Factors Influencing Heat Pump Adoption in Sweden, Germany, Switzerland, and the United Kingdom: International Comparative Case Study

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Contents

1. Executive Summary

Using a comparative case study approach, this report examines the factors that drive or hinder heat pump adoption in four European nations: Sweden, Germany, Switzerland, and the United Kingdom.

Heat pumps are a cornerstone of the UK Government's decarbonisation agenda, as outlined in the 2021 Heat and Building Strategy (HM Government 2021). The electrification of domestic heating is expected to reduce the UK's greenhouse gas emissions by approximately 17% (MCS 2023). In late 2020, the then Johnson government set a target of 600,000 heat pump installations per year by 2028. Recently, the Climate Change Committee reported that by 2040, more than half of all homes in the UK (52%) will need a heat pump installed to meet climate targets, up from the current level of around 1% (CCC 2025). Despite allocating grant funding of around £450m per year under the Boiler Upgrade Scheme (BUS), data for 2024 shows the UK is installing only about 60,000 heat pumps annually, indicating the government's target is unlikely to be met (DESNZ 2024a; MCS 2025). Given the significant gap between the desired and observed outcomes, understanding the factors that influence the UK's relatively low rate of heat pump adoption is crucial.

The four nations under investigation exhibit varying rates of heat pump adoption (i.e., annual sales) and penetration (i.e., total number installed). Sweden is the clear leader, with the highest number of heat pumps (22,727) and the highest annual sales (2,047) per 100,000 population. Switzerland ranks second, with a penetration rate of 4,940 and an annual sales rate of 467 units per 100,000 population. Germany ranks third, featuring a penetration rate of 1,962 and an adoption rate of 280 units per 100,000 population. Finally, the United Kingdom performs the worst on both metrics, with a penetration rate of 564 and an adoption rate of 89 units per 100,000 population. The European Heat Pump Association reports that, in 2023, heat pumps represented 93% of the market for space heating technologies in Sweden, 82% in Switzerland, 26% in Germany, and just 4% in the United Kingdom (EPHA 2024).

A 2023 study by the UK Collaborative Centre for Housing Evidence (CaCHE), using a systems thinking approach, found that the following features of the UK's domestic decarbonisation system interacted and influenced the UK's rate of heat pump adoption (Harrington 2023):

- High electricity prices
- Low relative gas prices
- High electricity to gas price ratio (EtGPR)
- Extensive gas network
- Low thermal performance of building stock
- Weak regulatory environment
- Insufficient grants, subsidies and incentives

This report investigates how the UK's domestic decarbonisation system compares to those of Sweden, Germany, and Switzerland, and whether the factors that most influence heat pump adoption in the United Kingdom are present (and to what extent) in the other three nations. Specifically, it examines whether (and to what extent) electricity prices (both absolute and relative to gas), the availability of relatively affordable gas for heating, the average thermal performance of housing stock, and the strength of regulatory environments and incentive regimes influence heat pump adoption rates across the comparative cases.

Based on the conclusions of the 2023 CaCHE report, Heat Pumps and Domestic Heat Decarbonisation in the UK: A Systems Thinking Analysis of Barriers to Adoption, the following hypotheses have been formulated:

- (H1) Countries with higher electricity prices tend to have lower rates of heat pump adoption compared to those with lower electricity prices.
- (H2) Countries with a greater provision of affordable gas for home heating tend to have lower rates of heat pump adoption compared to countries with less gas network coverage or higher gas prices.
- (H3) Countries with lower housing stock thermal performance tend to have lower rates of heat pump adoption compared to countries with higher performing housing stock.
- (H4) Countries with stronger regulations and more generous subsidies tend to have higher rates of heat pump adoption compared to countries with weaker regulations and fewer incentives.

Findings

Using the comparative case study approach, this research has identified two root causes and two non-linear factors that significantly influence a nation's rate of heat pump adoption. The root causes are electricity prices and the affordability of gas heating. The non-linear factors include the thermal performance of a nation's housing stock, the strength of its regulatory environment, and the generosity of grants and subsidies.

National Comparison Between Ranked Rates of Heat Pump Adoption and Penetration and Ranked Research Hypothesis Factors.

Nation	HPs per 100,000 pop. in 2022. Ranked highest to lowest	HPs sold per 100,000 pop. in 2022. Ranked highest to lowest	(H1) Electricity price. Ranked lowest to highest	(H2) Gas provision. Ranked lowest to highest	(H3) Housing stock heat demand. Ranked lowest to highest	(H4) Regulatory environment. Ranked strongest to weakest
Sweden	1	1	1	1	2	4
Switzerland	2	2	2	2	1	3
Germany	3	3	3	3	3	1
United Kingdom	4	4	4	4	4	2

As shown in the table above, reliable correlations are found between the price of electricity (H1), the availability of affordable gas (H2), and the rate of heat pump adoption in all four countries. However, the results indicate that the impact of a nation's housing stock thermal performance (H3) and regulatory environment (H4) on heat pump deployment is less clear-cut.

The lower a nation's electricity price, the higher its rate of heat pump adoption. Conversely, the higher the electricity-to-gas price ratio (EtGPR) and the greater the accessibility of gas for home heating, the lower the rate of heat pump adoption.

As non-linear factors, the thermal performance of a country's housing stock, along with its regulatory and incentive environment, were found to influence heat pump adoption in ways that depend on the root causes of electricity pricing and affordable gas provision. In countries with high electricity prices and low gas prices (i.e., a high EtGPR), stronger regulatory frameworks and more generous incentive schemes were found to promote higher rates of adoption. Conversely, in nations with low electricity prices and a low EtGPR, strong regulations and generous incentives were not necessary to encourage heat pump adoption.

These findings explain the rate of heat pump adoption in all four nations. The United Kingdom has the lowest adoption rate due to its high electricity prices and the widespread availability of relatively affordable gas heating (i.e., the highest EtGPR). Additionally, the UK's adoption rate is lower than Germany's, despite both countries having high electricity prices and high EtGPRs, because the UK's regulatory environment is weaker, its incentives are less generous, and the thermal performance of its housing stock is lower. Despite having a lower-performing housing stock than Switzerland, Sweden exhibits the highest rate of heat pump adoption, thanks to its low electricity prices and limited access to gas heating. Although Switzerland has a weaker regulatory environment and less generous incentives than Germany, its adoption rate is higher because both its electricity prices and EtGPR are lower.

Recommendations

This report suggests the following key policy recommendations for decision-makers in the United Kingdom, aimed at increasing the rate of heat pump adoption. The report takes a utilitarian and pragmatic approach to policy, prioritising proposals that offer the greatest impact for the least cost.

1. Addressing Root Cause 1: Lowering the Final Electricity Price

2. Addressing Root Cause 2: Increasing the Cost of Gas (or, reducing the Electricity to Gas Price Ratio)

Addressing Root Cause 1: Lowering the Final Electricity Price

The most impactful policy the UK government could pursue to increase heat pump adoption is to lower electricity prices. A reduction in electricity costs would allow heat pumps to compete more effectively with alternative heating systems, such as efficient gas boilers. The case of Switzerland provides concrete evidence that consumer decisions can drive heat pump adoption in markets offering efficient gas boilers, provided the electricity price is lower.

Lowering electricity prices also reduces the retrofit burden faced by households, housing associations, and local authorities when considering heat pump installation. Adoption rates will increase if stakeholders don't need to invest as much in fabric and system upgrades. The Swedish case clearly demonstrates that lower electricity prices allow heat pumps to be installed in homes with lower thermal performance without resulting in unaffordable heating costs.

Lowering electricity prices also reduces the need for grants and subsidies, as market forces drive heat pump adoption. Both the Swedish and Swiss cases demonstrate that incentive schemes are less critical when electricity prices are lower.

The UK Government's ongoing Review of Electricity Market Arrangements (REMA) has identified several ways to reduce electricity prices, including (DESNZ 2023):

- Split Market (Green Power Pool)
- Pay-as-bid spot market rules
- Zonal pricing

Addressing Root Cause 2: Increasing the Cost of Gas (or, reducing the Electricity to Gas Price Ratio)

Besides lowering electricity prices, another impactful policy the UK government could adopt to increase heat pump adoption is to raise the cost of gas heating for certain consumers.

Narrowing the electricity-to-gas price ratio would enable heat pumps to compete more effectively in the market and reduce the crowding out caused by efficient gas boilers. However, given that 75% of households rely on gas as their primary heating source, many of whom are on fixed incomes or in fuel poverty, any plan to increase gas prices must be means-tested or targeted at those who can afford higher costs.

Currently, gas is almost four times less expensive than electricity per kilowatt hour in the UK (Ofgem 2025). This means that even heat pumps operating at three times the efficiency of gas boilers are still more expensive to run. Given the additional fabric and system upgrade costs necessary for efficient heat pump operation, an electricity-to-gas price ratio (EtGPR) of 4.0 undermines the economic rationale for their installation for many households, housing associations, and local authorities.

If the EtGPR were reduced to between 2 and 2.5, heat pumps would offer a running cost advantage over gas boilers for a larger proportion of consumers. With a clear running cost benefit, many more consumers would justify the higher unit, installation, and fabric and system upgrade costs.

The two commonly cited methods for lowering the electricity to gas price ratio are:

- Shifting social policy and environmental levies
- Implementing a carbon tax

This report finds that the most effective policy interventions to increase the UK's rate of heat pump adoption would be lowering electricity prices through a pay-as-bid spot market trading rule and imposing a carbon tax on household gas consumption.

Pay-as-bid spot market rules

Pay-as-bid trading rules for the UK's spot market could lower electricity prices for all

consumers by ensuring the wholesale price more accurately reflects the proportion of lower-cost renewable electricity in the supply mix (Harrington 2024). Currently, the wholesale price is often driven by the higher cost of gas-generated electricity, even though a significant portion is supplied by renewables. This happens because the spot market operates on system marginal pricing (SMP), where all electricity is traded at the price of the last unit required to meet demand at any given time.

Pay-as-bid trading rules, in contrast, would mean electricity is traded at the price bid by generators into the spot market, rather than at the price of the last unit required to meet demand. Renewable electricity would be traded at the price set by renewable generators, nuclear electricity by nuclear plants, and gas-generated electricity by gas plants. As a result, the wholesale price would decrease because electricity would no longer be traded at the price of the highest-cost unit (the marginal unit) needed to meet demand. Instead, it would be traded at the prices that generators actually bid into the spot market.

Implementing a carbon tax

A carbon tax would be a new tax on household gas usage. Currently, the UK does not levy a carbon tax on household gas consumption, though a Climate Change Levy (CCL) is applied to business gas use. Both the Grantham Research Institute on Climate Change and the Environment and the New Economics Foundation have published research supporting the introduction of such a tax (Burke et al. 2020; Kumar 2023).

The advantage of a carbon tax on household gas consumption is twofold. First, as a new form of taxation, it can be set at a rate that brings the electricity-to-gas price ratio to an appropriate level, with the flexibility to adjust as needed. Second, because a carbon tax generates new state revenue, the proceeds can be used to offset increased costs for lower-income households or invested in projects that reduce electricity prices, such as grid, storage, and transmission infrastructure. In this way, a carbon tax could raise gas prices without exacerbating social inequality while simultaneously supporting the necessary investment to lower electricity prices.

Rather than being a secondary benefit, the redistribution of carbon tax revenues should be seen as a central pillar of an effective and socially equitable heat decarbonisation strategy. Channelling these funds toward targeted heating subsidies for vulnerable households ensures that the financial burden of higher gas prices does not fall disproportionately on those least able to absorb it — a risk that could otherwise undermine public support for the transition. At the same time, investing these revenues in energy flexibility infrastructure helps to future-proof the electricity system and reduce electricity prices, enabling the grid to accommodate growing demand from electrified heating while maintaining reliability and affordability. Taken together, these measures create a virtuous cycle: they not only help align short-term cost signals with long-term climate goals, but also ensure that the transition remains politically viable and socially fair.

2. Introduction

This report examines the factors that drive or hinder heat pump adoption in four European nations: Sweden, Germany, Switzerland, and the United Kingdom. These countries exhibit varying adoption rates, with Sweden having the highest, followed by Switzerland, Germany, and the UK with the lowest.

Using a comparative case study approach, this research identifies two root causes and two non-linear factors that significantly influence a nation's rate of heat pump adoption. The root causes are electricity prices and the affordability of gas heating. The non-linear factors include the thermal performance of a nation's housing stock, the strength of its regulatory environment, and the generosity of grants and subsidies.

The lower a nation's electricity price, the higher its rate of heat pump adoption. Conversely, the higher the electricity-to-gas price ratio (EtGPR) and the greater the accessibility of gas for home heating, the lower the rate of heat pump adoption.

As non-linear factors, the thermal performance of a country's housing stock, along with its regulatory and incentive environment, were found to influence heat pump adoption in ways that depend on the root causes of electricity pricing and affordable gas provision. In countries with high electricity prices and low gas prices (i.e., a high EtGPR), stronger regulatory frameworks and more generous incentive schemes were found to promote higher rates of adoption. Conversely, in nations with low electricity prices and a low EtGPR, strong regulations and generous incentives were not necessary to encourage heat pump adoption.

These findings explain the rate of heat pump adoption in all four nations. The United Kingdom has the lowest adoption rate due to its high electricity prices and the widespread availability of relatively affordable gas heating (i.e., the highest EtGPR). Additionally, the UK's adoption rate is lower than Germany's, despite both countries having high electricity prices and high EtGPRs, because the UK's regulatory environment is weaker, its incentives are less generous, and the thermal performance of its housing stock is lower. Despite having a lower-performing housing stock than Switzerland, Sweden exhibits the highest rate of heat pump adoption, thanks to its low electricity prices and limited access to gas heating. Although Switzerland has a weaker regulatory environment and less generous incentives than Germany, its adoption rate is higher because both its electricity prices and EtGPR are lower.

This report concludes that the most impactful policy interventions UK policymakers could pursue to accelerate heat pump adoption are addressing the high electricity prices and the provision of affordable gas heating. Policy options to tackle these root causes of the UK's relatively low adoption rate are discussed in the final section of the report.

3. Background

Heat pumps are a cornerstone of the UK Government's decarbonisation agenda, as outlined in the 2021 Heat and Building Strategy (HM Government 2021). The electrification of domestic heating, supported by the installation of ground-, air-, and water-source heat pumps, is expected to reduce the UK's greenhouse gas emissions by approximately 17% (MCS 2023). In late 2020, the then Johnson government set a target of 600,000 heat pump installations per year by 2028. Recently, the Climate Change Committee reported that by 2040, more than half of all homes in the UK (52%) will need a heat pump installed to meet climate targets, up from the current level of around 1% (CCC 2025). Despite allocating grant funding of around £450m per year under the Boiler Upgrade Scheme (BUS), data for 2024 shows the UK is installing only about 60,000 heat pumps annually, indicating the government's target is unlikely to be met (DESNZ 2024a; MCS 2025). Given the significant gap between the desired and observed outcomes, understanding the factors that influence the UK's relatively low rate of heat pump adoption is crucial.

A 2023 study by the UK Collaborative Centre for Housing Evidence (CaCHE) investigated this question using a systems thinking approach (Harrington 2023). The research found that the UK's high electricity prices, along with the relationship between electricity and gas prices for home heating (i.e., the EtGPR), were the most important factors influencing the observed outcomes.

Based on interviews with key stakeholders (i.e., owner-occupiers, landlords, local authorities, housing associations, retrofitting organisations, developers, home builders, and heat pump installers), as well as extensive empirical research, the following features of the domestic decarbonisation system were found to interact and influence the UK's rate of heat pump adoption:

- High electricity prices
- Low relative gas prices
- High electricity to gas price ratio (EtGPR)
- Extensive gas network
- Low thermal performance of building stock
- Weak regulatory environment
- Insufficient grants, subsidies and incentives

In the United Kingdom, there is no legal obligation for existing homeowners or housing providers to install heat pumps (or equivalent clean heat technologies) in their homes. Nor is there a prohibition on homeowners replacing or installing new gas boilers in existing homes at this time — although policy signals suggest a longer-term shift away from fossil fuel heating. It is only recently that the UK has regulated the installation of clean heat technologies (including heat pumps) in new homes through the Future Homes Standard (FHS) 2025 in England and the New Build Heat Standard (NBHS) 2024 in Scotland. Such mandates do not currently exist in Wales or Northern Ireland. Therefore, homeowners and other housing providers must make a voluntary decision to purchase and install a heat pump (or equivalent clean heat technology).

Because the majority of homeowners and housing providers in the UK live in or rent out homes with relatively low thermal performance, there is a prevailing concern over the running costs of heat pumps compared to efficient gas boilers. Heat pumps perform better in homes with higher thermal efficiency (all else being equal). Given the high cost of electricity relative to gas (i.e., the EtGPR) and the low average thermal performance of the housing stock, heat pumps are not cost-competitive with efficient gas boilers for many UK homes. As a result, most homeowners and housing providers face the prospect of additional fabric or heating system upgrades to close the running cost gap between heat pumps and gas boilers. These additional upgrade costs further diminish the perceived competitiveness of heat pumps in the market.

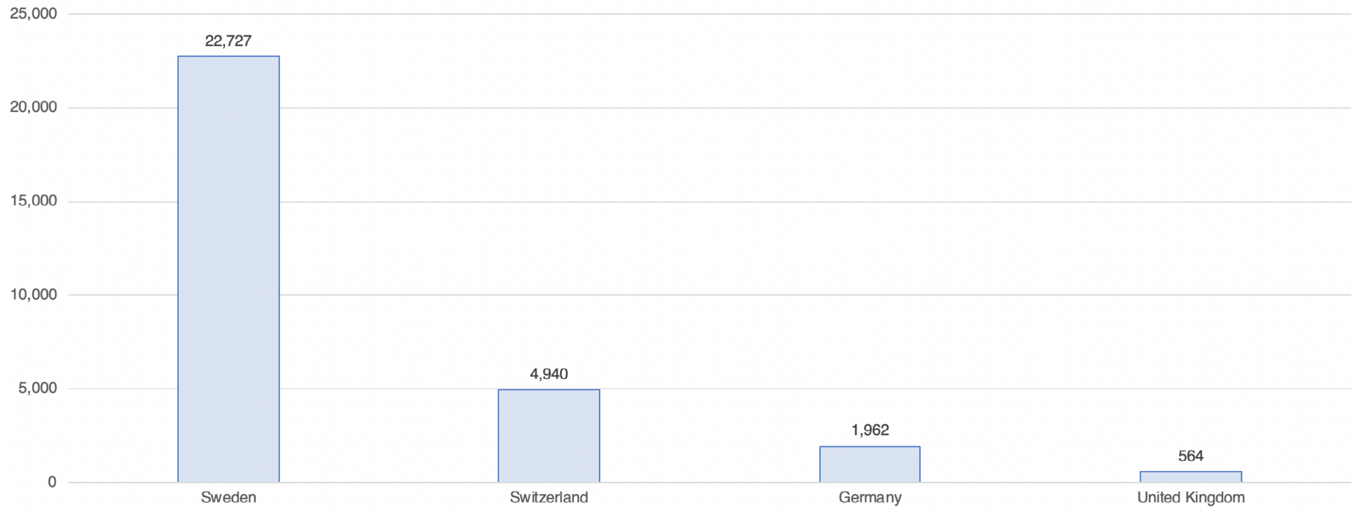
In sum, the economic rationale for heat pump adoption in the UK is weak, primarily due to the high cost of electricity. Given that many UK homeowners are still facing a cost-of-living crisis, while housing providers are routinely under resource constraints, CO2 reduction and climate-related arguments in favour of heat pump adoption have not outweighed the material concerns against them.

4. National Heat Pump Adoption Rates

This report investigates how the UK's domestic decarbonisation system compares to those of Sweden, Germany, and Switzerland. The reason these nations were selected is discussed in the methods section. To provide context for the analysis, it is important to understand how heat pump installation rates differ across these four nations.

Because the population figures for the case study countries differ, rather than discussing the total number of installed heat pumps or the total number of heat pumps sold annually, the data has been normalised to per 100,000 population figures. Heat pump 'penetration' refers to the total number of installed heat pumps, while heat pump 'adoption' refers to the number of heat pumps installed annually.

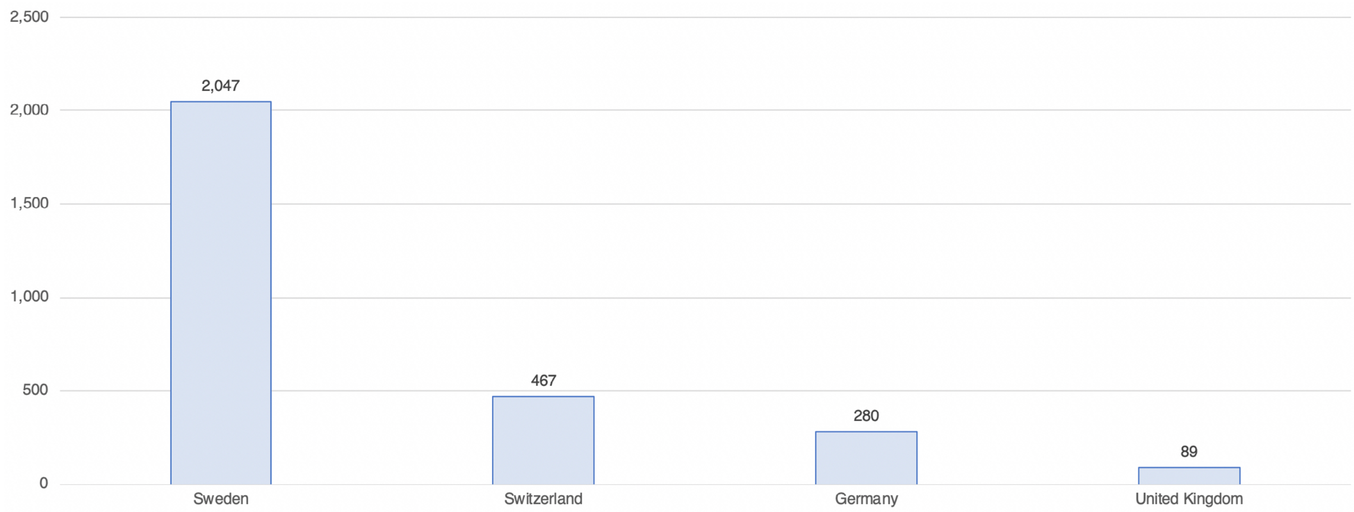
Figure 1. Heat Pump Penetration by Country – Heat Pumps per 100,000 Population (2022).



Data: EHPA 2023.

