Powering Energy Efficiency: policy context and recommendations in Germany and the United Kingdom

A Centre for Economics and Business Research (Cebr) report for GRUNDFOS

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Disclaimer

Authorship and acknowledgements

This report has been produced by Cebr, an independent economics and business research consultancy established in 1992. The views expressed herein are those of the authors only and are based upon independent research by them.

London, November 2022

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Foreword

Glynn Williams, UK Country Director at Grundfos

Improving quality of life for people is at the heart of our business, which is why we collaborated with Cebr to produce the 'Powering Energy Efficiency' report. In the midst of an energy crisis, efficiency is a surprisingly under-represented topic, particularly in the UK and Germany. Our aim was to change this by uncovering the untapped potential of energy efficiency and the savings to be yielded if governments take action now.

Grundfos is a proud pioneer of solutions to the world's water and climate challenges. Since originating in Denmark in 1945, we have honed our skills to produce pumps that use as little energy as possible, making a real difference to people and the world we live in. We are now the largest pump solutions provider in the world, providing millions of pumps every year to households, businesses, water utilities and the industrial sector.

We have never underestimated the importance of energy efficiency and the report findings are clear - at a time when Europe is facing a precarious economic outlook, homes and businesses cannot afford to be losing out on the savings that better energy efficiency can unlock. Cebr has calculated that in the UK homes and businesses are losing out on up to £3.1 billion (€3.5 billion) worth of savings due to barriers to implementing low-cost energy efficiency improvements, while in Germany there are €7.5 billion (£6.5 billion) worth of missed savings for the same reason. Respondents from both nations (60%) are most concerned about rising energy bills this winter, and worryingly over a quarter (28%) of German and UK business owners are considering staff redundancies to combat the energy crisis.

Despite the long-term savings potential of energy efficiency, our report shows that people are put off due to perceived upfront costs and a lack of information on their positive impact. There is a huge gap between the barriers and the benefits which must be overcome.

Energy efficiency will become an even more salient issue as countries, including the UK and Germany, aim to transition away from fossil fuels and pursue more sustainable measures for heating homes and businesses. It is the single most important factor in meeting the Paris Agreement as 40% of the CO2-emission reduction goal can be met by energy efficiency improvements alone. Ensuring that heating systems are more efficient is vital if we are to see a further reduction in emissions, as well as costs for households and businesses the world over.

Whilst there is plenty that the Government can and should be doing via economic and environmental incentives to affect change, particularly around regulation and enforcement of energy saving measures, it is apparent that the gap in knowledge must be urgently addressed first.

We therefore call upon the UK and German governments to launch public awareness campaigns that will finally dispel damaging myths around energy efficiency improvements and lead to the cost savings that our households and businesses deserve. There also needs to be a rethink of EPC ratings and a greater understanding of the need for installation best practice including hydraulic balancing across heating systems, and the role that district heating is set to play in the future.

Against an ever-changing landscape of political and economic uncertainty, it's essential that governments step in to start making energy efficiency a priority. With this report we provide them with the evidence base to do so and we urge them not to shy away from the compelling case we present.

Introduction

The purpose of this report

Since the late 20th century, a growing awareness of the finite nature of fossil fuels and the impact of their use on the planet has informed ambitious environmental policies by governments around the world. These policies are aimed at reducing energy usage and at using cleaner sources of energy.

Domestic and non-domestic heating are major consumers of energy and have made relatively slow progress in decarbonisation thus far relative to sectors like electricity generation. Therefore, future environmental efforts, such as the push for Net Zero, will rely heavily on improving their energy efficiency and reducing associated emissions. Moreover, the need to establish more robust energy security has also become exceedingly clear. The recent energy price and security crisis, exacerbated by Russia's invasion of Ukraine, has created cost pressures which put households at risk of fuel poverty and businesses in severe difficulty. Countries across Europe have faced elevated energy costs, combined with high general inflation, in large part due to the conflict in Ukraine that has seen Russia reduce its supply of gas. This has further demonstrated the potential benefits of energy efficiency.

This report focuses on Germany and the United Kingdom (UK) and considers the role that energy efficiency can play at not only helping to address this energy crisis in the short term but also support the long run transition to net zero. Both households and businesses have been put under increasing pressure, with some energy intensive businesses in Germany, for example, already shutting down or reducing production.

The German and UK governments have needed to provide immediate support to both households and businesses to help with the large rise in energy costs. September 2022 saw Germany introduce an energy support package to the tune of EUR 200bn. Both in the immediate and longer term, there is a need to reduce dependency on Russian imports of gas. Germany's deputy chancellor, Robert Habeck, has recently said that there is a need for reduced consumption. Another part of Germany's response has been to restart operations at coal power stations that were in either disuse or approaching closure and it has also temporarily halted the phasing-out of two nuclear power plants. Other German measures have included banning the heating of leisure pools that use energy from the grid and limiting temperatures in corporate offices to 19°C.

In the UK, there has also been extensive support to households and businesses. Household bills have been capped, on average, at £2,500 – rising to £3,000 in April 2023, albeit with cash payments to certain vulnerable households. In the absence of these measures, bills were expected to rise to over £4,300 in the spring[i]. Businesses have obtained similar support for a six-month period, with further support expected to be announced in a few months' time[ii].

This report reviews the current state of energy efficiency policy and outcomes in two key markets, Germany and the UK. It has been produced by the Centre for Economics and Business Research (Cebr), an independent London-based economics consultancy. It was commissioned by Grundfos, a global leader in advanced pump solutions and water technologies and one of the biggest pump manufacturers in the world, producing more than 17 million units annually. The goal of this research is to help identify where government policy in Germany and the UK could advance energy efficiency at this crucial time.

This research has been informed by a Censuswide survey of German and UK households and businesses, results of which are included in the report, and a virtual roundtable hosted by Cebr and BCW – we are very grateful to the participants, listed below, for their insight:

- Cara Holmes, Senior Policy Researcher at Citizens Advice
- Alex Luke, Senior Researcher at Onward
- Henning Ellerman, General Manager at DENEFF
- Glynn Williams, UK Country Director at Grundfos
- Chris Skeen, Global Product Director at Grundfos

Report structure

This report is structured as follows:

- Key Findings, summarising the headline results of the research
- Executive Summary, condensing the research into a few pages and including recommendations
- For each of Germany and the UK in turn:
  - Recent history of energy strategy
  - Review of energy efficiency literature
  - Discussion of current energy policy
- Selected comparative statistics for Germany and the UK
- Conclusion

Key Findings

- International comparisons show that Germany and the UK both rank highly on the stringency of their energy efficiency policies and the ambition of their targets – but on outcomes they lag behind comparable European countries.

- Germany and the UK have both been successful in reducing and decarbonising their overall energy consumption in recent decades, but in both countries there remains significant scope for decarbonisation in the heating of domestic and non-domestic buildings. In Germany, rates of building energy efficiency renovations are half of the 2% (of the building stock per annum) target.

- Key barriers to greater adoption of energy efficiency measures include the perceived upfront costs of energy efficiency improvements, lack of information on their positive impacts, and lack of available qualified installers. For example, in our survey, when asked what prevented them from improving the energy efficiency of their heating system, 25% of households and 32% of businesses named upfront costs as the biggest reason.

- Potential to save money on energy bills is the most powerful motivator for households and businesses to improve their energy efficiency. In our survey, 60% of households and 50% of businesses were worried about rising energy bills.

Executive Summary

Energy efficiency in Germany and the United Kingdom

Germany and the UK have created ambitious targets and strategies for the reduction of energy consumption and decarbonisation of energy sources. As well as the environmental rationale for these policies, there are socio-economic and geo-political reasons, which include the reduction of fuel poverty and the lessening of energy dependency on countries such as Russia.

Both countries' targets are ambitious by international standards, and they have significantly reduced and decarbonised overall energy consumption – but crucially their energy efficiency outcomes with respect to the heating of buildings are less impressive, and relatively slower progress has been made.

Our research, including a roundtable with industry experts, identified key barriers to the realisation of better domestic and non-domestic energy efficiency in heating, whether through installation of new systems, maintenance, or small improvements to existing systems:

- Upfront costs of investment, especially for poorer households or smaller non-domestic users – raising funds may not be possible and long pay-back periods can result in households and businesses choosing not to proceed. Well-designed government support through loans or grants can reduce this issue.
- Insufficient numbers of operatives qualified to carry out efficiency improvements and install technologies such as heat pumps and district heating.
- Among those who rent, not being able to choose their heating system – this is especially relevant in Germany where private rental of housing is dominant. Incentives or regulations for landowners may encourage them to invest in making the heating system more efficient.
- Age of the housing stock – especially in the UK. Older buildings tend to be less well-insulated and fitted with less efficient heating systems. Retrofitting may also be more challenging.
- Lack of information – for instance on the costs and environmental benefits of making heating systems more efficient, what support is available for domestic or non-domestic users, and possible low-cost measures which can nevertheless deliver a high rate of return.
- Users may default to like-for-like replacement of heating systems or their components instead of modernisation and improvement. This is related to issues like upfront costs (despite life-time costs being lower) and lack of information. It is particularly relevant in non-domestic contexts, where repurposing of buildings may present an opportunity to install low carbon, energy efficient heating systems – but one that is too often missed.
- Poor government scheme design, for instance drawn-out application processes, poor enforcement of standards, or short-term schemes; these can all lead to poor experiences of accessing government support and put households and businesses off doing so. Participants at the roundtable felt that in some cases incentives may not be sufficient, and firmer regulation is required.

Survey results

Data from a Censuswide survey was analysed to investigate key barriers to investments in energy efficiency improvements and of take up of energy efficiency schemes. This survey identified major issues affecting both the non-residential and residential sectors of the UK and Germany, which broadly support and reinforce the findings from our wider research.

- **Initial costs of action are a barrier to improvement**: The perception of high upfront costs is a significant determining factor in the decision to invest in heating efficiency, with 31% of UK household respondents listing this as the biggest reason for not investing compared with 20% for Germany. 32% of business respondents across the UK and Germany claim the biggest reason for not improving their heating efficiency is upfront costs.

- **Businesses are also concerned about potential disruption and availability of installers**: UK businesses fear disruption more than their German counterparts (cited by 25% rather than 15% of respondents) whilst concerns about the lack of installers and maintenance professionals affected the decisions of German businesses more than those in the UK (26% compared to 18%).
- **Significant numbers of German and British households have inefficient heating systems**: 16% of households complain of some areas being too warm while some are too cold (20% for British households, 13% for German). Slowness to warm up and noisiness are also identified as common concerns. These issues could be addressed through comprehensive retrofits, and in some cases by simpler measures including installation best practice, i.e. hydraulic balancing.
- **Rising energy bills are a major concern**: For both households and businesses in each country, the most common concern around heating systems is rising energy bills. 64% and 56% of households in the UK and Germany respectively cited this as a major concern. 50% of businesses across both countries said they were worried about energy prices, making this the most commonly cited business concern, second to inflation in general (much of which, of course, is driven by rising energy prices).
- **Businesses are equally likely to raise prices as they are to invest in efficiency upgrades**: 36% of businesses across the UK and Germany have made their businesses more energy efficient to deal with rising bills, whereas 36% have increased prices as a result. In each case, a further 45% would consider doing so, suggesting that continued high energy prices will drive further energy efficiency enhancements in some cases but further price rises in others.
- **Homes and businesses are losing out on as much as £3.1 billion of savings each year in the UK:** based on the potential annual saving from 'low-hanging fruit' – simple, cheap, quick to install energy efficiency measures like hydraulic balancing. This is based on Grundfos figures for potential reductions in energy bills and survey data revealing that 63% of businesses and 74% of homes are prevented from making energy efficiency improvements. This equates to a missed cumulative annual saving of £3.1 billion (€3.6 billion) – though this does not take into account installation costs.
- **Homes and businesses are losing out on as much as €7.6 billion of savings each year in Germany:** this is also based on potential savings from straightforward measures such as hydraulic balancing. 67% of businesses and 75% of homes are prevented from making energy efficiency improvements, equating to a missed annual saving on heating bills of €7.6 billion (£6.6 billion).

Recommendations to policymakers

Germany:

- Promote more rapid development of energy efficiency policy and regulatory frameworks for the residential and non-residential heat sectors to more closely match progress made in the energy sector.
- Shift tax incentives by moving towards lower levies on electricity and relatively higher taxes on heating oil and natural gas for heating, to incentivise switching towards the use of electricity for heating.
- Enhance information campaigns to streamline and clarify incentives for consumers and businesses to upgrade heating systems to more energy efficient ones, and promote awareness of their benefits.
- Continue subsidy schemes for both insulation and efficient heating systems, but with a focus on SMEs and low-income households.
- To counter the principal agent tenant/landlord disincentive problem, introduce minimum energy performance standards in privately-rented homes.
- Accelerate and expand the smart meter roll-out to all households and enable the long-term digitalisation of the buildings sector to achieve energy savings and unlock flexibility of demand.
- Introduce a government funded training programme for installers and energy technicians (including chimney sweeps) to learn how to properly install and maintain energy efficient heating systems in domestic and non-domestic buildings along with standardised rules and guidelines for installation and efficiency monitoring.

United Kingdom:

- Ensure that clear information for domestic customers is available on the benefits of low carbon heating systems, e.g. in terms of typical financial savings, environmental benefits, and ease of installation.
- Ensure that non-domestic users can easily access information on life-time costs of different systems – this can help tackle misconceptions around the costs and benefits of energy efficient systems.
- Target domestic energy efficiency schemes to maximise additionality of take-up and the socio-economic benefits to the poorest households, and increase support for SMEs. For example, this could take the form of new grant funding schemes specifically aimed towards these groups.
- Continue to target domestic users who currently have inefficient, high-carbon heating systems – for instance those who are not on the gas grid.
- Provide targeted support and information for non-domestic users with inefficient, high-carbon heating systems. This may include those with older premises or not on the gas grid, and for large premises potential benefits may be very significant.
- Publish estimates of and targets for the number of energy efficient domestic and non-domestic installations on an annual basis, similar to the retrofit targets used in Germany.
- Ensure that measures are in place to guarantee consistent best practice in installation and retrofitting of energy efficiency improvements. These might include quality marks for traders, well-enforced rights of redress for those who have received substandard work, and improved skills provision for energy efficiency improvements.
- Prioritise schemes that offset the upfront costs of installing new, energy efficient heating systems for domestic and non-domestic users.

