Domestic heat pumps: A rapid assessment of an emerging UK market

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Executive summary

The importance of heat pumps to decarbonising residential heating in the UK is widely acknowledged. In October 2021 the UK government set out its approach to building a market for heat pumps capable of deploying 600,000 units per year by 2028. This strategy was praised by the Committee on Climate Change for setting a clear direction of travel. The Committee also warned that significant risks to delivery remain. Recent events relating to geopolitics, politics, energy markets and wider society, widely regarded as unprecedented and disruptive, have the potential to increase this risk. They also have the potential to create new challenges, opportunities, and drivers for priming a market for residential heat pumps in the UK in the short and medium term.

This report examines how the UK market for residential heat pumps has developed in recent years, up until April 2023. The report therefore captures how the market has evolved during a period of unprecedented and highly disruptive events, including in geopolitics (i.e. Russia's invasion of Ukraine in February 2022), national politics (including the rapid succession of Prime Ministers and Chancellors), energy markets (e.g. rising gas prices), the economy (e.g. inflation) and society (cost of living crisis). Guided by nine expert interviews and the existing literature, a whole system approach was developed to collect data across four thematic areas of relevance to residential heat pump deployment – policy and regulation, business environment, wider society, and users – as well as on the focal technology itself.

The rapid review found that:

- The rate at which heat pumps are being taken up is increasing but remains at very low levels.
- Most of the UK government's central policy instruments - designed to foster a market-based approach to transforming how the nation heats the housing stock - have yet to be delivered. Only one policy instrument - the Boiler Upgrade Scheme - has been implemented.
- Business model innovation is occurring despite uncertainty about government commitment. Energy utilities are leading this space with a variety of new heat pump installation offers having appeared on the market since the start of 2023.
- The installer base is growing and appears capable of delivering the number of heat pumps required under most transition scenarios in the short term. Government financial support for retraining existing heating engineers and industry investments in training facilities provide a positive medium-term outlook.
- The potential for the market to be accelerated through deployment in new build is low. The Future Homes and Buildings standard, widely expected to mandate the use of heat pumps over gas boilers in all new houses from 2025 has yet to be passed into legislation. Meanwhile, the rate of new builds is far below government targets, at just below 180,000 in 2022 compared to a target of 300,000.
- Investments in UK manufacturing capacity are dwarfed by those made in continental Europe
- Societal awareness of and interest in heat pumps is increasing, with more people becoming aware of the technology during Winter 2022.
- The motivation for adoption is increasing but the willing and able to pay market is likely shrinking.
- Heat pump running costs have reduced because of government intervention in energy markets but remain highly uncertain in the long term.

1. Introduction and background

1.1 Review context

Heat pumps are a critical technology in decarbonising residential heating in the UK. Their deployment is widely regarded as a complex, disruptive, multi-actor challenge. Accumulated knowledge suggests a coordinated approach is required to reduce costs, build supply chains, raise awareness, and scale the market. Responding to this challenge the UK government has set out a market-based approach to increasing the deployment of residential heat pumps in the UK.

On the 1 November 2022 Collins announced their word of the year 2022: ***'Permacrisis'*** said to define 'an extended period of instability and insecurity'. Collins are said to have chosen the word as it "sums up quite succinctly how truly awful 2022 has been for so many people". '*Partygate', 'Kyiv'* and *'warm bank'* all made the long list, aptly summing up a year of rapid, seemingly uncontrollable change.

This report examines the development of a UK market for residential heat pumps given recent events in geopolitics (i.e. Russia's invasion of Ukraine in February 2022), national politics (such as the rapid succession of Prime Ministers and Chancellors), energy markets (e.g. rising gas prices), the economy (e.g. inflation) and society (cost of living crisis). Accordingly, the report tackles a simple, yet pertinent question: How is the UK market for domestic heat pumps developing?

To answer this question we take a systemic, co-evolutionary approach. We recognise that deploying heat pumps requires widescale change to existing socio-technical systems. These systems comprise webs of interlinked elements such as market and regulatory institutions, actors, infrastructures, and artefacts, which together provide a range of societal needs, such as heat. Altering these systems to deploying heat pumps subsequently involves the emergence of supportive policy and regulation to shape markets and incentivise technology uptake. It requires the creation of a thriving marketplace in which new value propositions and service offers can emerge backed up by a skilled workforce and robust supply chains. It also requires fostering societal awareness and understanding of the technology and for cultural norms and practices around the technology and broader heat practices to change to accommodate the technology into everyday life. Without supportive change across each of these areas and more, heat pumps are unlikely to be deployed at the speed and scale required to reduce and ultimately curtail residential emissions.

This review is the first step in a wider research process. The evidence gathered in the review will then be used to inform a series of workshops designed to facilitate discussion on what steps are required to accelerate deployment of heat pumps in the UK. Together, the review and workshops are being undertaken to foster a more responsive mode of governing system change, capable of identifying and responding to disruptive events and system developments. Our wider aim, therefore, is to ask what, if any, implications for policy arise from recent disruptive events, for the development of a UK market for residential heat pumps?

1.2 Review method

Heat pumps have been supported by government policy since at least 2011. Despite this, few indicators currently exist to provide a rounded, whole-system understanding of the state of the

emerging market. As the Climate Change Committee (CCC) point out[1], a range of metrics and indicators would be useful to assess market growth. Such metrics might include the number heat pumps being deployed across the UK, where they are being deployed (e.g. building type) and at what cost, the variety of heat pumps on the UK market, the number of trained installers, consumer interest in the technology or market-based financial support available.

In the absence of standardised indicators, assessing how a market for residential heat pumps is developing relies on the collation of available information from diverse sources. It necessitates judgements about what is important and results in a patchy, incomplete picture.

To understand what elements are important within such an emerging market, we reviewed the literature and interviewed nine experts from across policy, practice, and academia during March 2023 (Table 1). These interviews were semi-structured and open-ended allowing for the expertise of interviewees to shape what aspects of an emerging market had been affected by recent disruptive events. These interviews were guided by the question: How have the multiple crises experienced across 2022 impacted the UK market for residential HPs in your opinion?

Table 1: Experts interviewees

Job title	Organisation	Sector	Date
Team Leader, Built Environment*	Climate Change Committee	Independent	2023.02.27
Electrification of Heat Lead	DESNZ	Government	2023.03.01
Senior Associate	Regulatory Assistance Project	Third	2023.03.01
Director of External Affairs	Centre for Net Zero	Industry	2023.03.06
Senior Research Fellow	University College London	Academia	2023.03.09
Emeritus Reader	University of Aberdeen	Academia	2023.03.10
Director for Growth & External Affairs	Heat pump Federation	Industry	2023.03.15
Managing Director	Alto Energy	Industry	2023.03.16
Manager International Affairs	NIBE Energy Systems	Industry	2023.03.20

* Email interview rather than open dialogue

Interviews were transcribed and inductively coded for insights about what elements of the formative market might have changed and how. These insights were grouped according into four thematic areas of relevance plus the focal technology, heat pumps (Figure 1).