As illustrated by Figures 1 and 2, Sweden is the clear leader in terms of heat pump adoption and penetration. Sweden has the highest number of heat pumps (22,727) and the highest annual sales (2,047) per 100,000 population. Switzerland ranks second in heat pump adoption, with a penetration rate of 4,940 and an annual sales rate of 467 units per 100,000 population. Germany follows with the third highest adoption rate, featuring a penetration rate of 1,962 and an annual sales rate of 280 units per 100,000 population. Finally, the United Kingdom performs the worst on both metrics, with a penetration rate of 564 and an annual sales rate of 89 units per 100,000 population.

Figure 2. Heat Pump Adoption Rate: Heat Pumps Sold per 100,000 Population (2022).



Data: EHPA 2023.

Furthermore, Figures 1 and 2 reveal that Sweden's penetration rate is 40 times greater than that of the UK, while its annual adoption rate is 23 times higher. Switzerland's penetration rate is nearly 9 times greater, and its annual adoption rate is about 5 times higher than that of the UK. Germany's penetration rate is 3.5 times greater, while its annual adoption rate is 3 times higher. The European Heat Pump Association reports that, in 2023, heat pumps represented 93% of the market for space heating technologies in Sweden, 82% in Switzerland, 26% in Germany, and just 4% in the United Kingdom (EPHA 2024).

These data indicate varying rates of heat pump adoption across the four nations. Nesta has previously classified the UK and Germany as 'low success' adopters, Switzerland as a 'moderate success' adopter, and Sweden as a 'high success' adopter of heat pumps (Sarsentis and Orso 2023).

Given these divergent rates of heat pump adoption (and the designations provided by Nesta), this report expects to find marked differences between the domestic decarbonisation systems in Sweden and the UK, a mixed comparison between the UK and Switzerland, and notable similarities between the UK and Germany. In other words, the factors influencing heat pump adoption in the UK should more closely align with those in Germany than in Switzerland, while the factors influencing heat pump adoption in Sweden should contrast sharply with those in the United Kingdom.

Put another way, based on the data, Germany and the UK are expected to share significant barriers to adoption, while these barriers should be absent in Sweden. Conversely, many of the enablers of heat pump adoption seen in Sweden are likely to be absent in the UK. Switzerland, on the other hand, is expected to share some of the UK's barriers, while also presenting enablers not observed in the UK.

This report will investigate whether the factors that most influence heat pump adoption in the United Kingdom are present (and to what extent) in Sweden, Germany, and Switzerland. Specifically, it will examine whether (and to what extent) electricity prices (both absolute and relative to gas), the availability of relatively affordable gas for heating, the average thermal performance of housing stock, and the strength of regulatory environments and incentive regimes influence heat pump adoption rates across the comparative cases.

5. Methodology

This report employs the comparative case study method, drawing on data obtained through semi-structured interviews and questionnaires with nation-specific subject area experts, empirical data to validate findings, and an examination of each country's historical context. The interpretation of results is guided by systems thinking and the theory of path dependency.

5.1. Comparative Case Study

The comparative case study method examines multiple instances of a phenomenon, comparing and contrasting them to identify patterns, differences, interactions, and the underlying dynamics that shape particular outcomes. Delwyn Goodrick defines comparative case studies as,

> "… the analysis and synthesis of the similarities, differences and patterns across two or more cases that share a common focus or goal"
>
> Goodrick 2014

Since our aim is to understand the factors influencing the United Kingdom's rate of heat pump adoption, it is logical to compare these factors and outcomes with those observed in other nations. A practical consideration, however, is whether the institutions, contexts, and development trajectories of both origin and destination countries enable similar policies, processes, and technologies to transfer effectively — or whether substantial adaptation is needed, or even whether such transfers ultimately fail. Case selection is, therefore, critical.

In selecting the country cases, this research aimed to balance similarity and variation — choosing countries that are broadly comparable to the UK in key dimensions, but which differ meaningfully in their rates of heat pump adoption. The rationale behind this approach is twofold. First, ensuring regional, economic, political, and social comparability helps to control for contextual factors that might otherwise confound the analysis; if these were the main drivers of adoption, policy transferability would be limited. Second, variation in adoption rates allows for meaningful comparison of how different policy approaches perform under similar conditions.

Based on these criteria, three European countries were selected: Sweden, Germany, and Switzerland. All have advanced economies, democratic governance, and geographic proximity to the UK.

Table 1. Social, Economic, and Political Characteristics of Case Study Nations.

Nation	Geographic region	Economic stage	Political system	GDP per capita (USD)	Heat pump adoption rate
Sweden	Europe	Advanced	Democracy	54,450	High
Germany	Europe	Advanced	Democracy	44,337	Low
Switzerland	Europe	Advanced	Democracy	89,556	Moderate
United Kingdom	Europe	Advanced	Democracy	47,323	Low

Source: Trading Economics 2025.

As indicated by Table 1, all four nations are located in Europe. The UK has an advanced economy, democratic governance, a GDP per capita of around USD 47,000, and a low heat pump adoption rate. Sweden was selected due to its high adoption rate, with a GDP per capita of around USD 54,000. Germany, with a GDP per capita of around USD 44,000, was chosen for its relatively low adoption rate, offering a comparison point similar to the UK. Switzerland, with a much higher GDP per capita of approximately USD 90,000 and a moderate adoption rate, adds further variation within a comparable regional and political context. This mix provides a useful comparative framework for identifying policy-relevant drivers of adoption that could apply in the UK context.

5.2. Expert Interview & Questionnaire

In October 2023, semi-structured interviews were conducted with individuals possessing expert knowledge of heat pumps and the factors influencing their adoption rates in the three nations being compared to the UK. CaCHE is extremely grateful for their participation and contribution to this project. Two of the interviewees were highly cited academics who have published in peer-reviewed journals, including Energy Policy, Energy, Energies, Applied Energy, Energy Research & Social Science, Sustainability, Energy and Buildings, and the International Journal of Sustainable Energy. One of these academics also served as an advisor to the United Nations on decarbonisation matters. The other interviewee was the vice president of a heat pump industry body and the former secretary general of a heat pump association.

Each expert participated in an interview lasting between 45 minutes and an hour, which was recorded, transcribed, and conducted via Microsoft Teams. The interviews began with several predetermined questions (see Appendix A). Once these were addressed, follow-up questions and further probing were used to gather more detailed information on the issues raised. After transcription, the data was analysed using manual thematic coding, identifying recurring ideas, patterns, and themes. Following the thematic coding, axial coding was applied, organising the initial codes into relationships (e.g., cause-effect, similarity, contrast) to identify critical patterns and interactions.

The experts also completed a questionnaire consisting of 10 questions, providing as much detail as possible, supporting data, and a list of relevant sources for further reading related to each answer. The questionnaire is available in Appendix B. The experts were each paid €1,000.00 for their time and contribution.

As discussed in the forthcoming results and findings, all interview and questionnaire data were contextualised and validated through research triangulation with government and local authority statistics, as well as academic and research literature.

5.3. Systems Thinking

This report is underpinned by a form of analysis known as systems thinking. Rather than representing a single methodology, systems thinking encompasses a spectrum of approaches developed across the physical and social sciences — ranging from structured, quantitative methods such as System Dynamics and Hard Systems Thinking, to more interpretive and reflexive approaches like Soft Systems Methodology and Critical Systems Thinking (Checkland 1993; Ison 2017).

Discussing each of these approaches is beyond the scope of this report. Suffice it to say, they all share a common interest in understanding the dynamic operation of complex systems and how the relationships and interactions between different components produce specific outcomes. In, The Systems Way of Life, Capra and Luisi explain that the essential properties of all systems are:

> "properties of the whole, which none of the parts have. They arise from the interactions and relationships between the parts. These properties are destroyed when the system is dissected, either physically or theoretically, into isolated elements. Although we can discern individual parts in any system, these parts are not isolated, and the nature of the whole is always different from the mere sum of its parts"
>
> **2014, 65**

This report draws on heuristics from both hard and soft systems thinking. This approach is appropriate because the domestic decarbonisation system includes real-world technical elements with clearly defined and easily quantifiable inputs and outputs, such as housing thermal performance, fuel prices, and heat pump efficiency and running costs (i.e., suited for hard systems thinking). However, the system also encompasses more subjective aspects, such as the influence of regulations and incentives on the behaviour and decision-making of human stakeholders and social groups (i.e., suited for soft systems thinking). Systems thinking, with its focus on the dynamic interactions and interdependence between different parts of a system rather than merely the parts themselves, is particularly useful when addressing stubborn problems arising from complex environments (Gibb and Marsh 2019).

Apart from examining the complex interactions and dynamic operation of system elements, systems thinking is particularly focused on root causes. John Boardman and Brian Sauser suggest that systems thinking aims to:

> "break analysis and synthesis away from the strongholds of quick fixes, short-termism, simple mindedness, and singular action. It pays respect to complexity, variety, perspectives, nonlinearity, stakeholders, and counterintuitiveness"
>
> **2008, 91**

Root causes are the elements within a system or the dynamic interactions between system elements that condition a wide range of effects and interactions throughout the system. Identifying the root causes of a problem puts us in a much better position to offer policy advice that leads to meaningful, long-lasting solutions. In seeking the root causes of the UK's relatively low rate of heat pump adoption, this report aims to support the government's decarbonisation efforts and accelerate our transition to Net Zero. Professor Sir Ian Diamond, advisor to the UK Government Office for Science, endorses this approach:

> "Systems thinking provides the tools and methods to address these complex problems, providing insight and understanding of the interactions to ultimately improve our solutions and deliver more effective and efficient public services"
>
> **GOS 2022**

5.4. Path Dependency

Another concept that informs this report's interpretation of findings is the theory of path dependency. Path dependency suggests that decisions made or structures and institutions established in the past significantly influence the scope of social, economic, and political actions in the present and future. While present and future outcomes are not entirely determined by past events, they can be constrained by them. In other words, certain social, economic, and political choices are facilitated by past developments, while others become more challenging. In, Politics in Time, philosopher Paul Pierson encourages researchers to:

> "… remain attentive to the ways in which previous institutional outcomes can channel and constrain later efforts at institutional innovation"
>
> **2004, 133**

Path dependency is particularly relevant to this research because decisions made a century ago regarding the types of heating fuels and sources of electricity generation to invest in continue to influence the heating fuel sources and electricity generation observed in these nations today.

5.5. Research Hypotheses

As discussed, the aim of this report is to test the findings of prior research within the context of a comparative case study. Based on the conclusions of the 2023 CaCHE report, Heat Pumps and Domestic Heat Decarbonisation in the UK: A Systems Thinking Analysis of Barriers to Adoption, the following hypotheses have been formulated:

- (H1) Countries with higher electricity prices tend to have lower rates of heat pump adoption compared to those with lower electricity prices.
- (H2) Countries with a greater provision of affordable gas for home heating tend to have lower rates of heat pump adoption compared to countries with less gas network coverage or higher gas prices.
- (H3) Countries with lower housing stock thermal performance tend to have lower rates of heat pump adoption compared to countries with higher performing housing stock.
- (H4) Countries with stronger regulations and more generous subsidies tend to have higher rates of heat pump adoption compared to countries with weaker regulations and fewer incentives.

6. Research Findings

The report presents its findings in the order of the hypotheses. First, country comparative evidence regarding electricity prices and the electricity-to-gas price ratio (EtGPR) is presented. This is followed by evidence on the provision of gas for home heating, then by evidence concerning the average thermal performance of each nation's housing stock. Lastly, the report discusses country comparative evidence related to each nation's regulatory environment and incentive regime.

Each subsection summarises the comparative research and reflects on whether the evidence supports or challenges the corresponding hypothesis.

6.1. Electricity Pricing and the Electricity to Gas Price Ratio (EtGPR)

It is well understood that both the high absolute price of electricity and its high price relative to gas pose significant barriers to heat pump adoption in the United Kingdom (Rosenow and Lowes 2021; Boorman et al. 2021; Ralston 2022; Sissons 2023; Citizens Advice 2023; Parker and Leveque 2024; Orso et al. 2024). As Nesta explains:

> "The key factor affecting the running costs of heat pumps (and all clean electric heating) is the ratio of electricity to gas prices. Heat pumps typically use three to four times less energy than a boiler (depending on how efficient the heat pump is), but electricity has typically been three to five times more expensive per unit than gas. The high relative price of electricity in effect cancels out the efficiency bonus brought by heat pumps"
>
> Sissons 2023, 13

This ratio – known as the electricity-to-gas price ratio (EtGPR) – indicates how many times more expensive one kilowatt-hour (kWh) of electricity is compared to an equivalent kWh of gas. According to Ofgem's latest price cap (1 April to 30 June 2025), electricity costs 27.03 pence per kWh, while gas costs 6.99 pence per kWh (Ofgem 2025). Therefore, electricity is 3.9 times more expensive than gas. As of late 2024, the United Kingdom had an EtGPR of 3.9.

It is argued that to encourage the adoption of heat pumps, an EtGPR of 2.5 or lower is required. Nesta advises:

> "If electricity prices were no more than 2.5 times the cost of gas, heat pumps could more easily cost less than boilers over the same lifespan, paving the way for a phase-out of boilers altogether"
>
> Orso and Gabriel 2023

The European Heat Pump Association suggests:

> "To achieve a fast return on investment and encourage people to buy a heat pump, electricity should be no more than double the price of gas"
>
> EHPA 2024

Table 2. Electricity Prices for the UK, Sweden, Germany and Switzerland in 2024.

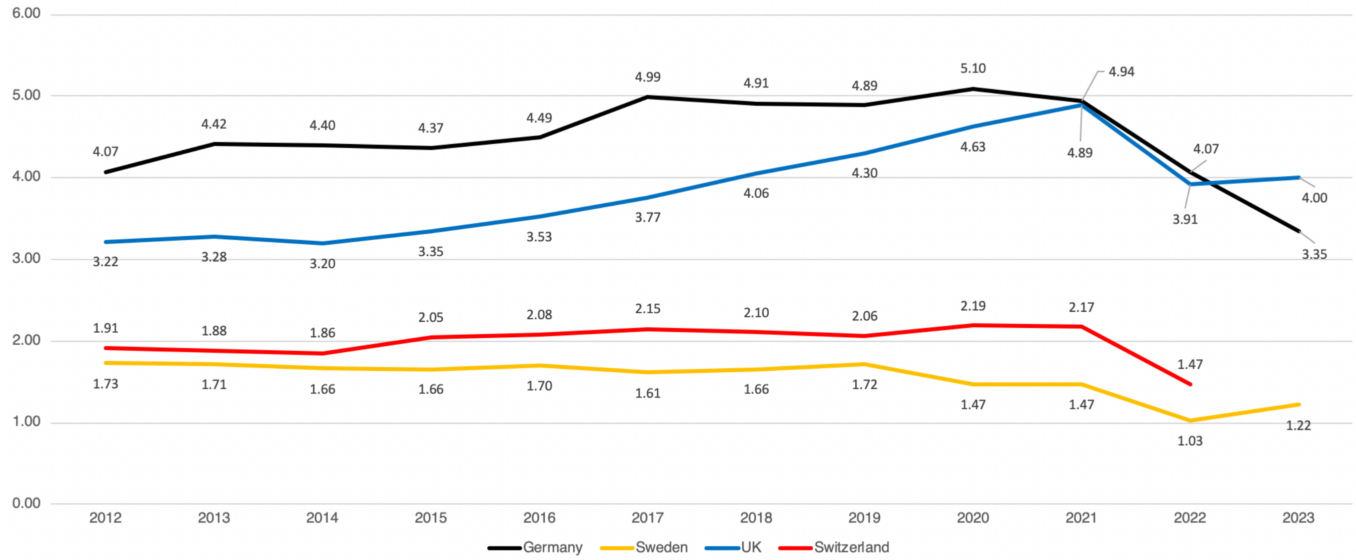
Nation	United Kingdom	Sweden	Germany	Switzerland
Price per KWh	0.245 Pounds	0.157 Euro	0.28 Euro	0.156 Francs
Normalised to Euro	0.30	0.16	0.28	0.17

Source: Eurostat 2024; Ofgem 2025; Statistica 2025.

As indicated by Table 2, the UK has the most expensive electricity of the four nations under review. At €0.30 per kWh, electricity is 87.5% more expensive for UK households than for those in Sweden, and 76.5% more expensive than for households in Switzerland. The price of electricity in Germany is comparable to that in the UK, being only 7% less expensive.

These figures suggest that heating an equivalent home with a heat pump is considerably more expensive in the UK than in both Sweden and Switzerland – all else being equal. When controlling for all other factors, the cost of running a heat pump is comparable between Germany and the UK.

Figure 3. Comparing the EtGPRs of the UK, Sweden, Germany and Switzerland Between 2012 and 2023.



Data: Eurostat 2024; DESNZ 2024b; Ofgem 2024b.

Turning to Figure 3, we observe that Germany and the UK have significantly higher electricity to gas price ratios (EtGPR) than Sweden and Switzerland. Germany's EtGPR has been above 4.0 almost every year between 2012 and 2023. The United Kingdom had an EtGPR between 3.0 and 4.0 from 2012 to 2017, and an EtGPR between 4.0 and 5.0 since 2018. In contrast, Sweden's EtGPR has not exceeded 1.75 for over a decade. Switzerland's EtGPR, averaging around 2.0 since 2012, is slightly higher than Sweden's but still considerably lower than that of Germany or the UK. On the surface, there seems to be a meaningful correlation between the electricity price and EtGPR of these countries and their respective levels of heat pump adoption and penetration.

6.1.1. Expert data

6.1.1.1. Sweden

The Swedish expert confirmed the positive influence of low relative electricity prices on the adoption of heat pumps. They explained that because electricity has historically been affordable in absolute terms, the transition away from older heating systems, such as oil burners and direct electric heaters, was relatively straightforward. In many cases, installing a heat pump not only provided sufficient thermal comfort but also helped reduce household heating costs. The expert remarked:

> "Electricity in Sweden has historically been very, very cheap… we have the preconditions for a low carbon society. In part, thanks to hydropower and nuclear power. We didn't need to do as much or make such difficult calls… We are in a lucky situation"
>
> INT1A

When the expert refers to 'difficult calls,' they are highlighting the UK's challenge of weighing trade-offs between capital expenditure for energy efficiency improvements, such as insulation, and the ongoing running costs of replacing a gas boiler with a heat pump in a home that hasn't undergone fabric upgrades. Generally speaking, it is much easier to persuade a household to install a heat pump if no additional retrofitting is required, and if the heat pump is expected to reduce their heating bills. The expert added:

> "In general, the running cost costs for the heat pump are seen as low"
>
> INT1A

The Swedish case differs significantly from the UK in that electricity prices have facilitated, rather than hindered, the adoption of heat pumps. The expert concluded:

> "Low electricity prices have been important for establishing electricity for heating and when the prices started to increase in the 90's the heat pump was seen an energy efficient option in the electricity heating segment"
>
> INT1B

In addition to low relative electricity prices, Sweden also imposes environmental taxes on fossil fuels to reduce their attractiveness to consumers. The expert noted:

> "Sweden's carbon tax policy also affected the cost of fossil fuels, including gas and oil, by imposing taxes on their emissions, further increasing their prices"
>
> INT1B

Because Sweden imposes environmental taxes exclusively on fossil fuels, the electricity-to-gas price ratio (EtGPR) remains comparatively low at around 1.22. In other words, since electricity is only 1.22 times more expensive than gas per kWh, while heat pumps typically deliver a 3-to-1 efficiency advantage, heat pump running costs are lower than those of gas boilers in the Swedish context. In contrast, the UK applies environmental and social policy costs to electricity, which make up approximately 16% of the final consumer price (Ofgem 2024c). This policy choice contributes to the UK's higher EtGPR of around 4. The expert continued:

> "Sweden has a long tradition of energy taxation. The CO2 tax is highest in the world at USD 140/tCO2-eq in 2017. In 1991, Sweden introduced the CO2 tax on fossil fuels to complement the energy taxation. From 2004 onwards, the CO2 tax was adjusted annually with the inflation and from 2017 onward an additional 2% annual increase was introduced. In 2018, the CO2 taxes for gasoline and diesel were reduced parallel to the introduction of the emission reduction obligation system"
>
> INT1B

6.1.1.2. Germany

The German expert confirmed that Germany faces similar challenges to the UK regarding heat pump adoption, particularly due to the high electricity price relative to gas. They stated:

> "This is the same issue in Germany. That is, the high price of electricity relative to gas"
>
> INT2B

In Germany, heat pump adoption rates were low when electricity prices were high relative to gas. Conversely, when electricity became more affordable compared to gas, adoption rates increased. The expert noted:

> "The fastest deployment increase resulted from the economic attractiveness of heat pumps as a result of VERY HIGH gas prices … I've seen a graph that has compared the relative price factor development of electricity in Germany over time. It showed very clearly that last year, when the demand for heat pumps skyrocketed, the ratio was 2:1"
>
> INT2B; INT2A

This observation aligns with UK studies showing that electricity-driven running costs significantly shape consumer perceptions of heat pump efficacy (Caird et al. 2012). Generally, consumers follow a rational choice model when selecting a heating system (Lamb and Elmes 2024), opting for the most cost-effective option. In both the UK and Germany, households prioritize heating systems that provide the best heat at the lowest cost. When electricity prices are three to four times higher than gas, heat pumps fail to meet cost expectations within this rational choice framework.

6.1.1.3. Switzerland

The Swiss expert provided additional evidence supporting the hypothesis that a country's electricity-to-gas price ratio (EtGPR) influences its rate of heat pump adoption. In Switzerland, where the EtGPR has consistently been 2.0 or lower, the expert did not consider electricity pricing to be a structural barrier to household heat pump installations. The expert stated:

> "In my opinion, fuel cost does not play a major role in the decision to retrofit a residence with heat pump"
>
> INT3B

This dynamic is reflected in consumer attitudes toward heat pumps in Switzerland. Due to the lower EtGPR, concerns about running costs do not undermine consumer perceptions of heat pump efficacy. The expert explained:

> "The public's attitude toward heat pumps in Switzerland has noticeably changed over the past ten years, going from cautious optimism to broad acceptance and enthusiasm. Confidence in heat pump functioning has increased as a result of technological advancements, increased efficiency, and successful installations"
>
> INT3B

In summary, the interview data from country experts supports the hypothesis that a nation's electricity price and electricity-to-gas price ratio (EtGPR) directly and meaningfully influence its rate of heat pump deployment. Both the Swedish and Swiss experts reported that electricity pricing was not a barrier to heat pump deployment in their respective countries. The Swedish expert believed low electricity prices were a driving factor for their adoption, while the German expert viewed electricity pricing as a limiting factor, noting a clear correlation between a lower EtGPR and higher installation rates.

