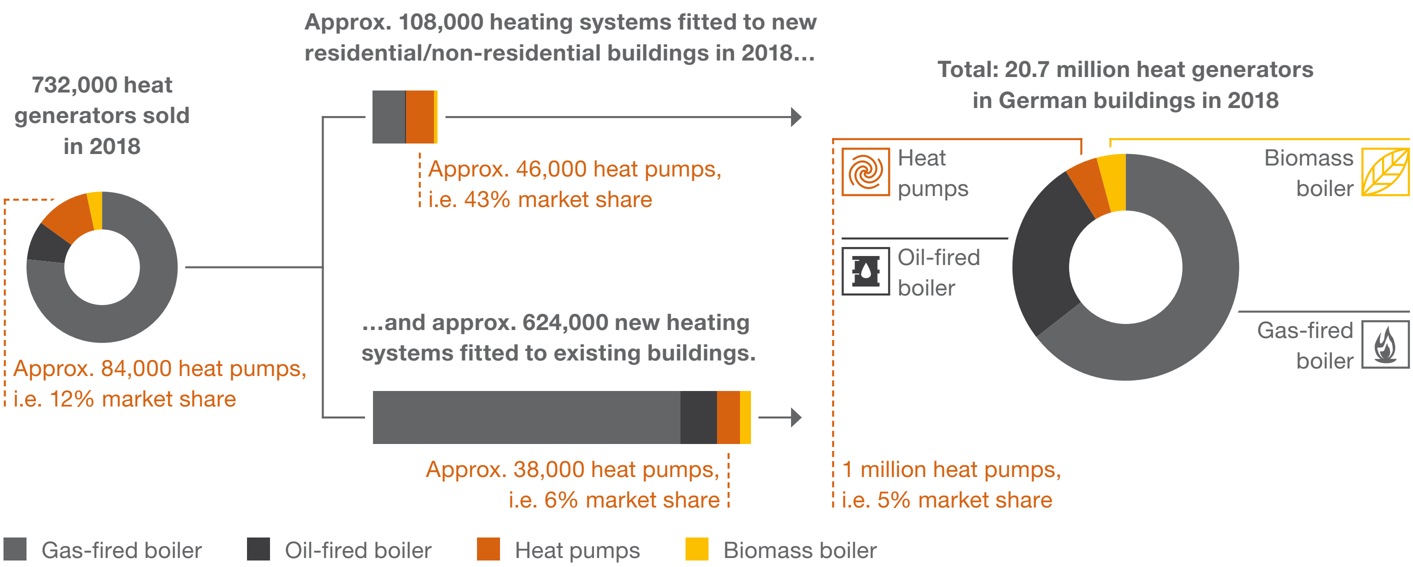


Source: Destatis (2019b).

[48] This is based on "Monitoring der KfW-Programme ‚Energieeffizient Sanieren' und ‚Energieeffizient Bauen' 2017" (2018), compiled by the Institut Wohnen und Umwelt GmbH and the Fraunhofer Institute for Manufacturing Technology and Advanced Materials (IFAM) for the KfW Banking Group. Among 'Efficiency House 55'-rated new buildings funded under the "Energieeffizient Bauen" programme, electricity is already being used to supply heat in 64% of cases, around 20% more than all other homes granted planning permission in 2017 (Figure 21).

However, a look at the climate goals which have been missed reveals that this is not enough, as the majority of new heating systems are replacements for old systems in existing buildings, and heat pumps are considered very rarely in these cases yet (Figure 22).[49]

Fig. 22 Sales and stock of heat generators in Germany



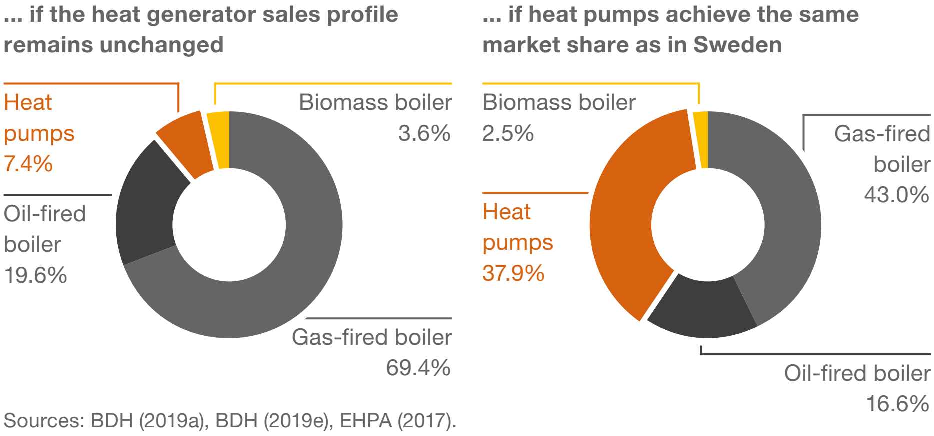
Sources: BDH (2019a), BDH (2019e), Destatis (2019b).

Heat pumps account for just 12% or so of total heat generator sales, with gas-fired condensing boilers forming the vast majority. With this sales profile, the proportion of heat pumps in existing buildings (currently around 5%) would only rise gradually and would remain a niche application (Figure 23).[50]

[49] Diagrams not to scale. Replacement of heating systems in existing buildings: the diagrams only include completed buildings predominantly heated using gas, fuel oil, heat pumps or biomass and they do not include buildings predominantly heated using electricity, district heating, other energy or zero energy; simplified assumption of one heat generator per completed building.

[50] The prospects for 2030 are based on the assumption that 4% of all heat generators will be replaced annually (i.e. service life of 25 years).

Fig. 23 Prospects for heat generator stocks in 2030



Sources: BDH (2019a), BDH (2019e), EHPA (2017).

Having the right framework in place when selecting new heating systems for existing buildings – whether replacing an old appliance or as part of a bigger renovation project – is crucial if we want to make heating more sustainable and less dependent on fossil fuels.[51] We need to act now: the long service life of heating systems (up to 25 years) means there are just two 'natural' points for replacing heating systems in existing buildings between now and 2050. Conventional fossil fuel-powered heating systems installed today are likely to continue operating until at least 2040 and are preventing us from achieving the goals of the energy transition.

20–25 years
The service life of a conventional gas-fired/ oil-fired heating system

This is not only about the long-term goal of (widespread) GHG neutrality by 2050; there are also interim goals for 2020, 2030 and 2040. But simply continuing to replace obsolete fossil fuel-based systems with new ones is making these goals increasingly difficult to achieve. If we carry on installing fossil fuel-based heating systems now, we will need to set ourselves increasingly ambitious targets in the future – for example, targets on the heat pump installation rate – to achieve the GHG reductions required and the heat pump roll-out needed to do this. Deferring the building upgrade programme now so that it culminates in an abrupt replacement of all heating systems and conversion to heat pumps in 2049 would be:

- less effective in terms of climate action, as more GHG emissions would be released to the atmosphere than if we act now and steadily reduce GHG emissions over time;
- uneconomic, as it would mean replacing heating systems that had barely been used;
- unfeasible in technical terms, as the production capacity and skilled personnel required for such a huge replacement programme are not available.