1 The recent history of Germany's Energy Strategy

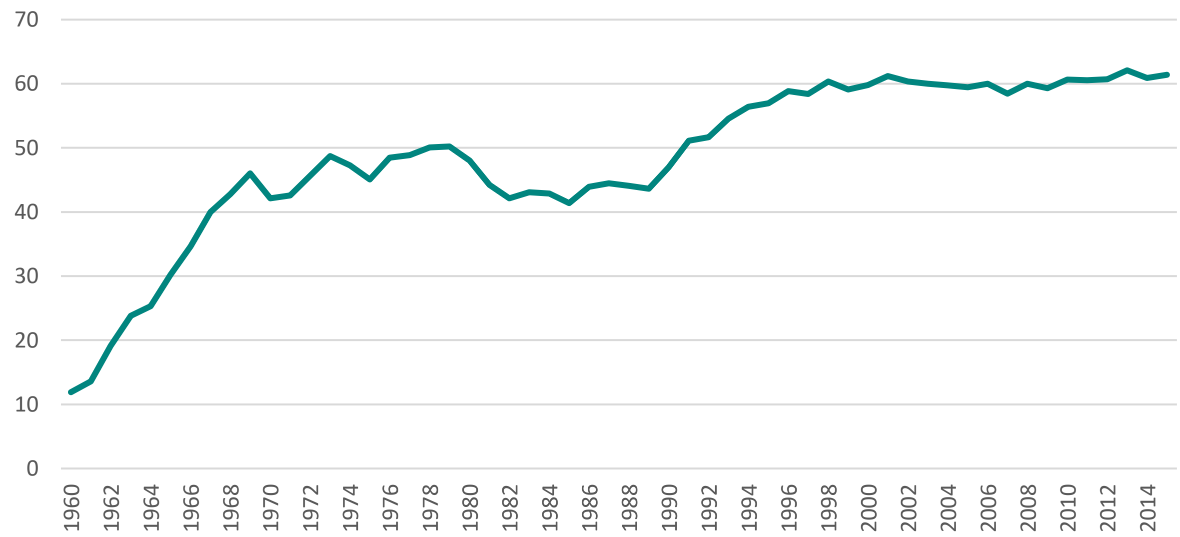
Germany is the world's ninth largest energy consumer and third largest in the G7 after the United States and Japan[iii]. This is partially due to its large population, with approximately 83.8 million residents in 2022, making it the most populous country in the European Union. However, due to significant efforts by multiple German governments, broadly supported by the electorate, many policies have been implemented with the aim of transforming Germany into a low carbon, nuclear free economy. This transformation is known as the 'Energiewende' and directly translates as 'energy turnaround'[iv]. As a result, per capita consumption of primary energy fell by 25.9% from a peak of 55,877 kWh in 1979 to 41,854 kWh in 2021[v]. These statistics include electricity, heating, and transportation.

Like most developed nations, Germany's energy system has been historically based on fossil fuels. Coal is Germany's most abundant indigenous energy source[vi], and was used to power the industries of West Germany following WW2, aiding the country's post-war economic boom. In the 1950s, the Saarland and Ruhr region in Western Germany had bustling economies driven by coal mining and heavy industries[vii]. Discontentment with the widespread use of coal emerged in the 1960s, as concerns about the health effects of particulate pollution grew. The possibilities of cleaner coal were emphasized in response, along with a 'high-stack' policy to dilute pollutants. However, high-stacks were subsequently blamed for spreading nitrate through the upper atmosphere, amplifying the slow dieback of German forests. Nuclear had been seen as an inexpensive solution, gaining political momentum in the 1970s when supply reliability and energy independence became important topics, however this view changed, being triggered by events of Chernobyl and Fukushima. Following these events, opposition to both coal and nuclear grew stronger with the emergence of the Energiewende movement[viii].

Russian reliance

Germany is highly dependent on imported Russian gas. By 2020 Russia supplied over 50% of Germany's natural gas and approximately one third of oil[ix]. The increasing reliance on Russian imports was again in part related to the Energiewende, as Germany sought to move away from coal as an energy source, with gas being viewed as a bridging technology to support the achievement of this transition.

Figure 1: Percentage of net German energy usage supplied by imports, 1960 - 2015, %



Source: World Bank Data

Figure 1 displays the percentage of German net energy consumption supplied by imports. Data indicates a rapid increase in the proportion of German energy sourced from overseas between 1960 and 1978, and then again from 1989 to 1998. Over the entire period from 1960 to 2015, imported energy grew from 11.9% to 61.4% of net domestic use. The more recent rise from the late 1980s onwards coincides with implementation of policies associated with the Energiewende movement.

Energiewende

The Energiewende can be seen as a series of federal laws built on top of one another, for the purpose of maintaining a goal of transforming the German energy system into one of the most energy efficient and sustainable in the world, while adapting to present realities. Its goals can be summed up as: i) reduce energy consumption in all sectors, under the principle of "efficiency first"; ii) use renewable energy directly where it makes economic and ecological sense and iii) cover the remaining need for energy by renewables-based electricity.

Timeline of significant developments in German energy policy:

- **1990:** Germany committed to reduce its GHG emissions by 21% from 1990 levels by 2008. By 2000 Germany had already achieved an 18.9% reduction in CO2 emissions corresponding to 231.4 million tonnes of CO_2 equivalent[x].

- **2000:** The Renewable Energy Act (EEG) was introduced, promoting investments in renewable energies, and the first nuclear phase-out law. The EEG is the central driver for the expansion of renewable energy in Germany through the inclusion of 1) a mandatory obligation of grid operators to connect renewable generators to the grid system 2) fixed remuneration rates for renewables (higher than the market price) 3) feed-in priority for electricity produced by renewables[xi].

- **2010:** In 2010 Germany's newly formed coalition government, led by Angela Merkel, adopted the 'Energiekonzept' a long-term energy strategy calling for a renewable-based economy by 2050. It included both mid and long-term targets for the development of Germany's renewable energy industry, improving energy efficiency, and reducing CO_2 emissions.

- **2014:** The EEG was updated into an EEG 2.0. This act introduced measures to manage the growth and competitiveness of renewable energy. The most consequential reforms involved reducing fixed tariffs, creating auctions for most solar producers, recalculating the surcharge to assist large industry, and forcing self-suppliers to pay a surcharge.

- **2017**: An amendment to the EEG 2.0 was made in 2017, introducing an auction-based system of determination for renewable electricity prices, replacing the fixed feed-in tariffs. Other amendments include efforts to reduce grid congestion[xii].

- **2018:** A newly elected coalition government dropped 2020 climate targets but the goal for renewables expansion was raised with the EU Renewable Energy Directive, which established a target of at least 32% of energy from renewable sources by 2030[xiii]. In the same year a ruling was made by German courts enabling cities to ban diesel cars, with Hamburg becoming the first to enact the law[xiv]. Domestic consumption of renewables overtook solid fuels for the first time, while the newly formed coal exit commission laid out a pathway for the country to end coal generation by 2038[xv].

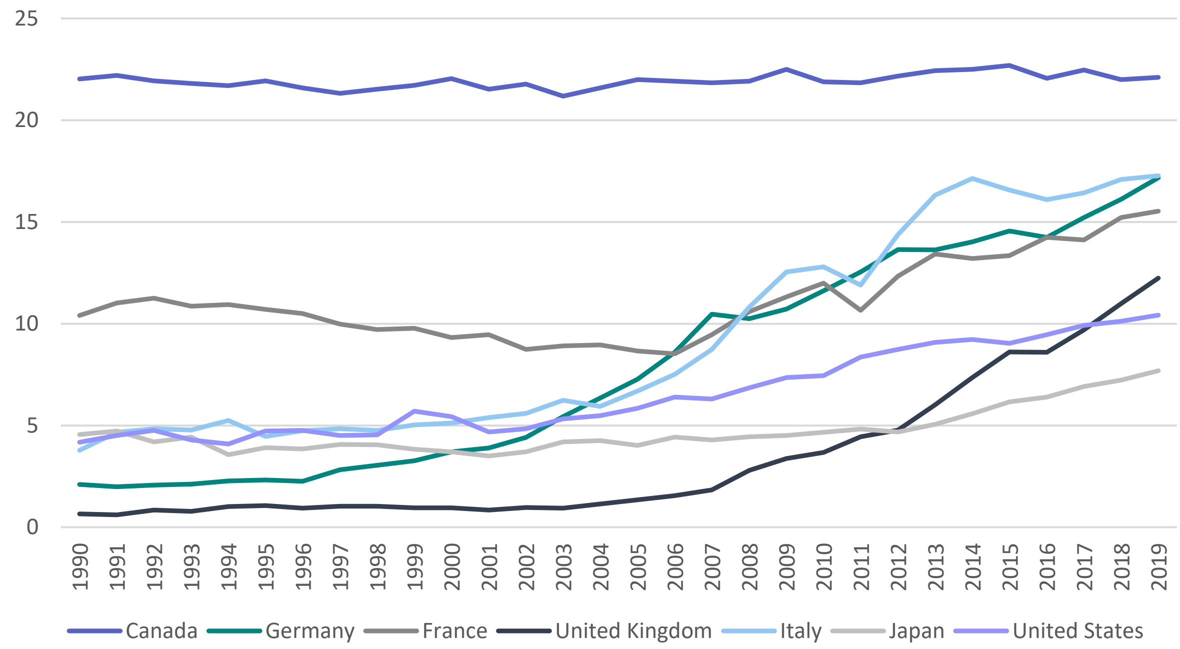
- **2019**: Germany's first climate law makes emissions reduction legally binding. A revision to the country's main climate plan committed Germany to being greenhouse gas neutral by 2045 with a 65% reduction in emissions compared to 1990 levels by 2030 and an 88% reduction by 2040[xvi].

- **2021:** An amendment to the climate law of 2019 created annual reduction targets for individual sectors such as industry and transport until the year 2030, in line with European greenhouse gas reduction plans[xvii].

- **2022**: Germany's economic minister, Robert Habeck, declared that the acceleration of renewables is key to reducing Germany's dependence on Russian fossil fuels. To this end, the newly elected German government has made numerous amendments to the EEG 2.0, passed the Onshore Wind Energy Act, changed species protection rules to enable greater wind energy utilisation and accelerated grid expansion among many other measures[xviii].

Figure 2 below presents the percentage of energy consumption generated by renewables in each of the G7 countries. Of all countries included, Germany increased by the most percentage points over the period (at 15.1%). Although Canada remained the country with the highest proportion of renewables throughout the period, they remained stagnant, with renewables increasing by only 0.1 of a percentage point.

Figure 2: Percentage of energy consumption of G7 countries generated by renewables, 1990 – 2019, %



Source: World Bank Data

It is evident that reducing dependence on Russian fossil fuels is of paramount importance to Germany's energy security. Despite the expansion of renewables, Germany still remains dependant on Russian imports. This presents a significant problem for Germany, as following Russia's invasion of Ukraine gas prices have soared while Russian exports of both gas and oil to the EU are facing severe disruptions[xix]. Before the start of Russia's aggression in Ukraine, just over half (55%) of gas consumed in Germany was imported from Russia. By the end of June 2022, this fell to about one quarter, putting extreme pressures on Germany to maintain sufficient reserves for the winter. Germany's ability to heat homes and power industry has become vulnerable, as gas is the single largest source of energy, at about 27% of Germany's overall mix[xx].

Recent efforts to expand the capacity of renewables will help bridge the gap, especially in the context of national coal and nuclear reduction targets. Moreover, the prioritisation of energy efficiency can continue to a role in reducing Germany's overall energy consumption and will provide some relief from Germany's current energy crisis. Greater energy efficiency not only decreases greenhouse gas emissions but facilitates a reduction of overall energy consumption, reduces costs for users and lowers grid congestion. The challenge to achieve greater energy efficiency is twofold, increasing efficiency at the source through systems of power generation such as heat pumps, and by better retention of energy generated.

2 Review of German energy efficiency literature

From reviewing literature, three main groups of obstacles to achieving optimal energy efficiency in Germany emerge: 1) under investment in energy efficiency technology, occurring from mechanisms such as credit constraints and asymmetric information 2) a skills shortage of installers and maintenance specialists and 3) Cultural issues specific to Germany such as preferences towards renting instead of home-ownership enhance the principal agent problem between landlords and tenants, disincentivising investments in energy efficiency modernisations in non-owner occupied homes.

Credit constraints and asymmetric information

The adoption of energy efficient technology and processes requires capital investment, and as a result, those with more capital have greater ability to become energy efficient. Conversely, credit constraints represent a well-recognised barrier to energy efficiency. Ameli and Brandt[xxi] utilise data from the OECD Survey on Household Environmental Behaviour and attitudes to investigate the main factors behind consumer choice regarding investments in energy efficiency and renewable energy technologies. Their empirical analyses, based on binary logit regression models, indicate that households' propensity to invest in clean energy technologies depends mainly on home ownership, income, social context and household energy conservation practices. Indeed, homeowners and high-income households are more likely to invest than renters and low-income households. In addition, environmental attitudes and beliefs, manifested in energy conservation practices or membership in an environmental non-governmental organisation, also play a relevant role in technology adoption. Their findings are supported by research by Bergmann (2019)[xxii] who investigated the economics of energy services and energy efficiency improvement projects in the German industrial sector. His results show that low capital availability was the joint most common barrier to energy efficiency of industrial sector firms, along with the belief that investments in energy efficiency and the usage of energy services would create external risks.

Asymmetric information, in particular that related to future energy savings, presents an important barrier to the adoption of energy efficient technology. Lanz and Reins (2019)[xxiii] study the supply-side implications of the associated incentive structure, building upon evidence to show that the supply-side part of the energy market has more information on what technology is best for customers. This informational imbalance leads to inefficiencies such as residents and businesses being slow to adopt energy-efficient technologies due to a lack of information.