[1] https://www.theccc.org.uk/publication/ccc-monitoring-framework/?chapter=3-buildings#future-improvements

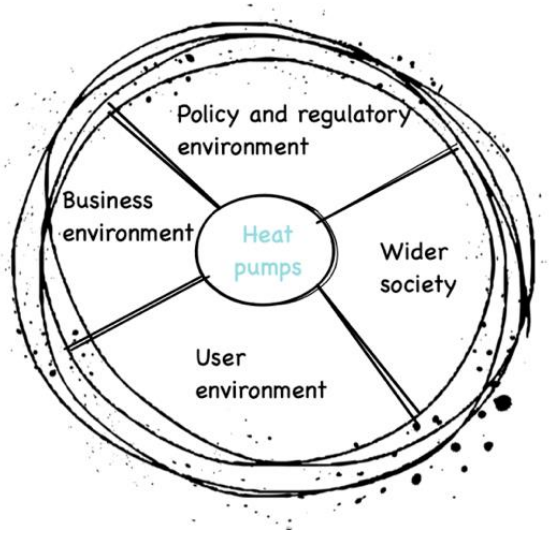

Figure 1: Four interrelated, thematic areas of relevance to the UK's heat pump market[2]

These four thematic areas were subsequently used to structure the following review. Data collection involved document analysis, secondary data collation and, in a few instances, primary data collection on key elements thought to have changed because of recent events. Effort was made to examine all points raised by interviews. In some instances, a lack of data limited our analysis. In other instances, where we could identify no publicly available data, we have noted their insights in the following and use them to outline areas where further research is required.

In the following review we present data by thematic area but start by setting out current rates of heat pump deployment, associated costs and performance achieved, as well as progress in deploying supportive technologies, like loft, cavity, and solid wall insulation. We conclude the review with a discussion of the results.

[2] Adapted from Geels and Johnson (2018) Towards a modular and temporal understanding of system diffusion and Mylan et al (2018) Rage against the regime

2. Results

2.1 Current status of technology deployment: heat pumps and associated technologies

Heat pumps

Between 2010 and 2020, the deployment of heat pumps across all buildings was estimated at approximately 30,000 units per year. Deployment in 2020 and 2021 is thought to have picked up, reaching 53,704 installations in 2021[3] whilst early estimates for 2022 suggest 60,000 HPs were installed across the UK[4].

This picture is promising. However, assessing progress remains tricky as no single comprehensive dataset on heat pump deployment across the UK exists. The most accessible data is provided through the Microgeneration Certification Scheme (MCS) data dashboard (Figure 2). It is thought to capture half of all deployment, with the remaining 50% largely deployed in new build. This data confirms a rise in MCS-certified installations from late 2020 onwards, the pronounced peak and trough in installations per month corresponding to the end of the Renewable Heat Incentive in March 2022 before the launch of the Boiler Upgrade Scheme in June 2022.

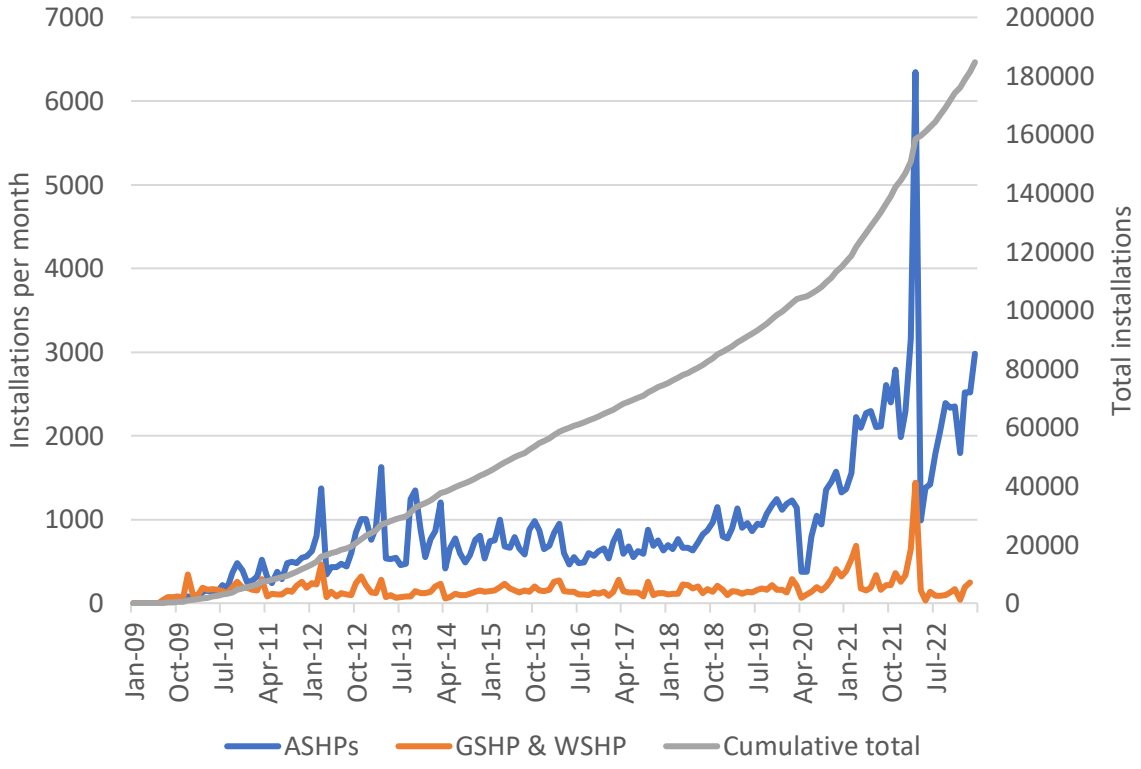

Figure 2: MCS registered heat pump installations in the UK
(Up to End of April 2023)

[3] Climate Change Committee (2022) Progress in reducing emissions 2022: Report to Parliament
[4] Rosenow, J., 2023. How to solve the UK's heat pump problem

The MSC dashboard also records the cost of each MSC-registered installation and price per kW (Figure 3). This data suggests the average price per kW is slowly rising.

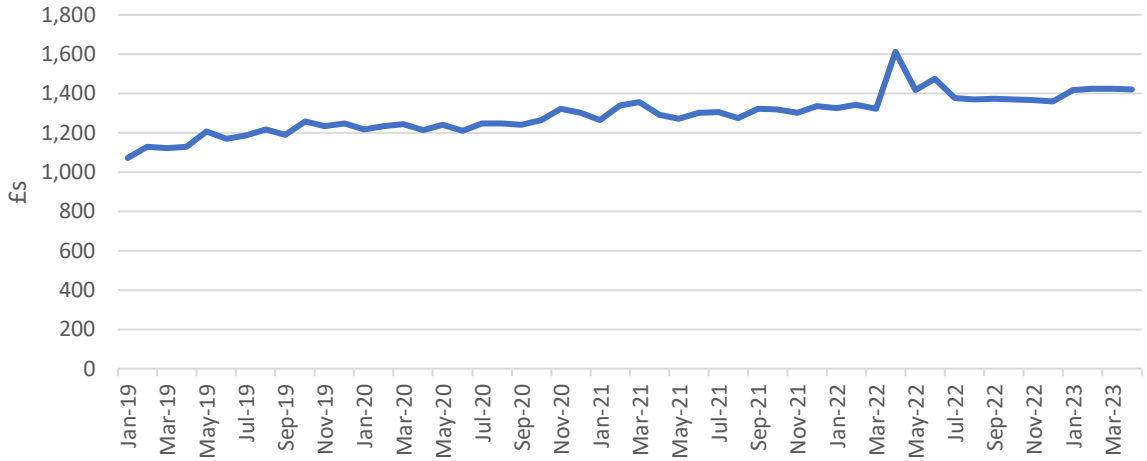

Figure 3: Average install cost per kW per month

Recent evidence from the government-funded Electrification of Heat Demonstration project[5] suggests:

- There is no property type or architectural era that is unsuitable for a heat pump[6], and
- the in-situ performance of heat pumps – the seasonal performance factor (SPF) – has increased over the last decade by 0.3 to 0.4 points to reach a median seasonal performance factor of 2.80 for air source heat pumps[7].

