KfW Research
Focus on Economics

Heat pumps are gaining ground in Europe – electricity prices matter

No. 487, 20 February 2025

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Heat pumps are a key technology for decarbonising domestic heat. They require no fossil energy sources and enable the efficient heating of new buildings and many existing buildings.

Sales of heat pumps have been growing in Europe for years – with significant regional differences. In 2023, the market share of heat pumps already exceeded 90% in Scandinavia. That same year they accounted for 27% of heating systems sold in Germany. The number of heat pump sales fell in 2024 but their market share remained steady in Germany.

A primary factor for the use of heat pumps is their cost-effectiveness. Beyond the purchase cost, the electricity price relative to the natural gas price as a fossil alternative is relevant because heat pumps operate exclusively on electricity.

The present study analyses the influence of the relative electricity price on the diffusion of heat pumps. In Europe, heat pumps are widespread in countries where the electricity price is low relative to the gas price. This remains true even if other country-specific factors are considered. An analysis for new buildings in Germany confirms this correlation and presents an overview of the regional distribution at the district level.

The analysis suggests that the electricity-to-gas price ratio is a relevant lever for strengthening the diffusion of heat pumps in Germany and Europe. A reliable and rising carbon price can contribute here and may indeed arise due to the expansion of the European Emissions Trading System. Attractive heat pump electricity tariffs that are based on time-of-use prices can also be part of the solution, since heat pumps have the potential to operate flexibly and therefore enable load shifting.

Heat pumps enable climate-friendly heating

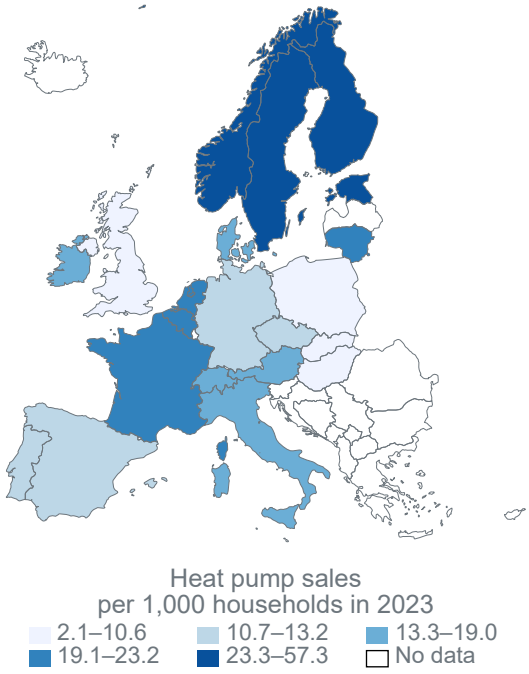
Heat pumps are an innovative and future-proof technology on the road to a climate-neutral building sector. They work like an inverted refrigerator and make use of a circulating refrigerant to extract heat from their environment and use it for heating (see Box 1). Energy is required only to carry the heat and compress the refrigerant. As a result, heat pumps have a high coefficient of performance and can turn 1 kWh of electricity into as much as 4 kWh of heat.[1]

Their electricity-based operation requires no combustion and therefore provides significant climate benefits over gas or oil heating systems. A study on the influence of heat pump technology on the energy demand of households in the UK reveals that running a heat pump reduced overall energy demand by 40% and carbon emissions by a good one third. The study also explains that flexible time-of-use electricity tariffs can achieve relevant load shifts, even on the coldest days and for all types of buildings.[2]

Scandinavia is a forerunner in Europe

Overall, the sale of heat pumps in Europe has roughly quadrupled in the past ten years, with a minor year-on-year drop only in 2023, although the sales figures remained above the 2021 level. But according to data from the European Heat Pump Association (EHPA), there are differences between countries (Figure 1).

Figure 1: Heat pump sales in Europe, by country



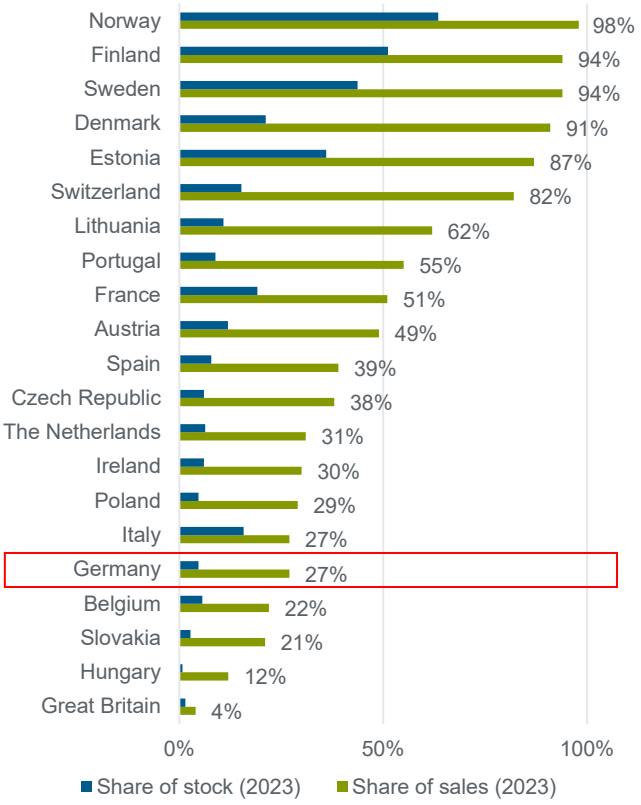
Note: The categories reflect quintiles.

Source: Geobasis: Natural Earth (2024); data source: EHPA (2024).

According to the EHPA, around 11 heat pumps were sold per 1,000 households in Germany in 2023. In Switzerland it was 17, in France 23, in Sweden 36 and in Norway, the top performer, it was a high 57 heat pumps per 1,000 households. This put Germany in 17th place among 21 surveyed countries, while Scandinavian countries took the top spots.

The total number of existing heat pumps also reflects this pattern. The Nordic countries are in the lead. In Norway and Finland, half of all residential buildings already have a heat pump, while in Germany the share is 5% (Figure 2).

Figure 2: Heat pumps stock and sales in Europe



Note: The share of stock quantifies the share of buildings with heat pumps in all buildings, while the share of sales refers to the share of heat pumps in all heat generators sold.