6.1.2. Background on national electricity

6.1.2.1. Sweden

The price of electricity in Sweden is closely tied to its history of generation and supply (Bladh 2011). By the 1930s, hydropower had become the dominant form of electricity generation, providing around 50% of the country's supply. This trend continued over the following decades, and by 1950, hydropower accounted for nearly 90% of electricity generation. The 1960s saw the introduction of nuclear power plants, and by 1980, nuclear power contributed to half of the electricity generated, with the balance coming from hydropower. Today, only 2% of Sweden's total electricity is generated by fossil fuel power plants (MoI 2019). As a result of Sweden's reliance on cheaper sources of electricity generation—such as hydropower (~40%), nuclear (~30%), and wind (~17%)—consumer electricity prices remain lower than in comparable countries like Germany and the UK.

6.1.2.2. Germany

The history of electricity generation in Germany differs markedly from Sweden's, closely mirroring the UK's reliance on fossil fuel power plants (Renn and Marshall 2020). By 1930, the majority of electricity in Germany was generated by coal-fired power plants (~90%), with a small proportion coming from hydropower (~10%). In the post-war period, oil and gas-powered plants were introduced, but fossil fuels continued to account for around 90% of Germany's electricity. In the 1960s, nuclear generation began. By the 1980s, 30% of electricity came from nuclear plants, half from coal, 10% from gas and oil, and hydropower had dropped to ~5% of the electricity mix. The early 2010s saw a dramatic shift away from nuclear power toward renewable energy sources. Today, no nuclear power plants are online in Germany. The current generation mix consists of around 52% renewables (wind 27%, solar 12%, biomass 8.5%, hydro 3.8%) and 42% fossil fuels (coal 26%, gas 16%) (DeStatis 2023a). Although Germany generates a significant portion of its electricity from renewables, the ongoing reliance on fossil fuels has resulted in higher electricity prices compared to countries like Sweden.

6.1.2.3. Switzerland

The history of Swiss electricity generation is similar to that of Sweden, but unlike Germany or the UK (Ferraro 2023). Like Sweden, by 1930, hydropower accounted for around 90% of Switzerland's electricity generation, with coal supplying the remainder. By 1950, hydropower contributed about 95% of electricity generation, while gas and oil generation dropped to around 5%. The 1960s saw the introduction of nuclear power plants, and by the 1980s, nuclear energy accounted for nearly 30% of the electricity mix, with hydropower providing 60% and fossil fuels making up 5%. This structure remained in place until the 2010s, when the phase-out of nuclear power began, and interest in renewables increased. Today, Switzerland has a diversified generation mix, with renewables accounting for 67% of electricity (hydropower 56.6%, solar 4.5%, biomass 3%), while nuclear plants provide 32% of supply (SFOE 2024). Because nearly all of Switzerland's electricity generation comes from lower-cost sources such as renewables and nuclear, consumers in Switzerland enjoy lower electricity prices than those in countries like Germany and the UK.

6.1.3. Summary role of electricity pricing

The review of the country comparative evidence provides strong support for the first research hypothesis (H1): countries with higher electricity prices tend to have lower rates of heat pump adoption compared to those with lower electricity prices.

Sweden and Switzerland, both of which have higher rates of heat pump adoption than the UK and Germany, also benefit from lower absolute electricity prices and lower electricity-to-gas price ratios (EtGPR). Germany, which has a rate of heat pump adoption similar to that of the UK, has an EtGPR comparable to that of the UK, along with high absolute electricity prices relative to Sweden and Switzerland. Switzerland, with a higher rate of heat pump adoption than Germany but lower than Sweden, enjoys lower electricity prices and a lower EtGPR than Germany, though its electricity price and EtGPR are still slightly higher than those in Sweden. This comparison clearly shows that electricity pricing plays a significant role in influencing the rate of heat pump adoption across all these countries.

The history of electricity generation in the case study countries reveals a path-dependent effect on contemporary electricity pricing. Sweden and Switzerland both developed significant hydropower infrastructure between 1900 and 1950, later supplemented by nuclear power generation during the 1960s to 1980s. As a result, their current electricity generation mix features a notable absence of fossil fuel sources. In contrast, the UK and Germany initially favoured coal and, later, gas-powered plants in their early electricity transitions, with minimal hydropower development. Consequently, fossil fuel power plants remain a significant component of electricity generation in both Germany and the UK, leading to higher electricity prices and electricity-to-gas price ratios (EtGPR) that are nearly twice as high as those in Sweden and Switzerland.

This historical legacy presents a challenge for the UK, as its continued reliance on fossil fuel-based electricity generation contributes to higher electricity prices and an unfavourable electricity-to-gas price ratio. Future policy will need to focus on lowering the price of electricity — particularly through investments in storage, transmission, and grid infrastructure, as well as electricity market reform — to create a pricing environment more conducive to heat pump adoption.

6.2. Gas Provision for Home Heating Supply

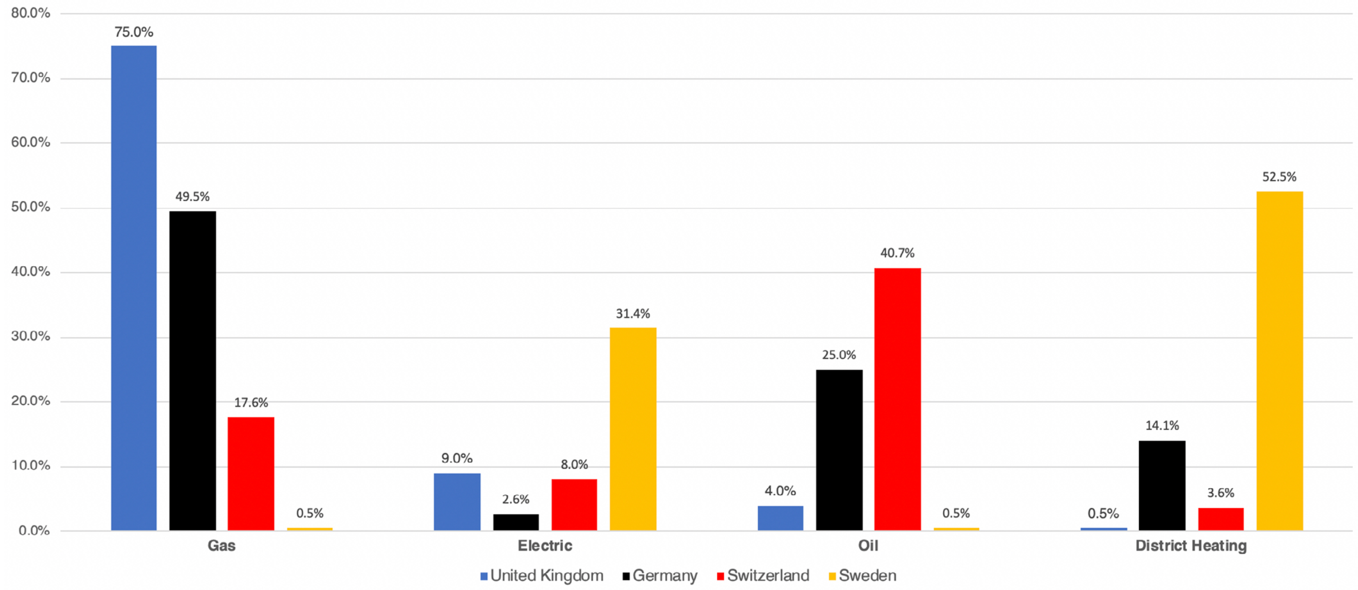
The availability of relatively affordable gas for home heating contributes significantly to the UK's high electricity-to-gas price ratio (EtGPR). The United Kingdom boasts an extensive and efficient gas network that serves as the primary heating source for three-quarters of households. Not only is gas comparatively inexpensive, but electricity costs are disproportionately high. Furthermore, the majority of homes in the UK are connected to this gas supply, meaning that most households are currently equipped with gas boilers.

Replacing a gas boiler with a heat pump involves not only the installation of a new heating unit but also the replacement of the water tank and, in many cases, the pipework and emitters (e.g., radiators). Additionally, larger water tanks often require more internal space, which can result in the loss of storage or living space in the home. Consequently, the decision to replace a gas boiler with a heat pump requires a significant financial investment from the household.

Due to the high EtGPR in the UK, many households struggle to justify the investment in a heat pump based on potential future savings in running costs. To make heat pumps more cost-effective, households might need to consider additional fabric improvements, such as insulation, draughtproofing, and other measures to reduce heat loss. However, these fabric improvements represent an additional financial burden that UK households must weigh against the anticipated long-term savings on heating costs.

As shown in Figure 4, the distribution of fuel sources for household heating varies significantly across the four nations. Gas is not the primary fuel source for space and water heating in all the comparison countries. While 75% of UK households rely on gas for heating, only 49.5% of German households do. In Switzerland, just 17.6% of households use gas for space and water heating, and in Sweden, this figure is less than 1%.

Figure 4. Fuel Source Proportions for Household Space & Water Heating in the UK, Germany, Sweden[1] and Switzerland in 2020/21.



Data Source: ONS 2023; Scottish Government 2024a; NISRA 2024; BMWK 2021; SEA 2024; FSO 2024a.

Once again, the UK and Germany are positioned at one end of the spectrum, with Sweden at the other. In terms of relatively affordable gas provision, Switzerland falls between Sweden and Germany. The Swedish Heating Boilers and Burners Association confirms that gas boilers are uncommon in Sweden, citing the 'relatively limited development of the gas grid' as a key factor (SBBA 2021).

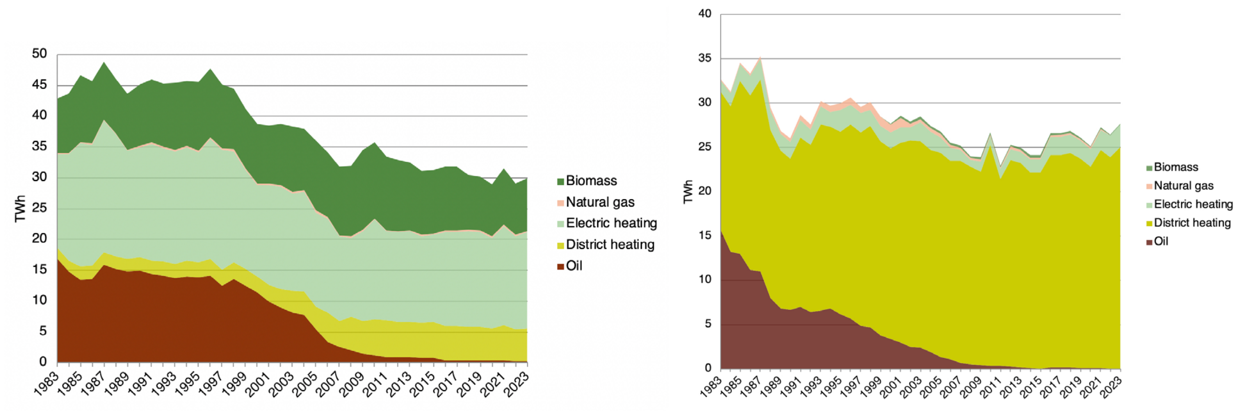
The prevalence of district heating further highlights the structural differences between Sweden and the UK. In Sweden, 52.5% of homes are heated by district heating systems, compared to just 14.1% of homes in Germany and 3.6% in Switzerland. District heating, being a communal system, offers significant efficiencies during technological transitions. Shifting from biomass or fossil fuel-powered district heating to large-scale district heat pumps is arguably less complex than replacing individual heating systems. Replacing a single large heating system can be less technically and socially challenging than replacing hundreds or thousands of individual systems across the same area (IEA 2020).

Furthermore, as shown in Figure 5(b), decarbonising Sweden's multi-dwelling buildings is less technically challenging than in the UK, as over 90% of these buildings are already served by district heating. In contrast, the UK faces significant challenges in decarbonising tenement and apartment buildings. There is ongoing debate among local authorities about whether to adopt community-based solutions or individual-level interventions (LGA 2022).

1 Unlike the data for the UK, Germany, and Switzerland, the Swedish Energy Agency does not differentiate between direct electric heating and heat pumps. While in the other three countries, 'electric' refers to direct electric heating, in Sweden, this category primarily includes heat pumps, as 43% of all households in Sweden are heated by heat pumps.

Figure 5. Domestic Energy Consumption for Heating and Water in Sweden (1983 – 2023):

(a) 1- and 2-Dwelling Buildings; (b) Multi-Dwelling Buildings.



Source: SEA 2024.

6.2.1. Expert data

6.2.1.1. Sweden

The Swedish expert was unequivocal in stating that Sweden's progress in heat pump deployment was largely supported by its longstanding history of electrification. Since electric heating systems were already predominant before the advent of heat pump technology, the transition faced far less technological resistance. The expert described what could be considered path-dependent effects, which made the adoption of heat pumps in Sweden less challenging than it might have been otherwise. The expert explained:

> "The role of heat pumps must be understood in relation to the electricity system. Sweden has since the introduction of nuclear power in the late 70's had substantial supply of electricity for heating. Since the 1980s heat pumps were seen as an energy efficiency measure and a way to reduce electricity consumption. Low electricity prices have been important for establishing electricity for heating and when the prices started to increase in the 90's the heat pump was seen an energy efficient option in the electricity heating segment"
>
> INT1B

The Swedish case differs from the UK's in that heat pumps replaced direct electric heating systems in many cases (rather than gas boilers). In the 1990s, before the widespread adoption of heat pumps, between 25 and 30% of domestic heating was provided by direct electric heating, around 40–50% by district heating (from biomass, waste incineration, fossil fuels, and surplus industrial heat), 10–15% by oil burners, and about 10% by wood-burning stoves, pellet stoves, and biomass boilers (Johansson 2021).

The implication of Sweden's historical heating system mix is that, for more than half of households, switching to a heat pump would result in running cost savings due to the increased efficiency of the new technology. A heat pump is approximately three times more efficient than direct electric heating and delivers superior performance compared to oil and wood-burning stoves (Nadel 2018; Casasso et al. 2019). The expert confirmed the heat pump's economic advantage with reference to fuel costs:

> "In contrast to electricity, the prices of alternate fuels for domestic heating, such as natural gas and heating oil, tended to be higher in Sweden. Natural gas infrastructure is limited, and oil is imported, making these fuels less cost-effective options for many households"
>
> INT1B

6.2.1.2. Germany

The interview with the German expert revealed strong parallels between Germany and the UK regarding the influence that gas provision had on heat pump deployment. The expert explained:

> "I think the two countries are quite similar in terms of their gas dependency… Gas dependency is typically the main factor that I associate with decarbonisation success… Either you have cheap gas and a negative view of electricity, and especially the use of electricity for heating, or you don't… And those countries that have cheap gas or have access to cheap gas, often have a tradition of telling people heating must be affordable, cheap"
>
> INT2A

What the expert referred to could be described as a form of status quo bias or technological lock-in. In a country where gas is cheap and widely available, consumers tend to view electric heating systems less favourably and prefer gas boilers. This is because electric systems typically don't offer a clear heating advantage and are often more expensive to run. In other words, heat pumps are at an economic disadvantage when they have to compete in a market where gas heating is low-cost. The expert provided more detail on the German context:

> "German authorities have allowed the population to increase their dependency on cheap Russian gas, and it seems that the population and society has actually accepted this as fine"
>
> INT2A

In 2020, around half of German households were connected to the gas network. While this figure is lower than the 75% of households connected to gas in the UK, it still presents a significant challenge to the widespread adoption of heat pumps and helps explain why the adoption rates in the two nations are similar.

6.2.1.3. Switzerland

The expert confirmed that the situation in Switzerland differs from that in the UK. While the UK's energy system is shaped by an extensive gas network that provides affordable gas heating to the majority of homes, Switzerland lacks this type of infrastructure. Instead of gas, oil is the dominant heating fuel in Switzerland. This is not to say that switching from oil burners to heat pumps doesn't come with its own challenges. Rather, the point is that when less than 20% of households are connected to gas, a smaller proportion of Swiss consumers face the difficult choice of adopting a heating system that doesn't offer obvious commercial advantages. The expert stated:

> "As I understand it, in the UK, gas is very cheaply priced in terms of relative cost comparison. And then there is the existing gas grid which is already there, or even being extended. So that's another difference between our nations which refers to ease of connection. When you compare the possible options for consumers… This impacts the UK's ability to decarbonise"
>
> INT3A

The expert also suggested that Switzerland's electricity infrastructure may offer certain advantages in terms of grid capacity and provision. It is worth noting that grid capacity has become a limiting factor in the UK in recent years. Several reports indicate that new build developments in the UK (which may include heat pumps as their clean heating system) have been delayed due to insufficient grid capacity (BBC 2022; Blackman 2024; Tapper 2024). While Switzerland lacks an extensive gas network, it does have a resilient electricity grid. The expert noted:

> "The infrastructure and capacity of the energy system in Switzerland is adequate and regularly undergoes modernisation… The electricity grid in Switzerland is quite dependable and effective, and it can supply all of the country's energy needs"
>
> INT3B

6.2.2. Background on national gas for heating supply

6.2.2.1. Sweden

At just 0.5%, Sweden has a particularly low proportion of homes relying on gas as their primary space heating fuel (SEA 2024). This figure can be explained by the marginal role gas has played in Sweden's energy history (Åberg 2013). Although gas became widely available in the late 19th and early 20th centuries, it was primarily used for cooking and water heating rather than space heating. While natural gas became available in the 1980s, the rise of district heating in the mid-20th century, followed by the advent of nuclear power in the 1970s, largely crowded gas out of Sweden's energy market for much of the 20th century. As demand for gas has remained low for almost a century and a half, Sweden never invested in the kind of gas network infrastructure present in both Germany and the UK.

6.2.2.2. Germany

The history of gas reliance in Germany parallels that of the UK. As a result, both nations have a high proportion of households relying on gas as their primary fuel source for space and water heating. After WWII, gas infrastructure played a major role in reconstruction (Mez 2003; Blackbourn 2013). In the 1970s, gas importation from the Soviet Union led many households to switch from coal and oil to natural gas. The development of gas pipelines by Russia in the 1980s and 90s further increased the availability of affordable natural gas in Germany, accelerating its adoption as the dominant heating fuel. It is only in the past two decades, with the rise of renewables, and more recently, due to disruptions in energy supplies from Russia following their invasion of Ukraine, that Germany has begun to reduce its dependence on gas. Despite this shift in sentiment, almost half of all German households remain on the gas network. Many German consumers therefore find themselves in a situation similar to those in the UK, weighing their interest in decarbonisation against their capacity to invest in heat pump installation and the prospect of higher heating bills.

6.2.2.3. Switzerland

At around 18%, the proportion of Swiss households currently relying on gas as their primary fuel source for space and water heating is midway between the figures for Germany (50%) and Sweden (0.5%). This situation reflects the country's unique energy history (Simon 2022). In the early 20th century, gas entered the market but remained a secondary fuel source behind coal and wood. By the 1960s, oil became the dominant source for heating, and as a result, the gas network remained relatively underdeveloped. While the gas network expanded during the 1970s oil crisis, as rising prices reduced oil's competitiveness, dependence on gas never surpassed that of oil. Considered a cleaner alternative to oil heating, natural gas gained popularity in the 1980s and 90s. However, in the early 2000s, the Swiss government introduced strict environmental policies that encouraged a shift toward renewable energy generation. As a result, although gas played an important role in the Swiss energy supply mix, competition from oil and later renewables prevented it from achieving the dominance it had in both Germany and the UK.

6.2.3. Summary role of gas for home heating

This research suggests that there is a relationship between the rate of heat pump adoption in a nation and the extent to which households are connected to relatively affordable gas for home heating. According to the second research hypothesis (H2), countries with a greater provision of affordable gas for home heating tend to have lower rates of heat pump adoption compared to countries with less gas network coverage or higher gas prices. The evidence gathered from expert interviews, questionnaires, and empirical country-level and historical data supports this claim.

Of the four nations, Sweden has the highest rate of heat pump adoption, followed by Switzerland, which has a higher rate of adoption than Germany, and Germany, which surpasses the UK. Critically, Sweden has virtually no gas network, while the UK has one of the most extensive networks in Europe. In Germany, although nearly half of all households are connected to the gas network, this figure falls far short of the UK's 75%. Switzerland is positioned between Sweden and Germany in terms of gas connectivity, supporting the inverse relationship suggested between the availability of relatively affordable gas and heat pump adoption rates.

As with electricity pricing, the current reliance on gas as a primary fuel source for space and water heating is a path-dependent effect of each nation's unique energy history. Gas never gained a foothold in Sweden, as it was crowded out by affordable electricity generated from hydropower and nuclear plants, as well as the rise of district heating in the mid-20th century. In contrast, Germany invested heavily in gas network infrastructure during post-war reconstruction, securing an ongoing supply of affordable natural gas from the Soviet Union and later the Russian Federation. As a result, gas remains the dominant heating fuel in Germany. Switzerland, which did not undergo the same post-war reconstruction as Germany, did not invest as heavily in gas infrastructure, leaving natural gas to compete against oil. Although the oil crisis of the 1970s and environmental concerns in the 1980s and 90s sparked greater consumer interest in gas, government regulation of fossil fuels and a shift toward renewables at the turn of the century limited gas network expansion in Switzerland.

The UK's extensive gas network is a deeply embedded aspect of its energy infrastructure, intrinsically linked to its historical reliance on fossil fuels for space and water heating. Transitioning away from this entrenched system will require significant investments in alternative electricity infrastructure. Additionally, policy measures aimed at making gas heating less economically viable, phasing out gas boilers, and incentivising the shift toward low-carbon heating solutions will be essential for facilitating the transition and reducing long-term dependence on gas.

6.3. Housing Stock Thermal Performance

The UK's existing housing stock is notorious for its low thermal efficiency (Shepheard et al. 2024). The majority of homes in the UK have an EPC rating of 'D' or lower (DLUHC 2023a). Although EPC ratings are estimates of energy efficiency, they provide valuable information about expected levels of insulation, airtightness, and heat demand. A 2020 study by tado° found that the UK's housing stock was older and lost heat faster than any of its Western European neighbours (Tado° 2020).

In England, 52% of homes were built before 1965, with 20% constructed before 1919 (Baker et al. 2022). Additionally, 15% of homes in England (equating to 3.5 million homes) did not meet the Decent Homes Standard in 2020 (DLUHC 2020). Due to the inefficiency of the existing housing stock, 'heating systems in the UK have to work harder and consume significantly more energy to maintain the required temperatures than in comparable countries' (Baker et al. 2022, 4).

The quality and condition of the UK's housing stock exacerbates the issues associated with a high electricity-to-gas price ratio (EtGPR), further undermining the economic competitiveness of clean heating systems such as heat pumps. The lower the thermal efficiency of a home, the higher its heat demand. For the majority of homes in the UK, therefore, a heat pump will likely incur additional costs to provide thermal comfort while achieving a suitable seasonal coefficient of performance (SCOP). This may require increasing the surface area of the emitters or improving the insulation and airtightness of the property. Simply installing a larger unit may not be an appropriate solution, as it would consume more energy, produce more CO2, and be costlier to operate.