Loft, cavity, and solid wall insulation

Higher levels of home insulation can reduce both the running and purchase costs of heat pumps. This is because a well-insulated home will require less heat to stay warm and can allow for radiators to be run at lower temperatures, allowing a heat pump to run more efficiently. Increased insulation may also result in a smaller heat pump being required, potentially lowering lower purchase costs, and reducing the impact of heat pump deployment on the electricity system. Improved heat retention within the building fabric could also support the flexible operation of heat pumps. For these reasons the deployment of basic energy efficiency measures across the UK housing stock is widely regarded as important for the future uptake of heat pumps.

Current rates of deployment for loft, cavity and solid wall insulation are low, compared to historical standards. Government estimates suggest as of December 2022:

- 14.8 million properties had cavity wall insulation (71% of properties with a cavity wall)
- 17 million had loft insulation (67% of properties with a loft)
- 805,000 had solid wall insulation (9% of properties with solid walls)[8]

[5] https://es.catapult.org.uk/project/electrification-of-heat-demonstration/
[6] https://es.catapult.org.uk/news/electrification-of-heat-trial-finds-heat-pumps-suitable-for-all-housing-types/
[7] https://es.catapult.org.uk/news/heat-pumps-shown-to-be-three-times-more-efficient-than-gas-boilers/
[8] Household Energy Efficiency Statistics, detailed report 2022, https://www.gov.uk/government/statistics/household-energy-efficiency-statistics-detailed-report-2022

2.2 The UK policy and regulatory environment

Prior research suggests no single policy will drive forward deployment at the rate and scale required. A wide-ranging policy package is required[9]. Scoping interviews with experts pointed to the importance of a coherent policy package, delivered in a timely manner, to drive forward change.

In October 2021 the UK government set out its intension to pursue a market-based approach to building a market for heat pumps. This approach – which according to the Climate Change Committee is comprised of four main policy levers supported by further targeted interventions designed to tackle particular issues – has remained stable in the intervening period despite the UK experiencing a rapid succession of Prime Ministers, Chancellors, and Secretaries of State for Business, Energy and Industrial Strategy (BEIS) (Box 1).

The following provides a high-level overview of progress at delivering government policy grouped following the Climate Change Committee's assessment of UK government policy in this area, before summarising the UK's policy response to Russia's Invasion of Ukraine.

Box 1: High level political change in 2022

- 7 July 2022 **Prime Minister Boris Johnson** announced his intention to step down as leader of the Conservative party and Prime Minster following the resignation of his Chancellor Rishi Sunak and more than 50 ministers and party officials within 24 hours. Nadhim Zahawi was appointed Chancellor.
- 6 September **Liz Truss** became Prime Minister, installing long term ally Kwasi Kwarteng as Chancellor and Jacob Rees-Mogg as Secretary of State for BEIS.
- 14 October Kwasi Kwarteng was sacked following a mini fiscal event on 23 September. Widely regarded as an un-costed mini budget, it resulted in the depreciation of the pound, increased interest rates, and broader financial instability. Jeremy Hunt was brought in as Chancellor to 'steady the ship', promptly reversing nearly all announcements made in the mini budget.
- 20 October Liz Truss resigned saying she couldn't deliver on the mandate on which she was elected Conservative Party leader.
- 25 October **Rishi Sunak** became leader of the Conservative party and Prime Minister. Grant Shapps was brought in to replace Jacob Rees-Mogg at BEIS.
- 7 February 2023 BEIS was abolished and replaced by the Department for Business and Trade (merging the business part of BEIS with the Department of Trade), the Department of Energy Security and Net Zero (in doing so resurrecting a department focussed solely on energy and climate change following the abolishment of DECC in July 2016 by Theresa May) and the Department for Science, Innovation and Technology. Grant Shapps became Secretary of State for DESNZ.

[9] Lowes et al (2022) A policy toolkit for global mass heat pump deployment.

Primary policy instruments

Of the government's four central policy instruments announced in October 2021 (Table 2) only one has been fully implemented. Two remain under development and in one instance the process of designing a policy instrument has not yet started.

Table 2: UK government central policy levers in its market-based approach to priming a market for heat pumps*

Clean heat market Mechanism *A supply-side policy designed to incentivise heating system manufacturers to deploy heat pumps as a proportion of fossil fuel boiler sales, first announced Oct. 2021*	• Enabling primary legislation (Energy Bill 2022) yet to pass to upper house. Detailed scheme design has been set out in a consultation (March 2023) but government has yet to set out an implementation timeline or whether secondary legislation is required. • Proposed mechanism remains untested.
Boiler phase out dates *Demand-side policy prohibiting the installation of new or replacement fossil fuel boilers*	• Off gas grid - Government response to consultation yet to be published, despite closing in January 2022. No legislation tabled. • On gas grid – awaiting consultation.
Rebalancing levies *Market reform thought critical in making the operation of heat pumps competitive against fossil fuel boilers*	• Despite repeated commitments to tackle the imbalance between gas and electricity prices, a consultation has not yet been published.
Boiler Upgrade Scheme (BUS) *Demand-side policy to incentivise uptake of residential heat pumps, launched April 2022*	• Two thirds of funding allocated in first year.

* Shading in tables 1 - 3 uses the CCC's policy assessment indicators, whilst the assessment of policy has been undertaken by the project team.

Credible policy, no action need
Some risks, adjustments may be needed
Significant risks, policy development needed
Policy gap, new policy needed

Secondary policy instruments

Looking beyond what the Climate Change Committee (CCC) regard as the government's central policy levers, two additional policy instruments will be important in shaping how the market for heat pumps develops. ECO4 appears to be supporting heat pump deployment in fuel poor households but expected high levels of heat pump deployment in new builds looks less likely to materialise in the near term (Table 3).

Table 3: UK government supplementary policy

Future Homes Standard *Expected to require heat pumps in all new builds from 2025 onwards, potentially accounting for a third of all deployment that year*	• An uplift in standards introduced in June 2022 paves the way but government has yet to table a technical consultation for future standards before legislation can be initiated.
ECO4 *Government's primary policy to reduce energy poverty and reduce carbon; ECO4 was launched in April 2022 with a focus on multi-measure whole house retrofit, including heat pumps.*	• Heat pumps deployment has accelerated in 2022 with 1,619 units being installed in the first 9 months, compared to 692 units being installed throughout 4 years of ECO3.

Broader enabling measures

The UK government recognises that to deploy heat pumps requires tackling a variety of further delivery barriers. It has subsequently set out a range of interventions in multiple areas (Table 4). On the face of it, these additional policy measures appear extensive and broadly on track: announcements have been followed by timely policy delivery. A policy gap exists in only one area – planning. Meanwhile, the success of recent policy action to engage the public with heat pumps remains uncertain.