Source: EHPA 2023.

At first glance, the widespread use in northern Europe may come as a surprise because heat pumps use an external heat source. But heat pumps can use different heat sources (see Box 1). Scandinavian countries often use ground source heat pumps.[3] Furthermore, heat pumps have become more efficient over time. Today, a heat pump that relies on air as a heat source can be technically feasible – although electricity-intensive – and efficient even at low ambient air temperatures.

Countries where heat pumps are widespread are also characterised by electricity generation that is mainly based on renewables – in part supplemented by nuclear power. These countries use almost no gas or coal-fired power plants.[4]

For example, the share of gas and coal in electricity generation sits at 2% in Norway, 8% in Finland and 1% in Sweden. That makes electricity generation particularly cost-effective in these countries.

Box 1: How heat pumps work

Heat pumps use electricity to move heat from the environment into a building – and therefore do not need to generate heat themselves. They are distinguished by heat source: ground (geothermal energy), air (aerothermal energy) and water (hydrothermal energy). Like refrigerators, freezers, air conditioning systems and other compressor-based mechanisms, heat pumps allow a refrigerant to circulate that absorbs heat when it evaporates and emits heat when it liquefies.

In simplified terms, the heating cycle is as follows: The liquefied refrigerant is exposed to the heat source. The refrigerant heats up as a result and evaporates. During the phase change, it absorbs heat from the environment. Then, the compressor increases the pressure of the evaporated refrigerant, which raises its temperature. Next, a heat exchanger transfers the generated heat to the heating cycle. The gaseous refrigerant loses heat and condenses. The pressure is then reduced again so that the temperature of the liquefied refrigerant drops. When the refrigerant has reached its initial temperature, the cycle begins again.

The lower the temperature of the environment that provides heat, the more electricity is required. Nonetheless, heat pumps that use air as a heat source work efficiently in sub-zero temperatures because they use refrigerants that evaporate at temperatures well below zero.

Cost-effectiveness of heat pumps is key

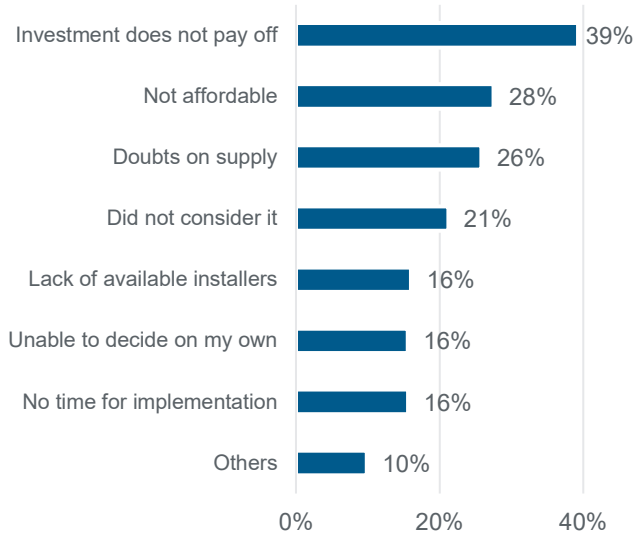
What are the reasons for differences in the use of heat pumps? The KfW Energy Transition Barometer provides insight into motives and barriers for installing a heat pump. Figure 3 shows that economic aspects are key in households' decision to invest in a heat pump.[5]

An obvious cost-effectiveness factor is the purchase cost of a heat pump. In addition, operating costs determine cost-effectiveness. The electricity-to gas price ratio is of relevance here because the alternative to a heat pump is often a gas heater. The electricity-to gas price ratio varies between European countries. It also fluctuated widely in recent years due to Russia's war of aggression against Ukraine and temporary government measures aimed at stabilising energy prices.

The following empirical analysis determines the extent to which the relative electricity price correlates with the sale of heat pumps.

Figure 3: Barriers to the acquisition of heat pumps

Frequency of mentions by households not using a heat pump yet but considering installing one. Multiple responses were possible.



Source: KfW Energy Transition Barometer 2024.

Countries with cheap electricity compared to gas have more heat pumps

First, it is interesting to take a cross-section view of the countries for a particular year and examine whether a correlation exists between the diffusion of heat pumps (per 1,000 households) and the electricity-to-gas price ratio in Europe. Because the decision to invest may take time, there is usually a lag of several months from the start of planning to the installation of the heat pump. For new buildings this can easily take more than a year. The following is based on a one-year lag. The electricity-to-gas price ratio represents the ratio between the two prices for household consumers according to Eurostat (for 2022).[6] Figure 4 reveals a negative correlation between this price ratio and the diffusion of heat pumps according to EHPA (for 2023). The picture is similar for preceding years.[7]

Correlation remains after controlling for other factors

A regression analysis enables a closer examination of the correlation between the sale of heat pumps and the relative electricity price. The appendix at the end of this study describes methodological details. Figure 5, Panel A shows the estimated coefficients for the electricity-to-gas price ratio of the preceding year. In the simple cross-section view (*Row I*), this estimated coefficient reflects the slope of the blue line in Figure 4, which is also negative. Accordingly, a low electricity-to-gas price ratio may come with high sales of heat pumps per 1,000 households.