The significance of lack of information as a barrier to the adoption of energy efficient technology for both businesses and households has been supported by evidence from Schleich (2009) [xxiv] who sampled data from German commercial and services sector firms, finding that lack of information about energy consumption patterns and energy efficiency measures rank highly in the relevant barriers to energy efficiency. On the residential side, Baumhof, Decker and Menrad (2019)[xxv] observe that home energy efficient refurbishment measures (EERMs) are not realised at the required level to achieve environmental targets in Germany. Utilising data from 1,085 German owner-occupiers they investigate factors influencing decisions to invest in EERMs or not, finding that measures to supplement existing information campaigns are likely to be effective tools for influencing homeowners to invest in EERMs. Other suggestions include increased monetary support, and presentation of the aesthetic appearance of refurbished buildings.

Skills Shortage

The installation and maintenance of modern energy efficient building heating systems, as well as the construction of modern energy efficient buildings, demand different skills to that of traditional heating systems and buildings. The European Commission identifies that an important barrier to the development of Nearly Zero Energy Buildings (NZEBs) and effective renovations is the lack of adequate construction skills[xxvi]. Additionally, in a study of building energy renovations, the European Commission found that approximately half of all installers across Europe already dealing with energy related renovations report energy efficiency measures being too complicated to install[xxvii].

> Our survey showed that 26% of German respondents (18% of UK respondents) cited lack of installers and maintenance professionals as the biggest reason for not improving their energy efficiency.

According to the German Sanitation, Heating and Air Conditioning Association, targets for the expansion of energy efficient renovations in Germany will not be reached due to the lack of workers with the skills to install and maintain them[xxviii]. However, Germany has approximately 21,000 working chimney sweeps, with more than 10,000 these being trained and certified building energy consultants. Many new buildings do not have a fireplace and chimney, either because they are heated with an electric heat pump or by district heating. There is also a significant need for advice (on building energy systems) among the German population.[xxix] There is therefore potential for workers in this profession to be upskilled, in order to fill the skills gap and improve renovation rates.

A related issue raised by Henning Ellerman of DENEFF at the roundtable event was how those who do have the relevant skills will want to use their time, and the potential need for further regulation to bring about the lower-investment measures which nevertheless can deliver significant savings:

"Selling a pump or hydraulic balancing simply isn't as enticing as spending that same time installing a new heating system or fixing up a bathroom in a fancy way, because then he can sell a lot more product in that same time. ... So, we've come to the conclusion that incentivising these kinds of measures only gets you so far. Especially for things like pump replacements and so on, you probably need to eventually go the way of regulating it."

Principal agent problem between tenant and landlord

Gebhardt (2013) [xxx] empirically evaluates whether the allocation of asset ownership impacts specific investments such as energy efficiency modifications. He finds that such investments are more frequent if the occupant is protected against expropriation because they own their own home and therefore concludes that renovations are significantly dependent on the ownership status. It follows that his predicts underinvestment in energy efficiency improvements for rental housing. Hence, the heating energy consumption of households that own their dwelling may deviate significantly from that of tenants.

Dieckhöner (2012)[xxxi] investigated the effects of energy efficiency subsidies on consumption in Germany's residential sector. She finds that investments in efficiency modernisations are much more likely to occur in owner occupied housing as landlords would seek to incorporate the cost of investment into rental prices, making them less price competitive. As such, they are dis-incentivised from doing this.

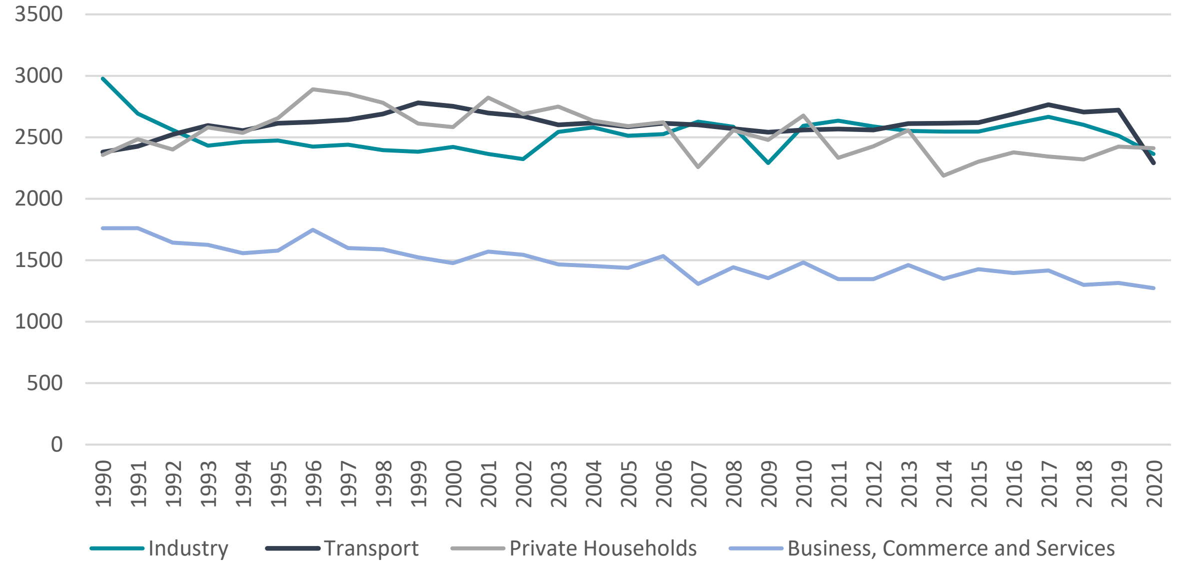
Combatting these barriers to energy efficiency requires significant planning and forethought. Econometric research conducted by Schleich (2004)[xxxii] finds that energy audits help to overcome barriers such as lack of time or information, uncertainty about energy costs, or the landlord/tenant dilemma. The results also indicate that audits conducted by engineering firms are more effective than those carried out by utilities or industry sector associations.

Brischke et al.(2015) [xxxiii] argue that the existing policy measures related to *Energiewende* in Germany concentrate primarily on improving energy efficiency as opposed to self-sufficiency. However, they also note that whilst energy efficiency in many sectors has been consistently improved, total energy use has remained stable. In this sense, energy efficiency improvements are being eaten up by higher levels of consumption and/or rising expectations of comfort. This, they argue, implies that there are limits to energy efficiency. There are, in addition, various studies that have assessed the magnitude of this 'rebound effect' for domestic heating. Greening et al. reviewed 75 studies: finding rebound effects in the range of only 10–30% for space heating. The rebound effect appears to differ by sector and scale of data analysed.

3 Energy Policy in Germany

Policies associated with Germany's Energiewende have changed the overall picture of energy consumption in Germany. In 2020, the residential sector accounted for almost 30% of total final energy consumption in Germany, with the industrial and transportation sectors closely following. The remaining 15.2% is attributed to the business, commerce and services sector as displayed in Figure 3.

Figure 3: Total Final Consumption by Sector in Germany, 1990 - 2019, Terajoules



Source: Federal Ministry for Economic Affairs and Climate Action

Figure 4 andFigure 5 present residential energy consumption by use and fuel type respectively.

Figure 4: Residential consumption by use, 2018, %

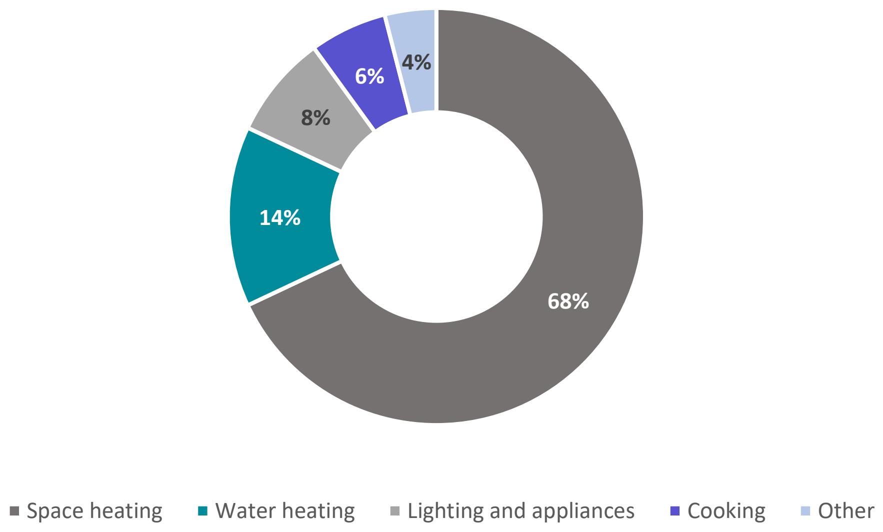
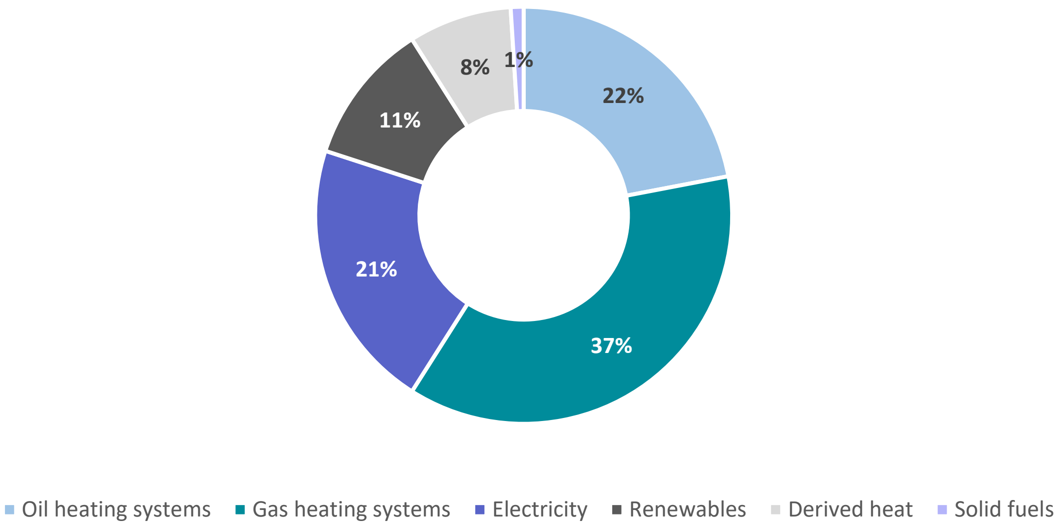


Figure 5: Residential consumption by fuel, 2018, %



Source: Eurostat

With households comprising approximately 25.5% of Germany's total final consumption according to the IEA and as presented in Figure 3, and space heating dominating home energy usage at 68%, reducing energy consumed by residential heating is likely to have a consequential effect on minimising overall energy consumption in Germany. Gas heating systems consume the majority of household energy, at 37% of all residential energy consumption, while gas, oil and solid fuels combined make up 60% of household energy consumption. By June 2022 a quarter of gas used by Germany was sourced from Russia. To reduce dependence on Russia, focus on energy efficiency will be key. The remainder of this section provides a more detailed look at recent energy policies in Germany, with particular focus on those related to energy efficiency.

Overview of recent energy efficiency policies

In 2010 Germany's federal government launched its 'Energy Concept', a long – term strategy setting out Germany's energy policy until 2050. This provided formulated guidelines for an environmentally sound, reliable, and affordable German energy system, while mapping a road to for renewables as a major source of energy[xxxiv]. Included in the plan were overall energy efficiency targets of a reduction of primary energy consumption of 20% until 2020 (and by 50% by 2050) compared with a 2008 base year. Also established in 2010, as the Energy Savings Climate Fund, one of the main sources of financing energy efficiency measures. This fund is now financed with revenues from permit auctions under the EU ETS. Programmes range from direct financial support to information, communication measures and advisory services[xxxv].

By 2013 it was estimated that key targets would not be met at the current rate of efficiency growth. To rectify this, the German Ministry for Economic Affairs introduced the National Action Plan for Energy Efficiency (NAPE) in 2014. Within NAPE, the schemes which delivered the most CO2 savings were 1) the competitive efficiency tender known as 'Step Up' and 2) the establishment of up to 500 energy efficiency networks in industry[xxxvi].

The Fukushima nuclear power plant in 2011 had a significant impact in limiting Germany's nuclear energy policy. In particular, the Federal government removed nuclear power as a 'bridging technology'. This has served to increase the reliance on both renewables as well as fossil fuels for electricity production[xxxvii].

The 'Climate Action Programme 2020' also came into force in 2014, containing measures to be implemented by 2020 in order to reach Germany's greenhouse gas targets, including an energy efficiency target of a reduction in CO2 emissions of 62 – 78 Mt CO2eqv. The programme also contained a set of NAPE measures, as well as those to increase efficiency in buildings, such as tax incentives for energy efficient refurbishment and expanding the low-carbon refurbishment programme, and in the transportation sector such as the HGV toll and car sharing legislation[xxxviii]. Lifelong tenancy is common in German culture, however, there are relatively strong tenancy rights. This has a potential for limiting the scope of sustainable investments in the case that tenants are not entitled to a reasonable share of benefits, such as those deriving from energy saving measures. Amendments to the Renewable Energy Act (2014), served to ensure that tenants and landlords both receive a share of the return from investments in sustainable energy technologies.

Germany did reach its targets as set out in the Climate Action Programme, although this was largely due to the Covid-19 pandemic and following economic downturn, in addition to weather conditions favourable for renewable energy production. However, it was initially thought that these targets would be missed notably because of slow progress in the heating and transport sectors[xxxix]. As a result, a 'Climate Action Plan 2050' was adopted in 2016. This plan included measures to increase energy efficiency within Germany's Energy, Buildings, Transport, Trade & Industry and Agriculture and Forestry sectors with long-term and interim targets for CO2 reduction set for 2050 and 2030 respectively. The plan operates on an 'efficiency first' principle, building policy around the assumption that energy demand must be significantly and permanently reduced in all sectors. In line with this, in 2016 efficiency labels for all boilers older than 15 years old were rolled out to help inform consumers of their own building efficiency and advisory and funding schemes available. In 2017 it became mandatory for district chimney sweeps to become licensed to issue these labels, whilst heating technicians, and certain energy consultants are also permitted to do so[xl].