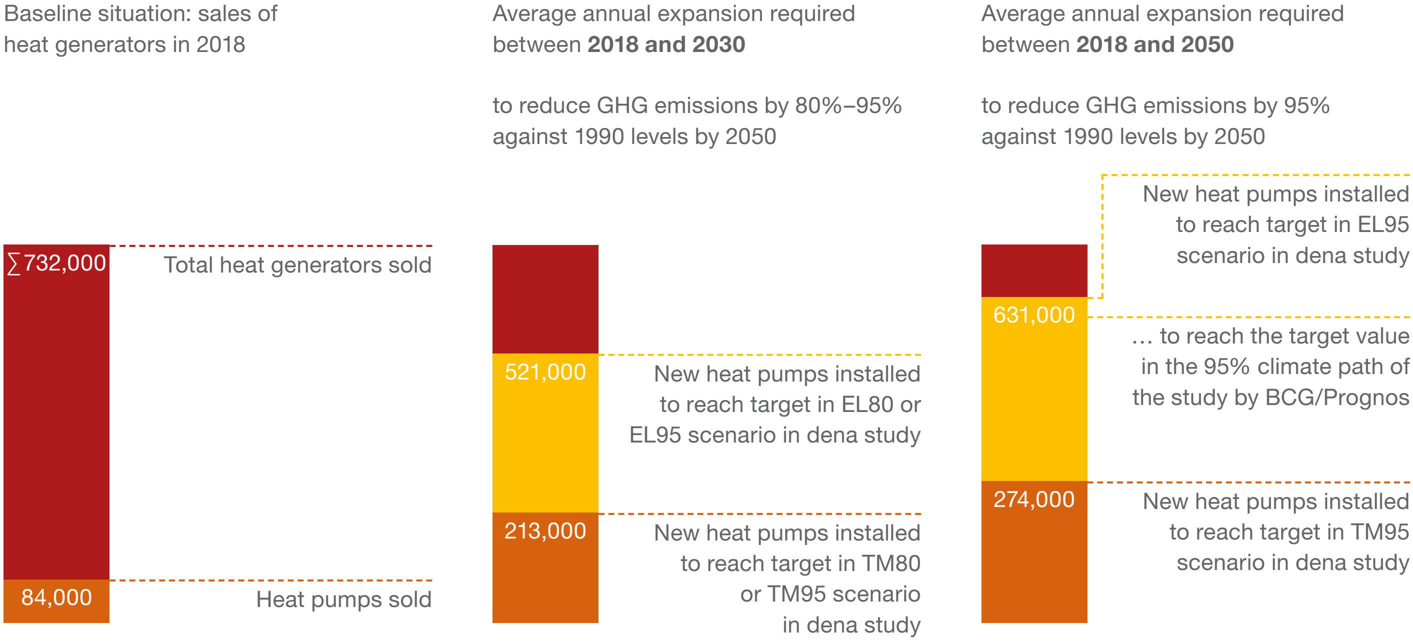
[51] The other option – building more new housing to increase use of heat pumps – is more expensive and less likely to happen.

The 'natural' replacement points will help us make progress towards climate and efficiency goals

The consensus based on scenarios from a wide range of studies is that more heat pumps are needed to achieve the climate goals. Heat pumps will expand their leading market position in new buildings as efficiency requirements are increased, and they will also become the new standard replacement for old boilers in existing buildings in the future.

Depending on the framework conditions and other climate measures, between 3.4 million and 7.1 million heat pumps are expected to be installed in the buildings sector by 2030, rising again to between 7.4 million and 17 million units by 2050.[52] With around one million heat pumps currently installed and around 80,000 added in 2018, the annual installation rate would have to rise to an average of 270,000 to 630,000 appliances to reach the goals for 2050 (Figure 24). And once the number of heat pumps installed has reached 17 million, installations would need to plateau at about 700,000 a year to maintain that figure, assuming a 25-year service life.

Fig. 24 Calculating the annual roll-out required to achieve the target ranges set out above



Sources: BCG/Prognos (2018), BDH (2019a), BDH (2019e), BWP (2020), dena (2018).

[52] The lower figures given for the targets above relate to the TM95 scenario and the upper figures to the EL95 scenario – cf. dena (2018). Both scenarios achieve a 95% reduction in GHG emissions by 2050. This ambitious target for reducing GHG emissions was chosen based on the declaration at the UN Climate Summit in New York to strive for carbon neutrality by 2050 as a long-term goal.

It is clear that the roll-out of heat pumps is proceeding too slowly to achieve any of these targets, and a closer look is required at the current building stock in particular. In light of this, the next section looks at the key considerations for heat pump installations and the specific use cases in which the roll-out can best be achieved.

2 Use of heat pumps in modernization

Principles of heating design (with heat pumps)

Various technical regulations must be met when designing any heating system for buildings, both for new builds and existing buildings. The building envelope, the heat transfer surface area of the radiators, and the flow temperature of the radiators form a triad that, if configured correctly, ensure a comfortable indoor environment even at the lowest outside temperatures (see box).[53]

Of the three parameters in the triad, flow temperature is the most important when installing heat pumps in existing buildings, since heat pumps work more efficiently at lower flow temperatures (low-temperature system). When planning a modernization, you need to strike the right balance between the three parameters from the outset to meet the requirements of the heating transition. When replacing heating systems, you should also remember that large heating areas are necessary – or, at least, recommended – in some circumstances. Conventional radiators with large heat transfer surface areas and underfloor heating systems in particular are designed to operate at low flow temperatures, making conversions to heat pumps feasible from a technical standpoint. Another option is to fit specialised aluminium radiators or fan convector heating.

Many existing buildings, particularly buildings constructed after the introduction of the Third Heat Insulation Regulation (3. Wärmeschutzverordnung) in 1995, are well insulated, so that existing radiators can still meet the heating load at low flow temperatures.

If the maximum heating load in winter is not met after the flow temperature is reduced, the insulation can be upgraded to lower the heating load or larger radiators can be installed (often only in certain rooms) to increase the amount of heat transferred.

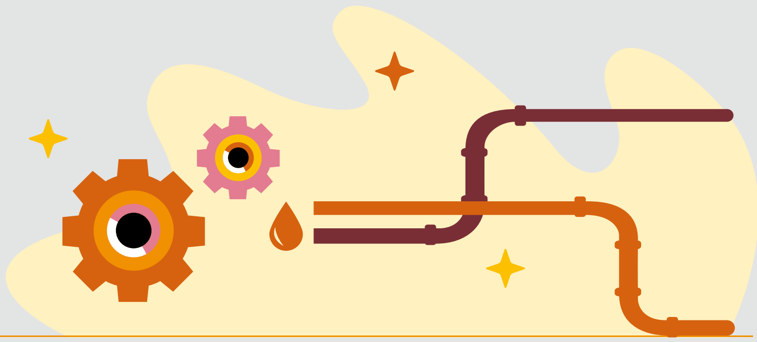
[53] The BWP has provided an online heating load calculator to determine the approximate heating load of rooms and buildings: www.waermepumpe.de/normen-technik/heizlastrechner.

In detail: building insulation, radiator design and flow temperature

The technical design specification of heating systems is based on the heating load in each room of the building. The **heating load** expresses how much heat output is required and must be supplied by the heating system to offset losses of heat to the colder external environment. The heating load will depend on the **building insulation** as well as the size of the building, as better-insulated buildings emit less heat to the environment.

The **radiators** installed must then be able to meet the heating load. Radiators with larger heat transfer surface areas and higher operating temperatures **(flow temperature)** produce more heat. This means that a radiator can emit the same amount of heat at a lower flow temperature if its heat transfer surface area is increased to compensate.

A prime example of this is underfloor heating that operates at a flow temperature of just 35°C to 40°C (depending on the design) but still supplies enough heat output for a comfortable living environment in winter. Older radiators with smaller heat transfer surface areas, on the other hand, need a flow temperature of between 55°C and 65°C.



Installing bigger radiators does not necessarily reduce the available space in a room, as they can take the form of wall heating or ceiling heating systems. Regardless of whether a heat pump is actually used, these types of surface heating (underfloor heating, wall heating or ceiling heating) offer a higher level of comfort. This is because heat transfer occurs predominantly by thermal radiation across a much larger area, instead of by convection to the passing air as with conventional radiators.

And insulation will soon need to be upgraded whatever heating system is used. The forthcoming carbon pricing policy will have a particularly severe impact on poorly insulated buildings heated by fossil fuels, with their high heating requirements and energy consumption to match. So there are many reasons to improve insulation, whether it is to use low-temperature systems powered by renewable energy, or reduce cost increases with fossil fuel-based heating systems.

If improving the building envelope – perhaps by fitting floor/ceiling insulation or replacing some windows – or replacing the radiators is not an option in an existing building, high-temperature heat pumps designed for flow temperatures of up to 70°C may be used. Other options are hybrid or bivalent systems where a heating element or a conventionally fired peak load boiler kicks in when maximum load is required.