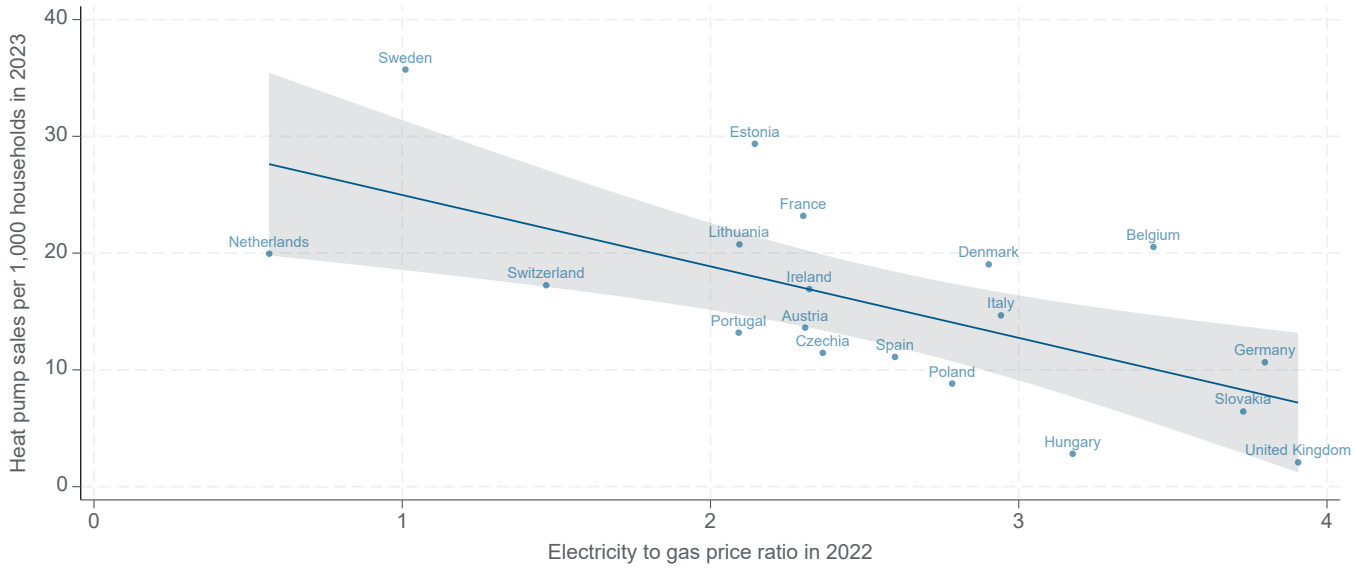
Besides the relative electricity price, there are other factors that potentially influence the sale of heat pumps. Promotional instruments could strengthen the sale of heat pumps, such as subsidies to the purchase price or reduced VAT rates (as in France, see Box 2), as well as technology promotion or installer training (as in Sweden, see Box 3).

Box 2: Case study France

France promotes the purchase of heat pumps with a range of state policies, some of which are socially differentiated. Under the MaPrimeRénov´ programme, **grants** are provided as individual measures for the purchase and installation of aerothermal, hydrothermal or geothermal heat pumps that are staggered according to income, household size and region.[8] For example, a two-person household with an annual reference income of less than EUR 58,827 is eligible for a grant if it resides in or around Paris. In other regions, this threshold is EUR 44,907. In addition, a **reduced VAT rate** of 5.5% is applied on the systems themselves irrespective of income (instead of the regular 20% VAT rate). This reduces the purchase cost.

Figure 4: Electricity-to-gas price ratio correlates with sale of heat pumps in Europe

Each blue dot represents a country in Europe. The blue line shows the linear correlation and the grey area its 95% confidence interval.

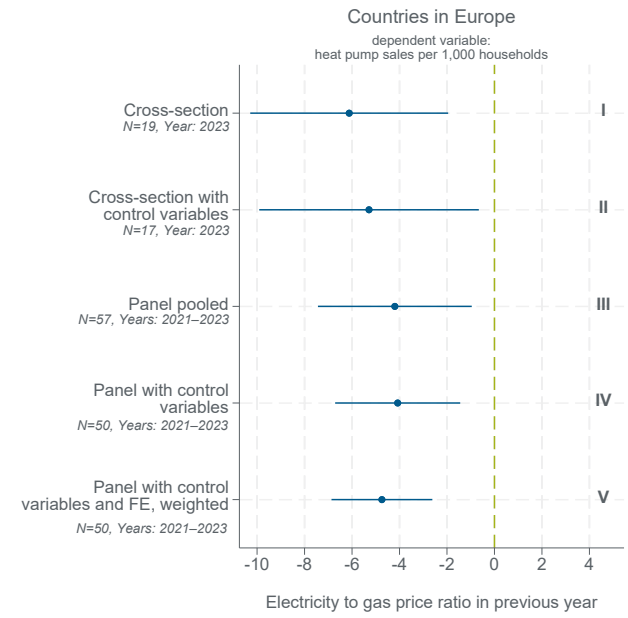


Source: EHPA 2023, Eurostat.

Figure 5: Regression analysis for countries in Europe and districts in Germany

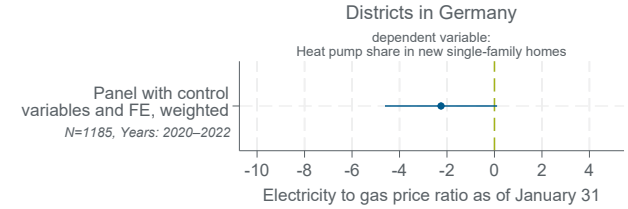
Each row represents a linear regression. The blue dot shows the estimated coefficient of the electricity-to-gas price ratio on the diffusion of heat pumps, the blue line its 95% confidence interval. Details are contained in the appendix at the end of the study.

A



We observe up to 19 countries, control variables lagged by one year.

B



We observe 396 districts, control variables lagged by one year.

Note: In Panel B, the share of heat pumps refers to the share of building permits for single-family homes in which a heat pump that uses air or water as a heat source is the primary source of heat energy.

Source: Panel A: EHPA, Eurostat. Panel B: Federal Statistical Office, Verivox.

A study on the diffusion of heat pumps in municipalities in Switzerland in 2021 reveals a positive correlation with the share of single-family homes and the home ownership rate.[9] The number of job vacancies in construction (as an indicator of skilled worker availability) could also influence the sale of heat pumps. Further, wealthier households are more likely to use a heat pump than households with a lower net income, even if the differences for heat pumps are slightly less pronounced than for other innovative technologies such as photovoltaic systems or electric vehicles.[10] We therefore controlled for these potential influencing factors in *Row II* in Figure 5. Whereas the control variables are statistically not or only weakly significant, this model specification indicates again that a favourable electricity-to-gas price ratio in the preceding year plays a role for the sale of heat pumps in the current year.

In addition, it could be possible that the negative correlation was only relevant in the year 2023. For this reason, *Row III* in Figure 5 presents the correlation for the years 2021, 2022 and 2023 jointly ('pooled') – and confirms the link again. *Row IV* considers the influencing factors already added in *Row II*. The price effect remains evident. Finally, fixed effects are added for each year and each country in the pooled sample in *Row V*. This approach filters out specific effects in different years (such as a general gas price increase) and countries (such as generally higher or lower sales of heat pumps), thereby focusing only on the relative price changes between the years in the estimation. *Row V* thus represents the strictest specification. Moreover, this regression uses weights that express the average population status of the respective country during the period of analysis. The estimation is therefore not dominated by small countries. This specification confirms the negative correlation between the sale of heat pumps and the electricity-to-gas price ratio of the preceding year.