In 2019, the German government released the Energy Efficiency Strategy 2050, central to which was NAPE 2.0. The aim of the action plan is to reduce energy consumption in different sectors across the German economy, such as transport, commerce, and buildings, focussing particularly on reducing demand for heating and cooling purposes which account for approximately 50% of final consumption in Germany. NAPE 2.0 includes 17 measures to increase energy efficiency of buildings, 13 for the energy efficiency of industry, commerce and trade services in Germany and 12 to improve energy efficiency of the transportation sector[xli].

The National Energy Efficiency Plan was shortly followed by the Energy Efficiency Roadmap 2045, which sets out how a 50% cut in primary energy consumption could be achievable by 2045. In 2020, the buildings energy Act was adopted implementing measures to increase the energy efficiency of buildings. It brought together three separate pieces of legislation (the Energy Conservation Act, the Energy Saving Ordinance, and the Act on the Promotion of Renewable Energy in the Heat Sector) into a single cohesive law, regulating energy performance requirements for new construction, existing building stock, and the use of renewable energy for heating and cooling buildings[xlii].

In July 2022, the German government passed the largest energy policy amendment package in decades. At over 593 pages long it includes amendments to five laws aimed to accelerate the expansion of renewables and energy efficiency. The five laws amended include:

- The Renewable Energy Act – amendments made aim at increasing pathways to expand renewable capacity and measures to achieve them.

- The Offshore Wind Act – rules regarding subsidies have been redesigned by the 2022 package, while tender volumes have been increased, accelerating the build-out of offshore wind.

- The Onshore Wind Act – changes made include the enactment of the new 'Wind Energy Area Requirements Act, which obligates 2% of Germany's land be available for wind power, consequently amending the Federal Building code.

- The Federal Nature Conservation Act – amendments standardise and simplify species protection assessments and measures, enabling a quicker process of granting permits, especially of wind energy projects.

- The Energy Industry Act – new regulations accelerating the grid expansion needed to improve the national integration of renewable energy[xliii].

National household energy campaigns have primarily included a focus on improved technical innovation, greater energy efficiency, improved energy transmission, and high-tech grid management in order to enable greater proliferation of renewables[xliv]. While overarching policies are developed at a federal level, much of the practical actions required to deliver improved energy efficiency fall on local municipalities and civil society. The highly devolved nature of local administration means that local municipalities are primarily responsible for either taking direct action (in terms of their own energy use/supply) or indirect action such as providing the necessary conditions for private/semi-private sustainable investments or supporting civil society actions aimed at lowering energy consumption. This means that progress can occur at varying rates across the country.

Market Incentive Programme (MAP)

The full title of MAP is the market incentive programme for funding-support to measures to use renewable energies in the heating market. Heating is the biggest building contributor to greenhouse gas emissions, therefore many schemes such as MAP seek to increase efficiency in the heating of buildings. MAP provides funding support for the installation of heating and cooling systems, certain heat storage units and local heating grids that operated from using renewable energy, in both residential and non-residential buildings. The programme includes two elements of support. For smaller installations, including small solar collector installations, efficient heating pumps and biomass facilities, investment grants are funded through the Federal Office of Economics and Export Control (BAFA)[xlv]. Installations of this type can receive grants of up to 35%, however, if an old oil heating system is replaced, funding may increase to 45%. While gas condensing boilers that have been built with the ability to integrate renewable energy can receive funding of up to 20%. For larger installations, the federal government provides grants or large solar thermal installations, large efficient heating pumps, biomass fuelled heating and power installations, bio-gas power lines, deep geothermic power installations, local heating grids, and large heating storage units for heating from renewable energy. At the time of writing, more than 1.8 million systems have already been funded through MAP[xlvi].

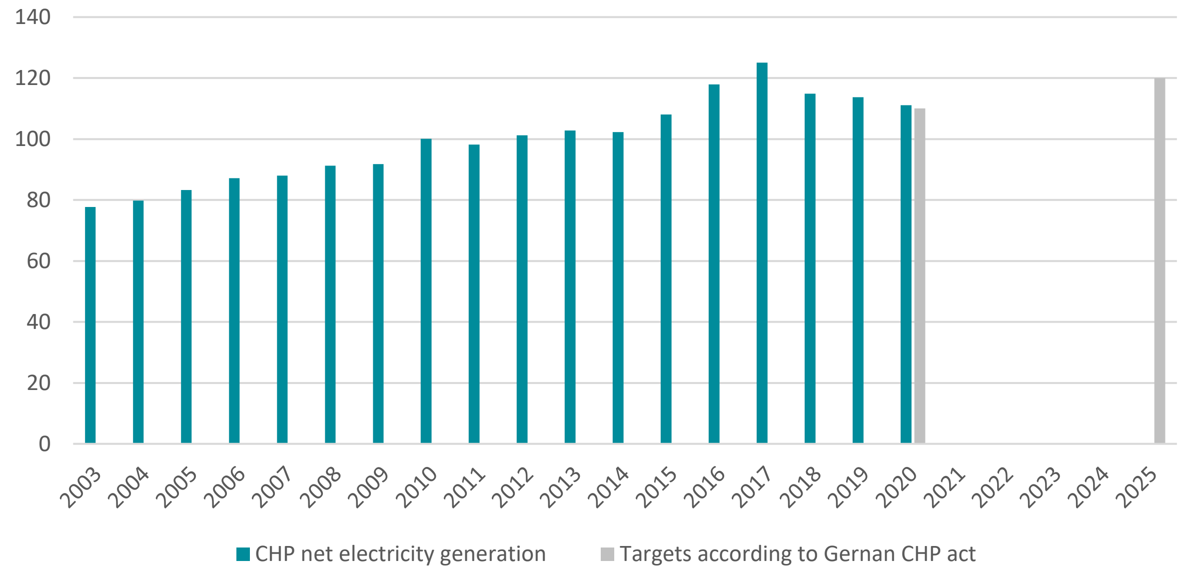
The Incentive programme on energy efficiency likewise provides funding support in three areas: 1) the installation of ventilation facilities combined with a measure to refurbish building casings 2) replacement of inefficient heating units with efficient heating 3) market introduction for stationary fuel-cell-based heating units in both new builds and existing buildings.

Another related scheme is the Funding Support Programme on Heating Optimisation, which aims to incentivise the replacement of inefficient circulation pumps used for space and water heating with highly efficient heat pumps, and the optimisation of existing heat facilities with hydraulic balancing.

Combined Heat and Power (CHP)

CHP is a highly efficient process that captures and utilises heat which is created as a by-product of electricity generation. In Germany, two main laws have been enacted with the aim of promoting CHP and as a result, Germany has become Europe's largest cogeneration market, with vast potential for growth. In 2000 the law for the protection of electricity generation encouraged the promotion of CHP, as CHP plants were at the time disadvantaged as electricity prices fell as a consequence of market liberalisation. However, CHP was not the primary focus of this law, and no financial aid was provided within it for CHP development[xlvii]. In 2002 the Combined Heat and Power Act was passed, aiming to increase electricity generation from CHP plants to support the launch of the fuel cell sector and provide funding for the construction and expansion of heating and cooling systems. Funding framework was based on the application of a surcharge, whereby operators of funded CHP installations are entitled to the payment of a supplement for a limited period of time, known as the CHP bonus. In 2016, revisions to the 2002 CHP Act doubled government funding to €1.5 billion, while restricting funding to plants not powered by coal. The 2016 amendments also stipulated that the surcharge payment was only applicable to electricity from cogeneration if it fed into a public supply grid (with exceptions for small CHP plants and those used by electricity intensive enterprises)[xlviii].

Figure 6: Volume of electricity generated by CHP 2003 – 2020 and targets 2020 – 2025, TWh



Source: Working Group on Energy Balances

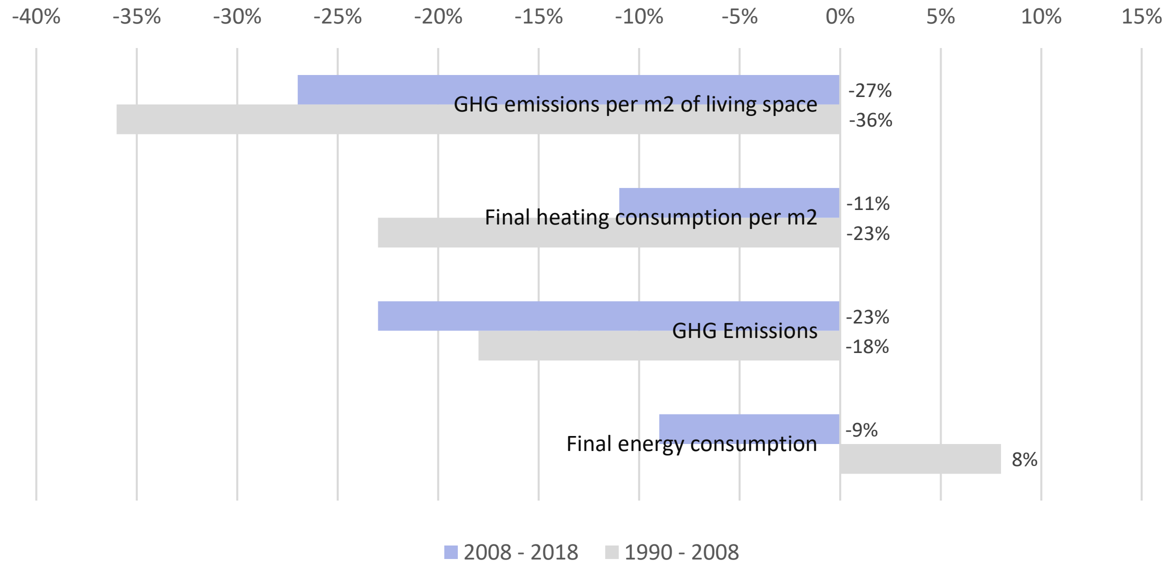
In 2017, the level of funding for CHP switched from being determined by government, to becoming established through an auction process. This helped meet expansion targets in a cost-effective manner while ensuring funding is transparent. As of 2021, a total capacity of 200 MW was being auctioned each year, of which initially, 150 MW came from conventional CHP plants and 50 MW from innovative CHP systems[xlix]. Figure 6 above presents recorded electricity generated by CHP in Germany from 2003 to 2020 along with targets set by the German government until 2025. The decline between 2017 and 2020 is due to a change in the way that energy statistics are measured, since 2018 CHP plants have been measured more accurately. The target CHP electricity generation for 2025 is 120TWh[l].

General Outcomes

Germany is often seen as a source of inspiration for energy efficiency policy as indicated by the High Council on Climate's 2020 report[li]. However the effects of such policies have been debated, for example in October 2020, French newspaper Le Monde published an article on the energy efficiency of Germany's building stock, claiming that energy consumption had not been reduced, energy retrofitting policies had failed and that CO_2 reduction targets were likely to go unmet[lii].

Figure 7 below displays the percentage change in various energy indicators between 1990 and 2008, and in the ten years from 2008 to 2018.

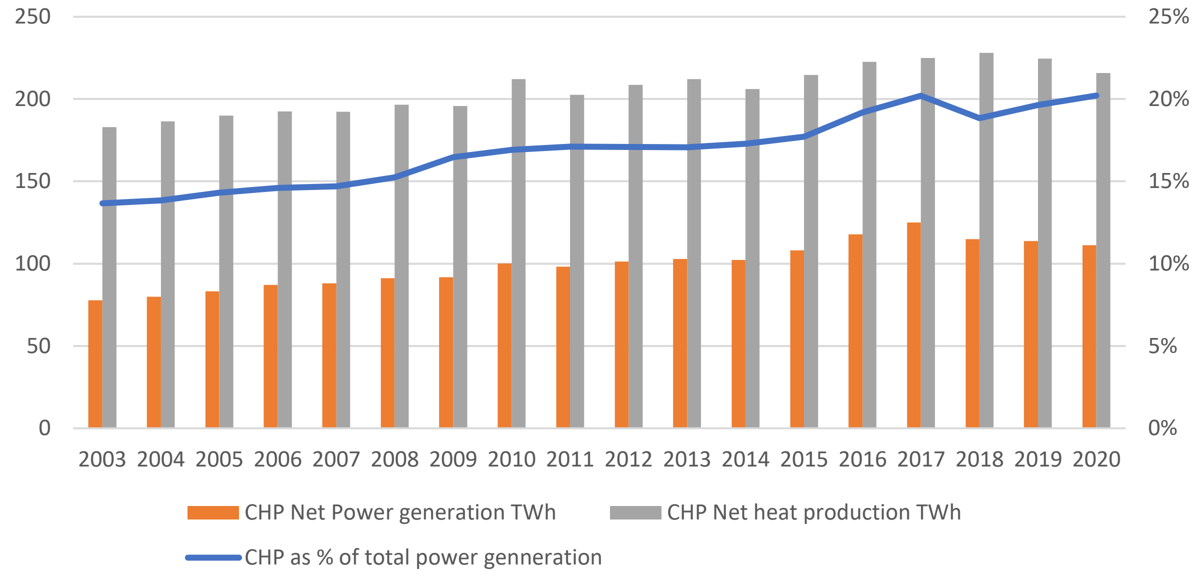
Figure 7: Change in energy-climate indicators for German residential sector, 1990 and 2018, %



Source: IDDRI, data BMWi 2020

Between 1990 and 2008, final energy consumption in Germany increased by 8%, but fell again by 9% over the following 10 years rendering consumption almost stationary over the entire 28-year period. For greenhouse gas emissions per meter squared of residential space the trend fall was greater from 1990 – 2008 than from 2008 – 2018, however averaged per year, the decline was more rapid in the latter period at an average of -3% per annum. However, these gains were partially offset by a 36% increase in the residential surface area from 1990 to 2018[liii].

Figure 8: CHP net heat and power generation TWH, CHP as % of total power generation, %, 2003 – 2020



The decline in residential emissions have occurred while CHP energy generation has grown. Figure 8 above presents data on CHP heat and power generation in Germany from 2003 to 2020.

Over the period 2003 to 2020 net power generated via CHP increased by an impressive 43%, translating to an increase in the proportion of power generated by CHP from 14% to 20% over the same period. Net heat produced through CHP grew by 18% from 183 TWh to 216 TWh.