The high price of electricity would have less impact on the economic competitiveness of heat pumps if the performance of these systems were not so significantly affected by the inefficiency of the UK's housing stock. Conversely, the inefficiency of the housing stock would be less of a concern if the economic competitiveness of heat pumps were not so severely undermined by the high cost of electricity. Unfortunately, the UK faces both of these mutually reinforcing barriers: high electricity prices (both in absolute and relative terms) and low housing stock efficiency.

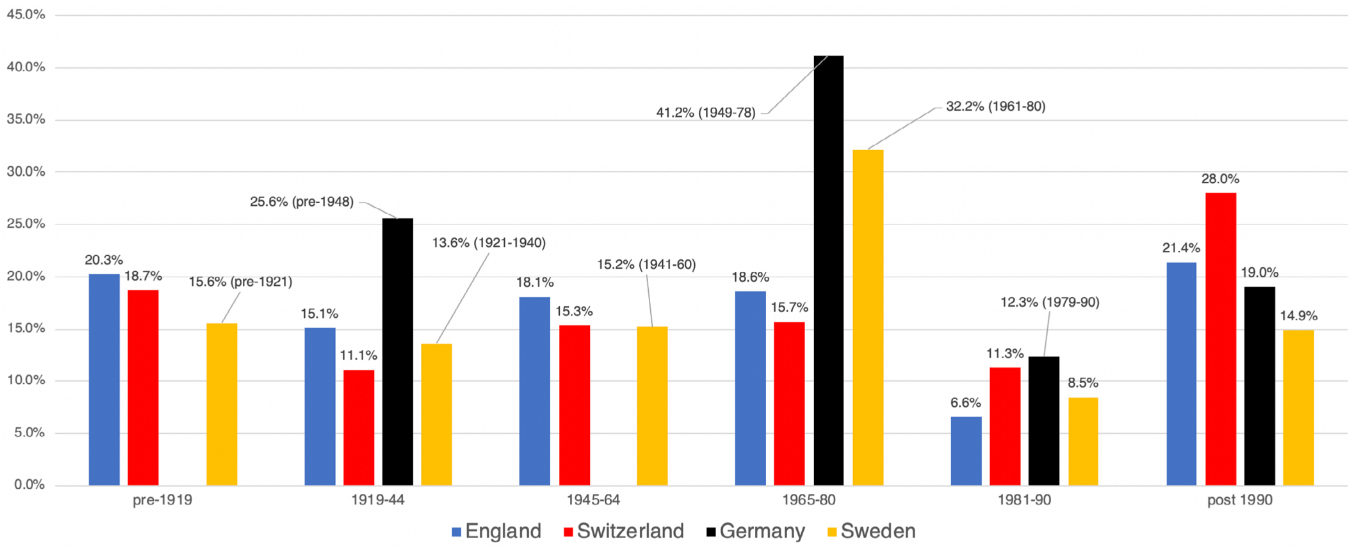
Age

One way to compare the thermal and energy efficiency of existing housing stock is by considering the period of construction. As a general rule, the older the housing, the less efficient it tends to be. While there are many caveats to this claim, given the broad trend towards improved building regulations and advances in construction techniques and materials, it is reasonable to suggest that homes built in 1930 are less energy- and thermally efficient than similar homes built in 2000. A recent House of Commons Library research briefing notes:

> "The factors linked most strongly to energy efficiency are a property's age and type. Newer homes have much higher ratings, as do purpose-built flats, while older homes, converted flats and bungalows have the lowest average ratings"
>
> Bolton 2024, 4

Figure 6 attempts to compare the existing housing stocks of the UK, Germany, Sweden, and Switzerland by period of construction. Unfortunately, there are certain challenges when comparing the official data. Firstly, England and Wales, Scotland, and Northern Ireland each conduct separate housing surveys, making UK-wide comparisons difficult. Secondly, as illustrated by Figure 6, while Switzerland and England use essentially the same 'age brackets' for assessing their housing stock, Sweden and Germany each use different ranges—i.e., distinct years of demarcation and fewer 'brackets.

Figure 6. Profile of Housing Stock by Construction Period[2] for England, Switzerland, Germany, and Sweden.



Data Source: EHS 2024; FSO 2024b; DeStatis 2024; SCB 2024.

Despite these data challenges, several observations can be made with reference to Figure 6 and Table 3:

- 1. England has the highest proportion of housing constructed before 1945 (i.e., the oldest housing stock) among the four comparison countries.
- 2. England has a lower proportion of housing constructed after 1980 compared to Germany and Switzerland.
- 3. England has a higher proportion of housing built after 1990 than Germany and Sweden.

Table 3. Comparison of Select Housing Stock Construction Periods for England, Sweden, Germany, and Switzerland.

Country	Pre-1945	Post-1980	Post-1990
England	35.4%	28%	21.4%
Sweden	29.2%	23.4%	14.9%
Germany	25.6%	31.3%	19%
Switzerland	29.8%	39.3%	28%

Data Source: EHS 2024; FSO 2024b; DeStatis 2024; SCB 2024.

Space Heating Demand

Related to the average age, condition, and construction of a country's housing stock is its average heat demand. Heating demand refers to the amount of energy, in kilowatt hours

2 It is challenging to precisely compare stock age distribution between countries as their respective authorities select different period ranges for classification. This report has created a chart for comparison but notes where data sit outside the X-axis classification ranges in the data labels.

(kWh), required to heat a home—i.e., the home's demand for heat. The Passivhaus Trust confirms that space heating demand is a 'key criterion' and a 'good proxy' for a building's fabric performance (Palmer and Lewis 2022).

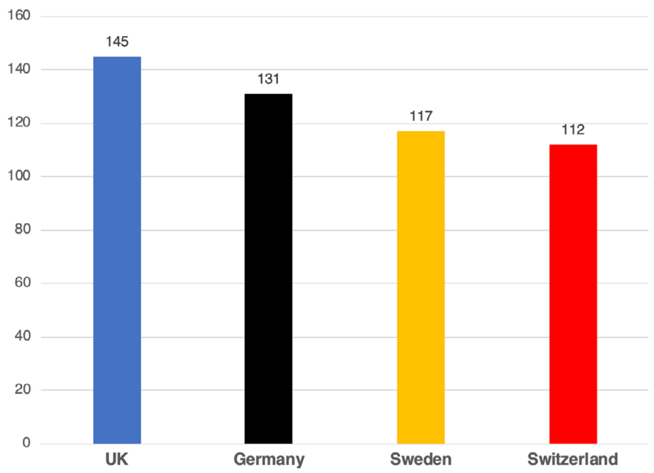
Table 4. Average Space Heating Demand for the UK, Germany, Sweden and Switzerland (kWh/m2/annnum).

Nation	United Kingdom	Germany	Sweden	Switzerland
kWh/ m2.year	145	131	117	112

Source: Mitchell and Natarajan 2020; DeStatis 2023b; Savvidou and Nykvist 2020; Steicher et al. 2019.

As illustrated by both Table 4 and Figure 7, the UK and Germany have significantly higher average space heating demand figures than Sweden or Switzerland. The fact that the UK has the highest heat demand aligns with the data showing that this country also has the highest proportion of homes built before 1945 (see Figure 6 and Table 3). Similarly, the observation that Switzerland has the lowest heat demand figure is consistent with the data indicating that this country has the highest proportion of homes built after 1990.

Figure 7. Average Space Heating Demand for the UK, Germany, Sweden and Switzerland (kWh/m2/annum).



Source: Mitchell and Natarajan 2020; DeStatis 2023b; Savvidou and Nykvist 2020; Steicher et al. 2019.

6.3.1. Expert data

6.3.1.1. Sweden

The Swedish expert argued that there is a correlation between housing stock thermal efficiency and the rate of heat pump adoption. They suggested that because Swedish homes are better insulated and experience less heat loss overall, the deployment of heat pumps is less challenging. This argument is based on the view that heat pump performance is influenced by building fabric. The better insulated a home, the higher the potential operational efficiency of a heat pump—everything else being equal. Conversely, homes with lower levels of insulation result in lower relative heat pump efficiency. This performance dynamic impacts heat pump adoption rates due to consumer concerns about higher running costs and the need for additional investment in fabric upgrades. The expert stated:

> "I know compared to the UK, Sweden has much better insulation, U-values…everything is much better in terms of fabric… I would say that, compared to the UK, we have a better standard of building fabric and that would make installing a heat pump much easier"
>
> INT1A

Lower electricity prices, combined with better-insulated homes, help alleviate consumer concerns about heat pump running costs in Sweden—a dominant and unresolved issue in the UK. The expert confirmed:

> "In general, the running cost costs are seen as low for the heat pump."
>
> INT1A

Although the average level of building thermal efficiency is higher in Sweden than in the UK, there are still areas where this is not the case. The Swedish expert noted that many rural homes are older, lack adequate insulation, and therefore present the same installation challenges faced in the UK. The expert remarked:

> "In the countryside it's almost all old houses with old people that don't have much of an incentive to invest in a heat pump"
>
> INT1A

According to the expert, Sweden's housing stock advantage could be attributed to specific and deliberate government policy. They noted that a nationwide construction program initiated in the 1960s resulted in a legacy of much newer homes on average compared to the UK. The expert explained:

> "The 1960s marked the beginning of a period of massive nationwide multifamily dwelling construction. This period, when quantity and rapid production were prioritised, is known as the "Million Home Programme" in Sweden and lasted through the 1970s. These dwellings constitute 40% of the total multi-family dwelling stock in Sweden today"
>
> INT1B

The expert indicated that building regulations aimed at improving housing energy efficiency were introduced nearly fifty years ago. This long-standing emphasis on insulation and heat loss has made the adoption of heat pumps easier today than it would have been had these regulations not been implemented. The expert asserted:

> "The 1977 Swedish building regulations including improved energy efficiency and reduced heating demand has contributed to have more air-to-air heat pumps"
>
> INT1B

6.3.1.2. Germany

Unlike the Swedish interviewee, the German expert did not believe there was a significant relationship between building thermal efficiency and the rate of heat pump adoption. They dismissed the idea that the level of insulation and heat loss in the existing housing stock was a key factor influencing heat pump deployment in Germany. The expert stated:

> "Thermal efficiency and airtightness are not the most important factors for heating system replacement. More important is the general perception of the suitability of heat pumps, the skills of installers and the investment and operating cost"
>
> INT2B

However, a closer examination of the expert's statement reveals key insights that warrant further scrutiny. They suggest that consumer perceptions of heat pump suitability are important, as are considerations regarding investment and operating costs. This report argues that consumer perceptions of heat pump suitability cannot be separated from issues of a home's thermal efficiency, as the level of insulation and heat loss are critical factors influencing surveyors' installation and system design recommendations. Moreover, since surveyors' recommendations form the basis for capital investment and operating cost assessments, these financial considerations are equally tied to a home's thermal efficiency. This report suggests that consumer perceptions and considerations about investment and operating costs are symptoms of a home's thermal efficiency, rather than independent root causes of heat pump adoption rates.

The expert reiterated their position that the level of insulation and heat loss in Germany's existing housing stock was not a factor in the country's rate of heat pump adoption, stating:

> "Impact of existing building stock is rather negligible, as the majority of heat pumps was installed in new buildings, renovation is only coming into focus as of recently"
>
> INT2B

Once again, this statement warrants closer scrutiny. If the thermal efficiency of housing stock is not a factor in the rate of heat pump adoption in Germany, it raises the question of why the majority of heat pumps have been installed in new homes, while the rate of installation in the existing stock has been much lower. This report suggests that the pattern of heat pump deployment in Germany supports the claim that the level of insulation and heat loss in the housing stock influences heat pump installation. New build homes, with the highest levels of insulation and the lowest levels of heat loss (on average), are considered ideal for heat pump installation. In contrast, the existing stock is more challenging due to the potential need for additional investment in renovation.

It seems that the testimony of the German expert is somewhat at odds with the question at hand. The expert appears to be arguing that German consumers, as well as German authorities and the building sector, hold an incorrect view about the level of insulation required to install a heat pump. The expert believes that heat pumps can and should be installed in a much broader range of homes than is currently being considered. They noted:

> "Stricter buildings standards were introduced since 1982… As a general rule of thumb, all buildings build after 1982 are fit to be immediately or with little renovation be replaced with a heat pump"
>
> INT2B

Critically, however, whether the view held by consumers, industry, and German authorities about heat pump suitability is correct or not (and evidence suggests it is overstated), the fact remains that beliefs about housing stock thermal efficiency drive these perceptions. Therefore, despite the German expert being unwilling to confirm a relationship between the rate of heat pump adoption in Germany and the thermal efficiency of their housing stock, this association was nevertheless implicit in their testimony.

6.3.1.3. Switzerland

The Swiss expert was unequivocal about the relationship between the thermal efficiency of Switzerland's housing stock and its rate of heat pump installation. They quantified the performance of Swiss homes based on their heating demand. Heating demand refers to the amount of energy required to provide adequate thermal comfort to the occupants. It can be expressed either as the total annual energy required (i.e., kWh/y) or as the energy required per square meter of internal area (i.e., kWh/m^2). Both formats allow for a reasonable comparison between different homes. Homes with lower levels of insulation and higher heat loss have greater heat demand, all else being equal, while homes with better insulation and lower heat loss have reduced heat demand. Describing the thermal efficiency of the Swiss housing stock, the expert stated:

> "The average specific final space heating demand is 178 kWh/m2-year for buildings constructed before 1920. It is 27 kWh/m2-year for buildings constructed between 2006 and 2015. However, since the average for the total Swiss residential stock of buildings in 2016 was 128 kWh/m2-year, this

implies there is a much larger share of old buildings with poor thermal efficiency, which would have definitely played a large part in limiting the uptake of HPs in Switzerland"

INT3B

Based on their analysis of heat demand measures, the expert determined that a significant proportion of the Swiss housing stock exhibited much lower levels of insulation and higher levels of heat loss compared to newly constructed buildings. The expert suggested that the high proportion of low-performing homes in Switzerland posed a challenge to the rate of heat pump installations. The expert explained:

"The decarbonisation of heating is not an easy task because the built environment in Switzerland spans across an entire century of old houses and buildings… We can divide the housing stock it into 2 parts: old buildings and new buildings. The new buildings are naturally, very energy efficient. So, there is no problem integrating decarbonised heating technologies into those buildings. The challenge, however, comes with decarbonising heating in the older buildings. The stock of those buildings is rather inefficient in terms of fabric, U-values, airtightness and so forth – there are several challenges"

INT3A

The challenge posed by low-performing homes in Switzerland is similar to that experienced in the UK. Homes with lower levels of insulation and higher heat loss generally require additional investment in fabric upgrades to ensure optimal heat pump performance. When heat pumps are installed in homes with low thermal efficiency that do not undergo fabric upgrades, the running costs of these systems are higher. This creates a financial dilemma for many Swiss households, much like that faced by those in the UK. They must either invest in fabric upgrades to reduce running costs or avoid the additional upfront costs at the expense of higher ongoing heating bills. In either case, there is a significant financial consideration. The expert confirmed:

"Old building stock which is characterised by high specific heat demand, limit the deployment of heat pumps as they need to undergo deep retrofits prior to shifting to heat pumps"

(INT3B).

Although there may be similarities in the age and thermal performance of the housing stock in both Switzerland and the UK, the expert noted that the impact of retrofit requirements might be felt differently in the two nations. Since the financial capacity of the average Swiss household is greater than that of households in the UK, their ability to pay for fabric improvements or bear higher heating bills is also greater. The expert noted:

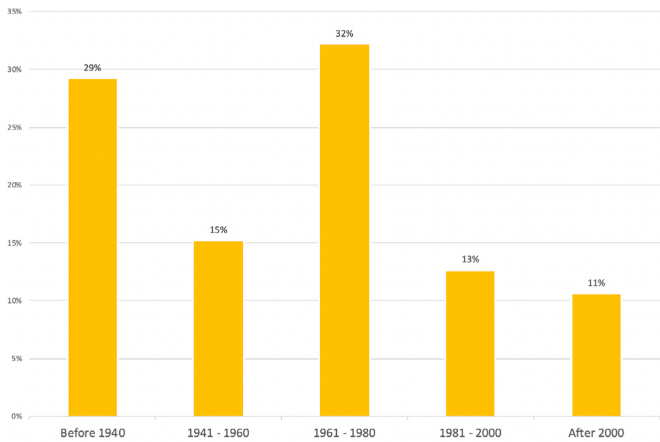
"Simple issues like the per capita GDP is very different between Switzerland and the UK. The difference in per capita GDP is significant. In Switzerland it's about 75,000 or 80,000 USD per person, and probably around half that in the UK… this is one major difference when we look at the UK. There is definitely less of a resource constraint in Switzerland"

(INT3A).

6.3.2. Background on national housing stock thermal performance

6.3.2.1. Sweden

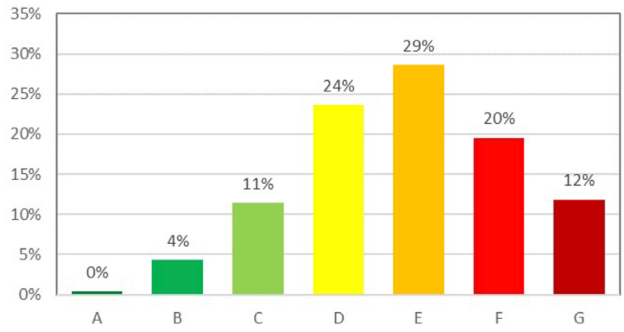
Figure 8. Distribution of Swedish Housing Stock by Year of Construction (2023).



Data source: SCB 2024.

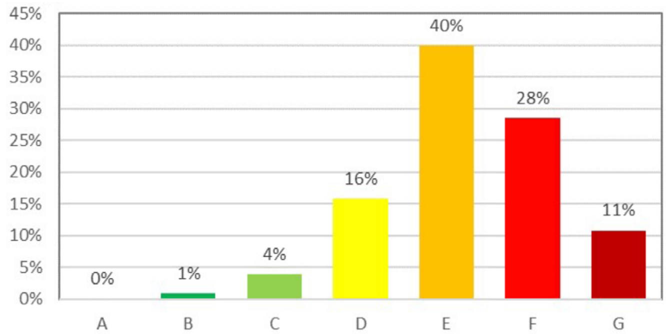
At around 29%, Sweden has a large proportion of homes built before 1940 (SCB 2024). This is partly due to Sweden avoiding the extensive bombing campaigns that affected countries like Germany during WWII. After 1945, Sweden experienced a post-war boom, during which state intervention facilitated mass housing construction in the 1940s and 50s to address shortages (Hall 1991). Between 1965 and 1974, the Swedish government launched the 'Million Homes Programme,' resulting in the construction of a large number of multi-family apartment blocks, row houses, and single-family homes over a ten-year period (Hall and Vidén 2005). Although the energy efficiency of these homes is low by modern standards, they are still more energy-efficient compared to homes built in the early part of the 20th century. As illustrated by Figure 8, the largest proportion of Swedish homes were constructed between 1961 and 1980.

Figure 9. Distribution of Energy Classes for Energy-Declared Houses as of 1 July 2019.



Source: MoI 2019.

Figure 10. Distribution of Energy Classes for Energy-Declared Apartments as of 1 July 2019.



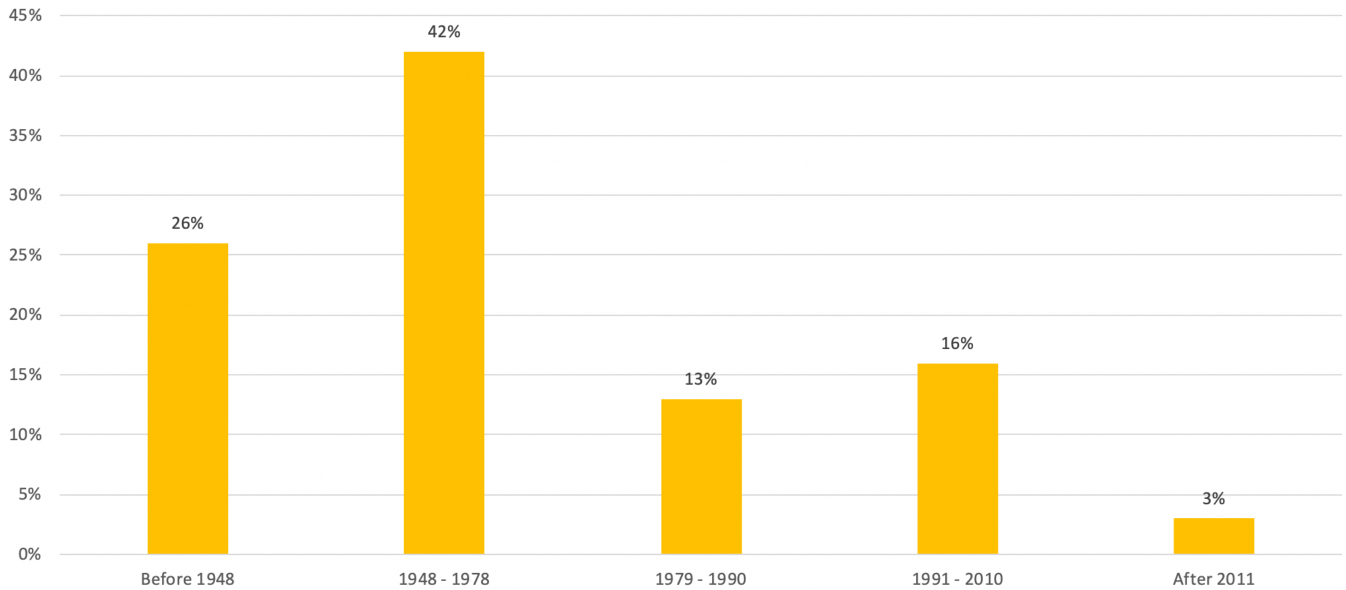
Source: MoI 2019.=

In 1975, following the oil crisis, Sweden updated its Building Code, and further tightened standards in 1980, significantly improving the energy and thermal efficiency of new homes. For the past fifty years, Swedish homes have focused on reducing heating demand and enhancing thermal performance (Nilsson 2017). In the 1990s, Sweden introduced programs aimed at improving the insulation and heating efficiency of older homes, and by the turn of the 21st century, the country became a leader in Passivhaus construction. This push for greater energy efficiency continued into the 21st century with the 2012 EU Energy Performance of Buildings Directive (EPBD).