The size of the correlation is also relevant

For Europe, the estimates reveal a statistically significant correlation in the order of magnitude of -4.1 to -6.1. If we focus on the strictest estimate in *Row V*, an electricity-to-gas price ratio reduced by 1 is associated with an increase in the sale of heat pumps of around 5 heat pumps per 1,000 households.

What can be expected from a more favourable relative electricity price for a country like Germany with around 11 heat pumps sold per 1,000 households in 2023 and an electricity-to-gas price ratio of around 4 in the previous year? In such a country, halving the electricity price (or doubling the gas price) could mean nearly doubling heat pump sales.[11]

Box 3: Case study Sweden[12]

Heat pump technology has been promoted in research and development projects by the Swedish Energy Agency, among others, already since the 1970s. Up until that time, heat generation was heavily dependent on oil. In response to the oil crises, Sweden switched to alternatives. Along with the expansion of heating networks, one focus has been on heating with electricity, especially with heat pump technology given its higher efficiency compared to direct electric heating. Today Sweden is one of the four largest exporters of heat pumps in the world.[13]

Government tenders support the development of the technology with the aim of increasing efficiency and reducing costs. Not least, **training of installers and information campaigns** has generated acceptance for consumers. Since the 1990s, Sweden has also levied a substantial **tax on CO_2**, including for heating in households, so that the cost of electricity is now roughly on a par with fossil fuels. Apart from the general option of claiming the cost of installer services as a tax deduction, Sweden today offers no financial incentives for acquiring a heat pump. Nonetheless, it is the natural choice for consumers, with more than 40% installed in existing buildings and a market share of 94% of all heating systems currently sold (Figure 2).

Differences in heat pump diffusion also within Germany

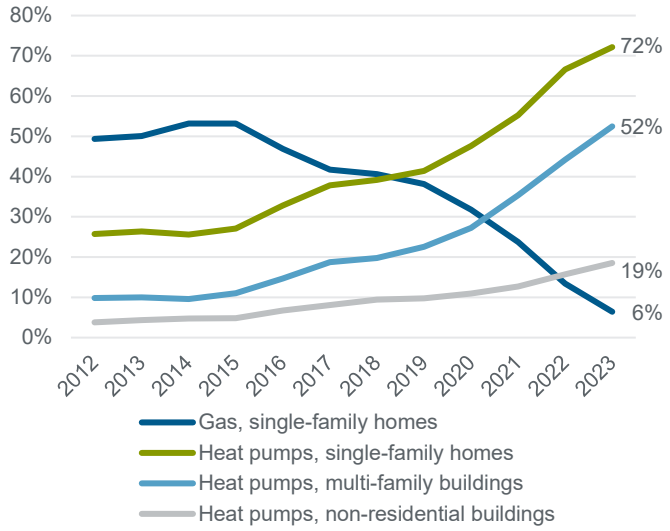
In the next step, we examine whether an analysis within Germany confirms this correlation. Here we focus on regional differences at the level of administrative districts.

With regards to new buildings, a significant structural change has taken place in Germany. Heat pumps have been the main heating system for more than five years now, dethroning gas heating from its former dominance. In nine cases out of ten, these heat pumps use air or water as a heat source. Figure 6 illustrates the share of newly erected buildings in Germany that use such a heat pump for space heating.[14] That share has risen significantly in all types of buildings since the year 2014. In 2023, it was 72% in single-family homes, 52% in multi-family residential buildings and 19% in non-residential buildings. The share of natural gas in newly built single-family homes, on the other hand, has declined steadily since 2015 and now sits at 6%.

An upward trend in heat pumps can also be seen in all heating systems sold, that includes new heating systems in existing buildings. While a good 11% of all heating systems sold in 2019 were heat pumps, that share more than doubled to 27% in 2023.[15] Although only 193,000 heat pumps were sold in 2024, their market share again reached an historic high of 27% amid generally weaker building activity and 712,500 heating systems sold.[16] Furthermore, the increase in funding applications at the end of the year has made the Federal Association of the German Heating Industry more optimistic. In December alone, almost 46,000 funding applications for heat pumps – or roughly one quarter of the total volume of applications of 2024 – were already approved.[17]

Figure 6: Share of heat pumps in new buildings has grown

Shares by type of new buildings in Germany



Note: The shares refer to the share of building permits in which a heat pump that uses air or water as a heat source is the primary source of heat energy.

Source: Federal Statistical Office.[18]

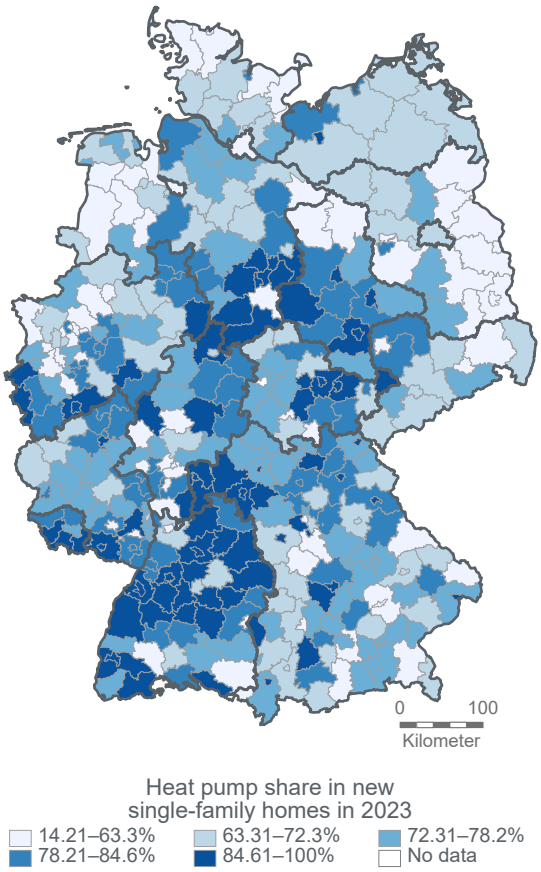
Figure 7 shows that the share of heat pumps in newly built single-family homes varies by region. It is above average particularly in the south-west of Germany. In northern Germany, heat pumps are less common.