In terms of CO_2, German emissions are expected to have declined by 36% from 1990 to 2019, according to data from the Federal Ministry for Economic Affairs and Climate Action[liv]. Table 1 presents CO_2 emissions by cause in Germany from 1990 to 2019, in Mt and as a percentage of total CO_2 emissions. Despite the significant decline in emissions over the period, the percentage caused by the combustion of fossil fuels increased over the period, while emissions from land use, change and forestry transformed from positive to negative.

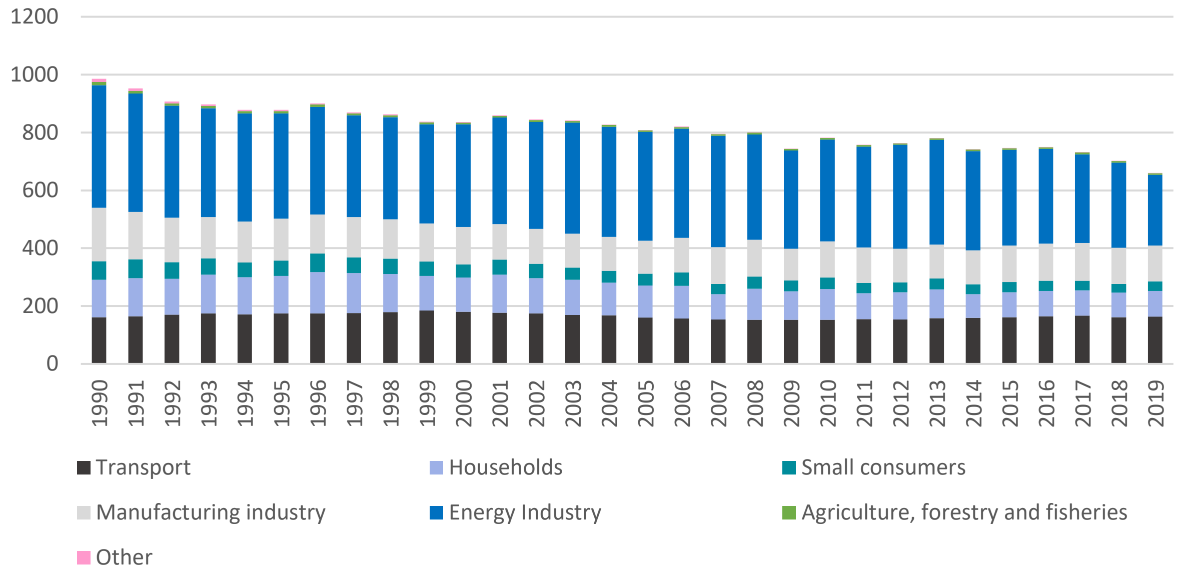
Table 1: Net CO_2 Emissions Germany, by cause, Mt, %, 1990 – 2019

	1990		2000		2010		2019	
	CO2 Mt	% of total	CO2 Mt	% of total	CO2 Mt	% of total	CO2 Mt	% of total
Combustion of Fossil Fuels	985.7	91.72%	836.7	95.43%	781.9	95.34%	660.7	95.53%
Fugitive Emissions	3.8	0.36%	3.0	0.34%	2.6	0.31%	2.0	0.29%
Industrial Processes	59.7	5.55%	57.5	6.56%	46.0	5.60%	45.9	6.64%
Solvents	3.2	0.30%	2.7	0.30%	2.5	0.31%	2.8	0.41%
Land use, change and forestry	22.3	2.08%	-23.1	-2.63%	-12.8	-1.57%	-19.8	-2.86%

Source: BMWi 2021

Figure 9 below presents the makeup of Germany's fossil fuel combustion by sector. Germany's energy industry is consistently the largest contributor to CO_2 emissions via fossil fuel combustion however, over the period, its CO_2 output has fallen by 42.2%. Conversely, CO_2 emissions from the transportation sector grew by 1% over the period, while households saw a decline of 31%.

Figure 9: Combustion of Fossil Fuels by Sectors, CO_2 Mt, 1990 – 2019



Source: BMWi 2021

Despite specific measures designed to increase energy efficiency of buildings, such as setting legal requirements, grants, subsidies and low interest loans the building refurbishment rate in Germany has not reached the politically desired 2% per year (it remains around 1%). In Germany the total building stock accounts for 38% of final energy consumption, and 30% of overall GHGE. Based on an average energy consumption of 177 kWh/m^2 estimated savings of energy efficiency refurbishment investments could range between 50% and 70%[lv].

4 Recent history of the UK's energy strategy

Timeline

As the home of the Industrial Revolution, the UK was a major, early consumer of energy, especially coal used in industrial processes and later generation of electricity. Until the 1970s, the UK imported 50% of its energy and remained heavily reliant on coal. The discovery and exploitation of North Sea oil and gas changed this, and the country was a net energy exporter for much of the 1981-2004 period. The UK continues to extract domestic oil and gas resources whilst also relying on imports of oil and gas. The UK economy has become significantly less energy-intensive since about 1990, as energy consumption has declined overall even as the economy has grown. It has also become less carbon-intensive as a result of this improved efficiency, and as gas and low-carbon energy sources have grown in importance at the expense of coal and oil.

Key recent developments in UK energy policy are listed below:

- **1964:** Continental Shelf Act makes provision for exploration and exploitation of North Sea oil and gas, with production starting in the 1970s.[lvi]
- **1980s:** Privatisation of much of the energy sector in Great Britain: Gas Act 1986 and Electricity Act 1989, provision for creation of regulators such as Ofgem.
- **2000:** Utilities Act makes various energy market reforms, including the introduction of the Renewables Obligation, providing a market-based incentive for increased electricity generation by renewables, and the Energy Efficiency Commitment for suppliers.
- **2002:** UK government launches pilot carbon trading scheme.
- **2008:** Climate Change Act makes provision for five-yearly 'carbon budgets' (with eventual aim of an 80% reduction of emissions by 2050) and establishes the Climate Change Committee to advise government.
- **2013:** Energy Market Reform (EMR) programme: creation of the Capacity Market, a mechanism to guarantee that generation sources could be called upon to supply power when required during shortfalls in supply, and to allow (mainly large non-domestic) consumers to be paid to adjust their demand; creation of Contracts for Difference (CfDs), guaranteeing a 'strike price' per unit to low carbon energy producers[lvii].
- **2016:** Formation of the Department for Business, Energy and Industrial Strategy (BEIS), with the following energy-related strategic objectives: ensure the UK's energy system is reliable and secure; deliver affordable energy for households and businesses; support clean growth and promote global action to tackle climate change.
- **2019:** 'Net Zero' target enshrined in law commits the UK to reduce net greenhouse gas ambitions to zero by 2050, with wide-ranging implications for energy sector.[lviii]
- **2020:** The Ten Point Plan for a Green Industrial Revolution is published. Relevant points include decarbonising the overall energy mix through advancement of offshore wind, hydrogen, and nuclear, and greener buildings, both domestic and non-domestic[lix]. Further to this, the UK Hydrogen Strategy sets out some steps towards developing the UK's low carbon hydrogen sector[lx], and £700m of funding for the Sizewell C nuclear reactor was recently announced[lxi].

Central to questions of the UK's energy policy are the objectives of security, affordability, and decarbonisation (encapsulated in the BEIS objectives above), sometimes referred to as the energy trilemma. In November 2018, Secretary of State for BEIS, Greg Clark, said that as 'cheap power is now green power', this trilemma was coming to an end, and instead proposed four guiding principles for strategy[lxii]:

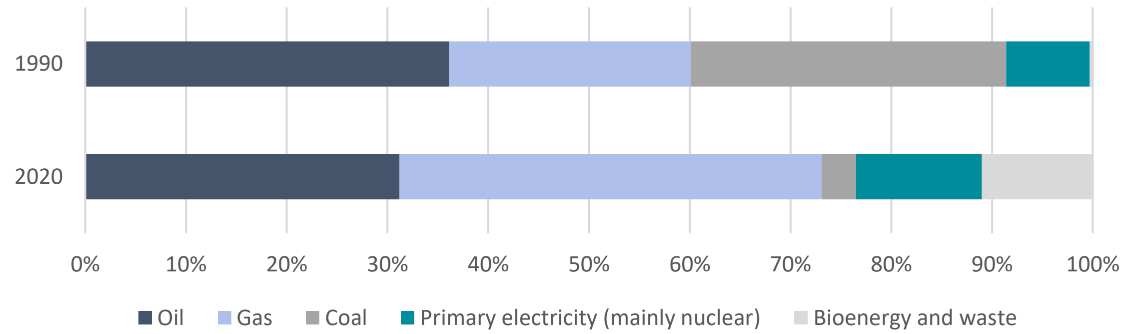
1. The market principle – use market mechanisms wherever possible to take full advantage of innovation and competition.
2. The insurance principle – given intrinsic uncertainty, government must be prepared to intervene.
3. The agility principle – regulation must be agile and responsive to reap the opportunities of the smart, digital economy.
4. The "no free-riding" principle – consumers of all types should pay a fair share of system costs.

The 'Energy policy in the UK' chapter of this report explores in more detail selected current and recent government policies used to promote domestic and non-domestic energy efficiency as part of this wider strategy.

Production, consumption, and emissions

Overall, electricity and natural gas make up roughly 20% and 30% respectively of the UK's final consumption of energy (most of the rest is petroleum used in transport)[lxiii]. Looking at primary energy consumption, sources have changed significantly, reflecting the policies and developments outlined above. Figure 10[lxiv] shows how in the last 30 years coal has declined in importance whilst gas, primary electricity (mainly nuclear but also wind, solar, etc.), and bioenergy/waste have all come to contribute more.

Figure 10: UK inland energy consumption, 1990 and 2020, by source



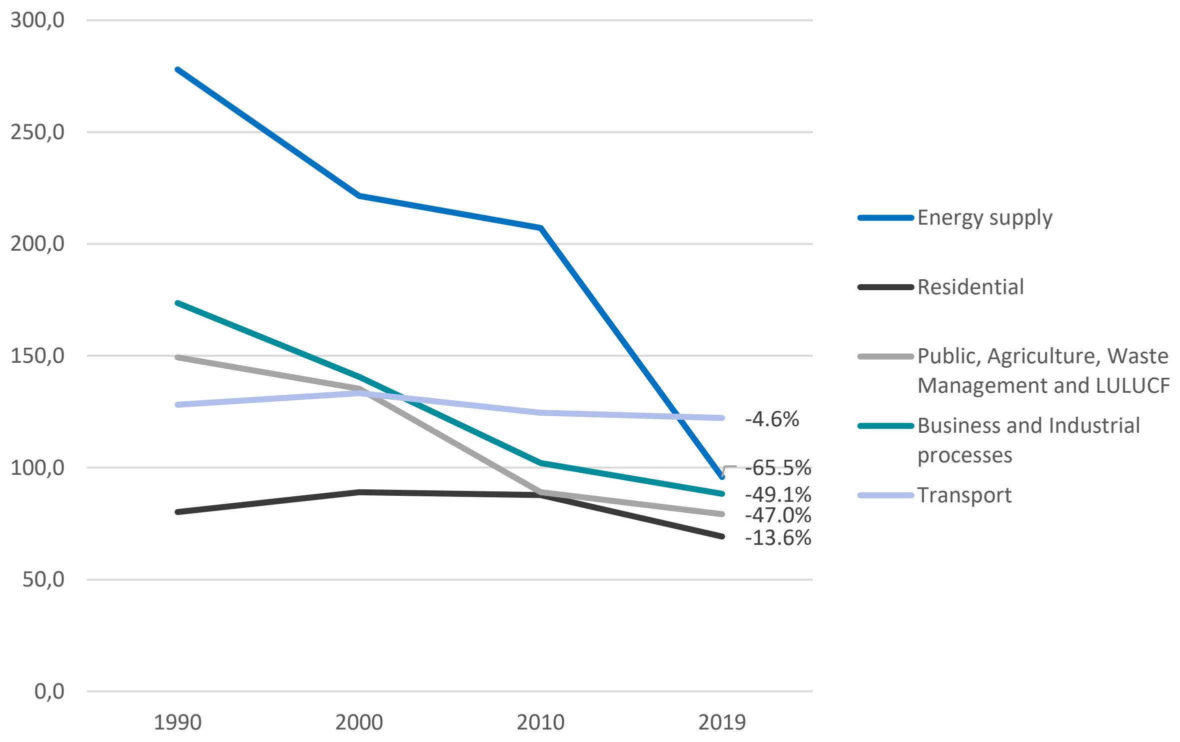
The UK imported some 50% of its energy until the mid-1970s. As North Sea oil and gas production was developed, this changed rapidly, and in 1981 the UK became a net energy exporter. It lost this position for a few years following the 1988 Piper Alpha disaster, then again in 2004; by the early 2010s the UK was back to importing nearly half of its energy, though this has since fallen back.

Imports are sourced from various countries: crude oil mainly from Norway and the United States; petroleum products from the Middle East (and via the Netherlands); 55% of gas imports are from Norway, with most of the rest arriving as Liquefied Natural Gas (LNG) from Qatar, Russia, and the United States.

Total energy consumption has declined even as the UK's population and economy have grown – from 214 million tonnes of oil equivalent in 1990 to 185 in 2019[1]. As a result, the UK's energy ratio and carbon ratio[2] have fallen – in 2019 they stood at 47% and 34% respectively of their 1990 levels.

This process of decarbonisation has taken place at different speeds across sectors, as shown in Figure 11 below[lxv3]. Whilst the rapid move away from coal to renewables and gas has led to energy supply emissions falling by almost two thirds, less progress has been made in residential and transport emissions.

Figure 11: Territorial greenhouse gas emissions by sector, 1990 to 2019 (million tonnes of carbon dioxide equivalent)



Of the 47.8 GW of cumulative installed renewable capacity in 2020, at least 6.8 GW of this was microgeneration, more than 80% of which was solar PV. Microgeneration has grown significantly in just the last decade, from just 117 MW in 2010 to 6,805 MW in 2020.

1 163.3 million tonnes of oil equivalent in 2020 – but this was lowered by the Covid-19 pandemic. The pandemic also explains some of the fall in the oil share of primary energy consumption in 2020 relative to 1990, as transport was disproportionately affected.

2 Primary energy consumption divided by GDP at constant prices and carbon dioxide emissions divided by GDP at constant prices respectively.