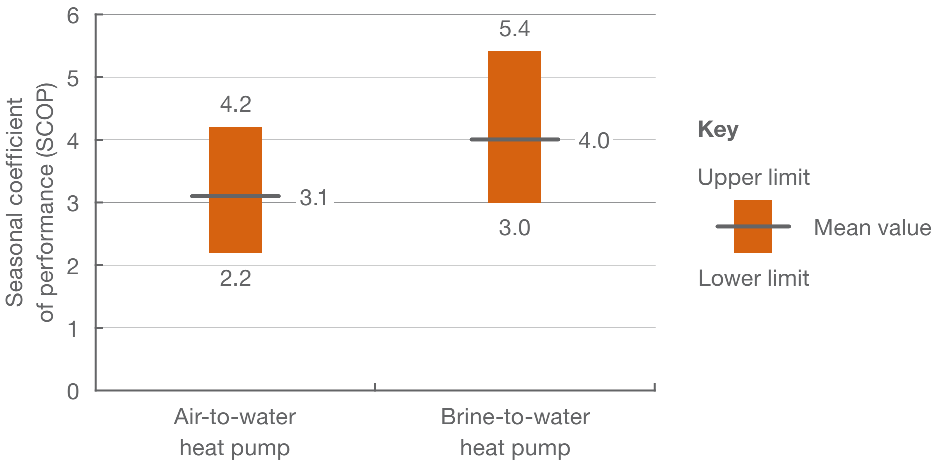
Lack of information or prejudice often stops people from considering heat pumps as an option when choosing a new system to install in existing buildings, even though they would be feasible solution from a technical standpoint. This challenge can be addressed with targeted information campaigns and by educating homeowners, energy consultants and installers.

Heat pumps achieve high efficiency levels in existing buildings, too

The precise SCOP achieved when a heat pump is operating will depend mainly on the necessary temperature difference between ambient heat and flow temperature. The SCOP can be increased by accessing ambient heat at higher temperatures (in the ground, for example) or reducing the flow temperature of the heating system (see above).

The field measurements taken by the Fraunhofer Institute for Solar Energy provide a good summary of SCOP levels achieved in real life. They were taken over various periods from a large number of appliances across several projects (Figure 25). The results show that the SCOP varies from property to property, and the variations can sometimes be very large.

Fig. 25 Seasonal coefficients of performance measured in Fraunhofer ISE research projects



Source: Fraunhofer ISE (2018): "WP Monitor".

But lower SCOPs do not indicate poor-quality equipment. The SCOP is actually a measure of the system's efficiency which accounts for a wide variety of factors such as temperature required, weather conditions and user behaviour. In Germany, even a heat pump with a SCOP of less than 2 is still more environmentally friendly than a natural gas-fired condensing boiler (see also Figure 7). All of the heat pumps measured by the Fraunhofer Institute were above this threshold.

The results of the measurement series in realistic use cases also show how SCOPs have improved due to advances in heat pump technology over time. It is important to note that research and development is far from over in the heat pump sector, and that providers will continue to improve system efficiency.

Building classes and potential emission reductions in the housing sector

Despite the potential technical obstacles that may still have to be dealt with, it is worth analysing the current German housing stock in more detail to gain an idea of the potential in the buildings sector as a whole. Classifying housing stock by building type and year of construction will help to assess the potential for renovation and climate measures: this information can provide an indicative measure of how energy efficient the building stock currently is, as well as the investment and priorities required to accelerate the process of upgrading to current energy efficiency standards.

Figure 26 shows the German housing stock with years of construction up to and including 2017. The years of construction are shown in classes in accordance with the First Heat Insulation Regulation of 1977 and the Third Heat Insulation Regulation of 1995. Both of these regulations led to significant changes in the efficiency levels of new buildings. The residential floor space, typical annual final energy consumption per m^2 and typical distribution of energy sources are used to estimate the annual GHG emissions of each category of housing.[54]

Around a third of total emissions come from single-family houses built before 1979. Another third of emissions come from terraced houses and apartment buildings built in the same period. That leaves just a third of emissions from other types of housing, with an almost equal split between those built between 1979 and 1994 and those built since 1995. This is due in part to the numbers and sizes of buildings, but also the age of the building materials and the tendency for them to have older heating technology installed. Relatively old single-family houses offer huge potential for heat pump installation, sometimes in combination with other efficiency measures such as insulation. At the same time, this is where there is the greatest risk of conventional heating systems being installed when the heating system is replaced, unless the framework conditions change (see start of chapter).

So raising awareness of heat pump options could increase the use of heat pumps in the course of the modernization of buildings in the near future. Homeowners stand to benefit from the right framework conditions, whether or not heat pumps end up being installed. Changes of this kind would also help achieve the 2% annual rate for upgrading to current energy efficiency standards envisaged by the German Government.

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[54] The chart below shows emissions from residential buildings as 92.9 million tonnes of CO_2e. These emissions form part of the emissions for the buildings sector, which comprise 132 million tonnes of CO_2e (Figure 14). The buildings sector comprises the trade, commerce and services sector in addition to residential buildings. Since non-residential buildings in the trades, commerce and service sector are not included in this evaluation, the potential emission reductions shown are minimum values.

Fig. 26 Approaches for unlocking the potential of German housing stock with heat pumps

Year of construction

Type of housing	Before 1979	1979–1994	Since 1995
SFH	34.3 million tonnes CO_2e	9.2 million tonnes CO_2e	6.0 million tonnes CO_2e
TH	10.8 million tonnes CO_2e	3.6 million tonnes CO_2e	2.9 million tonnes CO_2e
AB	18.4 million tonnes CO_2e	3.8 million tonnes CO_2e	3.8 million tonnes CO_2e

Approach 1:
point out long-term costs to property owner, link with the fact that the building will soon need an energy efficiency upgrade anyway

Approach 2:
Serial modernization for quicker implementation and cost benefits

- Optimum conditions for installing a heat pump (ideal for year of construction and type of housing)
- Good conditions for installing a heat pump (ideal for year of construction or type of housing)
- Variable conditions for installing a heat pump (examine on case-by-case basis)

Sources: BDEW (2017), BMWi (2019b), Destatis (2016), Destatis (2019a), Destatis (2019b), IWU (2015), UBA (2019a), UBA (2019b).

From a purely technical standpoint, single-family houses and terraced houses built in or after 1995 are particularly suitable for having heat pumps installed. This is partly because installing heat pumps does not require major building work (see section above with the basic concepts), but also because their heating systems will have to be replaced in the next few years in any case, based on a 25-year service life. Since these buildings are often owner-occupied, installing a new system benefits the owner directly by making the building more comfortable to live in and reducing its energy costs. It is also much easier to carry out new installations involving just one or two households than an entire apartment block.

So heat pump solutions can be readily implemented in single-family houses and terraced houses built between 1979 and 1994, and in apartment buildings built since 1995 as this is where the conditions are optimal, either in terms of feasibility, occupant approval or technical considerations. Carrying out modernizations in series, as with the Energiesprong approach from the Netherlands,[55] is particularly suitable for terraced houses and apartment buildings of any age as they use a standard model to make a large number of relatively similar alterations to the buildings. This allows the upgrades to be completed more rapidly and at a lower cost.

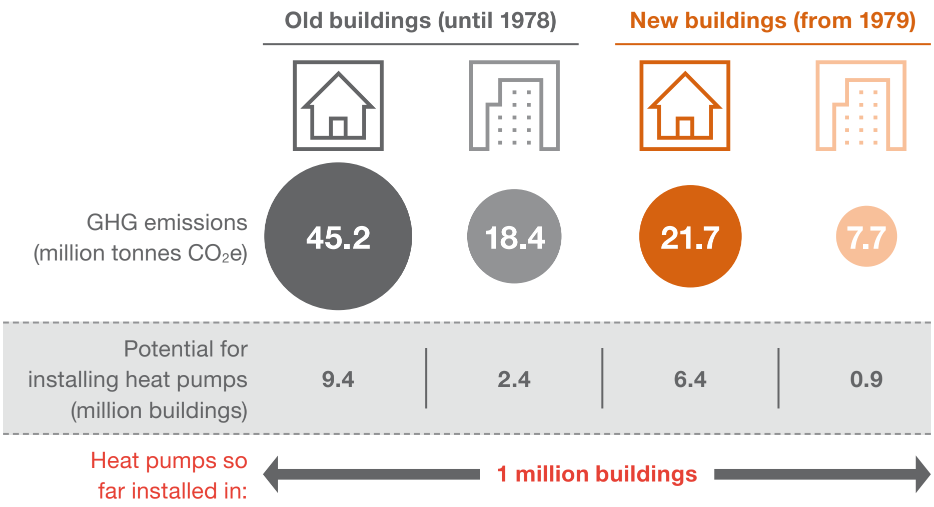
It is clear that the considerable potential for heat pumps in current buildings is sometimes not fully utilised due to lack of information, and sometimes because they are not seen as cost-efficient. Raising awareness among stakeholders would be one way to address this. People also tend not to factor in cost efficiency across the whole service life of heating equipment when selecting a new system. A price structure that still favours gas-fired heating systems, for example, may change if more attention is paid to emissions, and so a decision based purely on current prices could turn out to be disadvantageous, particularly in view of the imminent roll-out of the carbon pricing system. This prospect is particularly relevant for owners of buildings built before 1979: installing a heat pump when upgrading the building envelope or heating system, perhaps in combination with a photovoltaic system, can make the building more self-sufficient in terms of energy and less affected by external energy prices, increasing the property value in the long term.