Table 4: Broader policies intended to enable heat pump deployment in the UK, grouped by area

Training and skills	• A Home Decarbonisation Skills Training Competition (worth £9.2 million) was launched in September 2022 to deliver training to building retrofit, energy efficiency and heat pump sectors. • £5 million Heat Training Grant was announced in March 2023 to support up to 10,000 opportunities to train in heat pump installation.
R&D	• £60 million invested in heat pump R&D and innovation in implementation via the Heat Pump Ready programme.
Finance	• Zero rate VAT on energy efficiency, solar PV and heat pumps enacted from March 2022. • Great British Insulation Scheme announced November 2022 as £1 billion worth support to improve energy efficiency of worst performing homes without access to other support measures.
Supply chain investment	• £30 million Heat Pump Investment Accelerator Competition launched March 2023.
Public engagement	• Energy Advice service was launched in July 2022 including info and sign posting on funding support to install heat pumps. • BUS marketing campaign was launched in January 2023.
Planning	• Government has acknowledged the role local area energy planning could play in supporting heat pump deployment but has yet to bring forward any policy proposals.

The UK's policy response to Russia's invasion of Ukraine

Russia's invasion of Ukraine and the consequent energy supply crises it provoked, prompted a rapid reassessment of energy policy in the UK and across Europe. Increasing energy security in the face of Russia's weaponization of gas supplies became the common focus. The IEA declared events as 'the first truly global energy crisis' and suggested it could represent 'a historic turning point towards a cleaner and more secure future'[10].

In the UK **the British Energy Security Strategy** was launched on 7 April 2022, an **Energy Price Guarantee** was announced in September 2022 before a second energy White paper - **Powering up Britain -** was launched on 30 March 2023. In addition, a commitment to reduce energy demand in buildings and industry by 15% by 2030 was introduced by the Chancellor in the Autumn statement in November 2022 (for further details see Box 2).

Reflecting on these events at the end of 2022, the UK Energy Research Centre (UKERC) argued in its annual review of energy policy that "The UK [was] unique in Europe in that its response to the energy crisis [was] focused almost entirely on supply-side measures and subsidies", going on to

[10] IEA (2022) World Energy outlook 2022

conclude “whilst moving swiftly to protect consumers through subsidies was essential, neglect of the demand side was a hugely wasted opportunity ”[11].

Box 2: UK government energy policy response to Russia’s invasion of Ukraine

British Energy Security strategy – the strategy concentrated on long-term supply-side measures (namely the expansion of nuclear capacity, investment in hydrogen, offshore wind and onshore solar) and short-term price support subsidies for consumers. The package of support for households topped £9.1 billion and included a temporary reduction in Council tax (April 2022), and a £200 reduction on energy bills from October 2022 to be repaid through future bills. It also extended existing support to elderly and vulnerable households via the Warm Home Discount. In addition, it announced a “comprehensive energy advice service” to be launched in summer 2022 and zero rate VAT on energy saving materials, PV, and heat pumps for the next 5 years. The strategy largely ignored demand for energy and contained little new support for heat pumps.

Energy Price Guarantee - announced in September 2022 as one of the first acts of new Conservative government under Liz Truss, the guarantee limited average household energy bills to £2500 annually with government making up the shortfall in retail prices. The guarantee was extended in March 2023 to run until June 2023.

A commitment to reduce energy demand in buildings and industry by 15% by 2030 was introduced by the Chancellor in the Autumn statement in November 2022. Whilst short on new policy, an Energy Efficiency Taskforce was announced to oversee its delivery.

Powering up Britain - developed in response to a High Court ruling that the government's previous plans were insufficient to meet its climate targets, this white paper was accompanied by 18 additional policy documents and doubled down on increasing energy security through supply side measures. It reiterated existing policy ambitions to foster a market-based approach to deploying heat pumps, included new funding to extend the Boiler Upgrade scheme for an additional 3 years and launched a £30 million competition to encourage additional investment in heat pump manufacturing. In addition, it reiterated existing government funding for installer training and the government’s ambition to implement a market incentive for manufacturers to increase production of heat pumps relative to their boiler sales in 2024.

2.3 Business environment

Building a UK market for residential heat pumps is thought to require fostering domestic manufacturing capacity whilst expanding the installer base through training more system designers and engineers. Business model innovation is thought to be important for reducing the cost of installation and disruption involved.

Semi-conductor markets

Like most digital consumer goods, heat pump supply chains were recently affected by global semiconductor shortages in 2021 and 2022. The semiconductor industry appears to have recovered, although for products requiring basic chips, which includes heat pumps, shortages are expected to

[11] UKERC (2022) Review of Energy Policy 2022

continue into 2023[12]. The European Commission has responded to these shortages by targeting a doubling of the EU share of global production of semiconductors to one fifth by 2030[13], whilst the United States government has introduced a tax credit for semiconductor manufacturing facility investment through to 2026[14], measures which should improve the situation in the long term. No equivalent announcements have been made by the UK Government, meaning the UK will continue to rely predominantly on imports and remain exposed to any future global shortages which may occur. The risk to the UK heat pump market in the short to medium term appears low.

F-gases

A ban on poly-fluoroalkyl substances (PFAS), so-called forever chemicals, and the phase out of refrigerants with high global warming potential more broadly constitute a further concern to industry. Recent consultations within the UK and at the European Parliament have proposed a ban on PFAS and the phase out of refrigerants. Nonetheless, both the UK HSE[15] and the European Chemicals Agency[16] have recently proposed allowing a derogation for the use of PFAS in sealed heat pump systems, noting that the significant costs incurred by a ban would affect the heat pump market and compromise decarbonisation activities. Meanwhile, the European Parliament has voted for an accelerated phase-down of F-gas refrigerants, much opposed by industry bodies, leading to a complete phase out by 2050[17]. However, there have been no recently proposed changes to F-Gas regulations in the UK.

Business model innovation

Significant business model developments have come from the energy retail sector, with Octopus Energy, British Gas and Good Energy all moving into emerging UK heat pump markets. Octopus has been particularly active, making the following investments and additions to its service offering:

- £10 million investment in a new centre for heat pump R&D and installer training[18];
- Major investments in heat pump manufacturers, Renewable Energy Devices and Kensa Heat Pumps[19] [20];
- An installation service, offering heat pumps from £3,000;
- A 5-year warranty and service plan with monthly payments; and
- A heat pump specific 'Cosy Octopus' time-of-use tariff, with price dips to encourage scheduling heat pump operation outside of wholesale energy peak price periods.

This fits their wider strategy of assisting customers with the purchase of small-scale flexible energy resources, e.g. electric vehicles[21] and solar PV panels with batteries[22], which Octopus can then manage for mutual benefit between customer and energy supplier. Octopus can sell ancillary services to the electricity system operator, based on the predictability of demand from these

[12] 'Semiconductor supply chains - statistics & facts', Statista.
[13] 'Europe's Digital Decade', European Commission.
[14] 'CHIPS for America Act', U.S. Congress.
[15] 'PFAS RMOA', HSE.
[16] 'PFAS Proposal for a Restriction, ECHA.
[17] 'Industry faces tough new HFC phase down', Cooling Post.
[18] 'Octopus Energy agrees $600m deal with Generation Investment Management to accelerate global green energy mission', Octopus Energy. https://octopus.energy/press/octopus-the-next-generation/
[19] 'Octopus Energy invests in Northern Irish heat pump experts to build thousands of heat pumps a month', Octopus Energy
[20] 'Pump it up', Legal and General
[21] Octopus Electric Vehicles, Octopus Energy
[22] 'Solar Panel and Battery Installation', Octopus Energy.

aggregated resources, with some of the revenue passed on to customers as savings. Either to remain competitive, or in pursuit of a similar business model, Good Energy have recently acquired heat pump manufacturer Igloo Works[23], whilst British Gas now advertise heat pump installations from £2,999[24].