The relative electricity price is also relevant for the diffusion of heat pumps within Germany

The regional differences allow the correlation between heat pumps diffusion and the electricity-to-gas price ratio within Germany tobe examined more closely . Again, a regression analysis follows. The appendix at the end of this study describes the methodological approach.

In Figure 5, Panel B shows the estimated coefficient from regressing the electricity-to-gas price ratio on heat pump diffusion. It sits at roughly -2 and statistically differs from zero with a probability of 90%.[19] Accordingly, a low electricity-to-gas price ratio is associated with a high share of heat pumps in newly built single-family homes.

Figure 7: Share of heat pumps in newly built single-family homes by district



Note: The share refers to the share of building permits for single-family homes in which a heat pump that uses air or water as a heat source is the primary source of heat energy. The categories reflect quintiles.

Source: GeoBasis-DE / BKG 2020; data source: Own calculations based on the Federal Statistical Office.

Overall, the analysis of districts in Germany confirms that the electricity-to-gas price ratio negatively correlates with the share of heat pumps in new single-family homes. However, the correlation estimated for Germany is smaller than that for Europe because the analysis for Germany covers new buildings only, while the analysis for Europe comprises heat pumps in both existing and newly erected buildings. The estimated effects for Europe and Germany are therefore not directly comparable. The legal framework allows less scope for decisions on the type of heating system to be installed in newly erected buildings. In 2023, gas heating systems were installed in exceptional cases only. Local availability and in some cases even connection mandates determine the choice between a heat pump and district heating. Therefore, a smaller influence of the price signal in comparison with the analysis of existing and newly erected buildings at the European level appears plausible.

Conclusion

Heat pumps are a key technology on the road to climate-neutral domestic heating. It is encouraging that the sale of heat pumps has almost quadrupled in Europe in nearly ten years. In many countries, the heat pump is today the most widely sold heating system. Germany occupies a position in the lower quarter for both existing heat pumps and current sales. There is a clear need to catch up.

The KfW Energy Transition Barometer demonstrates the importance of cost-effectiveness for the investment decision. This analysis adds that heat pumps are most common where the price of electricity is favourable compared to natural gas.

The electricity-to-gas price ratio appears to be a relevant lever to further drive the diffusion of heat pumps. There are various approaches to doing this. One of them is a reliable and rising carbon price that translates to a higher gas price. Rising price signals for fossil energy sources are to be expected with the planned extension of the European Emissions Trading System to the heating sector. This will increase the relative cost-effectiveness of heat pumps. Because low-income households are the ones who often reside in energy-inefficient buildings[20], it is necessary to roll out accompanying measures such as grants or low-interest loans to overcome investment barriers.

Low electricity prices can also provide a positive incentive, e.g. based on attractive electricity tariffs designed for heat pumps. Flexible, time-of-use electricity tariffs may also help in future because heat pumps potentially allow efficient control of their electricity consumption, which enables load shifting to balance the grid.

In general, an efficient electricity market based on renewables forms the backbone for the use of heat pumps in Germany. The greater the share of renewables in the electricity mix, the more climate-friendly the use of heat pumps. The expansion of renewable capacity, grids and storage supports this. The role of the installer as a key actor in the choice of the heating system also appears important. The example of Sweden illustrates that a clear focus on heat pumps that includes targeted installer training can contribute to the success of heat pumps (see Box 3).

If the ramp-up of heat pumps can be successfully accelerated, it will make an important contribution to achieving the climate targets for Germany. At the same time it would avoid the payment of penalties to the EU which loom for heating and transport from the year 2030.

Finally, Germany is now one of the three largest heat pump exporters after China and France, followed by Sweden.[21] A fast-growing heat pump market would offer German manufacturers the opportunity to tap into markets and improve their competitive position.

Annex: Details on the regression analysis

Analysis of countries in Europe: The regression analysis on the diffusion of heat pumps in Europe and the electricity-to-gas price ratio relies on data from Eurostat and EHPA.[22] Details on the data sources are provided by the following endnote.[23]

Figure 5 Panel A *Row I* is based on regressing heat pump sales per 1,000 households in the year 2023 on the electricity-to-gas price ratio of the year 2022. The sample comprises the 19 European countries shown in Figure 1 for which both heat pump sales and the electricity-to-gas price ratio are available.[24] *Row II* additionally controls for the logarithm of the (nominal) gross domestic product per-capita, the logarithm of heating degree days, the share of single- and double-family homes, the home ownership rate, the rate of job vacancies in the construction industry, in each case from the previous year, and a dummy that captures whether the VAT rate for heat pumps is reduced or a purchase price subsidy exists for heat pumps in new buildings. As the data for Switzerland and the UK were not available for all control variables, the sample here contains 17 countries. *Row III* presents a panel data analysis, that is, a regression of heat pump sales per 1,000 households of the year 2023, of 2022 and of 2021 on the electricity-to-gas price ratio of the respective preceding year. In consequence, the analysis includes three observations for all 19 countries from *Row I*. *Row IV* adds the control variables mentioned in the description of *Row II*. In this case, the sample contains 17 countries. *Row V* also controls for year fixed effects and country fixed effects. Year fixed effects capture year-specific effects that are the same for all countries, such as an increase in heat pump sales resulting from a gas price shock that impacts all countries equally. Country fixed effects control for time-constant country-specific factors that influence heat pump sales; these can include constant differences in the purchase price in the countries or state subsidies for heat pumps previously not captured that remain unchanged in the analysis period. In addition, the regression in *Row V* uses weights that express the average population status of the respective country during the analysis period. This approach ensures that the correlation is not driven exclusively by small countries.

All five rows of Figure 5 Panel A show a negative estimated coefficient for the relative electricity price of the previous year. It is statistically significant to the 5% level in each case. *Row V* controls for many alternative influences that may correlate with the sale of heat pumps. That is why we take a closer look at this specification. The estimated coefficient for the electricity-to-gas price ratio of the previous year is -4.7. Accordingly, increasing the electricity-to-gas price ratio by one standard deviation is associated with a reduction in the sale of heat pumps per 1,000 households by roughly half a standard deviation.[25] Comparing country A with an electricity-to-gas price ratio of three with country B with an electricity-to-gas price ratio of four, country A is expected to have around five additional heat pumps sales per 1,000 households per year. This value is also relevant in terms of size because it sits at roughly one third of the mean value of heat pump sales per 1,000 households in our sample.