We can roughly summarise the heat pump situation and its potential in the housing sector as follows (Figure 27): there are currently around 1 million heat pumps installed in around 19 million residential buildings.[56] While more than 7 million heat pumps could be installed in the newer buildings (from 1979 or later), the vast majority (over two thirds) of GHG emissions come from pre-1979 buildings. It is these buildings in particular where there is medium- and long-term potential for making them more climate friendly by upgrading them to modern energy efficiency standards and replacing heating systems.

[55] Energiesprong is one way of standardising modernizations to current energy efficiency standards. It is a model from the Netherlands where series of renovations are carried out to modernize buildings quickly, sustainably and affordably to the point where the energy they generate is equal to the energy they need across a year (net zero standard).

[56] According to the BDH, 1 million heat pumps had been installed in Germany as of 2018. However, these heat pumps are spread across residential buildings, non-residential buildings and in some cases process heat supply in industry, so the 1 million figure should be seen as a maximum for the housing sector alone.

Fig. 27 German housing stock by building type, year of construction and GHG emissions – summary



Sources: BDEW (2017), Destatis (2016), IWU (2015), UBA (2019a), UBA (2019b).

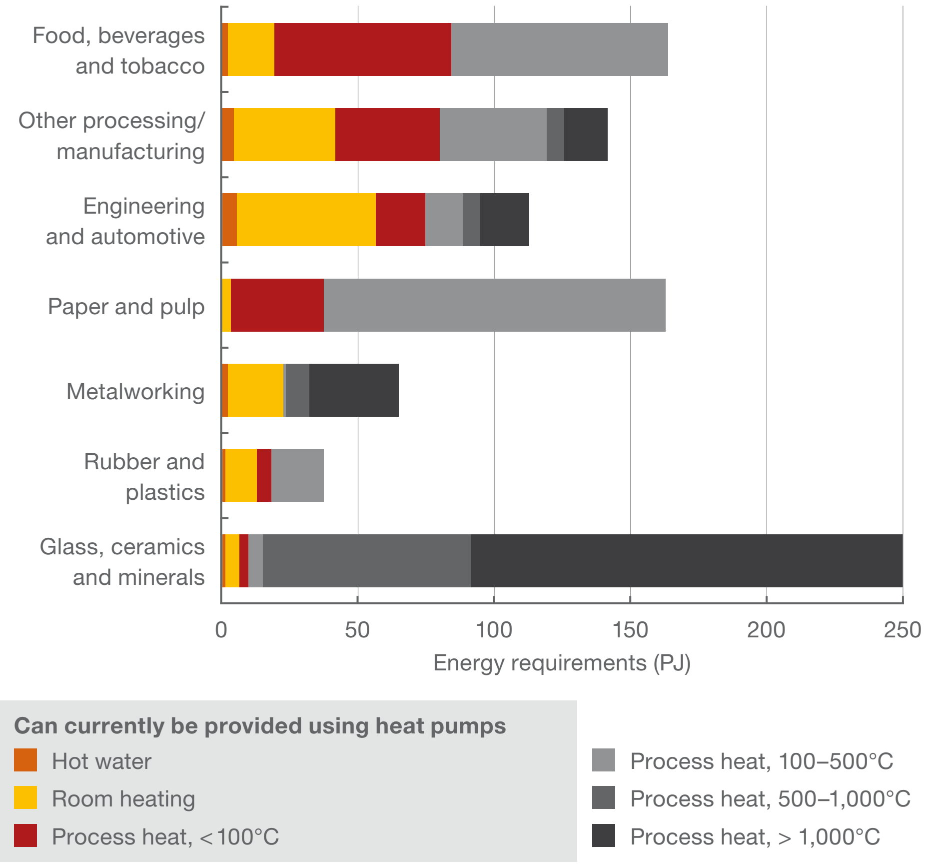
3 Potential for the industrial sector, too

It's not just the housing sector (and non-residential buildings, which are covered by similar criteria as in the previous section) where heat pumps can be used as a climate-friendly heating option. They can also be used in systems to provide room heating, hot water and process heat in the manufacturing and industrial sectors. The industrial sector alone has a final energy demand of around 2,700 petajoules (PJ), just under 30% of Germany's entire final energy demand.

Although heat pumps are less suitable for high-temperature applications in the chemicals, glass, ceramics and metals industries, they are well placed to supply low-temperature heat (< 100°C). This type of application accounts for around a fifth of industrial heat demand.[57] Systematic use of heat pumps to supply this type of heat in the industrial sector would achieve GHG emissions savings equivalent to around 18 million tonnes of CO_2e (Figure 28).[58]

[57] Cf. ifeu/ DLR (2010): Prozesswärme im Marktanreizprogramm.
[58] The analysis focuses on the direct GHG emissions from burning fuels to supply heat in the industrial sector. It does not include indirect GHG emissions from upstream processes (electricity generation, district heat generation).

Fig. 28 Energy demand for heating applications by industry and temperature level, 2017



Sources: Destatis (2019c), Fraunhofer ISI (2019), ifeu/DLR (2010), UBA (2019a).

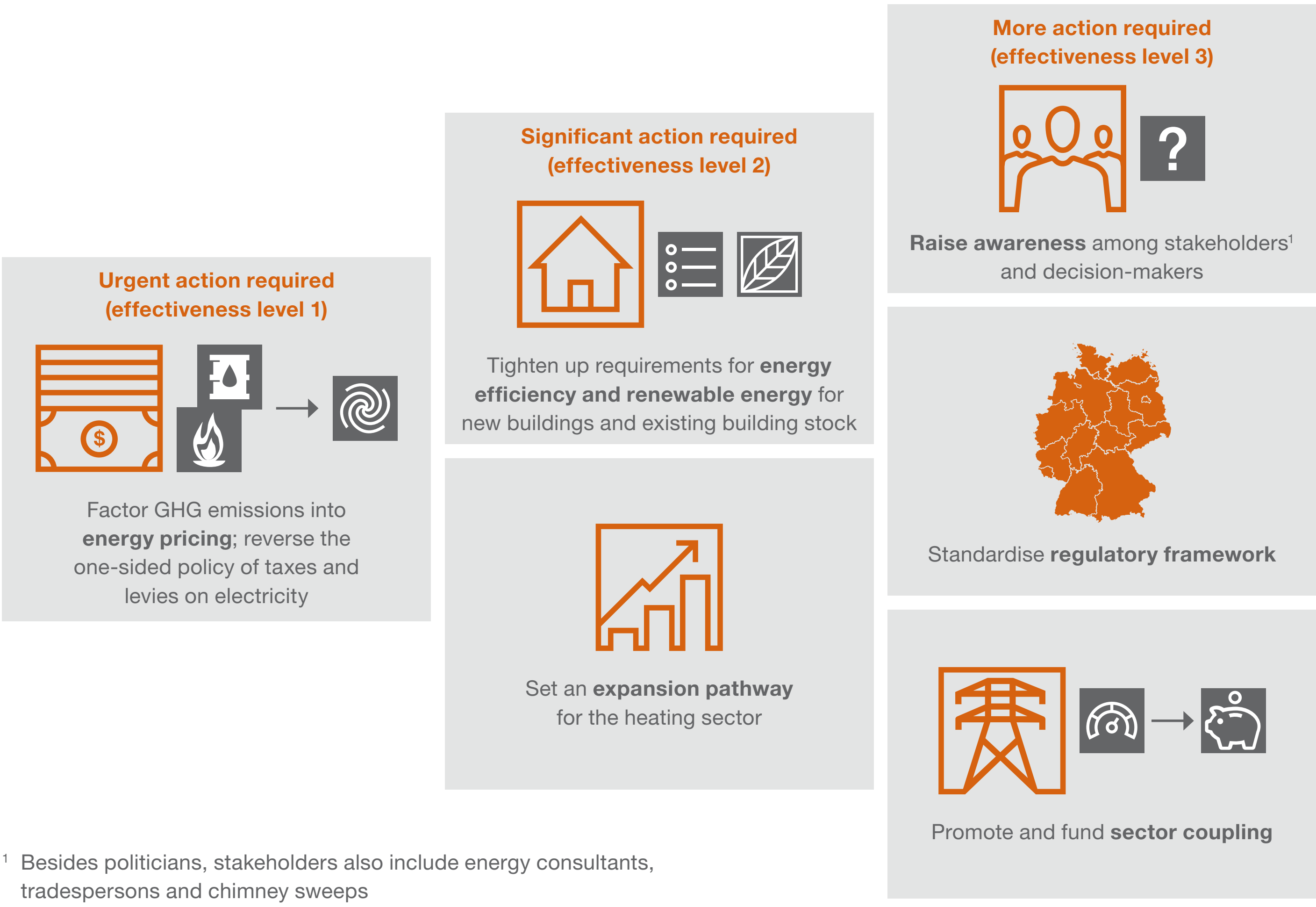
Heat pumps are already being used in industry for processes up to 100°C. In principle, the technology is also suitable for higher temperatures (up to 200°C).