Sweden's emphasis on public construction, renovation programs, and energy efficiency improvements since the 1960s has resulted in a housing stock with lower heating demand and better overall thermal performance than either Germany or the UK. However, due to the large number of homes built in the 1960s and 70s—before more stringent building standards were adopted—most existing homes still require retrofitting and fall short of the desired 'near-zero' energy rating of A to C. As shown in Figures 9 and 10, by 2019, 75% of houses and 95% of apartments were energy-rated D to G (MoI 2019)

6.3.2.2. Germany

Figure 11. Distribution of German Housing Stock by Year of Construction (2023).

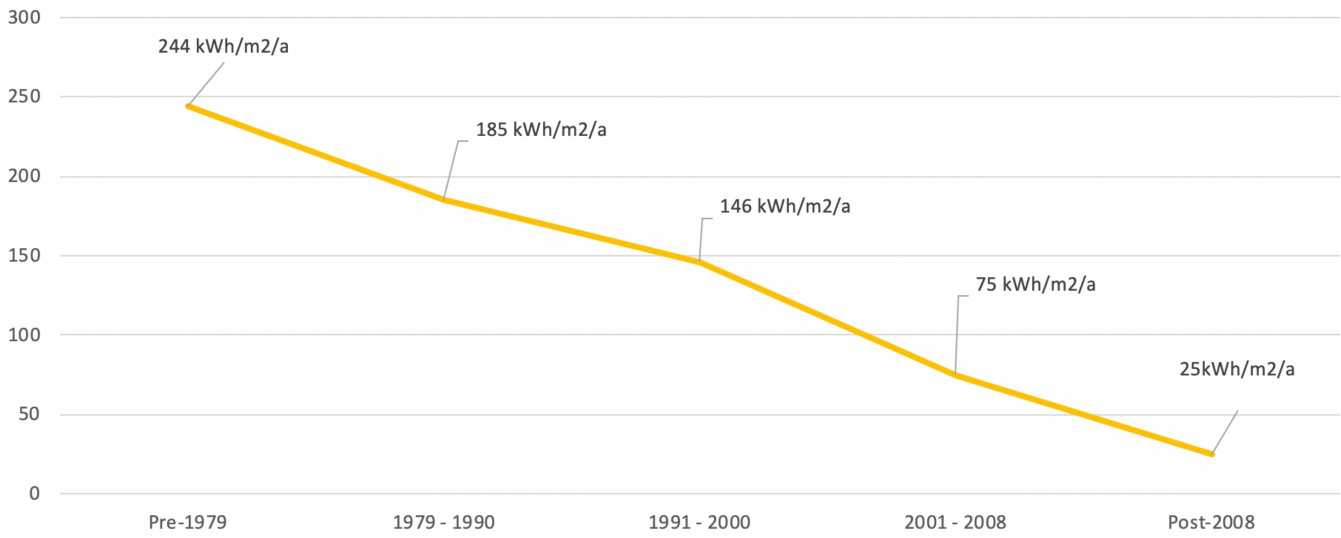


Data source: DENA 2023.

The effects of WWII are deeply embedded in the current structure of Germany's housing stock. As noted by Halbmeier and Schröder (2024), approximately 20% of the country's homes were destroyed by the war. In response, between 1945 and 1960, the West German government initiated several housing construction programs (Wohnungsbauprogramme), resulting in a significant number of prefabricated homes. These homes, however, were built with minimal insulation and little regard for energy efficiency. The 1960s and 70s brought additional state intervention, especially in East Germany under the Soviet Union's influence, leading to a boom in public housing, including many standardised apartment blocks (Plattenbauprogramme). Once again, these homes prioritised cost and delivery efficiency over thermal performance. Figure 11 demonstrates how these two waves of government-led construction shaped the current distribution of Germany's housing stock.

Similarly to Sweden, the 1973 oil crisis prompted increased attention to energy efficiency in Germany, culminating in the 1977 Thermal Insulation Ordinance (Wärmeschutzverordnung, WSchV), which was the first significant piece of legislation mandating better insulation and reduced heat demand in buildings. Following Germany's reunification in 1990, much of the housing stock in East Germany was found to be poorly insulated, leading to large-scale renovation projects aimed at improving energy performance. These efforts were crucial in addressing the substantial energy inefficiencies of the former East German housing stock.

Figure 12. Average Heat Demand (kWh/m2/annum) for New German Single-Family Homes by Period of Construction.



Data source: Ouwerkerk et al. 2024.

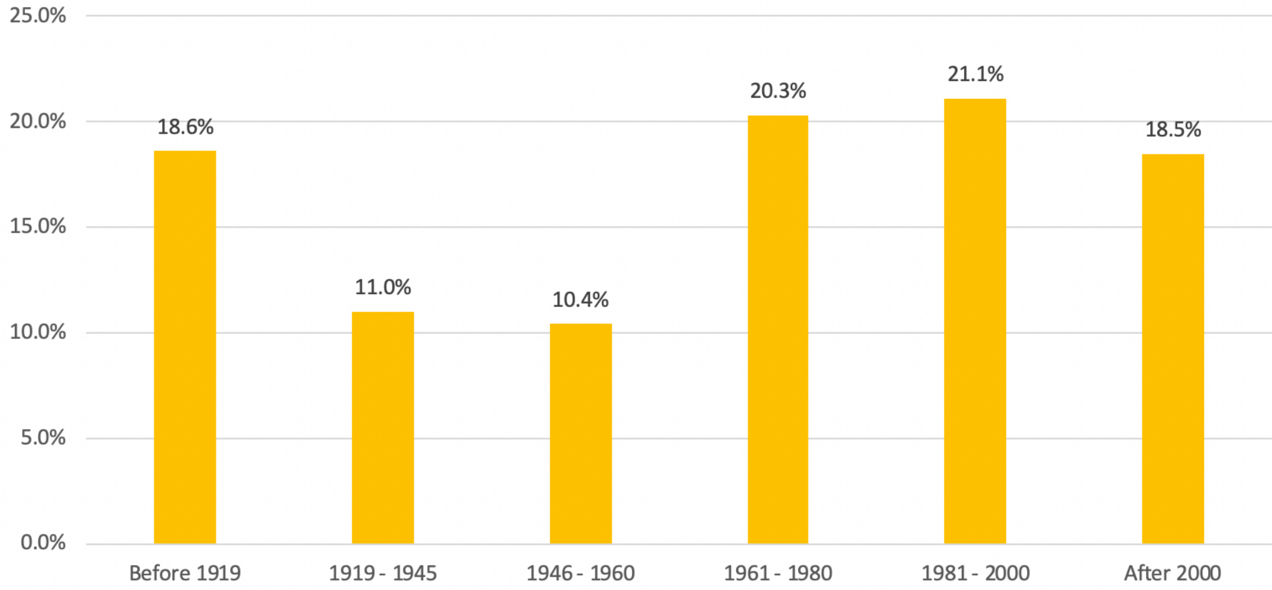
By the mid-1990s, sustainability and energy efficiency became key priorities in housing standards, with the revised Wärmeschutzverordnung (WSchV) introduced in 1995. This was later replaced by the Energy Saving Ordinance (Energieeinsparverordnung, EnEV) in 2002 (Bhadbhade et al. 2020). In 2013, the EnEV was updated to require new buildings to demonstrate approximately 30% lower energy consumption. In 2020, the Building Energy Act (Gebäudeenergiegesetz, GEG) replaced the EnEV, aligning German housing standards with the EU's near-zero energy (NZEB) targets. Figure 12 illustrates the impact these energy efficiency regulations have had on the average heat demand of new homes over time. Housing constructed before the 1977 Thermal Insulation Ordinance had an average heat demand of 244 kWh/m2/annum. By 2007, new homes built in Germany recorded an average heat demand of just 25 kWh/m2/annum. Over the course of three decades, these regulations reduced the average heat demand in new buildings by nearly 90%.

The challenge for Germany, however, is that the majority of its housing stock (i.e., 68%) was built before 1979.

6.3.2.3. Switzerland

The early 20th century saw a period of rapid urbanisation in Switzerland, with cities such as Basel, Zurich, and Geneva becoming home to early apartment blocks constructed in the 1920s and 1930s. These buildings were made from solid brick and stone but lacked modern insulation. Post-war economic prosperity in the 1950s through the 1970s drove major housing expansion, particularly the construction of mid- and high-rise apartment buildings. While materials shifted from brick to concrete, with many prefabricated elements, the thermal performance of these homes remained low, as energy efficiency was not yet a priority (Koch 2020). As illustrated by Figure 13, 51.8% of all homes in Switzerland were constructed between 1945 and 1980.

Figure 13. Distribution of Swiss Housing Stock by Year of Construction (2023).

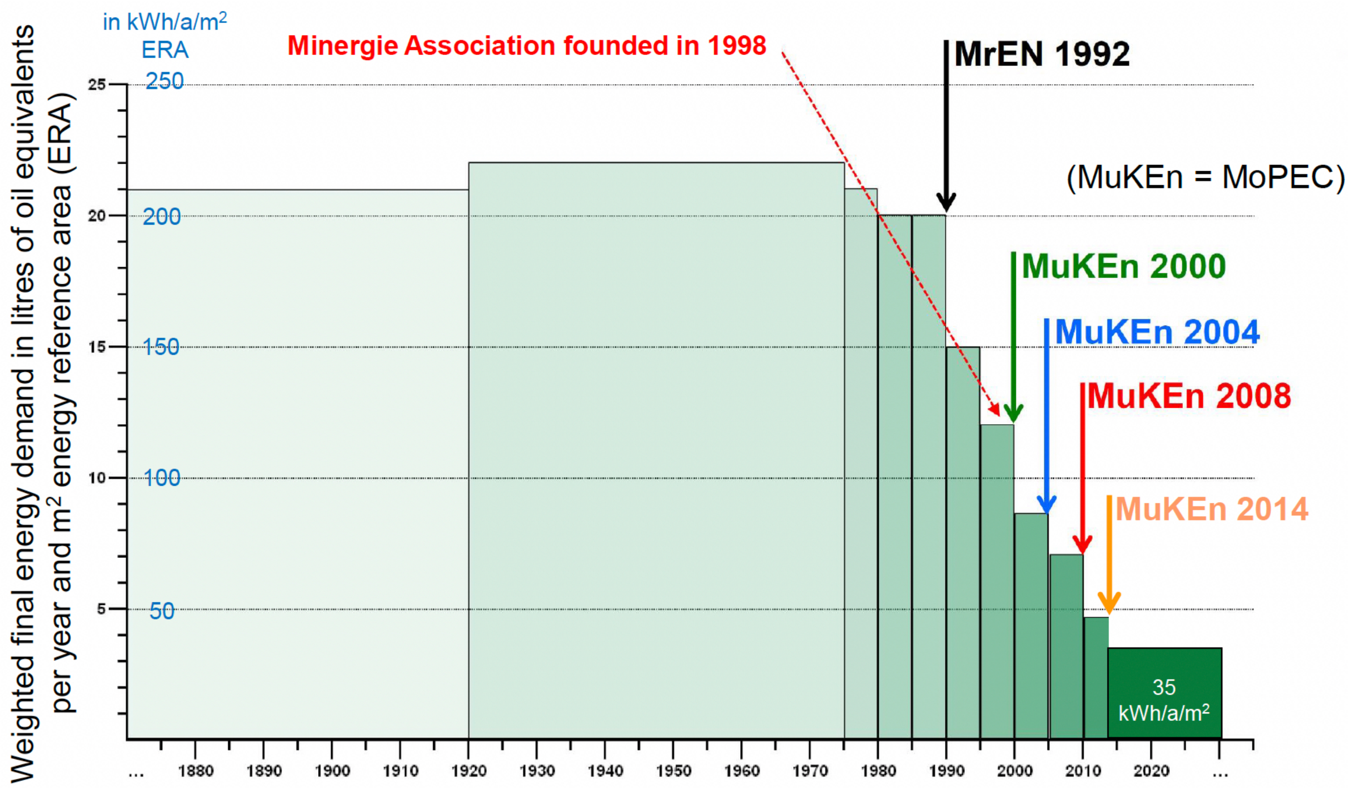


Data source: FSO 2024.

The 1973 oil crisis sparked considerable interest in improving energy efficiency standards in Switzerland, a response to the economic situation that was also observed in Sweden and Germany (Kirchgässner and Müller-Fürstenberger 1997). In 1975, the Swiss government introduced the first federal energy-saving recommendations for housing, known as the Guidelines on Thermal Insulation of Buildings (Weisungen über Wärmedämmung von Gebäuden). A decade later, in 1985, the Swiss government passed the Thermal Insulation in Building Construction (Wärmeschutz im Hochbau) ordinance, which established minimum thermal insulation standards for buildings to reduce energy consumption.

In 1991, Switzerland passed one of the world's first national laws governing carbon dioxide emissions. The Federal Act on the Reduction of CO2 Emissions (Bundesgesetz über die Reduktion der CO2-Emissionen) promoted energy efficiency by encouraging better insulation, renewable energy heating systems, and stricter efficiency standards. In 1998, the Minergie Standard, a voluntary low-energy building certification, was introduced to encourage energy-efficient housing design.

Figure 14. Average Heat Demand of Homes in Switzerland by Period of Construction, Showing Passage of Various Energy Efficiency Standards.



Source: Patel 2021.

In 2000, the Conference of Cantonal Energy Directors (EnDK) developed a set of standardized energy regulations for buildings in Switzerland, known as the Model Regulations of the Cantons in the Energy Sector (MuKEn, Mustervorschriften der Kantone im Energiebereich). The periodically updated MuKEn framework serves as a model that Swiss cantons can incorporate into their own building energy regulations. In 2014, the Thermal Insulation in Building Construction ordinance (Wärmeschutz im Hochbau) was updated to align with MuKEn standards. Figure 14 illustrates the impact of these various energy efficiency standards on the heat demand of homes built in Switzerland across different periods. Prior to the 1973 oil crisis, the average heat demand for homes constructed in Switzerland was around 205 kWh/m2/annum. By the time the Minergie Standard was introduced in 1998, the average heat demand had fallen to around 120 kWh/m2/annum. By 2014, when the Thermal Insulation in Building Construction ordinance was aligned with MuKEn, the average heat demand figure had dropped to less than 50 kWh/m2/annum.=

Due to the steady improvement in energy efficiency and building standards throughout the last quarter of the 20th century, the 1990s and early 2000s were characterised by widespread retrofitting programmes for existing homes in Switzerland. Enhancing insulation and reducing the heat demand of older homes remained a priority through the 2010s and into the present, with the federal government providing strong incentives to support these efforts.

6.3.3. Summary role of average housing stock thermal performance

The review of comparative country evidence regarding the thermal efficiency of existing housing stock presents a more complex indicator of heat pump adoption rates than factors like electricity pricing or the availability of affordable gas for home heating.

Although the average heat demand of the United Kingdom's housing stock (145 kWh/m2/annum) is significantly higher than that of Sweden (117 kWh/m2/annum), Germany (131 kWh/m2/annum), and Switzerland (112 kWh/m2/annum), which correlates with the relative rates of heat pump adoption, the relationship between heat pump adoption rates and heat demand does not hold consistently among the continental European nations. For example, Sweden has by far the highest rate of heat pump adoption (22,727 heat pumps per 100,000 population), despite Switzerland having the lowest heat demand but a significantly lower rate of heat pump adoption (4,940 heat pumps per 100,000 population).

Furthermore, research conducted by tado° in 2020 found that UK homes lose heat three times faster than those in Germany, confirming the correlation between housing thermal efficiency and heat pump adoption rates. However, the study also revealed that Swedish homes lose heat faster than those in Germany (1.2°C compared to 1°C per 5 hours) (Tado° 2020). This finding contradicts the heat pump adoption rates between the two nations, as Germany has 1,962 heat pumps per 100,000 population, compared to 22,727 per 100,000 in Sweden (2022 figures).

The non-linearity of the relationship between housing thermal efficiency and heat pump adoption rates observed in Sweden, Germany, and Switzerland requires further explanation. This report suggests that the price of electricity, along with the lack of a significant gas network in Sweden, are key factors that account for the observed differences. Electricity prices in Germany are 75% higher than in Sweden, and the electricity-to-gas price ratio (EtGPR) is 2.75 times higher in Germany. As a result, average Swedish consumers benefit from lower running costs when installing heat pumps, a benefit that German consumers do not enjoy. Similarly, electricity prices in Switzerland are 6% higher than in Sweden, while the EtGPR is 1.4 times higher in Switzerland.

The price of electricity is closely linked to the impact of housing thermal efficiency on heat pump performance. The higher the thermal efficiency of a home, the better the performance of the heat pump (all else being equal). However, when electricity prices are lower, the heat pump doesn't need to be as efficient to achieve a cost advantage over other heating systems. In other words, a lower electricity price can offset poorer thermal efficiency if the difference in electricity prices is greater than the difference in thermal efficiency. Both electricity price and housing thermal efficiency directly affect the running costs of a heat pump. If the electricity price difference between nations is large enough, it can compensate for lower housing thermal efficiency.

With respect to hypothesis 3 (i.e., countries with lower housing stock thermal performance tend to have lower rates of heat pump adoption compared to countries with higher performing housing stock), this research finds that the claim is partially supported. On one hand, the UK, with the lowest-performing housing stock among the four nations reviewed, also has the lowest rate of heat pump adoption. Similarly, Germany, which slightly outpaces the UK in terms of heat pump adoption but is far behind Sweden, demonstrates a significantly higher average heat demand than Sweden, with only a marginal advantage over the UK. On the other hand, Sweden, which leads in heat pump adoption, has a slightly higher average heat demand than Switzerland. Therefore, while thermal efficiency is a contributing factor to the rate of heat pump adoption, it is not sufficient, in isolation, to explain the observed differences between the four nations.

6.4. Regulatory Environment & Incentive Regime

The two regulatory domains with the greatest influence on the rate of heat pump installation in the United Kingdom are those related to building standards and the adoption of clean (or zero direct emissions) heating systems. In general, more stringent building standards result in a greater proportion of housing stock where heat pumps perform better (all else being equal). Regulations that mandate the installation of clean heating systems or prohibit the replacement and repair of gas boilers will increase the numbers of such systems (including heat pumps) over time.

Table 5 sets out all of the policies, regulations, and schemes available to stakeholders across the United Kingdom intended to encourage the adoption and installation of clean heating systems (including heat pumps). Importantly, while many policies motivate owner-occupiers and private and social landlords through grants and subsidies, only two pieces of legislation mandate the installation of clean heating systems in the United Kingdom. Namely, the New Build Heat Standard (NBHS) (2024) in Scotland, and the Future Homes Standard (FHS) (2025) in England. The NBHS and the FHS cover new construction only. Neither Northern Ireland nor Wales have comparable legislation making the installation of zero emissions heating compulsory. This means that the installation of clean heating systems is only mandated for new homes (be they public or private), and only in Scotland and England. While there is a clear, well-understood intention to phase out gas boilers across the UK, this process is not yet fully mandated or enforced, and significant gaps remain in the current regulatory framework. Despite policy signals toward the transition, the installation of clean heating systems, including heat pumps, remains voluntary for the majority of existing homes, with only limited legislative action in new builds in Scotland and England.

As of 2022, there were approximately 29.9 million dwellings in the United Kingdom. This total comprises about 25.2 million dwellings in England, 1.5 million in Wales, 2.67 million in Scotland, and 822,083 in Northern Ireland (DLUHC 2023b). Annually, the UK constructs around 250,000 new homes (MHCLG 2024). These figures suggest that clean heating mandates apply to less than 1% of the total UK housing stock.

Table 5. Policies, Regulations, and Schemes Promoting the Installation of Clean Heating Systems (including Heat Pumps) Across the United Kingdom, in 2025.

Policy/Regulation/Scheme	Description, Eligibility, Funding, and Impact.
Boiler Upgrade Scheme (BUS) (2022, England & Wales)	Description: Provides grants for replacing fossil fuel heating systems with renewable heating alternatives, like air source heat pumps, ground source heat pumps, and biomass boilers. Eligibility: Available to homeowners and landlords in England and Wales, with properties that are not part of a new-build. Does not apply to social housing or large-scale developments Funding: £7,500 for heat pumps and £5,000 for biomass boilers. Impact: Helps reduce carbon emissions, lowers household energy bills, and incentivises the transition to clean energy systems.
Home Upgrade Grant (HUG) Phase 2 (2023-2025, England)	Description: Provides funding for energy efficiency upgrades and clean heating solutions for homes not connected to the gas grid. Eligibility: Targeted at low-income households in England that are off the gas grid, including owner-occupiers and private renters. Funding: Varies by local authority, with Cosy Homes in Lancashire receiving £41 million in this phase. Impact: Supports vulnerable households in reducing fuel poverty, improving energy efficiency, and cutting heating costs.
Nest Scheme (2011, Wales)	Description: Provides free energy efficiency upgrades for low-income households, including insulation, heat pumps, and solar panels. Eligibility: Available to homeowners and private tenants in Wales who meet income-based criteria. Funding: Fully funded improvements for eligible households, depending on energy savings. Impact: Reduces energy bills, increases warmth, and mitigates fuel poverty for vulnerable households across Wales.
Warmer Homes Scotland (2015, Scotland)	Description: Provides funding for a range of energy efficiency measures, including insulation, heating controls, and renewable heating systems like heat pumps. Eligibility: Available to low-income households across Scotland that either own or privately rent their homes, and whose homes are deemed energy-inefficient. Funding: Up to £10,000 for eligible households. Impact: Improves energy efficiency and reduces heating costs for vulnerable individuals and families.
Home Energy Scotland Grant and Loan (2022, Scotland)	Description: Offers grants and loans for energy efficiency upgrades and the installation of renewable heating systems like heat pumps. Eligibility: Available to homeowners in Scotland with properties in need of energy efficiency improvements or renewable heating installations. Funding: Up to £7,500 for energy efficiency measures, and up to £7,500 for clean heating installations, with a total of up to £15,000 available. Impact: Helps homeowners reduce carbon emissions, lower energy costs, and achieve energy efficiency goals.