Analysis of districts in Germany: The regression analysis on the diffusion of heat pumps and the electricity-to-gas price ratio in Germany rests on data from the Federal Statistical Office and Verivox.[26] Details on the data sources are provided by the following endnote.[27]

Figure 5 Panel B is based on regressing the share of heat pumps in newly built single-family homes on the electricity-to-gas price ratio on 31 January of the same year.[28] The sample comprises the 396 districts in Germany for which the share of heat pumps, the electricity-to-gas price ratio and the control variables are available. That was the case for 99% of the districts in Germany. The regression controls for the logarithm of (nominal) gross domestic product per-capita, the logarithm of turnover per person employed in the trades sector and the share of district heating in newly built single-family homes, in each case from the previous year. The analysis draws upon a panel dataset, that is, a regression of the share of heat pump sales in single-family homes newly built in the year 2022, in 2021 and in 2020 on the electricity-to-gas price ratio on 31 January of the same year. In consequence, if available, the analysis includes three observations for each district. The estimation considers the share of heat pumps in newly built single-family homes of the years previously mentioned because the control variables are available only for the year 2021 and the years before. In addition, it considers year fixed effects, fixed effects for districts and (federal-state X year) fixed effects. Year fixed effects capture year-specific effects that are the same for all districts, such as an increase in the share of heat pumps in newly built single-family homes resulting from a gas price shock that impacts all districts equally. District fixed effects control for district-specific factors that are constant over time and influence the share of heat pumps in newly built single-family homes, such as federal subsidies for heat pumps, which do not change during the observation period. (Federal state X year) fixed effects cover state-specific factors for each year. These may be, for example, rules governing the distance between heat pumps and neighbouring buildings, which arise because of different state building codes and their modifications during the observation period. In addition, the regression uses weights based on the average number of newly built single-family homes in the respective district during the analysis period. This approach ensures that the correlation is not dominated by districts with low building activity.

Figure 5 Panel B also shows a negative estimated coefficient for the electricity-to-gas price ratio. This is statistically significant on the 10% level. That means the estimated coefficient is effectively different from zero with a probability of 90%. The analysis of districts in Germany tends to confirm that the electricity-to-gas price ratio negatively correlates with the share of heat pumps in newly built single-family homes. However, the correlation estimated for Germany is smaller than that for Europe.[29] One reason may be that the analysis for Europe comprises heat pumps in both existing and newly erected buildings. The analysis for Germany, in turn, covers newly erected buildings only. The size of the estimated effects for Europe and Germany is therefore not directly comparable.

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[1] In an empirical efficiency analysis, the Fraunhofer Institute for Solar Energy Systems identified a mean annual coefficient of performance (COP – combined generation efficiency for space and drinking water heating for (outdoor) air heat pumps of 3.3, with a range of 2.4 to 4.0. The COPs of ground heat pumps were slightly higher, at 3.6 to 5.2,
Cf. Fraunhofer ISE News #3 of 1 March 2024: Wärmepumpenfeldtest: Zwischenergebnisse bestätigen effizienten Betrieb auch im Altbau (*Heat pump field test: Interim results confirm efficient operation even in old buildings* – our title translation, in German).

[2] Cf. Bernard, L. et al. (2024): Decarbonizing Heat: The Impact of Heat Pumps and a Time-of-Use Heat Pump Tariff on Energy Demand, Working Paper 33036, National Bureau of Economic Research. However, refrigerants can also have a climate impact. The EU has therefore introduced a gradual ban of refrigerants that are particularly harmful to the climate for new heat pumps that will take effect from the year 2032.

[3] According to the EHPA (2023) European Heat Pump Market Statistics Report (Chart 1.0-2), the share of geothermal energy is particularly high in Sweden, among other countries.

[4] Cf. Römer, D. (2024): Raus aus der fossilen Stromerzeugung - wo steht Europa heute? (Phasing out fossil electricity generation – where does Europe stand today? – in German), Focus on Economics No. 459, KfW Research.

[5] Cf. Römer, D. and Salzgeber, J. (2024): KfW Energy Transition Barometer 2024: Energy transition in private households moving ahead despite uncertain environment, KfW Research.

[6] We based our calculation of the electricity-to-gas ratio on prices for household consumers including all taxes and levies, cf. endnote 23 for details.

[7] The same picture emerges if we ignore the time lag, cf. EHPA (2024): European Heat Pump Market and Statistics Report 2024, Report, European Heat Pump Association.

[8] MaPrimeRénov´ (2024): Les aides financières en 2024 (Financial aid in 2024 - our title translation, in French) contains details on the programme.

[9] Cf. Zhang, H. et al. (2024): Patterns in spatial diffusion of residential heat pumps in Switzerland. *Renewable Energy*, 223:120032.

[10] For Germany: cf. Römer, D. and Salzgeber, J. (2024): KfW Energy Transition Barometer 2024: Energy transition in private households moving ahead despite uncertain environment, KfW Research. For the USA: cf. Davis, L. (2023). The Economic Determinants of Heat Pump Adoption. Working Paper 31344, National Bureau of Economic Research.

[11] In 2023, 10.7 heat pumps per 1,000 households were sold in Germany. In the previous year 2022, the electricity-to-gas price ratio in Germany was 3.8. The estimated correlation of the two variables is -4.7 in the strictest specification (Figure 5, Panel A, *Row V*). Based on this, halving the electricity-to-gas price ratio, that is, reducing it by 1.9, could – all else equal – come with an increase in the sale of heat pumps by (-4.7)*(-1.9)≈8.9, that is, to a total sale of 10.7+8.9=19.6. At +80%, this is almost double the initial level.

[12] Johansson, P. (2017): A Silent Revolution: The Swedish Transition towards Heat Pumps, 1970-2015, Dissertation.

[13] In 2023, Sweden was even the third largest exporter, cf. UN COMTRADE: Trade Data, code 841861. Sweden ranked fourth in the years 2020 to 2022, cf. JRC (2023): Clean Energy Technology Observatory: Heat pumps in the European Union - 2023 Status Report on Technology Development, Trends, Value Chains and Markets, figure 30.