There are therefore many arguments for extensive deployment of heat pumps: the technology is mature and readily available, with a diverse range of potential uses; action is clearly needed; there is huge potential for a roll-out. The following chapter looks at why – in Germany, at least – take-up is still low.

F What measures can be taken to expand the domestic heat pump market?

There are a number of adjustments that could be made to achieve the roll-out of heat pumps that is so clearly useful in terms of industrial policy, and essential for climate policy and energy policy, respectively. A number of options are set out below, sorted by effectiveness. The diagram below summarises the actions required.

Fig. 29 Action required for a successful energy transition in the heating sector



[1] Besides politicians, stakeholders also include energy consultants, tradespersons and chimney sweeps

1 Factor GHG emissions into energy pricing

The regulatory framework is the biggest challenge facing low-emission heating technologies. This relates particularly to how energy prices reflect emissions and pollution. The prices for natural gas, fuel oil or electricity used to produce heat do not take into account the level of emissions they cause. As a result, the prices do not incentivise the use of low-emission energy sources.

Heating systems that burn fossil fuels – whether fuel oil or natural gas – create far more emissions per kWh of heat than heat pumps and therefore have a higher GHG emission factor. For example, the emission factor of an oil-fired heating system is three times higher than a heat pump operating with the current power generation mix, a large proportion of which is generated using renewable energy. As the share of green electricity rises in future, the difference in emission factors will grow even larger.

So far, energy prices for users of heating systems do not take account of the GHG emission factor. Running a heating system on fuel oil or natural gas costs 6 to 6.5 cents per kWh. A heat pump obtains reduced-rate heat pump electricity at around 22 cents per kWh. Because heat pumps are highly efficient (SCOP of around 3.5), the effective reference price is also around 6 to 6.5 cents per kWh.

This means that the price is the same for all three options, despite the huge differences in the levels of GHG emissions, which is clearly contrary to climate policy as it makes it far cheaper to emit a given amount of greenhouse gases by burning fuel oil or natural gas than by using electricity. The cost of emitting one tonne of GHGs using fuel oil is around €220. The cost of emitting one tonne of GHGs using electricity is around €430, nearly twice as much. The carbon price planned under the Climate Action Programme – €55 per tonne of CO_2 in 2025 – is nowhere near enough to create a pricing structure that is equitable in climate terms for all energy sources used for heating. GHG prices would need to be between €150 and €200 per tonne of CO_2e in the short term to correct the current differences in costs.

It is important to note here that the price of electricity includes both the EEG levy and (via the commodity price) the GHG costs of power plants under the EU Emissions Trading Scheme. For natural gas and fuel oil, however, GHG emissions are not priced in, either directly or indirectly. This is one of the reasons why using fuel oil or natural gas heating is cheaper than using a heat pump. As the share of wind and solar power increases, price differences for emissions in the heating sector will increase further by 2030. This is because increasing the share of renewable energy reduces emissions in the electricity sector, but this does not necessarily reduce the price to the consumer. Meanwhile, natural gas and fuel oil emissions remain constant.

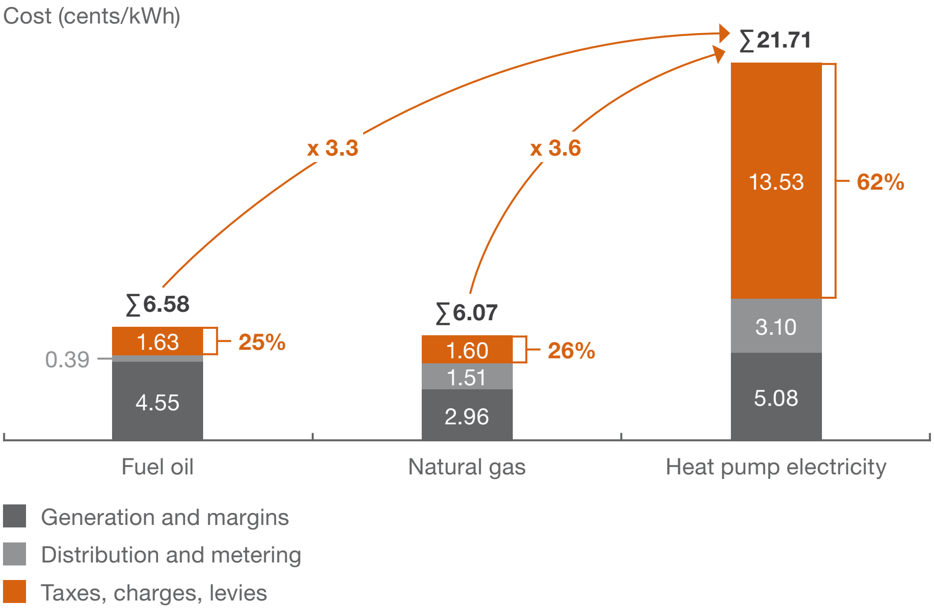
At present, households therefore have no financial incentive to switch to a low-emission energy source for their heating such as electricity, or to a lower-emission heating technology such as a heat pump. Action is therefore required to make it economically sensible to use lower-emission, electrically powered heating systems in all building types.

Recommendation 1 for the domestic heating market: a system of charges for all technologies and energy sources based on their actual emissions/emissions intensity. The planned carbon pricing system is a step in the right direction, but is not enough to ensure actual emissions are fully factored in.

2 Reverse the one-sided policy of taxes and levies on electricity

Energy price components include not only the actual costs of generation and distribution, but also significant levels of taxes, levies and charges (Figure 30). However, when solely looking at net costs of generation, distribution and metering, electricity is on a level that is comparable to fuel oil and natural gas.

Fig. 30 Breakdown of consumer prices for energy sources used for heating



Sources: BNetzA (2019), IWO (2019).

In Germany, fuel oil and natural gas are subject to lower taxes and levies than electricity when used as heat energy sources. The reason for this is that the costs of the energy transition have mainly been passed on to the price of electricity; hardly any have been passed onto fuel oil or natural gas. Funding for the energy transition is obtained from levies under the EEG and the Combined Heat and Power Act (Kraft-Wärme-Kopplungsgesetz, or KWKG). Large-scale power plants also pay GHG levies under the Emissions Trading Scheme and directly pass on these costs via wholesale prices, directly affecting their customers. Consumers in industry and manufacturing who require large amounts of electricity, or who operate competitive, energy-intensive processes, can also reduce the taxes and levies they pay. The costs of these privileges are passed on to the electricity price for all other consumers – households and other clients in the manufacturing sector. This increases the standard electricity price even more.