Innovation is also occurring in financing for heat pumps. This includes the development of leasing services, in which the high initial cost for a heat pump is avoided, by German provider Thermondo[25]. In contrast, EDF Energy are considering offering zero-rate loans to install heat pumps, built on the premise that consumers prefer to own their heating system rather than lease it[26]. The Heat Pump Ready Programme has also funded heat-as-a-service and 'Green Homeowner Loan' projects.

The development and use of MCS 'umbrella service' models represent a further area of business model innovation with potential for significant future impact. Umbrella service models allow for a heat pump system to be installed by a non-MCS-certified tradesperson whilst being accredited under the MCS (a requirement for BUS) through the installation being designed and commissioned by an MSC-certified contractor[27]. The umbrella service operator thus designs, commissions, and registers the installation, increasing the capacity of MCS-registered companies. For local trades people it increases their service offering to local clients whilst reducing the need for further training and costs associated with being MCS compliant. Umbrella service models are expected to become increasingly important in the new build sector where uniform house building techniques allow for a standardised heat pump specification to be provided by a qualified MCS registered umbrella scheme, which can then be carried out by suitably trained installers under the umbrella scheme.

A final example of business model innovation is Kensa's 'Heat the Streets' Project, which aims to tackle the high cost of groundworks when installing a ground-source heat pump. The project will demonstrate street-by-street installations of ground source heat pumps in existing buildings, by connecting them up to pipes linking shared deep vertical boreholes, which will act as the source of thermal energy. Such infrastructure permits a new business model for a ground-source heat utility provider. The provider covers the up-front cost of the pipe network and borehole installation, then charges customers a fee to connect to the shared network, much like any other utility provider, to eventually recover the costs for the boreholes. Customers can then install a ground-source heat pump at a much lower initial cost, and the fee paid to the provider would likely be less than the saving made relative to the cost of running an air-source heat pump (which typically operate with lower efficiencies).

The installer base

The Climate Change Committee has advised that over 1 million heat pump installations per year are required by the mid-2030s, for which the Heat Pump Association (HPA) suggests at least 6,800 installers are needed by the end of 2023, ramping up to 69,500 by 2035[28]. Nesta similarly estimates a requirement for 62,000 installers by 2035[29].

The MCS Data Dashboard provides the most comprehensive publicly available data on current installer numbers. One of the measures provided is the number of newly certified heat pump

[23] 'Good Energy has acquired Igloo Works', Good Energy.
[24] 'Centrica's British Gas joins Octopus Energy in heat pump price war', proactive.
[25] 'German heating solutions provider offers heat pump leasing', PV magazine.
[26] 'Energy giant rethinking UK heat pump finance', H&V news.
[27] Findings of the Umbrella Scheme Consultation, MCS.
[28] 'Building the Installer Base for Net Zero Heating', HPA.
[29] 'The heat pump installer gap', Nesta.

installation contractors each month (Figure 2). Although this shows that there has been a recent increase in new certifications since 2020, of the total 3,370 recorded from 2009 to May 2023, only 1,593 contractors remain MCS certified today. How many installers this represents is unclear, since data on the number of employed installers per certified contractor is not given. However, the Department for Energy Security and Net Zero (DESNZ) has recently implied an average of around 3 installers per certified contractor, based on its estimate of around 4,500 heat pump installers employed by MCS contractors[30]. Since many competent heat pump installers will not be MCS certified, there is reason to expect that the total number could be closer to the HPA target for 2023, based on these figures. On the other hand, Nesta's estimate for the total number of installers in 2022 was only around 3,000. Therefore, the best that could be said is that the UK is *possibly* on track to having the requisite number for 2023, whereas in the worst case the installer workforce needs to more than double in the short term.

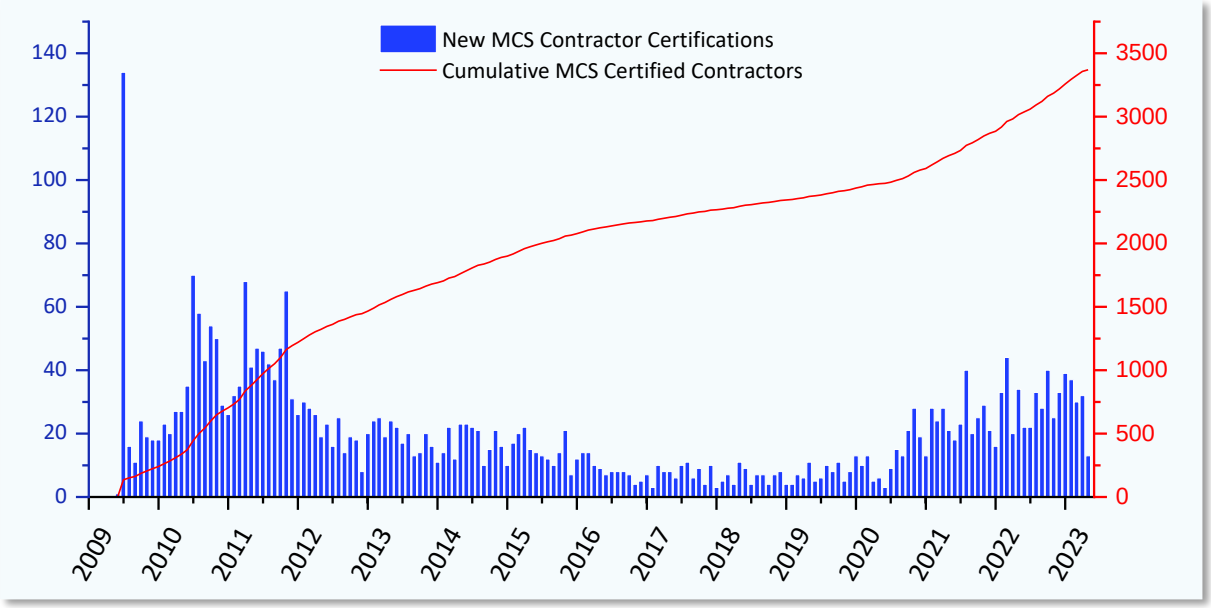

Figure 2: Monthly MCS Heat Pump Installation Contractor Certifications[31]

In a BEIS study from 2021[32], two of the top three reasons given for not considering heat pump training amongst existing heating installers were that they were nearing retirement or were too busy. MCS umbrella schemes may help to address these barriers by avoiding or reducing the burden of training. Unlike for the gas boiler installation sector, the assumption that an installer should be responsible for both specifying and fitting the system need not become the norm for heat pumps. With this division of responsibility, a one-to-many relationship can be achieved between MCS contractors and suitably qualified heat pump fitters, potentially aiding workforce scalability in the short-term. The third reason to not consider retraining was a lack of consumer demand, with the majority of those who would consider retraining suggesting it would be demand-led.