3 LULUCF = land use, land use change and forestry.

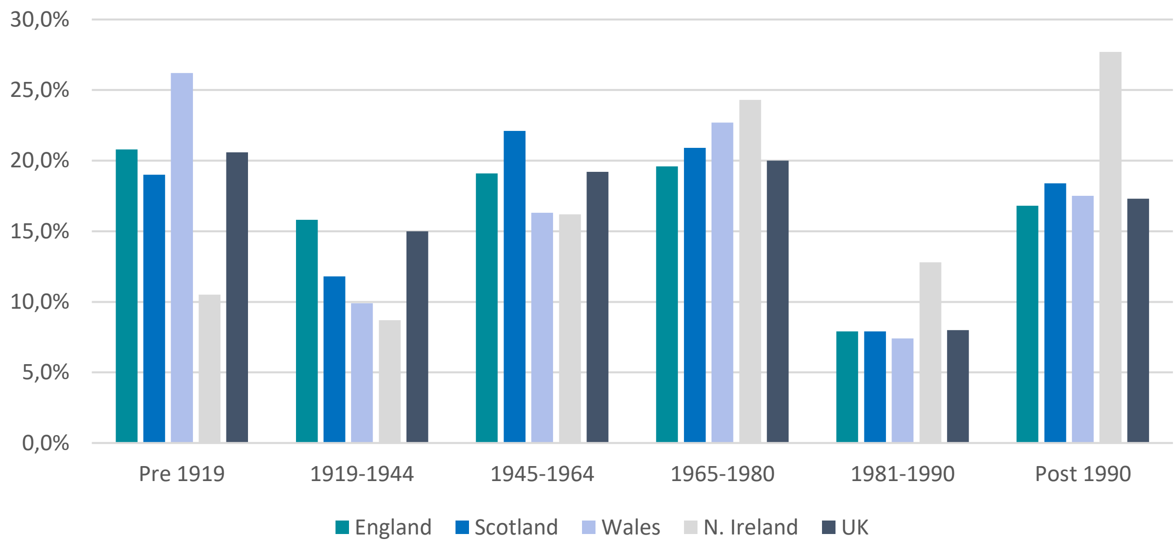
5 Review of the UK's energy efficiency literature

Energy efficiency performance

A report by the BRE Trust brings together statistics on UK housing conditions and heating systems, making intra-UK and international comparisons. This work draws on the regular housing conditions surveys in each of the four nations of the UK, the first of which was conducted in England and Wales in 1967 to inform slum clearance programmes and housebuilding. Since then, the focus of these surveys has shifted towards safe, healthy, and energy efficient homes. BRE Trust's research uses 2017 surveys from England, Scotland, and Wales, and a 2016 survey from Northern Ireland.

Within the UK, there is substantial variation in housing age, as shown in Figure 12. Over a quarter of homes in Wales were built before 1919, for example, whilst Northern Ireland's housing stock is significantly younger than the rest of the UK's. Overall, BRE Trust notes, 38% of the UK's housing was built before 1946 – more than anywhere in the EU28. Housing age is a major influence on heating systems and energy efficiency generally (i.e., through insulation, which tends to be poorer in older homes).

Figure 12: UK housing age, by nation



Source: BEIS RHI Evaluation Synthesis

Moreover, type and tenure vary significantly throughout the UK: there are a lot of flats but few bungalows in Scotland and vice-versa in Northern Ireland; owner-occupied housing is over-represented in Wales, as are social housing in Scotland and private rented housing in England and Northern Ireland.

Gas central heating is the dominant heating system in the UK as a whole, used in 83% of homes with similar levels in each of England, Scotland, and Wales. Northern Ireland is an outlier – only 24% use gas, with 68% of homes on oil-fired systems instead. Internationally, the UK's heavy use of gas-fired central heating is somewhat unusual – though not necessarily bad given that gas is cleaner than some alternatives like oil. In countries like Germany, France, and the USA there is a more diverse mix with greater shares for oil-fired, solid fuel, electric, and district heating systems. In countries of the former USSR, district heating has a much greater role.

A study based on European Commission data[lxvi] finds that:

- After adjusting for climate and average dwelling size, UK energy consumption is similar to the EU27+UK average – and therefore somewhat lower than that of France, Germany, and Italy, but above that of the Scandinavian and Iberian countries.
- Recently, the UK has reduced its domestic energy consumption relatively quickly. Over the period 2000-2017, it fell by 34% per dwelling (39% per m2), compared to an EU27+UK average of 17% (21%) – the majority of this was linked to the efficiency of space heating.

Analysis of the *Non-Domestic National Energy Efficiency Data (ND-NEED) 2022* statistics[lxvii] shows that the UK has also been successful in improving electricity and gas efficiency[4] in commercial and industrial premises.

- Electricity intensity (kWh per m^2 of floorspace) fell by 21% between 2012 and 2019. This varied considerably by type of premises, but the fall seen in offices, shops, and factories was similar to the overall trend. In hospitality, however, it fell by only 5%.
- Gas intensity fell less rapidly, by 10% between 2012 and 2019. This fall was particularly pronounced for hospitality, at 18%, as well as arts, community and leisure and emergency services.

Energy Consumption in the UK[lxviii] confirms this broad trend, showing that across the UK reduced intensity of energy usage has driven falling energy consumption, exceeding the effect of increased usage due to higher output everywhere but in services.

Economic impacts of energy policy

Recent economic modelling undertaken by Cambridge Econometrics evaluates the impact of the Climate Change Committee's (CCC) Balanced Net Zero Pathway[lxix]. Under this scenario, which is expected to successfully deliver the CCC's recommendations for the Sixth Carbon Budget, there would be £55bn of government investment in energy efficiency measures to 2050 and new heat pump installations would reach 900,000 a year by 2028. Cambridge Econometrics found that this would have significant and positive economic impacts – jobs would be created through investments in energy efficiency and low-carbon heating technologies themselves, and through their supply chains, and elsewhere in the economy as lower energy spending in the future freed up households' money to spend elsewhere (and these would outweigh negative employment impacts from the switch away from high-carbon heating technologies and fuels). These economic impacts are even higher when accounting for current high energy prices.

4 ND-NEED figures are for England and Wales only. Gas consumption figures in ND-NEED are temperature adjusted so any temperature differences between years will not influence the trend. Figures for 2020 are available show significant drops in gas and electricity consumption and intensity – however these are largely driven by the coronavirus pandemic so these figures are not used.

Barriers to take-up of energy efficiency

Research by Citizens Advice[lxx] highlights lessons learned from past energy efficiency and low carbon home improvement schemes (some of which are discussed in the following chapter). Their findings and recommendations are grouped into three categories:

- *Inform (Design and implement a simple and easy to access consumer journey; Take all opportunities to influence behaviour)*
  Schemes such as the Energy Company Obligation and Green Deal were associated with poor 'customer journeys' – for instance a lack of clarity on what support is available, long delays in the results of assessments, and unexpected additional costs. Citizens Advice also notes that current schemes do not fully take advantage of 'trigger points', such as when people move home or make significant improvements to their home, at which they are predisposed to making energy efficiency improvements.
- *Protect (Make clear that the government will take action to protect consumers from rogue traders; Demonstrate that there is regular, effective, monitoring and enforcement of standards of work; Provide trusted redress routes)*
  Previous schemes have provided opportunities for scammers and rogue traders, for instance by pretending to be registered with certain schemes when they were not, mis-selling add-on products and services, or simply providing poor quality work which does not provide the advertised benefits and is costly to fix; consistent enforcement of standards, rights of redress, and quality marks for traders could address this.
- *Support (Avoid boom and bust; Provide incentives that consumers will respond to; Schemes should be sustainable and fair)*
  'Stop-start' schemes with short timelines can lead to pressure-selling, inflated prices, and householders missing out on support they thought they would be entitled to. Some schemes, including the Green Deal, have provided incentives that are not sufficient to induce large changes in behaviour – for instance loans and/or small grants only – whilst others have provided generous support in the short term which is ultimately unsustainable, or proven ineffective at helping the poorest households.

This work from Citizens Advice identifies a range of issues with previous schemes, and therefore indicates how future schemes could be better designed to support householders. Taken together, these barriers are substantial and may be decisive in preventing people from accessing support for energy efficiency improvements despite current high energy prices – as Cara Holmes at Citizens Advice pointed out at our roundtable event, people stressed about the cost of living and facing 'heat or eat' choices do not necessarily have the mental space to navigate complex systems to see what support is available. Moreover, a lot of people take advice on home improvements from family and friends, so a bad experience for one household can lead to others being discouraged.

A recent study for BEIS [lxxi] focused on attitudes to take-up of low carbon heating systems among non-domestic consumers (NDCs) off the gas grid – 280,000 of the 1.65 million non-domestic buildings in England and Wales are not connected to the grid, and therefore use oil, LPG, or coal-based systems. These consumers therefore represent a large part of the total, the

Unsurprisingly, our survey showed that the most common concern around household heating systems is rising energy bills. This concern is slightly more prevalent in the UK – 64% identified this as a concern compared to 56% in Germany.

75% of UK households (compared to 67% in Germany) are interested in making their heating system more efficient – this both demonstrates the extent of interest in improving efficiency, and raises the question of how to overcome the barriers to this ambition being realised.

potential gains from them switching to low carbon heating systems are bigger (as the systems they currently use tend to be higher-carbon than conventional gas boilers), and insights from them may be applicable to other consumers, whether domestic or on the gas grid.

The study included detailed quantitative and qualitative surveys with NDCs off the gas grid. Key findings included:

- Whilst only 5% had a heat pump installed, most (79%) were satisfied with it – higher than satisfaction among those with oil boilers (67%) but lower than those with LPG boilers (86%).
- More respondents (45%) suggested that, if their current heating system failed, they would be unlikely to consider installing a low carbon alternative than would be likely to (33%).
- The most common reason for NDCs not considering the installation of a low carbon heating system was cost (55% of respondents[5]) followed by not having enough information (15%). Others felt that low energy efficiency/poor insulation made their building unsuitable for a low carbon heating system.
- Qualitative interviews identified potential misconceptions, including on what types of heat pump are available and their implications for energy bills and environmental performance.
- Interviewees stressed the importance of advance notice of future regulation – e.g. to avoid investing in a high carbon system then being required to remove it.
- The majority of NDCs wanted a financial incentive to move to low carbon heating; unsurprisingly, they expressed preferences for direct support like grants or tax breaks rather than loans.

Our business survey results show that the potential to achieve lower energy bills is a particularly important motivator for UK businesses; 57% said this was the biggest factor that would motivate them to improve energy efficiency, compared to just 36% in Germany (where the potential for government subsidies was a much closer second).

This study demonstrates some of the hurdles that remain to widespread uptake of low carbon heating systems, particularly but not exclusively in non-domestic buildings not on the gas grid. In particular, financial barriers remain and the cost/environmental benefits have not yet been communicated fully.

A recent report by Cebr for Kingfisher on the energy efficiency divide across the dwelling stock in England and Wales finds that households can only expect to recover the upfront investments of improving energy efficiency within 30 years, based on the savings from swapping from an Energy Performance Certificate rating of ‘D’ to a ‘C’ rating. This, however, is reduced by 23 years based on the assumption of £10,000 grant being available to households[lxxii].

5 Of the 45% unlikely to replace their heating system with a low carbon alternative and the 20% who said they were neither likely nor unlikely to.

6 Energy Policy in the UK

Past and present energy efficiency policies

Warm Front Scheme

The Warm Front Scheme, launched in 2000 and wound down after 2010, provided a total of 2.3 million households (11% of all households in England) with grants of up to £3,500 (£6,000 where oil or low carbon/renewable technologies were recommended) for improvements to insulation or heating. If the cost of the work exceeded the available grant, applicants paid the difference[lxxiii].

Our survey found that perceived cost is by far the biggest reason that UK households and businesses do not make their heating systems more efficient, cited by 31% of households and businesses (compared to 20% in Germany).

Measures installed under the scheme were predominantly insulation-related – e.g. loft insulation (0.7m installed), draughtproofing (0.6m), cavity wall insulation (0.5m). There were also 0.5m boiler replacements, and various less numerous insulation and heating measures. A National Audit Office (NAO) report found that[lxxiv]:

- Grant recipients' energy bills were reduced by on average £300 per year.
- Scheme satisfaction was high (86% of households satisfied, 5% dissatisfied).
- Cost of works undertaken was competitive.
- Overall value for money was, however, hampered by issues in scheme design and targeting:
    - some funds went to households which were already relatively energy efficient and/or unlikely to be in fuel poverty.
    - some households more in need of assistance may have cancelled works (due to not being able to pay the difference between the available grant and cost of work.

Renewable Heat Incentive

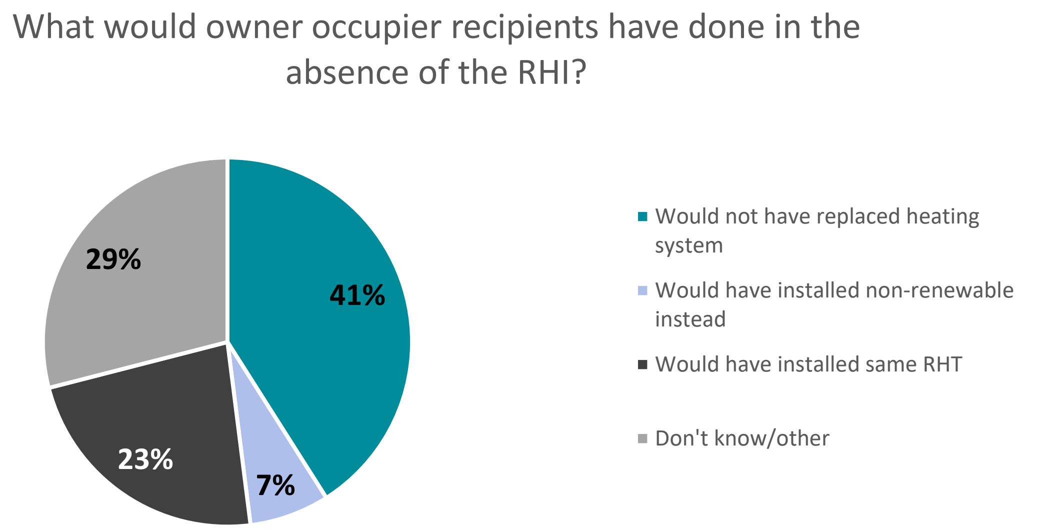
The Renewable Heat Incentive (RHI) is a scheme which provided financial incentives for domestic and business customers to install renewable heating systems. Those on the scheme receive quarterly payments over seven years based on factors including the technology installed and its estimated output. These payments were designed to offset the difference in costs between installing and operating the renewable heat technology (RHT) and a fossil fuel equivalent. Eligible RHTs include biomass boilers, solar thermal, and air, ground, or water source heat pumps. The scheme closed to new applications in March 2022.