New Build Heat Standard (NBHS) (2024, Scotland)	Description: Requires all new homes built from 2024 to use low-carbon heating systems, like heat pumps, and meet energy efficiency standards. It supports Scotland's Net Zero target by 2045. Eligibility: Applies to all new builds and major refurbishments. Funding: No direct funding is provided. Impact: Reduce carbon emissions, promote sustainable heating, and help meet climate goals.
Northern Ireland Sustainable Energy Programme (NISEP) (2010, Northern Ireland)	Description: Provides grants for energy-saving improvements such as insulation and heating system upgrades to businesses and low-income households. Eligibility: Available to low-income households, as well as non-profit organisations, businesses, and other entities in Northern Ireland. Funding: Varies depending on the specific energy-saving measure and eligibility. Impact: Helps to reduce heating costs and improve energy efficiency in homes and businesses across Northern Ireland.
Energy Act (2023, UK)	Description: Establishes a framework for supporting clean heating technologies, improving energy efficiency in buildings, and reducing carbon emissions across the UK. Eligibility: Relevant to homeowners, businesses, and public sector buildings, though specific funding programs are administered separately. Funding: Direct funding varies by subsequent schemes, such as the Boiler Upgrade Scheme and others that stem from the Act. Impact: Drives the UK's transition to cleaner energy sources, including renewable heating systems, and supports Net-Zero goals.
Future Homes Standard (2025, England)	Description: Requires all new homes built from 2025 to be fitted with low-carbon heating systems (e.g., heat pumps) and meet higher energy efficiency standards to reduce carbon emissions. Eligibility: Applies to all new builds in England. Funding: No direct funding is provided under the standard. Impact: Significant carbon reductions, improved energy efficiency, and lower energy bills for homeowners, supporting the transition to a sustainable housing sector.
Relaxation of Planning Regulations for Heat Pumps (2024, England)	Description: Removes certain planning restrictions for the installation of heat pumps, such as the requirement to keep heat pumps at least one meter from a neighbour's property. Eligibility: Applies to homeowners and landlords across England who want to install air source heat pumps. Funding: No direct funding is offered by this regulation. Impact: Simplifies the planning process, lowering barriers for homeowners looking to install clean heating systems, thus increasing heat pump adoption.
Climate Change (Scotland) Act (2009, Scotland)	Description: Sets legally binding targets for reducing greenhouse gas emissions, influencing policies like heat decarbonisation and clean heating adoption. Eligibility: Affects all households, businesses, and public sector entities in Scotland. Funding: Various funding programs are established under this Act to support decarbonisation. Impact: A significant driver for the adoption of renewable heating technologies and improved energy efficiency across Scotland.

Heat in Buildings Strategy (2021, Scotland)	Description: A comprehensive strategy to decarbonise Scotland's buildings, including the phasing out of fossil fuel heating systems in favour of zero-emission alternatives like heat pumps. Eligibility: Applies to all building types, including residential, commercial, and public sector buildings in Scotland. Funding: Includes multiple funding opportunities, such as grants and loans to support energy efficiency measures and renewable heating installations. Impact: Contributes to Scotland's goal of achieving Net-Zero emissions by 2045.
Amendment to Permitted Development Rights for Heat Pumps (2023, Northern Ireland)	Description: Eases planning permission requirements for the installation of air source heat pumps. Eligibility: Applies to homeowners and businesses in Northern Ireland. Funding: No direct funding for planning-related activities. Impact: Reduces planning barriers for heat pump installations, making it easier for households to adopt renewable heating systems.
Energy Efficiency Standard for Social Housing (EESSH) (2014 & 2019, Scotland)	Description: Sets energy efficiency targets for social housing to reduce fuel poverty and carbon emissions. Eligibility: Applies to social landlords in Scotland, ensuring that their properties meet specific energy efficiency standards. Funding: The Scottish Government has allocated £200 million to support the decarbonisation of social housing through the Social Housing Net Zero Heat Fund. Impact: Improves energy efficiency and reduces heating costs for social housing tenants, contributing to Scotland's carbon reduction goals.
Local Heat and Energy Efficiency Strategies (LHEES) (2022, Scotland)	Description: Requires local authorities to create strategies for heat decarbonisation and energy efficiency in their areas. Eligibility: Applies to all homes and buildings within the local authority areas. Funding: Varies by local authority, and is often provided through specific local programs. Impact: Structures heat decarbonisation efforts at the local level, making it easier for local communities to transition to low-carbon heating.
Social Housing Net Zero Heat Fund (SHNZHF) (2021, Scotland)	Description: Provides financial support for social housing providers to retrofit homes with low-carbon heating systems and improve energy efficiency, aiming to decarbonise the social housing sector. Eligibility: Open to social landlords, including local authorities and registered social landlords (RSLs), who manage social housing. Funding: Available through competitive bidding rounds, with the Scottish Government initially allocating £200 million to support these projects, including heat pump installations and energy efficiency upgrades. Impact: Reducing carbon emissions from social housing, improving heating systems for tenants, lowering energy bills, and helping Scotland meet its Net-Zero targets by 2045.

Warm Homes: Social Housing Fund (WHSHF) (2024, England)	Description: Provides funding to improve the energy performance of social housing by supporting the installation of energy-efficient measures and clean heating systems. Eligibility: Available to local authorities and registered social landlords responsible for social housing in England. Funding: The fund includes £1.29 billion for projects aimed at decarbonising social housing. Impact: Improves energy efficiency, reduces carbon emissions, and decreases heating costs for tenants in social housing.
Optimised RetroFit Programme (ORP) (2020, Wales)	Description: Supports the decarbonisation of Welsh social housing by retrofitting homes with energy efficiency measures and low-carbon heating technologies. Eligibility: Available to social housing providers in Wales. Funding: The exact funding per property or project depends on the measures proposed. In the first phase, the Welsh Government announced an initial £50 million for the programme. Impact: Helps reduce fuel poverty and greenhouse gas emissions in the social housing sector in Wales.
Affordable Warmth Scheme (2014, Northern Ireland)	Description: Provides grants to low-income households for energy efficiency improvements, including insulation and heating system upgrades. Eligibility: Available to homeowners and tenants in Northern Ireland who are in receipt of qualifying benefits or have low incomes. Funding: Up to £1,000 for homeowners (this typically covers insulation and basic energy efficiency measures). For those with higher needs, up to £6,000 is available for more comprehensive improvements such as upgrading heating systems or replacing old, inefficient boilers. Impact: Reduces energy bills, enhances home warmth, and helps alleviate fuel poverty.
Heat in Buildings Bill (Proposed 2025, Scotland)	Description: The forthcoming Bill will provide a statutory framework to ensure Scotland's buildings transition to zero-emission heating systems, phasing out fossil fuel-based systems. Eligibility: The Bill will apply to all sectors, including residential, commercial, and public buildings in Scotland. Funding: The Scottish Government will provide substantial funding, though specific amounts are yet to be finalised. Impact: This Bill will form the backbone of Scotland's efforts to decarbonise buildings, enabling substantial investments in clean heating technologies.
Energy Efficiency (Private Rented Sector) Regulations (Proposed 2025, England and Wales)	Description: Aims to require privately rented homes to achieve a minimum EPC rating of C, initially for new tenancies and later for all tenancies. Eligibility: Landlords will need to upgrade their properties to meet these standards. Funding: Government schemes like the Green Homes Grant to support funding. Impact: Reduced energy consumption, lower bills for tenants, and a significant contribution to the UK's decarbonisation goals

Source: UK Government 2021; UK Government 2022; UK Government 2023a; UK Government 2023b; UK Government 2024a; UK Government 2024b; UK Government 2025a; UK Government 2025b; Welsh Government 2025a; Welsh Government 2025b; Scottish Government 2021; Scottish Government 2022; Scottish Government 2023; Scottish Government 2024b; Scottish Government 2025a; Scottish Government 2025b; EST 2025; NIHE 2025; DESNZ 2025.

Table 6 presents the current new home building standards that apply across the United Kingdom. Broadly speaking, the standards estimate an average heat demand of 30-50 kWh/m2/year, depending on the home's design and heating system, with a heat loss figure (i.e., U-value) of around 0.18 W/m2K for walls and 0.13 W/m2K for roofs.

Research has shown that (controlling for user behaviour) heat pumps installed in new homes built to these specifications demonstrate running costs equivalent to gas boilers (all else being equal) (Mateo-Garcia et al., 2023). This suggests that the thermal performance of new homes (including levels of insulation, energy efficiency, and heat loss) currently being built in the UK is suitable for the installation of clean heating systems such as heat pumps. Importantly, however, these standards only came into effect recently. Therefore, many of the new homes being built across the UK up to 2023 may still require minor fabric upgrades and retrofitting work to ensure household heating costs remain competitive if gas boilers are replaced with heat pumps.

Table 6. Building Standards for New Homes Across the United Kingdom, in 2025.

Building Standard	Description	Minimum Energy Efficiency / Carbon Emission Reduction	Heat Loss (U-values)	Heat Demand (kWh/ m^2/year)
Building Regulations - Part L (England)	The 2021 update to Part L focuses on reducing carbon emissions from new homes, aligning with the UK's goal of achieving Net Zero by 2050. It includes stricter measures for energy efficiency and low-carbon heating systems.	- 31% reduction in carbon emissions compared to 2013 regulations. - Primary energy demand reduction	- Walls: 0.18 W/m^2K - Roofs: 0.13 W/m^2K	Average heat demand: 30-50 kWh/m^2/year depending on the home's design and heating system.
Building Regulations - Part L (Wales)	The 2021 Part L regulations for Wales are aligned with England's but with an added emphasis on reducing emissions and moving towards Net Zero by 2050. They require new homes to be highly energy-efficient with low-carbon heating systems.	- 35% reduction in carbon emissions compared to 2014 standards. - Stricter focus on Net Zero by 2050 goals.	- Walls: 0.18 W/m^2K - Roofs: 0.13 W/m^2K	Average heat demand: 30-50 kWh/m^2/year, depending on building type and heating system.
Building Standards - Section 6 (Scotland)	Section 6 sets standards for energy efficiency in new homes and focuses on reducing space heating demand while prioritising carbon reductions. This section also encourages the use of renewable energy systems such as heat pumps.	- Space heating demand reduced. - Focus on carbon emissions reduction for new builds.	- Walls: 0.22 W/m^2K - Roofs: 0.13 W/m^2K	Target: 30 kWh/m^2/ year for space heating demand.
Building Regulations - Part F & Part P (Northern Ireland)	Northern Ireland's building regulations set out the standards for energy efficiency and carbon reduction for new homes. These regulations aim to improve energy performance over time, with an emphasis on renewable energy technologies.	- Carbon reduction targets (ongoing updates). - Focus on improving energy efficiency over time.	- Walls: 0.22 W/m^2K - Roofs: 0.18 W/m^2K	Average heat demand: 30-50 kWh/m^2/year, depending on the design and system used.

Source: UK Government 2021; Welsh Government 2025c; Scottish Government 2025b; Northern Ireland Government 2022.

The following section will examine how building standards and regulations may have influenced the rate of heat pump adoption across Sweden, Germany, and Switzerland, and investigate how these regulatory landscapes account for the observed variance in their respective adoption rates.

6.4.1. Expert data

6.4.1.1. Sweden

The interview with the Swedish expert suggested that building standards, energy efficiency regulations, and the grant and subsidy regime had a modest influence on the rate of heat pump adoption. The expert confirmed:

> "Swedish building regulations including improved energy efficiency and reduced heating demand has contributed to have more air-to-air heat pumps"
>
> INT1B

Their general view, however, was that the regulatory environment was not the determining factor in the nation's overall success. The expert described a policy orientation characterised by the belief that the Swedish population had the financial capacity to adopt clean heating technologies (including heat pumps) without extensive government intervention. The expert noted:

> "I think policymakers think all people in Sweden can afford to make the transition. So, the grant schemes are just to encourage them to take the step – to push them to take the decision"
>
> INT1A

Unlike in the UK, Swedish policymakers appear less concerned about the household financial implications of transitioning to heat pumps. The expert pointed out that fuel poverty – an issue that features prominently in net zero discussions in the UK, especially in the context of social housing – is virtually unknown in Sweden. They commented:

> "For example, the term energy poverty is a super new word in Swedish. It entered the lexicon only last year. We have never had it in Sweden, because no one knew what energy poverty was. So, I think we still have work to do to convince policymakers that there are people out there in energy poverty – not in the UK sense of the word, but the Swedish version of it"
>
> INT1A

The Swedish ambivalence concerning financial barriers does not mean, however, that funding is unavailable for eligible households. Rather, these schemes are relatively limited and not specifically targeted at heat pumps. The expert explained that funds are available for energy efficiency upgrades in general, which may include fabric improvements such as insulation or clean heating technologies like heat pumps. They indicated:

> "In Sweden we take this position of being technology neutral. So, the authorities seldom give subsidies for specific technologies. But they do give general subsidies to people who want to invest in those technologies that reduce their energy consumption… The subsidy covers up to 50% of the investment cost for a more efficient heating system or improved insulation, however, the maximum subsidy level is at 30 000 SEK for each of these categories"
>
> INT1A; INT1B

While the regulatory environment is not a barrier to the widespread deployment of heat pumps in Sweden, it should not be seen as a critical factor driving their adoption either.

6.4.1.2. Germany

The German expert emphasised the role of regulations and government policy in shaping the country's heat pump deployment trajectory. In their view, there was a significant relationship between the regulatory landscape over the last three decades and the rate of heat pump adoption in Germany. The expert suggested that this regulatory history could be characterised by four distinct periods (or phases, as they described it). They elaborated:

> "Phase 1: (before 2000): introduction of efficiency measures to reduce energy demand of buildings, in parallel to the replacement of oil and coal boilers with gas, later with gas condensing boilers. Phase 2: (after 2000): focus on condensing boilers, some support for geothermal heat pumps, heat pumps have to compete in the market. Some subsidies, but more in an on-and-out manner that lead to a start-and-stop behaviour of heat pump installations. Also, subsidies for gas condensing boilers. Phase 3: (after 2020): introduction of significant subsidy schemes for heat pumps, introduction of CO2 tax on fossil fuels (Brennstoffhandelsgesetz). At the same time there was ambiguous communication on the possible future of hydrogen for heating. "Hydrogen ready" households can still receive subsidies. Phase 4: (after 2022): (i) clear commitment for heat pumps and hybrid heat pumps as part of political communication; (ii) confusion in the general public around the heating law (GEG) – still not resolved at the time of writing; (iii) removal of renewables levy on electricity, and in next couple years (hopefully), a massive reduction of other electricity levies"
>
> INT2B

To summarise what the expert asserted, the regulatory and policy environment in Germany over the last 30 years has been inconsistent and, at times, counterproductive to the widespread adoption of heat pumps. In particular, the period after 2000 saw government subsidies offered to households installing condensing gas boilers, while as recently as 2020, the prospect of a hydrogen solution to the heating decarbonisation problem stalled certain stakeholders who might have otherwise transitioned to heat pumps.

The German expert did not believe authorities had done enough in the 21st century to drive the clean heat transition. In fact, they attributed the slow rate of adoption in Germany, compared to some of its European neighbours like Sweden, to a lack of clear governmental commitment, guidance, and support. The expert stated:

> "In my personal opinion, the non-existence of government support has stopped deployment. Uncertainty of support conditions have led to a stop and go development. Subsidies have not been the most impactful tool to accelerate deployment"
>
> INT2B

Furthermore, the expert did not believe subsidies should be the primary policy tool to accelerate adoption. In their view, subsidies often had market-distorting effects. They noted:

> "We know from a past experience that subsidies are never a good idea for long term. In the short term, for fast acceleration of markets, they work"
>
> INT2A

They indicated that the downside of subsidies was inflating the average cost of heat pump installation, as contractors sought to extract the maximum government grants available for each project. The expert explained:

> "The heat pump manufacturer and installer groups went to the minister and said, the maximum amount of investment that can still be subsidised shouldn't be €30,000, it should be €45,000. And what that means is that the German industry thinks it's okay to charge €45,000 for a heat pump replacement replacing a gas boiler"
>
> INT2A

In general, the expert believed that German authorities should have been more explicit about the need to replace gas boilers with heat pumps over the last three decades and argued that mandates would have been more effective policy instruments than financial subsidies and grants for this purpose.

6.4.1.3. Switzerland

The expert suggested that there was a clear correlation between Switzerland's regulatory and policy environment over the last two decades and the rate of heat pump adoption. In particular, they indicated that improved building and energy efficiency standards were key drivers of the country's clean heat transition. The expert noted:

> "Over the past decade, Switzerland's building energy policies and regulations have undergone a significant evolution in response to the decarbonisation agenda. It has increasingly recognised the critical role buildings play in achieving carbon neutrality. Policies have shifted towards ambitious energy efficiency standards and a transition to low-carbon heating and cooling systems"
>
> INT3B

The expert argued that Switzerland's Net Zero targets were among the most ambitious in Europe, noting that these environmental objectives were supported by a political mandate delivered through the democratic process. They attributed the government's success to broad public support for these environmental goals. The expert stated:

> "Switzerland is quite ambitious with respect to its climate goals… in a sense the Swiss public has supported the Swiss energy strategy, and have voted for it. So, considerable political momentum is there to adopt a much higher and more ambitious climate strategy which then of course includes the decarbonisation of heating"
>
> INT3A

The expert emphasised the role that energy performance standards had played in improving building thermal efficiency, which in turn lowered heat demand and made the installation of heat pumps less challenging. The expert explained:

> "Policy interventions such as adoption of energy performance standards have helped to improve the energy efficiency and to lower the final energy demand in residential buildings. This in turn allows the use of heat pumps for domestic heating as the final heating demand to be fulfilled is much lower, which allows the replacement of fossil fuels boilers"
>
> INT3B

On the surface, Switzerland's federal canton system (i.e., the jurisdictional division of Switzerland into 26 semi-autonomous regions, each with its own constitution, government, and legislative authority) might appear to complicate nationwide

Net Zero strategies. However, the expert suggested that there was more or less a consensus on the direction of energy efficiency and decarbonisation policy. They pointed out:

> "In Switzerland, cantons are responsible for energy policy related to buildings and almost all 26 cantons have energy strategy, guidelines and masterplans… Regulations have been enacted to encourage the replacement of fossil fuel boilers for heating with heat pumps, aiming to significantly reduce the carbon footprint associated with residential heating. These policies provide incentives, subsidies, and tax benefits for households opting for electric heating solutions like heat pumps, lowering the energy consumption. The government has a set agenda for the gradual phase-out of oil and gas heating systems, relying more on the 'nudge' approach rather than the 'ban' approach, for an electrified future in heating"
>
> INT3B

In summary, the expert was confident that their nation's proactive and ambitious energy efficiency strategy in recent years was a significant contributing factor to the higher rate of heat pump adoption in Switzerland compared to comparable countries like Germany. Two decades of focus on building standards had lowered heating demand for many buildings, making them ready for heat pump installation without the need for extensive retrofitting, as may be the case with older homes.

6.4.2. Background on national regulatory environments and incentive regimes

6.4.2.1. Sweden

Reflecting on the suite of policies and regulations in Sweden intended to promote the adoption of clean heating technology (including heat pumps), we observe that the situation is not radically different from that found in the UK. As indicated by Table 7, there are no federal regulations mandating the installation of heat pumps, nor are there prohibitions governing the installation, repair, or replacement of gas boilers. Importantly, while the UK now has building standards mandating the installation of zero direct emissions heating in new buildings, this is not the case in Sweden, where home builders and developers exercise their own discretion. A clear point of departure between the two nations, however, is that Sweden has had a carbon tax on fossil fuels since 1991, whereas the UK has no such policy.

Table 7. Sweden's Key Policies and Regulations Promoting the Installation of Clean Heating Technology (including heat pumps).

Policies & Regulations	Description
Sweden's Carbon Tax (1991)	Purpose: Reduce carbon emissions by making fossil fuel-based heating more expensive. Eligibility: Applies to all sectors except industries under the EU Emissions Trading System (ETS). Funding: Tax levied on fossil fuels; revenues used for climate initiatives. Impact: Encourages shift to renewable energy, making heat pumps a cost-effective alternative.
Boverket's Building Regulations (BBR) (1994, updated regularly)	Purpose: Set mandatory energy efficiency standards for buildings, including heating systems. Eligibility: Applies to new buildings and major renovations. Funding: Enforced through compliance checks; no direct subsidies. Impact: Drives adoption of energy-efficient systems like heat pumps

Policies & Regulations	Description
Energy Performance Certificate (EPC) System (2006)	Purpose: Ensure transparency in building energy use and efficiency. Eligibility: Required for buildings sold, rented, or newly constructed. Funding: Government-managed certification process. Impact: Encourages homeowners to invest in energy-saving technologies, including heat pumps.
Renovation, Conversion, and Extension (ROT) Tax Deduction (2008)	Purpose: Provide financial incentives for homeowners to install heat pumps. Eligibility: Homeowners renovating their properties. Funding: Covers 30% of labour costs, up to €5,000 per year. Impact: Reduces upfront costs of heat pump installations.
Government Heat Pump Subsidy for Detached Houses (2023)	Purpose: Support homeowners in replacing fossil fuel-based heating with heat pumps. Eligibility: Owners of detached houses using electricity or gas heating. Funding: Covers up to 50% of material costs, up to €2,260, and 30% tax rebates up to €5,000 per year. Impact: Accelerates adoption of heat pumps in residential buildings.
Swedish National Renewable Energy Action Plan (2010)	Purpose: Achieve a 50.2% renewable energy share in total energy consumption. Eligibility: National-level strategy impacting multiple sectors. Funding: Government and EU funding for renewable energy projects. Impact: Promotes heat pumps as part of Sweden's renewable energy transition.
Miljöbyggnad Certification System (2011)	Purpose: Encourage sustainable building practices by rating buildings on energy efficiency, indoor environment, and material use. Eligibility: Voluntary certification for new and existing buildings. Funding: Private certification process. Impact: Encourages adoption of energy-efficient technologies like heat pumps to achieve high certification levels (Bronze, Silver, Gold).
Passive House Standard (2000s, widely adopted in Sweden)	. Purpose: Promote ultra-low energy building design through strict insulation, airtightness, and efficient heating systems. Eligibility: Voluntary standard for new constructions and renovations. Funding: No direct funding, but compliant buildings benefit from lower energy costs. Impact: Reduces energy demand and incentivises the use of heat pumps for heating and cooling.

Source: Swedish Government 2009; Swedish Government 2010; Swedish Government 2025; Boverket 2019; CAEPB 2024; Eliasson 2023; Santos 2023; SEI 2024; Janson 2008.

The grant, subsidy, and incentive programs for heat pump adoption are more generous in the UK than in Sweden. In Sweden, homeowners and social housing providers receive less government funding to encourage heat pump installation. Homeowners may be eligible for grants of up to €2,260 or a tax rebate of up to €5,000 annually for installing a heat pump in a detached home. In contrast, homeowners in the UK can receive up to £7,500 (approximately €8,900) for the same purpose. Regarding retrofitting costs associated with heat pump installation, Swedish authorities cover 30% of labour costs, up to €5,000 per year. In the UK, eligible households can access up to £50,000 (approximately €59,000) through the Energy Company Obligation (ECO4) program.

Given the lack of mandates for clean heating technologies, the absence of restrictions on gas boiler installations, and the relatively modest grant and subsidy programs in Sweden, the regulatory and policy environment does not appear to be a key driver of the country's successful heat pump adoption strategy. This suggests that the widespread adoption of heat pumps in Sweden is primarily driven by market forces and other structural factors.