Looking forward, the HPA states that its members have the capacity to train 40,000 existing heating installers to become heat pump installers each year[33]. With the government announcing a new £5

[30] 'Inquiry on the Boiler Upgrade Scheme – Government Response', DESNZ
[31] 'The MCS Data Dashboard Scheme Insights', MCS.
[32] 'Social research with installers of heating systems in off gas grid areas of England and Wales', BEIS.
[33] 'Installers', HPA.

million Heat Training Grant to help train 10,000 heat pump installation experts[34], large heat pump manufacturers offering discounted training as part of the same scheme, Kensa heat pumps offering free training courses[35] and Octopus Energy building an 'army' of installers by re-training existing heating engineers and plumbers[36], there are reasons to be cautiously optimistic. The number of installers should be able to keep pace with current demand, though it remains uncertain whether there will be sufficient numbers to help drive demand through increased competition.

New build

If implemented, the Future Homes Standard could, in effect, mandate the installation of heat pumps in many domestic new build properties, driving deployment in the sector. All projections heavily rely on this to achieve deployment targets. However, the extent to which legislation will provide a boost to the heat pump market depends on the future rate of new build development.

A reliable predictor of near-term new build completions is the rate of new build housing starts, i.e. the point at which work commences on a new building construction site. New build starts have fallen dramatically since Q2 2022 and the latest figures indicate the lowest quarterly rate in England since the Coronavirus pandemic (Figure 3); the total new build starts in England in 2022 was 178,111 (provisional data) [37] compared to 129,970 for 2021 and 177,920 for 2020. Current rates of new build starts suggest the deployment of heat pumps in this sector will not meet current expectations (e.g. 300k units in 2025) requiring the shortfall to be made up through deployment via the retrofit market.

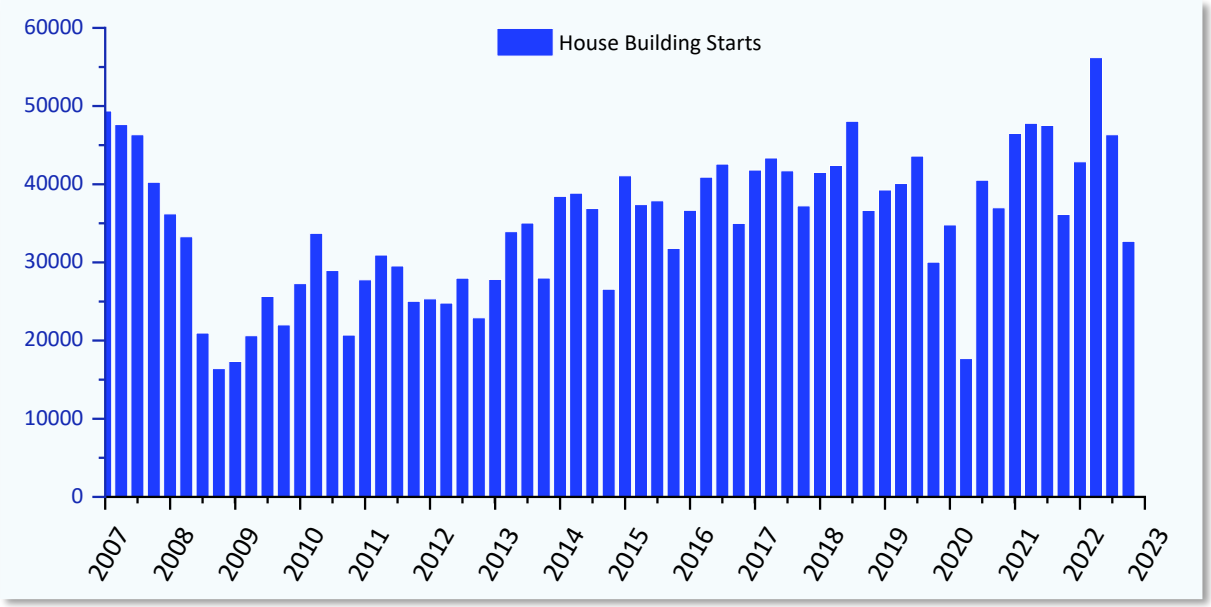

Figure 3: New Build Housing Starts in England, 2007 to 2023 (provisional data for Q4 2022)[38]

[34] '£14 million cash boost to accelerate rollout of low carbon heating', DESNZ.
[35] 'Heat Pump Training Course', Kensa Heat Pumps.
[36] 'Join the Octopus Heat Pump Army!', Octopus Energy
[37] 'Live tables on housing supply: indicators of new supply', DLUHC.
[38] Ibid.

UK manufacturing capacity

Since 2021, the amount of publicly disclosed investment in heat pump manufacturing capacity in EU countries has reached £1.28 billion (Figure 4). Japanese manufacturer Daikin has provided at least £324 million of this investment, along with another Japanese manufacturer Panasonic (£126 million), whilst similarly large investments have been announced by German manufacturers Steibel Eltron (£391 million), Bosch (£195 million) and Veissmann (£174 million). Bosch alone has announced plans to invest £870 million in manufacturing capacity by 2030. By comparison, disclosed investments in UK heat pump manufacturing capacity total £104 million, with the biggest single investment announced by British firm Kensa Heat Pumps (£70 million) in May 2023.

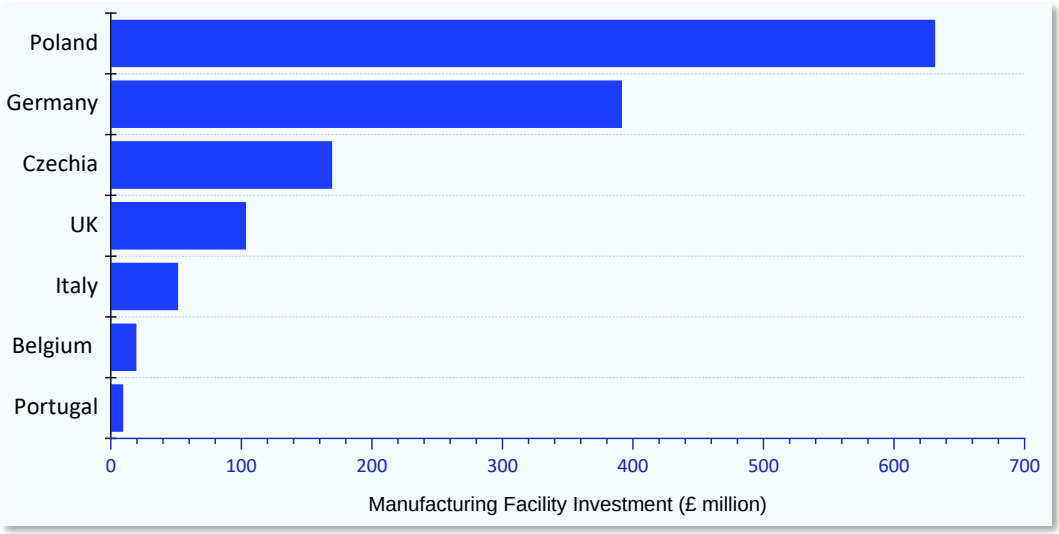

Figure 4: Announced Investments in Heat Pump Manufacturing Capacity by Country, 2021 to 2023[39]

Although it is expected to become one of the biggest markets over time, the UK market for heat pumps is currently small compared to many European countries. Its growth in 2022 was similarly low compared to others (figure 5), which may reflect its ageing housing stock, high penetration of the gas network and high spark spread. Securing the fourth highest amount of investment in manufacturing capacity in recent years is therefore commendable. However, the extent to which the largest heat pump manufacturers have opted to make substantial investments in continental Europe rather than the UK, could be a cause for concern.