Evaluation evidence produced during the scheme indicates that it was broadly successful and provides insights into future scheme design[lxxv].

It appears that across all customer groups there was additionality, i.e. the incentives led to RHTs being installed where they otherwise would not:

- A plurality (41%) of owner occupiers on the scheme would not have replaced their old heating system in the absence of the RHI. A further 7% would instead have replaced it with a non-renewable system. This is shown in Figure 13.
- Among non-domestic applicants, 63% would not have installed an RHT without the RHI in place, suggesting a greater degree of additionality – this is unsurprising as 58% stated that the financial case was the most important factor in their decision.
- For social landlords (e.g. housing associations) the evidence is less clear, but in some cases the RHI brought forward replacement of older systems.

Figure 13: Owner occupiers' decisions in the absence of the RHI



Source: BEIS RHI Evaluation Synthesis

Recipients were not typical of the UK more widely. Among owner occupiers, households with weekly incomes in excess of £1,000 and those off the gas grid were over-represented. That generally better-off households were more likely to apply tallies with findings that upfront costs remained a barrier to take-up. RHTs are generally more cost-effective off the gas grid, so it appears that the RHI was successful in accelerating take-up in the places where doing so makes the most sense. Among non-domestic applicants, agricultural businesses and organisations with over 50 employees were over-represented.

31% of new domestic accreditations (excluding social landlords) were for biomass boilers, which is higher than was expected. The reason for this is not entirely clear, but qualitative research suggested that it may be that they are seen as more familiar, more likely to work with existing systems, and easier to install – in other words the non-monetary barriers to take-up are lower. Incentivising future take-up of less familiar systems, like heat pumps, may therefore require more action to overcome these barriers.

Green Deal and Green Homes Grant

An example of a less successful government scheme is the Green Deal, which went live in January 2013 and came to an end in June 2015, at which point only 10,000 households had installed measures using the scheme, with 5,600 more in progress. Under the scheme, households would pay for a Green Deal assessor to visit their home and make recommendations; a loan would cover the cost of improvements, with repayments (generally set at less than the cost of the energy saved) added to energy bills, allowing repayments to be spread out over years. Despite the end of government financial support, householders can still apply for the scheme through a private company but in practice this is rare[lxxvi].

The Green Homes Grant, which was l"unch'd in September 2020, was also not successful, being scrapped in March 2021 rather than running until March 2022 as originally planned. The scheme covered two-thirds of the cost of improvements up to £5,000 for most households (up to £10,000 without contribution from homeowners for low-income households), with money going towards insulation or low-carbon heating systems. The scheme was intended to help 600,000 households, but ultimately less than 10% of this applied successfully. Delays in issuing vouchers and in accreditation of suppliers were cited as reasons for the scheme's failure[lxxvii].

Energy Company Obligation

The Energy Company Obligation (ECO) requires energy suppliers to help households with energy efficiency measures including insulation and boiler replacement and repair. Targets by supplier vary according to their shares of the gas and electricity markets in Great Britain. The scheme is for owner-occupiers and private renters; other than that eligibility requirements vary according to supplier and location but focus on the poorest and most energy-inefficient households. The scheme will continue until at least 2026[lxxviii][lxxix][lxxx].

Government incentives for renewable heating

The **Boiler Upgrade Scheme** (BUS), operated by BEIS and costing £450 million over three years, provides grants to property owners (domestic and small non-domestic) installing low carbon heating systems to replace fossil fuel systems in England and Wales[lxxxi].

In contrast to the RHI, it provides up-front financial support (£5,000 for an air source heat pump, £5,000 for a biomass boiler, £6,000 for a ground source heat pump) rather than payments spread over several years. This therefore addresses an identified issue with the RHI – that up-front costs remained a barrier to take-up – though with costs for purchase and installation of a heat pump potentially well in excess of £15,000, this barrier is reduced rather than removed and will remain significant for many households and organisations. The project has just been launched and is expected to run until 2025.

There are also policies to support the development of heat networks, notably the £338 million **Heat Network Transformation Programme** (HNTP) [lxxxii]. A core element of this is the £288 million Green Heat Network Fund (GHNF), which provides construction and commercialisation funding for new and retrofitted low-carbon heat networks[lxxxiii].

Beyond the immediate goal of incentivising take-up of low-carbon heating systems, both the BUS and the HNTP aim to grow nascent markets, e.g. for heat pumps and heat networks[6], creating standardisation and supply chain efficiencies, ultimately bringing costs down in the future and expanding UK manufacturing. Moreover, initiatives within the **Net Zero Innovation Portfolio** (NZIP) aim to accelerate commercialisation of innovative clean energy technology and processes. For example, the Heat Pump Ready Programme supports development of solutions for heat pumps at high densities and tools, technology, and processes to overcome barriers to domestic heat pump deployment[lxxxiv].

Home Energy Scotland provides support for similar improvements to the BUS (also covering insulation), but with greater targeting of funding and loans available, for owner-occupiers and private tenants[lxxxv]. Warmer Homes Scotland offers grant funding for improvements, but eligibility is limited to those in receipt of certain benefits or over 75s without a working heating system. Interest-free loans (including part-funding through cashback) are also available for homeowners. For heat pumps of all types and biomass boilers up to £10,000 (including a maximum of £7,500 cashback) is available. **Business Energy Scotland** provides support, including consultation, interest-free loans of up to £100,000, and grants of up to £20,000 to businesses for various energy efficiency upgrades – including upgrades to heating systems, insulation, and lighting, and installation of renewable generation[lxxxvi].

Support available in Northern Ireland is currently more limited. The RHI closed to new applicants in February 2016[lxxxvii]. The **Boiler Replacement Scheme** provides means-tested grants of up to £1,000 for the replacement of boilers over 15 years old – either for a more efficient oil or gas boiler, to switch from oil to gas, or to a wood pellet boiler[lxxxviii], but the scheme does not cover heat pumps.

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6 For example, installation of 600,000 heat pumps per year by 2028 is targeted.

Social housing is not eligible for the BUS, however a separate BEIS scheme, the **Social Housing Decarbonisation Fund** (SHDF), supports energy efficiency measures for these properties in England, allocating up to £800 million in funding between 2022 and 2025[lxxxix]:

- Owners of social housing – whether local or combined authorities, registered providers (e.g. housing associations), or registered charities – are eligible to apply.
- Proposals in the current wave of funding must include a minimum of 100 properties.
- The scheme is targeted at social housing with EPC ratings below C.
- Applicants must provide at least 50% of total eligible costs.
- Supported measures include energy efficiency measures such as insulation, and low carbon heating (LCH) technologies. BEIS expects applicants to focus on low temperature heat pumps when considering LCH – though other measures may be considered where these are not suitable for the dwellings in question.
- The SHDF emphasises a 'fabric first' approach; schemes including LCH alone will only be considered if the fabric of a home is sufficient pre-retrofit.

In Scotland, the **Social Housing Net Zero Heat Fund** fulfils a similar role, making available £200 million over five years. Similar to the SHDF, 'fabric first' is emphasised and grant funding is up to 50% of total costs – though the government also offers loan funding of up to 30%[xc].

The Welsh Government's **Optimised Retrofit Programme** aims to decarbonise Wales' social housing stock, with funding of £72 million in 2022-23 and £92 million for the subsequent two years[xci][xcii]. Successful bids will need to demonstrate how they support one or more themes, including low carbon insulation, home energy generation, renewable alternatives to fossil fuel heating, and improving resident comfort.

Future policy considerations

A common issue for UK households identified in the survey was some areas of the house being too cold and others too hot; 20% experienced this, compared to only 13% in Germany. Hydraulic balancing is a cost-effective way of solving this and improving energy efficiency.

At the virtual roundtable held as part of this project, Chris Skeen of Grundfos pointed out that there are cheap, easy-to-install *'low hanging fruit'*. These include magnetic filters, waste water heat recovery units, and thermostatic radiator valves[7]. Whilst these measures will not achieve the dramatic savings possible from an entirely new heat pump heating system, they can generally be fitted to existing heating systems by a trained plumber and are relatively inexpensive and still provide significant energy savings. Therefore, they can deliver relatively quick, cost-effective results – though as Henning Ellerman suggested, regulation may be needed to incentivise their installation rather than just larger, more profitable interventions.

Glynn Williams, also of Grundfos, strongly reinforced this, pointing towards 'up-furbishment' as something that is not emphasised enough. This refers to replacing heating systems or components thereof (specifically pumps) with better, modern versions rather than like-for-like: *'we're seeing lots of commentary about not building new buildings, but repurposing old buildings, existing buildings and that presents a huge opportunity for us, but it's a missed opportunity to not upgrade some of these products and simply replace them like for like.'* – given that the need for replacement may be driven by change of use, change of demand, and

7 Magnetic filters prevent debris and sludge from building up in heating systems. Waste Water Heat Recovery (WWHR) recovers heat from hot wastewater (i.e. from a shower) to pre-heat cold mains water, which will then require less energy to heat. Thermostatic radiator valves (TRVs) adjust the flow of water into individual radiators, allowing different levels of heating in different rooms.

so on, this is highly relevant in non-domestic as well as domestic contexts. It is clear, however, that upfront costs and lack of information deter businesses and households from investing: *'The market is ready for some energy efficient solutions of course, but there's that fear of the high technology products and the capital layout. We're still focusing on that; our installers are still focusing on that rather than looking at the life cycle cost.'* This again reinforces points that help offsetting or spreading upfront costs and stronger regulation could be crucial in speeding installation of more energy-efficient heating systems.

Alex Luke, of Onward, noted that although the Green Deal was ultimately not successful, *"there's somewhat of a consensus building in the sector that we need long-term low-cost finance and there's perhaps less of a consensus on exactly the best way to do that."* Possible solutions include the UK Infrastructure Bank subsidising loans tied to the property, allowing homeowners and businesses to spread the cost without fearing that they will lose out if they move or change premises – it seems that there would be widespread support from the industry for such policies.

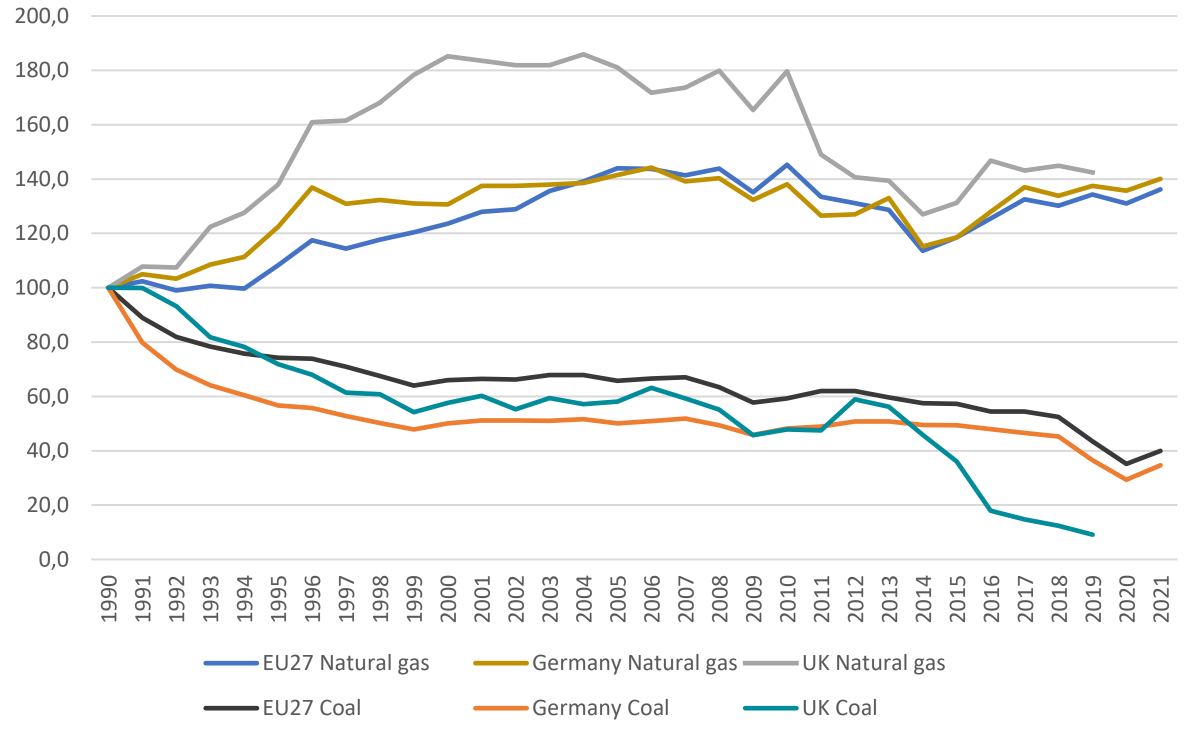
7 Comparative statistics

This section gathers relevant statistics for Germany and the UK, to compare trends and energy performance.

Inland consumption

Looking at overall consumption for all purposes, the big story is the move away from coal and towards gas, shown in Figure 14[xciiixciv].