[14] The picture for building completions is similar to the building permits presented in Figure 5, although there is a time lag for the share of heat pumps at completion. This is because the decision for a particular heating technology is taken when the building permit is issued, and completion then takes a certain amount of time.

[15] Own calculations based on the Federal Association of the German Heating Industry (2024): Marktentwicklung Wärmemarkt 2023 (*Development of heating market in 2023* – our title translation, in German).

[16] Own calculation based on the Federal Association of the German Heating Industry (2025): Heizungen: Absatz 2024 um die Hälfte eingebrochen (*Heating systems: sales plunged by half in 2024* – our title translation, in German), press release of 27 January 2025.

[17] Cf. Federal Association of the German Heating Industry (2025): Heizungen: Absatz 2024 um die Hälfte eingebrochen (*Heating systems: sales plunged by half in 2024* – our title translation, in German), press release of 27 January 2025.

[18] Own calculations based on the Federal Statistical Office: Table 3 31111-0005 Permits for new buildings: Germany, years, building type, energy use, energy type, retrieved on 17 December 2024. *Residential buildings with 1 residential unit are referred to as single-family homes and residential buildings with 3 or more residential units are referred to as multi-family residential buildings.*

[19] As in the analysis for Europe, other factors may correlate with the share of heat pumps within Germany, for example, the share of district heating or the income level. Because the result may also be specific to the period under review, the regression is based on pooling the years 2020, 2021 and 2022. Fixed effects for each year, for each district and for each federal state in each year, for example, control for an increase in the sale of heat pumps as a result of the gas price shock that impacted all districts equally, differences in the purchase price for heat pumps or different rules governing the distance between heat pumps and neighbouring buildings that arise from different state building codes and their variations over the analysis period. Applying weights, which account for the average number of newly built single-family homes during the analysis period, ensures that the correlation was not driven exclusively by small districts, for example.

[20] Cf. Römer, D. and Salzgeber, J. (2024): KfW Energy Transition Barometer 2024: Energy transition in private households moving ahead despite uncertain environment, KfW Research.

[21] In 2023, Germany was the second largest exporter, cf. UN COMTRADE: Trade Data, code 841861. Germany ranked third in the years 2020 to 2022, cf. JRC (2023): Clean Energy Technology Observatory: Heat pumps in the European Union - 2023 Status Report on Technology Development, Trends, Value Chains and Markets, figure 30.

[22] The confidence intervals are based on robust standard errors adjusted for clustering on country level.

[23] The data sources of the analysis of countries in Europe:

Heat pump sales: all based on EHPA:
- Heat pump sales per 1,000 households in 2023: EHPA (2024): European Heat Pump Market and Statistics Report 2024, page 10, Report, European Heat Pump Association.
- Heat pump sales per 1,000 households in 2022: German Energy Agency (dena) (ed.) (2023): Wärmepumpen im Gebäudesektor. Eine Technologie für eine fossilfreie Wärmeversorgung (*Heat pumps in the building sector: a technology for a fossil-free heating supply* – our title translation, in German). Page 14, as of September 2023.
- Heat pump sales per 1,000 households in 2021: Öko-Institut and Fraunhofer ISE (2022): Durchbruch für die Wärmepumpe. Praxisoptionen für eine effiziente Wärmewende im Gebäudebestand (*Breakthrough for the heat pump. Practical options for an efficient heating transition in existing buildings* – our title translation, in German). Study commissioned by Agora Energiewende. Page 33.

Electricity prices: EUROSTAT. Electricity prices for household consumers – bi-annual data (from 2007 onwards) [nrg pc 204 custom 13181544]. Data, Statistical Office of the European Union, 2024. [Selection: [Unit of measurement] Kilowatt-hour, [Taxes] All taxes and levies included, [Currency] Euro, [Energy consumption] Consumption of 2,500 kWh to 4,999 kWh – band DC] retrieved on 4 December 2024. The analysis uses the average of the half-yearly data.

Gas prices: EUROSTAT. Gas prices for household consumers – bi-annual data (from 2007 onwards) [nrg pc 202 custom 13181538]. Data, Statistical Office of the European Union, 2024. [Selection: [Unit of measurement] Kilowatt-hour, [Taxes] All taxes and levies included, [Currency] Euro, [Energy consumption] Consumption of 20 GJ to 199 GJ– band D2] retrieved on 4 December 2024. The analysis uses the average of the half-yearly data.

Heating degree days: EUROSTAT. Cooling and heating degree days by NUTS-3 region – annual data [nrg_chddr2_a__custom_14011379]. Data, Statistical Office of the European Union, 2024. [Selection: by country and region], retrieved on 2 December 2024.

Gross domestic product per capita: EUROSTAT. Gross domestic product (GDP) and main components per capita [nama 10 pc custom 2523843]. Data, Statistical Office of the European Union, 2024. [Selection: [na_item] National accounts indicator (ESA 2010): [B1GQ] Gross domestic product at market prices, [freq] temporal frequency: [A] annual], retrieved on 7 December 2024.

Ownership rate: EUROSTAT. Distribution of population by tenure status, type of household and income group [ilc lvho02]. Data, Statistical Office of the European Union, 2024. [Selection: Income situation in relation to the risk poverty threshold: Total, Type of household: Total, Tenure status: Owner, Time frequency: Annual, Unit of measure: Percentage], retrieved on 8 October 2024.

Share of single- and double-family homes: EUROSTAT. Distribution of population by degree of urbanisation, dwelling type and income group [ilc lvho01 custom 13192554]. Data, Statistical Office of the European Union, 2024. [Selection: Income situation in relation to the risk of poverty threshold: Total, Degree of urbanisation: Total, Type of building: Detached house, semi-detached house, Time frequency: Annual, Unit of measure: Percentage], retrieved on 8 October 2024.

Population: EUROSTAT. Population on 1 January by age and sex [demo_pjan$defaultview]. Data, Statistical Office of the European Union, 2024. [Selection: Age class: Total, Sex: Total, Time frequency: Annual, Unit of measure: Number], retrieved on 15 November 2024.

Share of job openings in the building industry: EUROSTAT. Job vacancy rate by NACE Rev. 2 activity – annual data [jvs_a_rate_r2__custom_14043824]. Data, Statistical Office of the European Union, 2024. [Selection: Statistical classification of economic activities in the European Community (NACE Rev. 2): Construction, Size classes in number of employees: Total, Unit of measure: Annual average] retrieved on 4 December 2024.