[39] Rapid assessment of reported public heat pump investment announcements in 21 EU countries from 2021 onwards, using standardised search protocol.

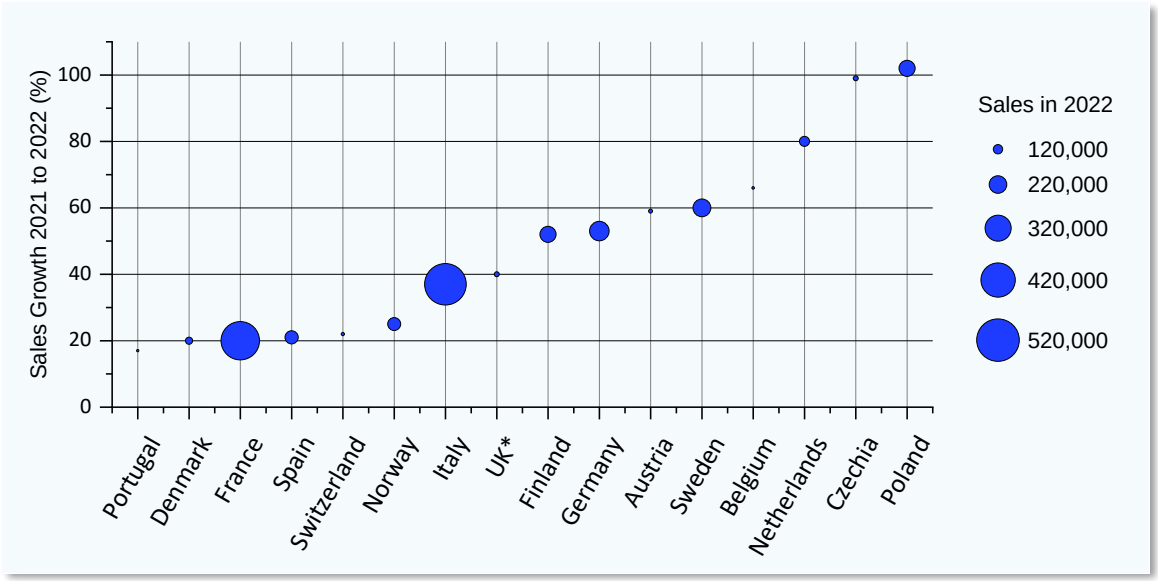

Figure 5: Growth in Heat Pump Sales from 2021 to 2022 by Country (*estimated data)[40]

The reason for the disparity in investments is not clear. The UK Government made the case for manufacturer investment in the UK in March 2023, within the Heat Pump Investment Roadmap[41], which highlighted favourable policy announcements and the UK government's ambitious targets for market growth. Part of the reason may reside in the general stagnation of business investment in the UK post-Brexit (Figure 6). The lack of detail and pace on core policy may also provide a reason.

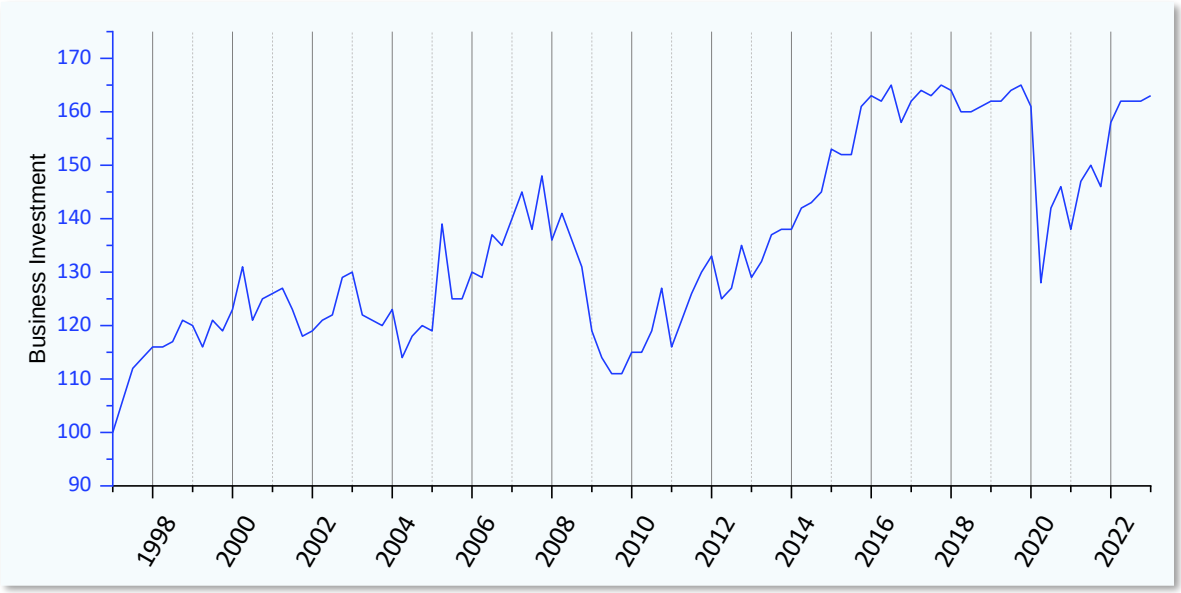

Figure 6: UK Business Investment, Seasonally Adjusted Chained Volume Measure (Index referenced to Q1 1997 = 100)[42]

[40] 'Heat pump record: 3 million units sold in 2022, contributing to REPowerEU targets', EHPA.
[41] 'Heat Pump Investment Roadmap', DESNZ.
[42] 'Home Economy Gross Domestic Product (GDP) Business investment in the UK Business investment in the UK: January to March 2023 provisional results', ONS.

2.4 Wider society

For society to adopt heat pumps *en masse*, people need to be aware of the technology and understand how to operate them. They also need to be willing to alter their heating practices to accommodate them, since heat pumps provide heating with different characteristics compared to typical routines of using gas boilers in the UK. This requires fostering trust in the technology and consumer confidence in a new market. For adoption to occur, households need to be motivated. They also require sufficient capabilities to proceed, including financial, physical (e.g. home ownership), social and organisational resources.

In the following section we explore the evidence on wider society's preparedness for heat pump adoption in three steps. First, we examine societal awareness. We then explore societal motivations before addressing societal capabilities to install heat pumps en masse. In the next and final section of this review we take a closer look at user experience of adoption.

Societal awareness

Public opinion polls and trackers provide some evidence on societal awareness of heat pumps. Building an understanding of how awareness has changed is not easy because the limited frequency of some reporting and changes to questions asked. For instance, the Public Attitudes Tracker run by BEIS has only recently started asking detailed questions about heat pumps. In the following we draw on survey-based research carried out by BEIS, YouGov (a leading market research company), NatWest (a commercial bank), and Public First (a London-based consultancy), in addition to our analysis of newspaper coverage.