Figure 14: Inland consumption of natural gas and solid fossil fuels (coal) in EU27, Germany, and UK (Index, 1990 = 100)



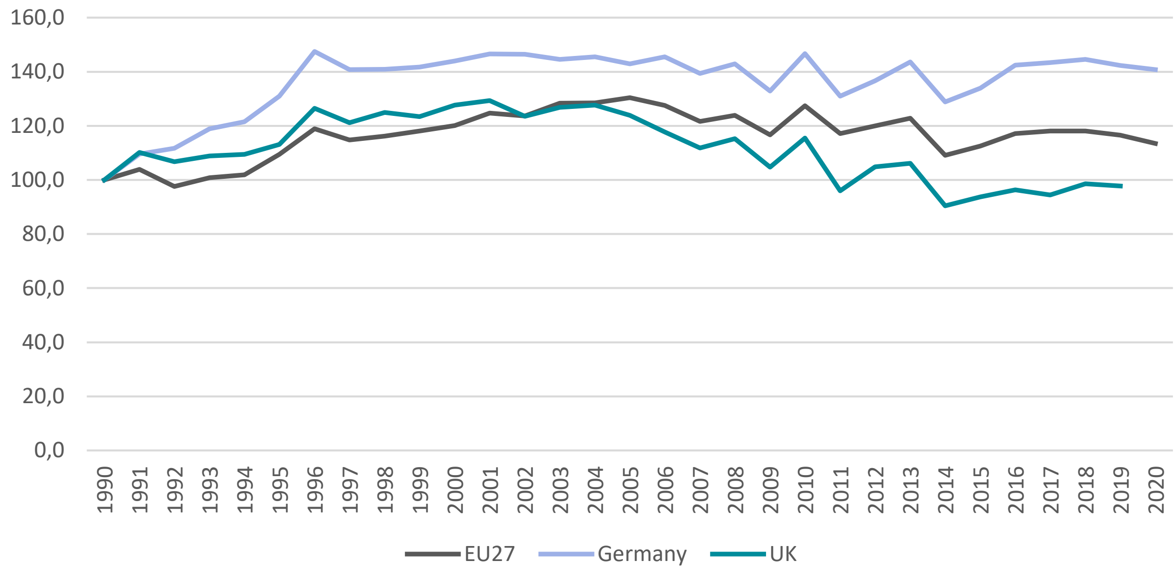
Germany closely tracks the EU27 average changes in consumption, albeit with slightly faster changes at the start of the period. Coal consumption in the UK falls off sharply after 2012, to under 10% of the 1990 level by 2019. There is a substantial 'bulge' in UK gas consumption compared to wider trends between the mid-1990s and early 2010s, coinciding with UK domestic gas production peaking in 2004[xcv]. Looking at consumption data by purpose, this is a result of increased use of gas as a 'transformation input', i.e. for electricity generation, as shown in Table 2. The UK starts from a lower base – in 1990 it uses less than a tenth as much gas in electricity generation as Germany does. This increases rapidly, to over 20 times the original level, whilst in Germany the increase is much smaller.

Table 2: Natural gas – Transformation input – energy use (TJ, index vs. 1990)

	1990	2000	2010	2019
EU27	2,613,582	3,555,598	5,606,778	4,960,304
	100.0	136.0	214.5	189.8
Germany	567,299	573,451	946,112	857,557
	100.0	101.1	166.8	151.2
UK	51,810	1,259,626	1,443,911	1,073,431
	100.0	2431.2	2786.9	2071.9

This explains the 'bulge' in UK gas consumption, but overall consumption is largely determined by final consumption for energy use – i.e. use of gas to heat buildings. In 2019 this made up 59% of total gas consumption in the EU27, 69% in Germany, and 58% in the UK. As shown in Figure 15, by 2019 use of gas in this way had fallen slightly in the UK compared to 1990, but in Germany it was up by over 40%. This explains why, despite the enormous increase in use of gas for electricity generation in the UK, the overall consumption increase is only slightly larger than Germany's.

Figure 15: Final consumption for energy use of natural gas in EU27, Germany, and UK (Index, 1990 = 100)



Looking at overall consumption in absolute terms, Germany and the UK use similar levels of natural gas, but Germany uses substantially more coal. Germany does of course have a population roughly one-third larger[xcvi] – though even after accounting for this its coal consumption is around 14 times higher, as shown in Table 3. Roughly 95% of coal consumption in Germany and 75% in the UK is for electricity generation.

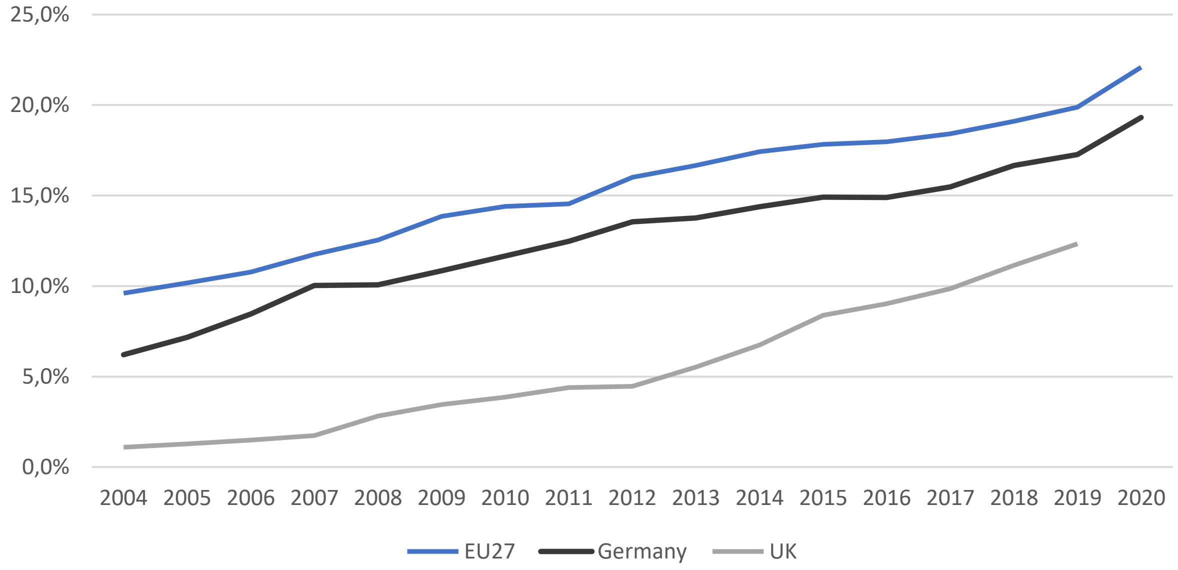
Table 3: Coal – Inland consumption (TJ, 2019)

		Inland consumption (TJ)	Population (millions)	Consumption per capita (TJ)
Germany	Natural gas	3,517,861	83.0	42,374
	Coal	188,625		2,272
UK	Natural gas	3,126,704	66.6	46,914
	Coal	10,545		158

Share of energy from renewable sources

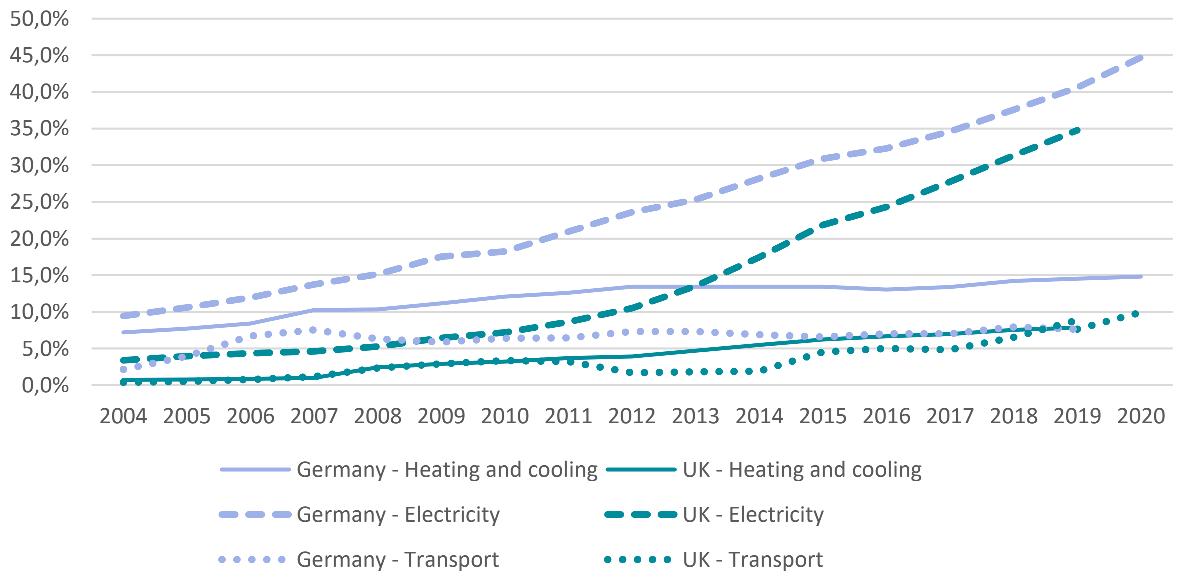
Total share of energy (for transport, electricity, and heating and cooling) from renewable sources has risen since 2004. This is reflected in both Germany and the UK as shown in Figure 16, however both of them, especially the UK, started from a lower base than the EU27 overall and remain below it today[xcvii].

Figure 16: Share of energy from renewable sources in EU27, Germany, and UK



The differences between Germany and the UK by energy use are explored in Figure 17. In both countries, renewable share in transport starts from a very low base and is only 8% or so at the end of the period. Renewable shares in electricity increase rapidly in both, reflecting the changes discussed above. In heating and cooling, however, which is most relevant to this work, pace of change is slow, and the increase in the renewable share is similar in both countries; however, Germany starts at a higher base, moving from 7.2% in 2004 to 14.5% in 2019 whilst the UK share increases from 0.7% to 7.8%.

Figure 17: Share of energy from renewable sources in EU27, Germany, and UK, by use



Energy efficiency outcomes and policies

The International Energy Efficiency Scorecard[xcviii] produced by the American Council for an Energy-Efficient Economy (ACEEE) ranks 25 countries[8] on 36 energy efficiency metrics, comparing and ranking them to identify which countries' energy-saving efforts are most ambitious and successful.

Overall, our countries of interest performed well in the 2022 rankings. The UK was ranked 2nd, after France, whilst Germany tied with the Netherlands for 3rd place. Metrics examined span the buildings, industry, and transportation sectors, plus overall 'national efforts' towards improved energy efficiency – a total of 25 points is available for each. Metrics may be policy-oriented (e.g. standards, targets) or performance-oriented (e.g. energy use per unit).

The buildings metrics are of course of most interest in the context of this research. Germany scored 20 out of 25 points, ranking 4th (after the Netherlands, France, and Spain). The UK scored 19.5, putting it joint 5th with China. Scores and ranks by metric are shown in Table 4.

Table 4: International Energy Efficiency Scorecard 2022, buildings metrics scores for Germany and UK

Metric	Max. points	Germany score	UK score
Appliance and equipment standards	**5**	4	2.5
Residential building codes	**3**	3	3
Commercial building codes	**3**	3	3
Building retrofit policies	**4**	3	4
Building rating and disclosure	**2**	2	2
Appliance and equipment labelling	**2**	2	2
Energy intensity in residential buildings	**3**	1	1
Energy intensity in commercial buildings	**3**	2	2

Both countries score well on policy-based metrics; for example they each receive the maximum 6 points available for residential and commercial building codes, which score countries on the presence and coverage of mandatory energy codes for these buildings – though Germany and the UK do fall somewhat short on building retrofit policies and appliance and equipment standards respectively.

On performance-based metrics, they each score less well, only receiving half the total available points for energy intensity in residential and commercial buildings. Residential energy intensities look at use per unit of floor area and per capita. Commercial energy intensities consider use per dollar of service-sector GDP and per commercial floor area. These

8 Australia, Brazil, Canada, China, Egypt, France, Germany, India, Indonesia, Italy, Japan, Mexico, Poland, Russia, Saudi Arabia, South Africa, South Korea, Spain, Taiwan, Thailand, The Netherlands, Turkey, United Arab Emirates, United Kingdom, United States.

intensities were adjusted for climate. To put these scores into context, top performer the Netherlands scored 2 for energy intensity in residential buildings and 2.5 for commercial buildings.

This split between the policy- and performance-based metrics in both Germany and the UK reflect that, whilst many ambitious policies and standards are in place, take-up of energy efficiency improvements – particularly in residential buildings – has been slow. Whilst there are no easily comparable metrics on the extent of barriers to take-up of energy efficiency improvements, this seems to demonstrate that they are significant – for instance this would include a lack of information on energy efficiency improvements, difficulty accessing government support, or simply insufficient support to meet the ambitious targets set.

8 Conclusion

Today's energy price and security challenges threaten to push households into fuel poverty, make businesses unviable, hold back economic growth, and create serious fiscal challenges for governments. Much of the recent public debate has focused on supply – but further measures to reduce demand through improved energy efficiency also have a part to play. Meeting ambitious national and international climate change targets will be impossible without action here. Heating of domestic and non-domestic buildings is a major source of energy consumption, and a sector in which relatively little progress on decarbonisation has been made.

Germany and the United Kingdom are prime examples of countries that have room to improve in this area. Both have set ambitious targets for making their economies less energy and carbon intensive. Both have made significant progress in some areas – for instance by rapidly transitioning away from coal-fired electricity generation towards the use of renewables like wind and solar. In both countries, however, energy efficiency in the heating of buildings has improved comparatively slowly and they compare less favourably to otherwise similar nations.

Germany and the UK each face some distinct challenges, but many of the barriers to further improvements are common to both. Our research shows that upfront costs are crucial in putting households and businesses off investing in more energy efficient heating systems; whilst lifetime costs are lower due to reduced consumption, the initial investment may be out of reach, and current government support is not sufficient to offset this. There are also misconceptions around the benefits of energy efficient, low-carbon systems – their environmental and financial benefits and ease of installation are not as widely appreciated as they might be. In both countries, further support may also be necessary to ensure that sufficiently skilled installers are available to enable energy efficiency improvements, and that high quality standards are maintained.

Though energy efficiency in heating cannot be revolutionised overnight, there is an abundance of relatively small and cost-effective improvements that can be made to existing systems which will deliver a high rate of return on those investments. These would deliver meaningful improvements to alleviate the current energy crisis and contribute to the achievement of the longer-term goals the German and UK governments have set for their respective energy systems. Indeed, energy efficiency will remain an important tool to achieve reductions in energy use so to improve energy security, affordability and reductions in carbon emissions.

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