6.4.2.2. Germany

The regulatory and policy environment in Germany, aimed at promoting the installation of clean heating technologies (including heat pumps), is similar to that of the UK, as it combines building regulations with funding schemes for heating system installations. However, Germany's framework differs from the UK's in terms of new heating system installations and boiler replacements. As shown in Table 8, under the Building Energy Act (Gebäudeenergiegesetz – GEG), it is no longer possible (with limited exceptions) to replace or install new gas boilers unless they use at least 65% renewable energy. Since only hydrogen-compatible boilers meet this requirement, and the availability of hydrogen for domestic consumption remains uncertain, this regulation effectively limits the market for new gas boilers in Germany. A similar rule exists in the UK, but it only applies to new homes.

Table 8. Germany's Key Policies and Regulations Promoting the Installation of Clean Heating Technology (including heat pumps).

Policies & Regulations	Description
Building Energy Act (Gebäudeenergiegesetz – GEG) (Revised: Jan 1, 2024)	Purpose: Requires all newly installed heating systems to use at least 65% renewable energy. A traditional fossil fuel-only gas boiler is no longer allowed unless an exemption applies. A new gas boiler can be installed if it is hydrogen-compatible ("H2-ready") and designed to transition to at least 50% hydrogen by 2030 and 100% hydrogen by 2045. Eligibility: Applies to all new heating system installations in residential and commercial buildings. Funding: Provides subsidies, low-interest loans, and tax benefits to support transitions to renewable heating. Impact: Encourages adoption of heat pumps, reduces fossil fuel reliance, and supports Germany's goal of climate neutrality by 2045.
Federal Funding for Efficient Buildings (Bundesförderung für effiziente Gebäude – BEG) (Revised: Jan 1, 2024)	Purpose: Provides financial support for energy-efficient building retrofits and heating system upgrades. Supports municipalities, social housing providers, and non-profit organisations in making buildings energy-efficient. Eligibility: Homeowners, businesses, and property owners upgrading heating systems. Funding: Offers a base subsidy of 30%, with additional bonuses (e.g., 20% for early replacement, 5% for high-efficiency heat pumps, and 39% for low-income households). Maximum funding covers up to 70% of costs. Low-interest loans via KfW Bank to finance remaining costs. Impact: Reduces upfront costs of switching to renewable heating, accelerating heat pump adoption.
Social Housing Subsidy Program (Wohnraumförderung) (Effective: Jan 1, 2002)	Purpose: Supports affordable housing construction and modernisation, including renewable heating installations. Eligibility: Municipalities, housing cooperatives, and private developers building rent-controlled housing. Funding: Direct grants and low-interest loans for energy-efficient heating systems (including heat pumps). The subsidy can cover up to 50% to 60% of the total capital expenditure for construction or renovation of social housing, grants and loans together can cover up to 90%, depending on the specific funding structure and conditions. However, the exact percentage varies depending on the state's specific regulations and the type of project. Impact: Ensures social housing developments comply with new energy efficiency and heating standards while keeping rents affordable.

Heating Optimisation Program (Heizungsoptimierungsprogramm) (Effective: Aug 2016)	Purpose: Supports the modernisation of heating systems to improve energy efficiency. Eligibility: Homeowners and building operators with existing heating systems. Funding: Covers up to 30% of heating optimisation costs, with a cap of €25,000. Impact: Reduces energy consumption, promotes use of high-efficiency heat pumps, and lowers heating costs.
Rebate Program for Residential Heat Pumps (Wärmepumpen-Förderprogramm) (Effective: Jan 1, 2023)	Purpose: Encourages heat pump installations in residential properties. Eligibility: Homeowners replacing existing heating systems. Funding: Provides a 25% base subsidy, with additional 5-10% bonuses for replacing old systems. Total funding can cover up to 40% of costs. Impact: Lowers installation costs for heat pumps, increases adoption of environmentally friendly heating solutions.

Source: IEA 2024; German Government 2025a; German Government 2025b; German Government 2025c.

In terms of direct funding for energy efficiency, insulation, and retrofitting work, German authorities offer programs similar to those in the UK. In the UK, schemes such as the Energy Company Obligation provide up to 100% of the cost of insulation or retrofitting, particularly for low-income households, vulnerable individuals, or those living in specific types of properties. Similarly, Germany's Energy Efficiency Programme for Low-Income Households (Energieeffizienzprogramme für Einkommensschwache Haushalte) and the Social Housing Subsidy Program (Wohnraumförderung) cover up to 100% of insulation or retrofitting costs through a combination of funding and financing, targeting low-income households or social housing. Additionally, Germany's Federal Funding for Efficient Buildings (BEG) program offers subsidies covering 50% to 70% of eligible costs, with a maximum grant of €30,000 for single-family homes. These schemes are often complemented by specific state or regional programs focused on energy-efficient housing.

Despite Germany having a more robust regulatory and policy environment for promoting the installation of clean heating systems (including heat pumps) than Sweden, it still exhibits a much lower rate of heat pump installations. This suggests that regulatory environments alone cannot explain the differing rates of heat pump adoption in the two countries. That said, Germany does have a modest installation rate advantage over the UK, alongside a more extensive prohibition on gas boilers and a mandate for clean heating systems. Therefore, while regulations certainly influence the rate of heat pump installations in Germany, their impact remains uncertain, and other factors must also be considered.

6.4.2.3. Switzerland

Switzerland's regulatory and policy environment strongly supports the installation of clean heating systems, including heat pumps, through several key initiatives. The country has a robust environmental framework, as highlighted in Table 9. Switzerland promotes domestic heat decarbonisation through its CO2 Act, which includes a carbon tax on fossil fuels, as well as improved energy efficiency standards for buildings. Over the past decade, political action at the local, cantonal, and federal levels has focused on reducing building heat demand. This has been achieved through voluntary schemes like the Minergie Certification and guidelines for heating system efficiency, helping to establish broad support for the nation's Net Zero transition. In the canton of Zurich, for instance, residents voted in 2021 to ban new gas and oil boilers.

Table 9. Switzerland's Key Policies and Regulations Promoting the Installation of Clean Heating Technology (including heat pumps).

Policies & Regulations	Description
CO_2 Act (Federal Act on the Reduction of CO_2 Emissions) (CO_2-Gesetz) (2013)	Purpose: Reduce carbon dioxide emissions across various sectors, including heating, by introducing carbon taxes and incentive measures. Eligibility: Applies to industries, building owners, and vehicle importers, encouraging them to transition to lower-emission solutions. Funding: Revenue from the CO_2 tax is reinvested into climate programs, including building energy efficiency initiatives. Impact: Encourages the shift away from fossil-fuel heating by making carbon-intensive options more expensive and promoting cleaner alternatives.
Swiss Energy Fund (Energie-Fonds) (1999)	Purpose: To support energy efficiency and renewable energy projects, including heat pumps and other sustainable building solutions. Eligibility: Homeowners and property owners, and commercial and industrial projects. Projects must meet energy efficiency criteria. Funding: Typically covers 10% to 20% of the total project cost. Available for both residential and commercial projects. Impact: Reduces CO_2 emissions and energy consumption and supports Switzerland's energy transition to renewables.
The Federal and Cantonal Buildings Programme (Das Gebäudeprogramm von Bund und Kantonen) (2010)	Purpose: Promote energy-efficient building renovations and the adoption of renewable energy sources. Eligibility: Building owners undertaking energy-efficient renovations or installing renewable heating systems. Funding: Up to CHF 450 million annually, sourced from one-third of the CO_2 levy on combustible fuels. Impact: Significant reductions in heating requirements and CO_2 emissions, contributing to Switzerland's national climate goals.
Zurich Ban on New Oil and Gas Heating Systems (2021)	Purpose: Prohibit the installation of new oil and gas heating systems to accelerate the transition to renewable heating. Eligibility: Applies to all buildings in the Canton of Zurich when replacing an existing heating system. Funding: No direct funding, but building owners can access federal and cantonal incentive programs to support the transition to renewable energy. Impact: Reduces reliance on fossil fuels for heating, lowering CO_2 emissions and encouraging the adoption of heat pumps and other clean heating solutions.
The Impulse Programme for the Replacement of Heat Generation Systems and Energy Efficiency Measures (Impulsprogramm für den Ersatz von Wärmeerzeugungssystemen und Energieeffizienzmassnahmen) (2025)	Purpose: Supplement existing programmes by targeting larger properties and inefficient electric heating systems. Eligibility: Owners replacing fossil-fuel or electric resistance heating systems, especially in larger properties and apartment buildings. Funding: CHF 2 billion over ten years, financed through the federal budget. Impact: Accelerates the transition to renewable heating solutions, enhancing energy efficiency and reducing greenhouse gas emissions.

Minergie Certification (Minergie-Zertifizierung) (1998)	Purpose: Promote sustainable, energy-efficient buildings through voluntary certification. Eligibility: Residential, commercial, and public buildings that meet strict energy efficiency and comfort standards. Funding: While there are no direct subsidies, certified buildings may qualify for financial incentives under cantonal and federal programmes. Impact: Encourages energy-efficient building design, reduces heating demand, and increases the adoption of renewable energy solutions.

Source: The Federal Council 2025; FOEN 2018; FOEN 2020; FOEN 2025; Swissinfo 2021.

Switzerland serves as an important case study because it has achieved a relatively high rate of heat pump installations without relying on nationwide mandates for clean heating systems or federal prohibitions on gas boilers. Unlike Germany or the UK, it is still possible to build a new home with a gas boiler from a regulatory standpoint. However, due to minimum energy performance standards for new buildings and a carbon tax on fossil fuels (including natural gas), gas boilers are becoming increasingly uncommon, with a strong shift toward renewable energy sources for heating.

Another observation is that Switzerland's funding landscape is less generous than that of Germany or the UK, despite having a significantly higher rate of heat pump installations than either country. Typically, cantonal subsidies cover 10% to 30% of the installation cost. For example, the cantons of Aargau and Basel-Landschaft offer up to CHF 5,000 (£4,350 equivalent) to eligible households. These findings suggest that a subsidy regime alone may not determine a nation's rate of heat pump adoption, and that other factors must be taken into account.

6.4.3. Summary role of the regulatory environment and incentive regime

This research has found that hypothesis (4) – i.e., countries with stronger regulations and more generous subsidies tend to have higher rates of heat pump adoption compared to countries with weaker regulations and fewer incentives – is not strongly supported by the comparative evidence across countries.

None of the four countries examined have nationwide prohibitions on the installation of gas boilers. Notably, the two countries with higher rates of heat pump adoption—Sweden and Switzerland—do not have regulations mandating heat pump installation in new buildings. In contrast, Germany and the UK, which have lower adoption rates, do have mandates for clean heating systems in new buildings. Additionally, German and UK authorities provide more generous grants and subsidies for heat pump installation than those offered in Sweden or Switzerland. It is also worth noting that both Sweden and Switzerland impose a carbon tax on fossil fuels.

Switzerland is a unique case, where longstanding environmental policies, a carbon tax, voluntary energy efficiency standards, and a more affluent population have combined to create a culture in which the installation of clean heating technologies, including heat pumps, is both desirable and widely accepted. For instance, residents of Zurich, a canton with a population of over 1.6 million, voted to ban new gas boilers four years ago. The prospect of such a democratic decision being made in any county in England or Northern Ireland, or any council in Scotland or Wales, seems inconceivable at present.

Taken together, these findings suggest that the rate of heat pump adoption is influenced by factors beyond just regulations and incentives.

One way to understand the situation is that stronger regulations and more generous incentives are often introduced by authorities to overcome other systemic barriers that hinder the voluntary or natural market adoption of clean heating technologies, including heat pumps. In Sweden, where electricity is abundant and affordable, heat pumps are a logical choice because their performance advantage can reduce overall heating costs for consumers. In contrast, in the UK and Germany, where electricity is expensive—both in absolute terms and relative to gas—many consumers lack a strong financial incentive to replace gas boilers with heat pumps. As a result, German and UK authorities have sought to encourage the installation of these often-uncompetitive systems by subsidising their purchase and installation costs.

In Germany and the UK, policymakers have regulated the new build sector to mandate the installation of clean heating systems, as housebuilders and developers continued to install gas boilers in new homes up until 2024. These government interventions were necessary because new home buyers were not demanding clean heating technologies, while many developers and builders, driven by profit margins, preferred to install the less expensive gas heating units. In contrast, the situation in Sweden and Switzerland is different, where new home buyers—motivated by lower electricity prices and a carbon tax—now expect clean heating systems as standard.

7. Interpretation of Findings

While the correlations presented in Table 10 offer valuable insights into the relationships between key factors such as electricity pricing, gas availability, housing stock thermal performance, and the regulatory environment, it is important to acknowledge the complexity of causal inference in this context. The interactions between these variables are likely non-linear, with some factors potentially shaping or amplifying the effects of others in ways that are not immediately apparent. For example, while electricity prices and gas availability are clearly related to heat pump adoption rates, their impact may be moderated by factors such as energy efficiency policies or building characteristics. Additionally, omitted variables – including domestic market and supply chain conditions, consumer and social sentiment, or the pace of innovation in heating technologies – may also play a significant role in influencing the observed outcomes.

Table 10. National Comparison Between Ranked Rates of Heat Pump Adoption and Penetration and Ranked Research Hypothesis Factors.

Nation	HPs per 100,000 pop. in 2022. Ranked highest to lowest	HPs sold per 100,000 pop. in 2022. Ranked highest to lowest	(H1) Electricity price. Ranked lowest to highest	(H2) Gas provision. Ranked lowest to highest	(H3) Housing stock heat demand. Ranked lowest to highest	(H4) Regulatory environment. Ranked strongest to weakest
Sweden	1	1	1	1	2	4
Switzerland	2	2	2	2	1	3
Germany	3	3	3	3	3	1
United Kingdom	4	4	4	4	4	2

As shown in Table 10, reliable correlations are found between the price of electricity (H1), the availability of affordable gas (H2), and the rate of heat pump adoption in all four countries. However, the results indicate that the impact of a nation's housing stock thermal performance (H3) and regulatory environment (H4) on heat pump deployment is less clear-cut.

Confirming Hypothesis 1, Sweden has the lowest electricity price, followed by Switzerland, then Germany, with the UK having the highest. The rates of heat pump deployment follow the same trend, with Sweden leading, followed by Switzerland, Germany, and the UK with the lowest adoption rate. Confirming Hypothesis 2, Sweden has historically had the lowest reliance on gas as a primary heating fuel, followed by Switzerland, then Germany, while the UK has had the highest reliance on gas provision.

However, confounding Hypothesis 3, Sweden—the clear leader in heat pump adoption—does not have the building stock with the highest thermal performance (or lowest average heat demand). Switzerland's housing stock has a lower average heat demand, while German homes lose heat more slowly on average than those in Sweden.

Confounding Hypothesis 4, Sweden and Switzerland—the countries with the highest rates of heat pump adoption—do not have nationwide mandates for heat pump installation or prohibitions on gas boiler installations. In contrast, both Germany and the UK mandate clean heating systems (including heat pumps) and prohibit gas boilers in all new buildings. Additionally, Germany and the UK offer more generous grant and subsidy programs to promote heat pump installation than Sweden or Switzerland.

While these results indicate that the price of electricity and the availability of affordable gas provision significantly influence the UK's rate of heat pump adoption, they should not be interpreted as implying that the UK's housing stock and regulatory environment are unimportant. Instead, these findings highlight a critical distinction between root causes and non-linear factors.

7.1. Root Causes

A root cause is a fundamental factor that has a significant impact on a particular outcome. It plays the primary role in determining the observed result and remains influential even when other contributing factors change. Identifying root causes is especially important in preventative analysis, as it helps pinpoint the most impactful areas for intervention. By addressing these fundamental drivers directly, policymakers are more likely to identify leverage points that can produce meaningful and lasting change, rather than simply treating surface-level symptoms.

The research suggests that electricity pricing, along with its relationship to affordable gas provision, can be considered the root causes of a nation's ability to decarbonise domestic heating through heat pump installation. When a nation's electricity price is sufficiently low, the thermal performance of its housing stock has less impact on the rate of heat pump adoption. Additionally, in such nations, the rate of heat pump adoption can remain high even with weaker regulations and a less generous subsidy regime. Conversely, countries with extensive and affordable gas provision may experience lower rates of heat pump adoption, even with higher thermal performance in housing stock, stronger regulatory environments, or more generous subsidy programs.

These findings are further supported by the following discussion of non-linear factors.

7.2. Non-linear Causes

Non-linear factors include those that influence particular outcomes but are dependent on preceding conditions. Their impact varies depending on the value of another factor, making them more or less relevant based on the state of that preceding factor. While this definition highlights one form of non-linearity, other sources are also conceivable — including threshold effects, diminishing returns, or tipping points — where small changes in one variable can lead to disproportionately large or unexpected shifts in outcomes.

The research found that a nation's existing housing stock and regulatory environment are non-linear factors influencing its rate of heat pump adoption. While poor thermal performance of building stock can limit the adoption rate, this effect can be mitigated if electricity prices are sufficiently low. Conversely, although high thermal performance in building stock can support higher adoption rates, this advantage can be diminished if households have access to relatively affordable gas heating.

While weaker regulations and less generous subsidies generally reduce a nation's rate of heat pump adoption, their influence is less significant if electricity prices are sufficiently low. Conversely, although stronger regulations and more generous subsidies typically increase adoption rates, their impact is diminished when households have access to relatively affordable gas heating.

These findings are explained through a discussion of the specific relationship between the root causes and non-linear factors.

7.3. Relationship Between Root and Non-Linear Causes

The relationship between root and non-linear factors is specific and needs to be clearly defined. Simply asserting that certain factors become less relevant in the presence of others is not sufficient to establish a root and non-linear causal relationship.

Electricity price -> housing stock thermal performance

The electricity price and housing stock thermal performance have a root and non-linear causal relationship with a nation's rate of heat pump adoption due to their respective impacts on heat pump running costs.

All else being equal, the better a home's thermal performance, the lower the running costs of a heat pump, due to its improved coefficient of performance. Homes with higher thermal performance retain heat better, have lower heat demand, and therefore require less energy to power their heat pumps while maintaining thermal comfort. Conversely, homes with lower thermal performance lose heat more quickly, have higher heat demand, and thus require more energy to run their heat pumps. In other words, when controlling for other factors, heat pumps are more expensive to operate in homes with lower thermal performance.

Critically, a nation's electricity price has an even more direct and evident influence on heat pump running costs. The higher the electricity price, the greater the running costs for heat pumps that are powered exclusively by electricity.

When electricity prices are high, households will seek to improve the thermal (or energy) efficiency of their homes to reduce the running costs of heating systems, including heat pumps. This is because households generally have limited control over the market price of electricity. However, improving thermal efficiency comes at a cost. Therefore, a key factor in household decisions about installing heat pumps in countries with high electricity prices is the cost, disruption, opportunity, and planning regulations associated with retrofit fabric upgrades such as insulation, window glazing, and draft-proofing. All else being equal, the lower a home's thermal performance, the more expensive the necessary fabric upgrades to bring heat pump running costs to a desirable level in the context of high electricity prices.

For countries with high electricity prices and low housing stock thermal efficiency, the challenges associated with fabric upgrades become a significant factor limiting heat pump adoption. This is particularly true in the UK. However, in countries with lower electricity prices, the importance of housing stock thermal efficiency is reduced, as they can avoid extensive retrofitting and fabric upgrades due to the lower running costs of heat pumps. This is why Sweden, with its lowest electricity price, can maintain such a high rate of heat pump adoption despite having homes with lower thermal performance on average compared to Switzerland (in terms of heat demand) and Germany (in terms of heat loss). To achieve reasonable running costs from heat pumps, fewer households in Sweden need to invest in fabric upgrades compared to the UK, thanks to the lower electricity price.

Electricity price (and gas provision) -> regulatory environment and subsidy regime

The electricity price and regulatory environment have a root and non-linear causal relationship with a nation's rate of heat pump adoption due to their interactions with free market forces, while the presence or absence of affordable gas heating serves as an important intermediary factor.

In countries with low electricity prices, installing a heat pump is seen as a rational financial decision by consumers, as these systems can reduce household heating costs. However, in countries with higher electricity prices, installing a heat pump is a less rational choice, as it may increase heating expenses (especially compared to affordable gas boilers). Additionally, heat pumps are significantly more expensive than gas boilers—typically two to three times the cost for both the unit and installation. For a heat pump to be a rational financial decision for households, it must be economically competitive with available alternatives, considering the costs of the unit, installation, and ongoing operation. =

Sweden has low electricity prices and lacks affordable gas heating for most households, meaning heat pumps do not face competition from gas boilers with low unit, installation, and running costs. As a result, regulations and subsidies to promote heat pump adoption are less necessary, as free market forces naturally drive consumers toward this technology. In contrast, the UK and Germany face high electricity prices and relatively affordable gas heating, creating a competitive disadvantage for heat pumps. In these countries, heat pumps must compete with gas boilers offering lower unit, installation, and running costs. Therefore, regulations and subsidies are essential to promote heat pump adoption, as free market forces would otherwise push consumers in the opposite direction.

Although Switzerland has a reasonable provision of gas heating, it also benefits from low electricity prices and a carbon tax on fossil fuels. The relationship between gas and electricity prices is relatively balanced (i.e., a lower electricity-to-gas price ratio), making it financially rational for many Swiss consumers to replace their gas boilers with clean heating systems like heat pumps. In this context, heat pump unit, installation, and running costs are more competitive with those of gas boilers. As a result, regulations and subsidies to promote heat pump adoption are less necessary, as free market forces naturally encourage consumers to make the switch.

Countries with higher electricity prices and the presence of affordable gas heating require stronger regulations and more generous subsidies to promote heat pump adoption, due to these two conditions. These regulatory measures and incentives are necessary to counteract the free market's tendency to favour gas boilers over clean heating systems, including heat pumps. In countries like Germany and the UK, the strength of regulations and the generosity of incentive schemes directly influence the rate of heat pump adoption. Germany's adoption rate slightly exceeds that of the UK, as its regulatory framework has been stronger and its incentives more generous for a longer period. However, Germany's superior regulatory and incentive structure has not resulted in higher adoption rates than Switzerland or Sweden, as both of these nations benefit from much lower electricity prices and higher EtGPRs – and Sweden also lacks a significant gas network.

8. Conclusion

The following section will analyse how the country comparative evidence aligns with each of the four hypotheses that guided the research.

> Hypothesis 1: Countries with higher electricity prices tend to have lower rates of heat pump adoption compared to those with lower electricity prices.

The research findings support the assertion that there is a strong correlation between a nation's electricity price and its rate of heat pump adoption. Countries with lower electricity prices tend to have higher rates of heat pump adoption, while nations with higher electricity prices experience lower rates of adoption.

Sweden and Switzerland have a distinct advantage in the electrification of heating due to the history of their energy production. Both countries developed significant hydropower infrastructure between 1920 and 1950, and later added nuclear generation in the 1960s and 70s. As a result, they have never relied on more expensive gas-powered generators and have been able to offer consumers relatively low-cost electricity.