The outcome of all this is a price for heat pump electricity that is three times the price for fuel oil or natural gas. This means that the energy transition in the electricity sector is progressing at the expense of the energy transition in the heating sector.

Recommendation 2 for the domestic heating market: shift the costs of the energy transition in the heating sector from electricity to fuel oil and natural gas. The failure to consider climate compatibility when setting charges and exemptions for the different energy sources is impeding the restructuring of the German energy system, as fuel oil and natural gas are only subject to negligible government charges.

Recommendation 1 (GHG components factored into energy prices) and recommendation 2 (removing charges on electricity prices) are both aimed at creating an energy pricing structure that is more in line with climate policy and will automatically act as an incentive to switch to more climate-friendly technologies. Germany still has a long way to go here, as the indirect pricing of GHG emissions at €150 to €200 per tonne of CO_2e for electricity is higher than for fuel oil and natural gas. The country could come closer to reaching this goal by increasing the price of fossil fuels, reducing the price of electricity, or a combination of the two.

Fig. 31 Difference between full annual costs of gas heating and a heat pumpin €

Reduction of electricity price...

Current status | … 0.625 cents/kWh net | … 2.08 cents/kWh net | … 3.42 cents/kWh net | … Entire EEG levy removed

Charge on price of natural gas
(GHG price in €/tonne CO_2e)

10 | 25 | 35 | 55 | 60 | 65 | 100

−595	−541	−487	−432	−378	−324	−270	−215	−161	−107
−534	−479	−425	−371	−317	−262	−208	−154	−100	−45
−472	−418	−364	−309	−255	−201	−147	−92	−38	16
−411	−356	−302	−248	−194	−139	−85	−31	23	78
−349	−295	−241	−187	−132	−78	−24	31	85	139
−288	−234	−179	−125	−71	−17	38	92	146	200
−226	−172	−118	−64	−9	45	99	153	208	262
−165	−111	−56	−2	52	106	161	215	269	323
−103	−49	5	59	114	168	222	276	331	385
−42	12	67	121	175	229	284	338	392	446

Range originally planned in 2030 Climate Action Programme

CO_2 price range:
€10–€60/tonne CO_2

Reduction in EEG levy:
0.25–0.625 cents/kWh

Currently being discussed:

CO_2 price range:
€25–€65/tonne CO_2

Reduction in EEG levy:
2.08–3.42 cents/kWh

The analysis looks at partial renovation of an existing single-family house, including replacement of an obsolete gas-fired boiler. 35% of the heat pump costs (brine-to-water geothermal heat pump) are funded under the Market Incentive Programme, revised in early 2020 and run by the Federal Office for Economic Affairs and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, or BAFA). Negative figure in red = gas-fired condensing boiler is cheaper; positive figure in yellow = heat pump system is cheaper.

Sources: BDEW (2017), BDEW (2018a), BDEW (2018b), BNetzA (2019).

Figure 31 shows the difference in costs between conventional gas heating and a climate-friendly heat pump for an existing single-family house.[59] Each box in the grid shows the difference in heating costs when the energy price is changed (increasing carbon price, removing charges on electricity price). Installing a heat pump is only more cost-effective than installing gas heating if the regulations under the Climate Action Programme are tightened – and even then, only after 2025 (orange box). The key thing now is to ensure that improved regulatory measures of this nature are perpetuated and reinforced to benefit climate-friendly technologies. The goal should be to enable the relevant decision-makers to invest with certainty. It must be clear to customers that their initial investment in a heat pump may be higher, but it will pay off in terms of lower running costs.

[59] The analysis looks at partial renovation of an existing single-family house, including replacement of an obsolete gas-fired boiler. 35% of the heat pump costs (brine-to-water geothermal heat pump) are funded under the Market Incentive Programme, revised in early 2020 and run by the Federal Office for Economic Affairs and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, or BAFA). Negative figure in red = gas-fired condensing boiler is cheaper; positive figure in green = heat pump system is cheaper.

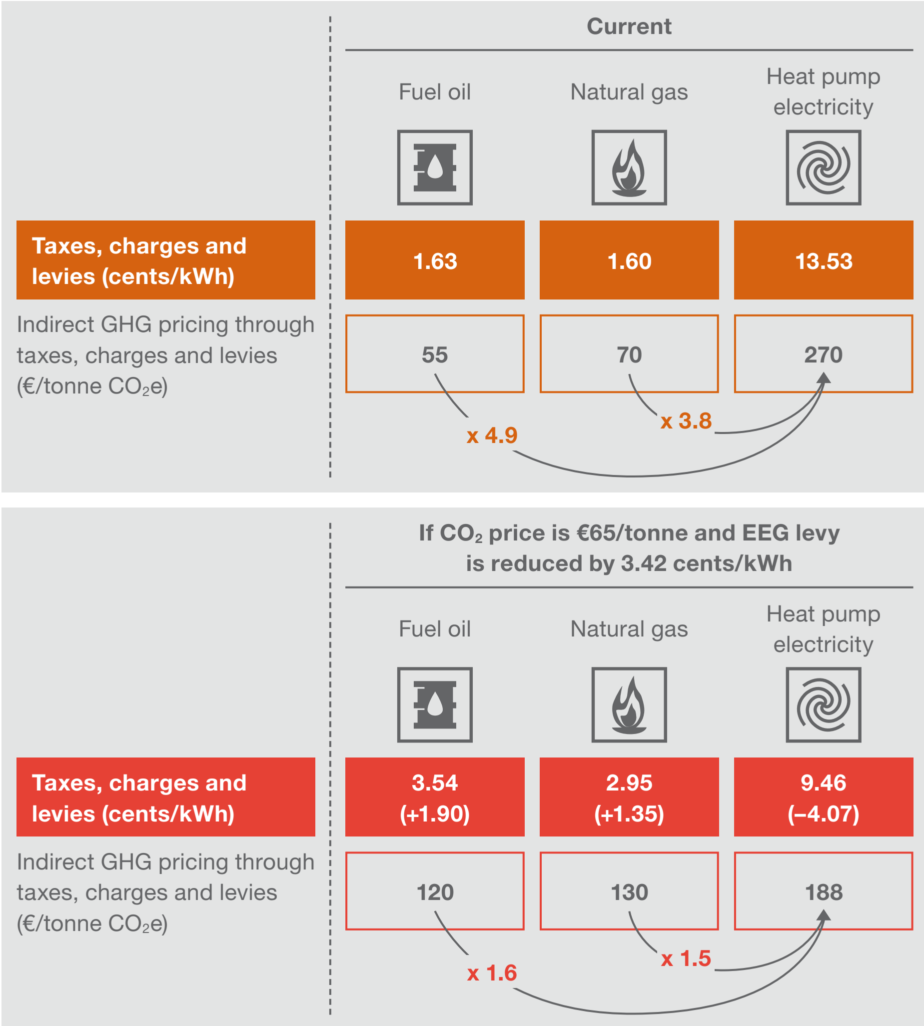
The ambitious carbon pricing route decided on by the arbitration panel and the reductions in the EEG levy worked out by the Federal Ministry of Finance should therefore be enshrined in law as soon as possible. As the diagram above makes clear, heat pumps will only be competitive if the triad of investment incentives, carbon pricing and removal of charges on electricity prices is implemented effectively. Reverting to the measures originally planned in the 2030 Climate Action Programme would not be enough to ensure the heating transition (grey box).

As Figure 32 shows, the planned change to the energy pricing structure (€65/tonne CO_2, EEG levy reduced by 3.42 cents/kWh) still does not make heat pump electricity less burdened with taxes, charges and levies than fuel oil and natural gas. At present, taxes, charges and levies on heat pump electricity are 4.9 times those on fuel oil and 3.8 times those on natural gas when put into relation with the respective GHG emission factors. The planned changes would reduce these factors to 1.6 and 1.5 respectively, but they are still greater than 1. At a factor of 1, the charges would be directly proportionate to the GHG emissions involved, which would further demonstrate the benefits of heat pump technology.