Reduced VAT rate and purchase price subsidy for heat pumps in newly erected buildings: on reduced VAT rates: EHPA (2024): Heat pumps versus boilers: taxes and running costs, Report, European Heat Pump Association, retrieved on 17 December 2024; on purchase price subsidies in newly erected buildings: EHPA (2023): Subsidies for residential heat pumps in Europe, Report, European Heat Pump Association, retrieved on 17 December 2024.

Maps: Natural Earth (2024): 1:50m Cultural Vectors, Admin 0 - Countries, retrieved on 21 February 2024.

[24] The countries included in the analysis are Austria, Belgium, the Czech Republic, Denmark, Estonia, France, Germany, Hungary, Ireland, Italy, Lithuania, the Netherlands, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland, and the United Kingdom.

[25] Multiplying the estimated coefficient of -4.7 with the standard deviation of the electricity-to-gas price ratio of the previous year of 1.0 and dividing the result by the standard deviation of heat pump sales per 1,000 households of 9.1 produces: (-4.7x1.0)/9.1=0.52≈1/2.

[26] The confidence intervals are based on robust standard errors adjusted for clustering on district level.

[27] Data sources of the analysis of districts in Germany:

Share of heat pumps in newly built single-family homes: Federal Statistical Office, Table 31111-06-01-4: Genehmigungen zur Errichtung neuer Wohngebäude und Nichtwohngebäude sowie Wohnungen in Wohngebäuden nach Zahl der Wohnungen und primär verwendeter Heizenergie - Jahressumme – regionale Tiefe: Kreise und krfr. Städte (*Permits for the construction of residential and non-residential buildings and units in residential buildings by number of units and primary source of heating energy – annual sum – regional depth: districts and cities with district status* – our title translation, in German), retrieved on 13 December 2024. Residential buildings with one residential unit are referred to as single-family homes.

Electricity prices: Verivox, data provided at personal request, electricity prices as of 31 January of the years 2020–2024. The Verivox consumer price index for electricity considers the prices of the basic suppliers and the 30 most important national electricity suppliers for an annual consumption of 4,000 kWh. The different price levels are weighted based on the number of households of the regions supplied. The weighting between the different tariff types is based on the currently published switching rates. All figures in euros, gross and rounded.

Gas prices: Verivox, data provided at personal request, gas prices as of 31 January of the years 2020–2024. The Verivox consumer price index for gas takes into account the prices of the basic suppliers and the 30 most important national gas suppliers for an annual consumption of 20,000 kWh and a maximum power consumption of 13 kW. The different price levels are weighted based on the number of households of the regions supplied. The weighting between the different tariff types is based on the currently published switching rates. All figures in euros, gross and rounded.

Share of district heating in newly built single-family homes: Federal Statistical Office, Table 31111-06-01-4: Genehmigungen zur Errichtung neuer Wohngebäude und Nichtwohngebäude sowie Wohnungen in Wohngebäuden nach Zahl der Wohnungen und primär verwendeter Heizenergie - Jahressumme – regionale Tiefe: Kreise und krfr. Städte (*Permits for the construction of residential and non-residential buildings and units in residential buildings by number of units and primary source of heating energy – annual sum – regional depth: districts and cities with district status* – our title translation, in German), retrieved on 13 December 2024.

Population: Federal Statistical Office, Table 12411-01-01-4: Population by gender – as of 31.12. – Regional depth: districts and cities with district status; retrieved on 10.12.2024.

Gross domestic product per capita: Federal Statistical Office, Table 82111-01-05-4: Gross domestic product/gross value added by economic sector – annual sum – regional depth: districts and cities with district status; retrieved on 29.10.2024.

Turnover by person employed in the trades sector: Federal Statistical Office, Table 53111-01-01-4: Skilled trades businesses, persons employed, turnover by type of trade – year – regional depth: districts and cities with district status; retrieved on 29.10.2024.

Maps: Federal Agency for Cartography and Geodesy (2023): Administrative areas, historic levels, date 31 Dec. 2020, vg5000_12-31.gk3.shape.ebenen, retrieved on 16 November 2023.

[28] To keep the time lag as short as possible, we consider building permits. The decision whether a heat pump will be included is taken when the application for the building permit is filed. Therefore, the electricity-to-gas price ratio at the beginning of a year appears to be relevant for the decision whether a heat pump is planned in the year of the building permit. Alternatively, building completions could also be considered. For these, however, a time lag would have to be considered. The correlation between building completions and building permits confirms this. The correlation is generally strong. However, the correlation of the share of heat pumps of building completions with the share of heat pumps in the building permits of the previous year or two years before is stronger than the correlation for the same year. Information on building completions can be found at the Federal Statistical Office, Table 31121-05-01-4: Fertigstellungen neuer Wohngebäude und Nichtwohngebäude sowie Wohnungen in Wohngebäuden nach Zahl der Wohnungen und vorwiegender Art der Beheizung - Jahressumme – regionale Tiefe: Kreise und krfr. Städte (*Completions of new residential and non-residential buildings and units in residential buildings by number of units and primary type of heating technology – annual sum – regional depth: districts and cities with district status* – our title translation, in German), retrieved on 9 December 2024.

[29] The analysis controls for many alternative factors that may correlate with the share of heat pumps in newly erected buildings. The estimated coefficient for the electricity-to-gas price ratio here is -2.2. Accordingly, increasing the electricity-to-gas price ratio by one standard deviation is associated with a reduction in the share of heat pumps in newly built single-family homes by roughly 1/8 of a standard deviation. Multiplying the estimated coefficient of -2.2 with the standard deviation of the electricity-to-gas price ratio of 1.1 and dividing the result by the standard deviation of the share of heat pumps in newly built single-family homes of 18.5 produces: (-2.2x1.1)/18.5=0.13≈1/8. The exemplary comparison of a district with an electricity-to-gas price ratio of three with one that has an electricity-to-gas price ratio of four suggests that in the district with an electricity-to-gas price ratio of three the share of heat pumps in newly built single-family homes is around 2.2% higher each year. In our sample, that is roughly 4% of the mean value of the share of heat pumps in newly built single-family homes. The negative correlation is hence smaller than in our analysis of the European countries.