Germany and the UK are in a very different position. During the post-war period, both nations invested heavily in gas-powered electricity production. Despite a significant shift towards renewable energy generation in the 2010s, gas-generated electricity still makes up a substantial portion of both countries' supply mix, resulting in much higher electricity prices today.

The higher the electricity price, the less attractive clean heating technologies powered by electricity, such as heat pumps, become from a running cost perspective. This issue is further compounded when heat pumps must compete with lower-cost alternatives, such as efficient gas boilers.

The cases of Germany and the UK show that it is challenging to motivate consumers to adopt a heating technology that is more expensive to operate, purchase, and install, especially when it doesn't offer a clear advantage in its primary function—home heating. While the potential for carbon reduction may appeal to a small segment of the market, the majority of households are not motivated to pay a premium for this environmental benefit.

> Hypothesis 2: Countries with a greater provision of affordable gas for home heating tend to have lower rates of heat pump adoption compared to countries with less gas network coverage or higher gas prices.

The research findings confirm a strong correlation between the availability of affordable gas heating and a nation's rate of heat pump adoption. Countries where households have access to relatively low-cost gas tend to have lower rates of heat pump adoption, while nations with limited access to affordable gas or a lower electricity-to-gas price ratio (EtGPR) tend to have higher adoption rates.

Once again, Sweden's history of energy production created path-dependent effects that facilitated the transition to a low-carbon society. With little to no investment in gas network infrastructure for domestic heating, Swedish heat pumps have not had to compete with efficient gas boilers in the market. Additionally, the carbon tax further lowers Sweden's EtGPR, making heat pumps a more attractive option.

Although Switzerland provides gas heating, the combination of a carbon tax on fossil fuels and lower electricity prices results in an EtGPR that allows heat pumps to effectively compete with gas boilers in the market.

The UK and Germany, however, experience a different dynamic where electricity prices are high, while gas prices remain relatively affordable. Because the EtGPR is higher in both countries, and an extensive network supplies gas to most households, heat pumps have to a certain extent been 'crowded out' of the market by gas boilers.

The UK, Germany, and Switzerland illustrate the impact of the electricity-to-gas price ratio on heat pump adoption rates. Switzerland is better positioned to overcome the challenges posed by extensive gas provision because its electricity prices are closer to gas prices. In contrast, Germany and the UK face the full adverse effects of extensive gas provision on adoption rates due to their significantly higher electricity prices.

> Hypothesis 3: Countries with lower housing stock thermal performance tend to have lower rates of heat pump adoption compared to countries with higher performing housing stock.

The findings of this research suggest that while the thermal performance of a nation's housing stock influences the rate of heat pump adoption, it is not a primary cause and becomes less significant when other factors are considered.

When electricity prices are high, the thermal performance of a country's housing stock becomes a greater barrier to heat pump adoption. Conversely, when electricity prices are low, the thermal performance of housing stock has less impact on adoption rates. This explains why Sweden, with low electricity prices, can maintain a higher rate of heat pump adoption despite having lower-performing housing stock compared to Switzerland and, by some measures, Germany.

Housing stock thermal performance and electricity prices interact to create a retrofit burden—i.e., the scale of system and fabric upgrades needed to keep heat pump running costs competitive with alternatives. Retrofit burden is a well-known barrier to heat pump adoption, as consumers weigh these additional costs against anticipated savings. When the cost of system and fabric upgrades exceeds the expected savings in running costs, or when these upgrades can't make heat pump running costs comparable to existing systems, many households choose not to adopt heat pumps. Where electricity prices are lower, the retrofit burden is also reduced.

In the UK and Germany, where electricity prices are high, housing stock thermal performance plays a role in influencing heat pump adoption rates. Since Germany generally has better-performing housing stock than the UK, its retrofit burden is lower. This reduced retrofit burden is reflected in the higher rate of heat pump adoption in Germany compared to the UK.

Hypothesis 4: Countries with stronger regulations and more generous subsidies tend to have higher rates of heat pump adoption compared to countries with weaker regulations and fewer incentives.

The research findings indicate that while the strength of a nation's regulatory environment and the generosity of its incentive schemes influence its rate of heat pump adoption, these factors are not root causes and become less influential when other factors are considered.

Sweden and Switzerland, with the weakest regulatory environments and least generous subsidy regimes for heat pump installation, have the highest adoption rates. In contrast, Germany and the UK, with stronger regulations and more generous incentives, show lower adoption rates. However, Germany, which has regulated heating systems in new homes for longer and offers higher household grants for heat pump installation, exhibits a higher adoption rate than the UK.

These results suggest that the regulatory environment and subsidy regime can influence a nation's heat pump adoption rate despite other barriers. In Germany and the UK, where electricity prices are high and gas heating is relatively affordable (i.e., a high electricity-to-gas price ratio), stronger regulations and more generous subsidies help overcome market failure, where heat pumps are to a certain extent 'crowded out' by gas boilers. For example, in the UK, there was little demand for clean heating from new homebuyers, and the higher cost of heat pumps led developers to continue installing gas boilers until regulations mandated clean heating systems (including heat pumps). In contrast, many developers and homebuilders in Germany actively promoted heat pumps and underfloor heating as key selling points. Before building regulations came into effect, more than half of all new homes in Germany were equipped with these technologies (Wehrmann 2022). Notably, Germany's heat pump adoption advantage over the UK can be largely attributed to the fact that around 63% of heat pump installations in Germany came from the new homes sector, even before the new building regulations.

Similarly, the electricity price-driven retrofit burden faced by households in the UK and Germany made more generous grants and subsidies a key factor in boosting heat pump installations. For example, when the UK government offered £5,000 under the Boiler Upgrade Scheme in July 2023, around 1,500 households installed a heat pump (DESNZ 2025). A year later, in July 2024, when the grant increased to £7,500, the number of installations rose to around 3,000. This 25% increase in the grant led to a 50% higher installation rate.

In summary, stronger regulations and more generous incentives have helped Germany achieve a higher rate of heat pump installation than the UK, as both countries face high electricity prices and relatively affordable gas heating. In contrast, Sweden and Switzerland, with lower electricity prices and higher EtGPRs, can achieve higher heat pump adoption rates without the need for strict regulations or generous grants, as heat pumps are more competitive against gas boilers.

9. Policy Recommendations

The following section presents key policy recommendations for decision-makers in the United Kingdom, aimed at increasing the rate of heat pump adoption. The report takes a utilitarian and pragmatic approach to policy, prioritising proposals that offer the greatest impact for the least cost. These recommendations are based on empirical evidence and an analysis of the findings from the comparative case studies presented in this report.

Given the report's conclusions, the focus is on addressing the root causes of the UK's relatively low heat pump adoption rate. This strategy should not be seen as dismissing the potential impact of policies targeting non-linear factors. However, following the report's logic, addressing the root causes will yield the greatest cost-benefit outcomes, as it will naturally reduce the influence of non-linear factors.

9.1. Addressing Root Cause 1: Lowering the Final Electricity Price

The most impactful policy the UK government could pursue to increase heat pump adoption is to lower electricity prices. A reduction in electricity costs would allow heat pumps to compete more effectively with alternative heating systems, such as efficient gas boilers. The case of Switzerland provides concrete evidence that consumer decisions can drive heat pump adoption in markets offering efficient gas boilers, provided the electricity price is lower.

Lowering electricity prices also reduces the retrofit burden faced by households, housing associations, and local authorities when considering heat pump installation. Adoption rates will increase if stakeholders don't need to invest as much in fabric and system upgrades. The Swedish case clearly demonstrates that lower electricity prices allow heat pumps to be installed in homes with lower thermal performance without resulting in unaffordable heating costs.

Lowering electricity prices also reduces the need for grants and subsidies, as market forces drive heat pump adoption. Both the Swedish and Swiss cases demonstrate that incentive schemes are less critical when electricity prices are lower.

The UK Government's ongoing Review of Electricity Market Arrangements (REMA) has identified several ways to reduce electricity prices, including (DESNZ 2023):

- Market (Green Power Pool)
- Pay-as-bid spot market rules
- Zonal pricing

9.1.1. Split Market (Green Power Pool)

A split market would lower electricity prices for certain consumers by separating the market for renewably generated electricity from the market for fossil-fuel generated electricity (Grubb et al. 2022). Since renewable energy has a lower cost base, consumers with access to the Green Power Pool would benefit from lower prices, while those purchasing electricity from suppliers using the main market would not see any price changes. Over time, as more renewable generators enter the market, the number of consumers with access to the Green Power Pool would increase.

9.1.2. Pay-as-bid spot market rules

Pay-as-bid trading rules for the UK's spot market could lower electricity prices for all consumers by ensuring the wholesale price more accurately reflects the proportion of lower-cost renewable electricity in the supply mix (Harrington 2024). Currently, the wholesale price is often driven by the higher cost of gas-generated electricity, even though a significant portion is supplied by renewables. This happens because the spot market operates on system marginal pricing (SMP), where all electricity is traded at the price of the last unit required to meet demand at any given time.

Pay-as-bid trading rules, in contrast, would mean electricity is traded at the price bid by generators into the spot market, rather than at the price of the last unit required to meet demand. Renewable electricity would be traded at the price set by renewable generators, nuclear electricity by nuclear plants, and gas-generated electricity by gas plants. As a result, the wholesale price would decrease because electricity would no longer be traded at the price of the highest-cost unit (the marginal unit) needed to meet demand. Instead, it would be traded at the prices that generators actually bid into the spot market.

9.1.3. Zonal pricing

Zonal pricing could lower electricity prices for some consumers by dividing the GB electricity market into geographically defined zones. Advocates argue that in zones with a significant share of renewable-generated supply, prices should decrease, as lower-cost renewables can meet demand more often (Octopus Energy 2025). Conversely, in zones where renewables cannot meet total demand, prices are not expected to change. This uneven pricing pattern is intended to signal where investment in renewable generation, grid infrastructure, storage, and transmission is most needed, which could eventually reduce electricity prices in those zones.

However, prior research suggests that the downward pressure a zonal pricing scheme would exert on electricity prices may be overstated or misunderstood (Harrington 2024). Since spot markets within each zone would still operate under a marginal pricing auction rule (locational marginal pricing), it is unclear why wholesale prices in zones would differ significantly or why any zone would see prices lower than under the current market structure. Zonal pricing alone does not address the intermittent nature of renewable electricity. Therefore, without additional investment in grid, storage, and transmission infrastructure, most zones will still rely on more expensive gas-generated electricity to meet demand. In this case, under locational marginal pricing, wholesale prices would not decrease.

For zonal pricing to effectively lower consumer electricity prices, it requires accompanying investment in grid, storage, and transmission infrastructure. However, it is unclear whether market participants who currently benefit from high electricity prices would be motivated to invest in ways that could undermine their profit margins. If public investment in grid, storage, and transmission infrastructure is the solution, such a program could lower electricity prices under the current market arrangement, without the need for zonal pricing.

9.2. Addressing Root Cause 2: Increasing the Cost of Gas (or, reducing the Electricity to Gas Price Ratio)

Besides lowering electricity prices, another impactful policy the UK government could adopt to increase heat pump adoption is to raise the cost of gas heating for certain consumers. Narrowing the electricity-to-gas price ratio would enable heat pumps to compete more effectively in the market and reduce the crowding out caused by efficient gas boilers. However, given that 75% of households rely on gas as their primary heating source, many of whom are on fixed incomes or in fuel poverty, any plan to increase gas prices must be means-tested or targeted at those who can afford higher costs.

Currently, gas is almost four times less expensive than electricity per kilowatt hour in the UK (Ofgem 2025). This means that even heat pumps operating at three times the efficiency of gas boilers are still more expensive to run. Given the additional fabric and system upgrade costs necessary for efficient heat pump operation, an electricity-to-gas price ratio (EtGPR) of 4.0 undermines the economic rationale for their installation for many households, housing associations, and local authorities.

If the EtGPR were reduced to between 2 and 2.5, heat pumps would offer a running cost advantage over gas boilers for a larger proportion of consumers. With a clear running cost benefit, many more consumers would justify the higher unit, installation, and fabric and system upgrade costs.

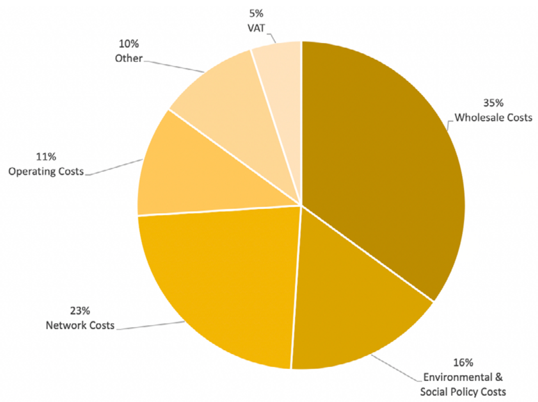
The two commonly cited methods for lowering the electricity to gas price ratio are:

- Shifting social policy and environmental levies
- Implementing a carbon tax

9.2.1. Shifting social policy and environmental levies

As shown in Figure 15, 16% of the final consumer electricity price in the UK is made up of various social policy costs and environmental levies. These include the Renewables Obligation (RO), Feed-in Tariff (FiT) Scheme, Energy Company Obligation (ECO), and the Warm Home Discount (WHD). If these costs were removed from electricity and applied solely to gas, the cost of gas could increase by around 62% (while the price of electricity should, in parallel, drop by 16%), lowering the electricity-to-gas price ratio to 2.0. Research groups Nesta and Climate Xchange have explored the potential impact of such a shift on households and the UK's decarbonisation goals, suggesting that "shifting them to general taxation or spreading them more evenly across gas and electricity could incentivize the transition to low-carbon heating powered by electricity" (Kavan 2024; Boorman et al. 2021).

Figure 15. Consumer Electricity Bill Breakdown (Oct – Dec 2024, Single-Rate Metering Arrangement, Direct Debit).



Source: Ofgem 2024c.

However, the implementation of such a policy must be carefully considered (Citizens Advice 2023). A 62% increase in heating costs would significantly impact many households currently relying on gas for heating. Therefore, any shift of social policy and environmental levies from electricity to gas should be targeted only at households that can bear the increased heating expenses.

A further concern is that if the program is successful—driving a growing number of households from gas to electric heating—the burden of these social policy and environmental levies will fall on an increasingly smaller population, creating an unequal distribution of costs. Ultimately, these costs will either need to return to electricity once it becomes the dominant heating source or be shifted to general taxation. In the end, moving social policy and environmental levies from electricity to gas is, at best, a partial and temporary solution to lowering the electricity-to-gas price ratio.

9.2.2. Implementing a carbon tax

A carbon tax would be a new tax on household gas usage. Currently, the UK does not levy a carbon tax on household gas consumption, though a Climate Change Levy (CCL) is applied to business gas use. Both the Grantham Research Institute on Climate Change and the Environment and the New Economics Foundation have published research supporting the introduction of such a tax (Burke et al. 2020; Kumar 2023).

The advantage of a carbon tax on household gas consumption is twofold. First, as a new form of taxation, it can be set at a rate that brings the electricity-to-gas price ratio to an appropriate level, with the flexibility to adjust as needed. Second, because a carbon tax generates new state revenue, the proceeds can be used to offset increased costs for lower-income households or invested in projects that reduce electricity prices, such as grid, storage, and transmission infrastructure. In this way, a carbon tax could raise gas prices without exacerbating social inequality while simultaneously supporting the necessary investment to lower electricity prices.

Rather than being a secondary benefit, the redistribution of carbon tax revenues should be seen as a central pillar of an effective and socially equitable heat decarbonisation strategy. Channelling these funds toward targeted heating subsidies for vulnerable households ensures that the financial burden of higher gas prices does not fall disproportionately on those least able to absorb it — a risk that could otherwise undermine public support for the transition. At the same time, investing these revenues in energy flexibility infrastructure helps to future-proof the electricity system and reduce electricity prices, enabling the grid to accommodate growing demand from electrified heating while maintaining reliability and affordability. Taken together, these measures create a virtuous cycle: they not only help align short-term cost signals with long-term climate goals, but also ensure that the transition remains politically viable and socially fair.

Furthermore, because a carbon tax on household gas would be specifically designed to lower the electricity-to-gas price ratio (rather than serve as a revenue source for existing social or environmental policies), it would no longer be required once its objective is achieved. Additionally, since the carbon tax is set at a specific rate—rather than based on contributions from a shifting pool of gas households, as with social policy and environmental cost schemes—the burden would not increase as the number of gas households declines. Both Sweden and Switzerland have effectively used a carbon tax to lower the EtGPR.

In conclusion, this report finds that the most effective policy interventions to increase the UK's rate of heat pump adoption would be lowering electricity prices through a pay-as-bid spot market trading rule and imposing a carbon tax on household gas consumption. Lower electricity prices and higher gas prices would make heat pumps more cost-competitive with efficient gas boilers, driving greater consumer adoption. Additionally, revenues from the carbon tax could be redirected towards targeted heating subsidies for vulnerable households and investments in energy flexibility infrastructure to support the transition.

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Appendix A

Semi-Structured Interview – Preliminary Questions

1. How would you describe the rate of heat pump adoption in [nation]?
2. What factors explain the rate of heat pump adoption in [nation]?
3. What are the main drivers of heat pump adoption in [nation?]
4. What are the principle barriers to heat pump adoption in [nation]?
5. How does the price of electricity relate to heat pump adoption in [nation]?
6. How does the supply of gas for home heating relate to heat pump adoption in [nation]?
7. How does [nation's] average housing stock thermal performance relate to its rate of heat pump adoption?
8. How do regulations and incentives in [nation] influence the rate of heat pump adoption?

Appendix B

Expert Questionnaire

Question 1 – Existing Housing Stock:

Provide a general description of the average age, thermal efficiency, and airtightness of [nation's] existing housing stock at the time the decarbonisation agenda took shape (approximately ten years ago).

When the decarbonisation agenda took shape and heat pumps began to be deployed across [nation], what proportion of homes required significant fabric upgrades (in the order of €5,000-€10,000) prior to the installation of a heat pump to permit the heat pump to perform to manufacturer's specifications?

To what extent has the thermal efficiency and airtightness of your nation's existing housing stock impacted the rate at which heat pumps have been deployed in [nation] over the last ten years?

Please suggest any references, reports, and/or studies that clarify/support this position.

Question 2 – Electricity:

Describe the relationship between the domestic price for electricity in [nation] as compared to the price for alternate fuels for domestic heating such as gas and oil. [This is considerable issue in the UK since electricity is considerably more expensive than gas…]

How is the price of electricity calculated, and what tariffs and/or taxes are attached to electricity? Have these configurations changed over the last five to ten years in response to the decarbonisation agenda?

Describe the capacity of the electricity grid and its infrastructure in [nation] at the time the decarbonisation agenda took shape (approximately ten years ago). In what ways has the capacity of the electricity grid and its infrastructure impacted the rate at which heat pumps have been deployed in [nation] over the last ten years?

Please suggest any references, reports, and/or studies that clarify/support this position.

Question 3 – Labour Market:

Describe the labour market situation in [nation] with respect to qualified heat pump installers, and ongoing maintenance personnel at the time the decarbonisation agenda took shape (approximately a decade ago).

In what way has the number of qualified heat pump installers and service people impacted the rate at which heat pumps have been deployed in [nation] over the last ten years?

How has the labour market for qualified heat pump installers and service people evolved over the past decade in your nation?

Please suggest any references, reports, and/or studies that clarify/support this position.

Question 4 – Regulations:

Describe the relationship in [nation] between the political discourse surrounding the decarbonisation of domestic heating and existing policy mandates and regulations governing the use of fossil fuels for domestic heating as well as the electrification of domestic heating and the installation of heat pumps.

How has policy evolved over the last ten years in response to the decarbonisation agenda?

In what ways have policy interventions governing the use of fossil fuels for domestic heating as well as the electrification of domestic heating and the installation of heat pumps impacted the rate at which heat pumps have been deployed in [nation] over the last ten years?

Please suggest any references, reports, and/or studies that clarify/support this position.

Question 5 – Government Support:

Describe the landscape of financial support and subsidy provided by the government in [nation] in support of individuals interested in installing a heat pump in their home over the past ten years.

To what extent has your government's level of financial support impacted the rate at which heat pumps have been deployed in [nation] over the last ten years?

N.B. Studies and research supporting this position are critical.

Question 6 – Retrofit:

Describe the relationship between groups involved in and advocating for retrofit programs (i.e., the promotion of fabric improvement for existing homes so they are better insulated and more thermally efficient) and groups advocating the widespread deployment of heat pumps in [nation].

In what ways has the interplay between the retrofitting of existing homes and the installation of heat pumps impacted the rate at which heat pumps have been deployed in [nation] over the last ten years?

Please suggest any references, reports, and/or studies that clarify/support this position.

Question 7 – Consumer Sentiment:

Describe public sentiment concerning the performance and suitability of heat pumps as a domestic heating technology in [nation] when the decarbonisation agenda began to take shape (approximately ten years ago).

How has public sentiment concerning the performance and suitability of heat pumps evolved over the last decade?

To what extent has public sentiment concerning the performance and suitability of heat pumps as a domestic heating technology impacted the rate at which heat pumps have been deployed in [nation] over the last ten years?

N.B. Studies and research supporting this position are critical.

Question 8 – Consumer Advice:

When the decarbonisation agenda began to take shape (approximately ten years ago), what informational resources were available to consumers interested in installing a heat pump in their home.

If someone in [nation] wanted to install a heat pump today, how would they go about: (a) identifying the correct heat pump for their home; (b) selecting a suitable installer; (c) understanding the scope of upgrade work their home might require; and, (d) obtaining the forms of government support to which they are entitled?

To what extent has access to this kind of information impacted the rate at which heat pumps have been deployed in [nation] over the last ten years?

Please suggest any references, reports, and/or studies that clarify/support this position.

Question 9 – Building Standards:

Describe the relationship between building standards (regarding insulation and airtightness) in [nation] and the decarbonisation agenda over the past ten years.

Since when was it that building standards were introduced in [nation] such that new homes can have heat pumps installed and then these units will perform to the manufacturer's specifications without the need for additional fabric upgrades?

To what extent has [nation's] historic building standards impacted the rate at which heat pumps have been deployed over the last ten years?

N.B. Studies and research supporting this position is critical.

Question 10 – Energy Ratings:

Describe how homes in [nation] are individually assessed for their energy efficiency and given an EPC rating.

Describe the relationship between the fuel cost implications and the carbon emission measurement for specific homes, in the context of [nation's] use of EPCs and a home's energy efficiency.

To what extent have [nation's] method and measure for determining a home's EPC rating and energy efficiency impacted the rate at which heat pumps have been deployed over the last ten years?

N.B. Studies and research supporting this position are critical.