The price of €25 to €55 per tonne of CO_2 specified for 2021 to 2025 by the German Government under the 2030 Climate Action Programme is inadequate for these purposes. A GHG price of €50 to €100 per tonne of CO_2e would reflect the spread of costs to Germany if the country were to miss its legally binding climate protection goals and be forced to buy emission allowances for the non-ETS sector from other EU member states.[60] The German Government's plan to limit the costs to the public by watering down climate legislation will be ineffective if the changes required to reduce GHG emissions are omitted and taxpayers end up indirectly paying for purchasing emission allowances from other countries – perhaps at even higher prices.

[60] The €50 to €100 price range per tonne of CO_2e referred to above is based on "Die Kosten von unterlassenem Klimaschutz für den Bundeshaushalt – Die Klimaschutzverpflichtungen Deutschlands bei Verkehr, Gebäuden und Landwirtschaft nach der EU-Effort-Sharing-Entscheidung und der EU-Climate-Action-Verordnung" (2018) by Agora Energiewende and Agora Verkehrswende.

Fig. 32 GHG-related taxes, charges and levies on energy sources



The carbon prices in this diagram do not take account of any related increases to VAT that may be made. As VAT on electricity is calculated based on its price including the EEG levy, the impact of VAT has been included in the scenario in which the levy is reduced.

Sources: BDEW (2017), BDEW (2018a), BDEW (2018b), BNetzA (2019), IINAS (2019), IWO (2019).

3 Tighten up requirements for energy efficiency and renewable energy for new buildings and existing building stock

Tightening up requirements on energy efficiency and the use of renewable energy will help to increase the number of heat pumps used, which will provide a positive, long-term stimulus to German energy supplies in terms of security of supply, environmental compatibility and affordability. This meets the requirements of the energy policy triad (see Chapter C). Heat pumps are also a future-proof solution that can keep pace with any future developments on emissions reduction targets.

The efficiency of a heating system is important, and not just in terms of expected heating costs. Statutory requirements for new buildings and renovation/ upgrading of existing buildings also affect which heating system is selected. Heat pumps meet these requirements, as contained in regulations such as the current EnEV. All new homes in Germany will also have to meet a 'nearly zero-energy building' standard from 2021 onwards.[61]

Recommendation 3 for the domestic heating market: consider extending the mandatory minimum quota of renewable energy for modernizations of the existing housing stock.

Consideration could be given to extending mandatory renewable energy quotas by setting a minimum percentage for heat from renewable sources or a renewable energy-based heat network. Germany could follow the pioneering example of Denmark and the Netherlands and set up an incentive scheme so that heating systems based purely on fossil fuels are systematically forced off the market.

The public sector could also set an example to other sectors in terms of the heating transition. One way of doing this could be to require any heating solutions installed in new buildings and large-scale renovations to match or exceed heat pump quality standards in terms of emissions. The German Government announced in the 2030 Climate Action Programme that it would be issuing an order requiring renovations to federal buildings to meet the 'Efficiency House 55' standard.

[61] Cf. Article 9 of Directive 2010/31/EU of the European Parliament and the Council of 19 May 2010 on the energy performance of buildings.

4 Set an expansion pathway for the heating sector

The Government has pressed ahead with the expansion of renewable energy in the electricity sector with a clear strategy and long-term goals. This is a crucial step where long-term investments and new technologies are concerned. Investments in the heating sector are also long-term and also involve launching new technologies on the market, or increasing the use of these technologies. As a result, a rigorous, transparent strategy also needs to be developed and communicated for the heating sector. This would promote the roll-out of heat pumps and provide the security that homeowners, tenants and investors need.

Scenarios outlined in relevant studies from the energy industry assume that between 3.4 million and 7.1 million heat pumps need to be in use in 2030 in order to meet climate goals. To achieve this, annual heat pump sales need to be increased from the current figure of 80,000 units to an average annual rate of 210,000 at least – and preferably 520,000. If the upper limit was achieved, heat pumps would become the climate-friendly standard technology for heat generator sales, which have numbered around 700,000 units per year in recent years (see Chapter E).

An expansion in heat pump sales would lead directly to an immediate increase in the use of renewable energy, as heat pumps make use of ambient heat. And where installing a heat pump makes it economically viable to install a photovoltaic system or other systems for generating regenerative electricity (by increasing self-consumption, for example), rolling out heat pumps will also indirectly increase renewable energy as a percentage of the power generation mix.[62] This would therefore address two climate policy goals at the same time.

Recommendation 4 for the domestic heating market: review options on a pathway for expanding heat pump use. The current funding programmes operated by the Federal Office for Economic Affairs and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, or BAFA) and the Kreditanstalt für Wiederaufbau (KfW) could be formally linked to an expansion pathway defined by legislation, as with funding for photovoltaic systems under the EEG.

[62] Self-consumption of self-generated, regenerative electricity from new systems under the EEG and legacy systems outside the EEG funding period in place of using electricity from the grid is more attractive in financial terms than feeding electricity into the grid under the EEG feed-in tariff. Increasing self-consumption levels thus improves the profitability of operating these systems.

The funding would fall at a defined monthly rate for as long as the number of heat pumps rises in line with the expansion path. If numbers fall below the path, this fall in funding is stopped; if they rise above it, funding falls at a higher rate. This allows the expansion to proceed cost-effectively without being over-funded. Under the EEG scheme, this approach has achieved significant reductions in the cost of manufacturing renewable technology as well as a considerable increase in its share of the power generation mix.[63]

One way of removing entry barriers for potential operators and thereby facilitating the achievement of the expansion pathway would be to factor the positive effects on GHG emissions into funding programmes, as part of the restructuring of funding programmes under the Climate Change Act. This would make any measures that bring about a reduction in GHG emissions eligible for funding since any such reduction in emissions, however small at the outset, would increase further with a greener power generation mix. And since consumers will want to run their new heat pumps profitably, a lower bound for the SCOP of installed heat pumps will nonetheless be in effect.

5 Raise awareness among stakeholders and decision-makers

There are various stakeholders at national level that will influence take-up of low-emission heating technologies. Politics influences the structure and levels of energy prices and determines the regulatory environment in the form of laws, regulations and funding programmes. Private, business and public-sector consumers need to make decisions about economic efficiency and environmental protection. A range of other stakeholders are also involved in making the decision to purchase – energy consultants, tradespeople and chimney sweeps in particular.

Complexity and stubborn regional practices encourage the use of tried-and-tested solutions that work and appear to be cheaper despite being less climate-friendly, efficient or future-proof. The huge pressure on public sector clients in particular to select the cheapest product can prevent them from going for efficient, climate-friendly solutions. At the same time, heat pumps are often ignored until late in the planning process, or dismissed entirely as too technically complex.

[63] The cost reductions are reflected in the EEG feed-in tariffs. System operators will only install renewable energy systems if the EEG payments allow them to be run at a profit (under the market premium model combined with revenue from the electricity market). For example, since payments for photovoltaic systems have fallen since the EEG came into force in 2000 from around 50 cents/kWh to 4.9 cents/kWh in the last tender for solar power systems of over 750kWp (bidding deadline 1 October 2019. Source: BNetzA), this means that costs must also have dropped at the same rate. Renewable energy accounted for 6.3% of gross electricity consumption in 2000 and increased to 37.8% in 2018 (Source: UBA, referencing AGEE-Stat).

During the (thermal) energy transition, public sector clients applying innovative solutions would lead by example and would promote the use of low-emission technologies. One solution could be to launch a campaign to raise awareness and counter misconceptions about heat pumps.

Recommendation 5 for the domestic heating market: inform all relevant stakeholders of the suitability and options for low-emission, climate-friendly technologies to support the heating transition. The heating transition will affect all levels of the buildings sector and the heating industry, though its impact will vary across the various stakeholders. These include not only homeowners, housing associations and builders but also renovation companies, tradespeople, energy consultants, building services consultants, architects, local authority decision-makers and financial service providers.

6 Standardise planning application process at state level

Heat pumps that obtain heat from the ground or water will often require planning permission. These are subject to special conditions in designated water protection areas. Obtaining permission is not only time-consuming and costly, but the process varies from one state to another. This is confusing for providers and consumers alike, increases bureaucracy and removes the certainty around planning that is so urgently needed. While brine-to-water and water-to-water heat pumps score highly because they are so efficient, the strict regulatory requirements make them difficult to install.

Recommendation 6 for the domestic heating market: review and standardise planning requirements across all German states to remove the current obstacles to installing more efficient heating technologies.

7 Promote and fund sector coupling

Networking the electricity, heat and transport sectors is essential for increasing the proportion of renewable energy in all sectors and compensating for the fluctuations in electricity supply from wind and solar power. Stepping up coupling of the electricity and heating sectors in particular needs to ensure that more low-emission, electrically powered heating technologies are installed: heat pumps generate heat during periods of plentiful electricity supply so that the stored heat (for example, heat in the water circulating in the heating system) can be used at periods of low electricity supply. However, this requires economic incentives such as modern electricity tariffs. Rolling out smart meters is also key.

They allow better use of price signals and incentives to use electricity in other sectors, including heating, in the interests of consumers. Self-generated electricity (particularly from photovoltaic systems) can also be used to run the heat pump, creating a decentralised solution for electricity and heat generation.

Recommendation 7 for the domestic heating market: expand sector coupling by undertaking grid expansion and promoting combined, decentralised heat and power generation, as well as rewarding flexible consumers.

8 Roll out heat pumps together with insulation

Renovating buildings is another key component in improving energy efficiency under the Climate Action Strategy. There are two benefits of investing in insulation and replacing windows: they enable long-term energy savings by reducing a building's heat demand, while work on the building envelope provides an opportunity to replace the heating system. However, the German renovation business is continuing to stagnate due to the high investment costs and uncertainty over future energy pricing and potential regulatory changes. Insulated buildings are particularly suited to realising the potential for increased efficiency offered by heat pumps, since the reduction in heating load will normally allow the flow temperatures required in the heating system to be reduced.

Recommendation 8 for the domestic heating market: more funding for cost-optimised insulation measures. This would forestall stagnation in the renovation business and incentivise the use of low-emission technologies.

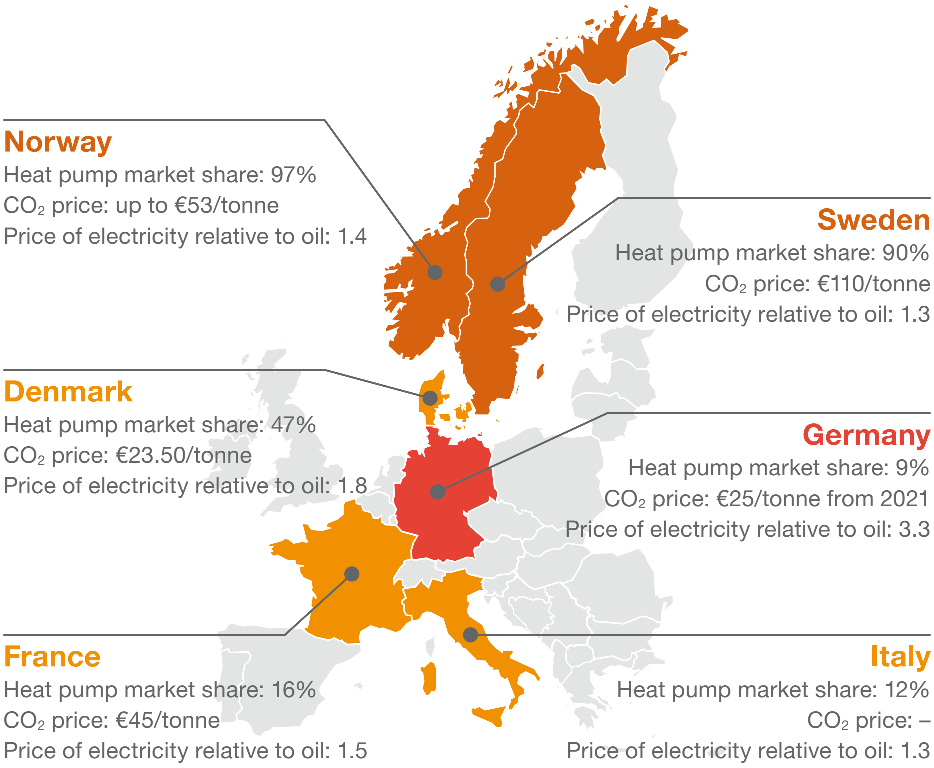
9 Improve the operating framework for the domestic market

As mentioned above, differences in the tax treatment of the various energy sources has led to Germany having one of the biggest disparities between electricity and fuel oil prices in Europe. The summary below (Figure 33) is based on an analysis of the relative prices of electricity and fuel oil, current CO_2 prices and differences in the operating framework between countries with respect to the heating market and the market share of heat pumps.

This analysis reveals a correlation between the energy price ratio and the extent to which the potential of heat pumps is realised: in the Scandinavian countries in particular, the price of electricity is low relative to fuel oil – and heat pumps have boomed. The price of electricity in Finland, Norway and Sweden is just under 20 cents/kWh.[64] This is partly a result of geographical obstacles to creating nationwide gas networks or district heating systems. However, it is also a result of policy measures and market incentive programmes that make heat pumps highly affordable for private consumers. Although electricity prices in Denmark are high, it also has relatively high prices for fossil fuels and has imposed regulatory conditions to increase the use of heat pumps, such as banning oil-fired or gas-fired heating.

Recommendation 9 for the domestic heating market: make use of best practice from other countries (such as market incentive programmes) and from other industries (such as e-mobility).

Fig. 33 Regulatory framework for heat pumps in selected European countries



Source: EHPA (2019c).

[64] Cf. EHPA (2019c): Energy prices – electricity vs. oil.

G The German heat pump market needs to expand to maintain the competitiveness of this growth industry

Heat pumps are a mature, climate-friendly technology that is undergoing a global boom. So far, the major markets have been in Asia and North America. The German market, however, is still dominated by appliances running on fossil fuels. The current framework conditions are making it difficult for the heating industry to expand into the growing heat pump market. As a result, there is a real risk that the German heating industry will lose out on the global market. If this happens, it will miss out on an opportunity to meet the increasingly strong global demand for innovative, sustainable heat generators. The risk of losing the global and national heating market is an existential threat to the entire heating industry in Germany.

In order to compete internationally, domestic manufacturers need to develop a range of products that are relevant, customer-oriented and cost-efficient. To do this they need to invest in scalable technology, expansion of production capacity, and automation, supported by the right policy framework. The German Government should draw up a strategic road map for heat pumps to create robust framework conditions within which manufacturers could work and implement the transformation from conventional fossil fuels to innovative, climate-friendly technologies.

Ideally, the starting point for any road map would be existing opportunities for rolling out heat pumps in Germany in the short to medium term. Economies of scale and learning effects could clear the way for more demanding use cases – buildings built from 1979 are already suitable for installing heat pumps, for example. The road map could start with these buildings and aim for 7 million homes which together account for around 30 million tonnes of CO_2e. Older buildings will require major renovation in the future for reasons related to climate policy and energy policy, affecting over 11 million homes and over 60 million tonnes of CO_2e. Building modernizations reduce energy demand and make homes more comfortable to live in. They also provide economic and commercial benefits that are particularly important in the context of the coronavirus crisis.

Efforts under industrial, energy and climate policy to stimulate expansion of the German heat pump industry will help not just the heating industry but also the tradespeople carrying out the work, mostly in small and medium-sized enterprises (SMEs). So heat pump policy is also SME policy, often impacting on rural businesses and adding value in rural economies. Even measures that are easy to implement, such as campaigns to raise awareness among potential customers, manufacturers and tradespeople, or best practice from other countries, can have a significant impact. What's important is that decision-makers in both the public and private sectors need to be aware of the innovative opportunities in the heating and buildings sectors, and reduce their reliance on outdated conventional solutions.

The restructuring of German energy prices that was started in the 2030 Climate Action Programme could focus more on the emissions caused by the various energy sources, and reduce the levies and charges on electricity prices. This policy would give the heating industry the clarity it needs to plan a shift towards heat pumps. Ambitious requirements on energy efficiency and the use of renewable energy in new builds and existing buildings could be implemented. Consideration could also be given to a flexible funding model for climate-friendly heating technologies similar to the EEG approach, based on a specific expansion pathway.

References

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Contact

Dr. Volker Breisig
Partner Energy & Utilities Consulting
Tel: +49 211 981-4428
volker.breisig@pwc.com

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