In 2020, reported awareness and knowledge of low-carbon heating technologies was low. 39% of respondents to a one-off BEIS survey[43] reported having heard of a ground source heat pump, whilst 25% reported having heard of an air source heat pump. Since then, knowledge of low carbon heating has increased. A survey for Public First[44] in 2021 recorded awareness of ground-source heat pumps at 50%, and 45% for air-source heat pumps. Data from BEIS' Public Attitude Tracker survey supports this trend (figure 7). Moreover, it suggests there is a steady proportion of the population that have not heard of low carbon heating and a fluctuating but again steady proportion of the population that hardly know anything about low carbon heating. It also suggests a large rise in the number of people learning more about heat pumps from Autumn 2022 onwards. If this trend continues, it suggests over half of the population are becoming more knowledgeable of heat pumps.

[43] BEIS. (2020, January). *Transforming heat: public attitudes research report*
[44] Public First. (2021). *Public First Poll for ECF*.

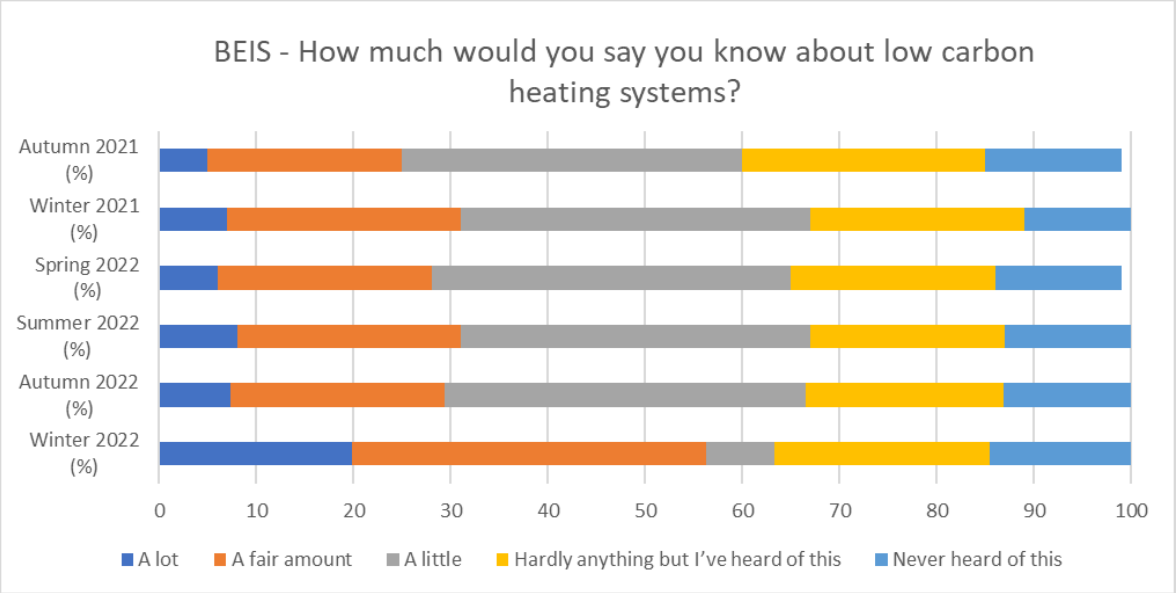

Figure 7: How much do you know about low carbon heating systems?[45]

More recently, survey questions have switched from asking about awareness of, to intentions to adopt low carbon heating systems. In October 2021, YouGov reported that only 9% of adults in the UK were 'somewhat likely' to replace their gas boiler with a heat pump in the next few years, with 3% stating they were 'very likely' to do so.[46]

A second means to gauge societal interest in heat pumps was suggested by our expert interviewees. They suggested newspaper reporting on heat pumps had increased significantly over the last year, and suggested this indicated increased interest in the technology in general. To examine this hypothesis, we analysed four nationwide UK newspapers (The Daily Telegraph, The Guardian, The Times and the Independent) via Lexis Nexis, gathering data on the number of articles (both news coverage and comment/opinion pieces) on heat pumps (Figure 8) and their broad orientation: whether they positioned heat pumps in a positive or negative light, which is reported on below.

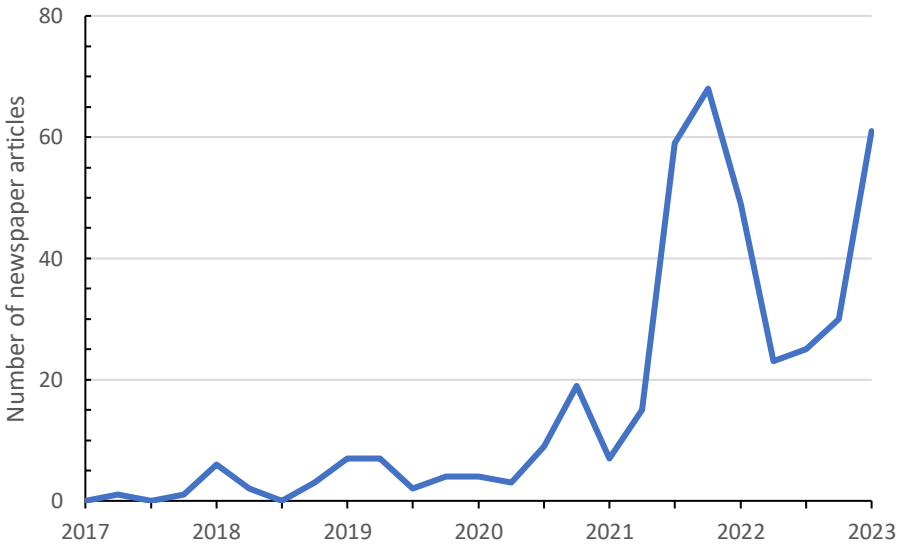

Figure 8: Newspaper articles on heat pumps 2017 to 2023 per quarter

[45] BEIS. (2023). *BEIS Public Attitudes Tracker Winter 2022*
[46] YouGov (2021, October) Daily Question

This analysis suggests that as a topic, heat pumps are heating up. Between 2020 and 2021 the number of newspaper articles discussing heat pumps increased over three-fold, from 35 in 2020 to 149 in 2021. After a slight decrease in 2022 (N=127), 2023 is set to be the busiest media year so far: 61 articles discussed heat pumps in Q1 2023 alone.

Societal motivation for adoption

Societal concern over climate change has grown steadily over recent years. Extreme, record-breaking heatwaves experienced across much of the country in 2022 are thought to have directed attention to environmental concerns for many.[47] However, the latest BEIS Public Attitudes Tracker for Winter 2022[48] shows a slight reduction in the percentage of respondents who are 'very concerned' about climate change compared to Autumn 2022, indicating a potential recent shift in what the public perceive as an urgent matter. As heat pumps are widely regarded as the principal means for eliminating the carbon emissions associated with residential heating in the UK, increased recognition and concern over climate change should provide a motivation for heat pump adoption. Moreover, there is some evidence that level of concern about climate change is positively correlated with household income[49]. This may be relevant to self-financing of heat pump installations.

Evidence suggests that those in the higher social grade show more concern for climate change, when comparing two social grades (ABCD1 upper class and C2DE lower class) frequently used to explore the British social class structures.[50] However, when looking at public opinion on what the general public as a whole think the UK Government should be focusing their attention on, 73% of the overall adult population think the cost of living crisis is a more pressing matter than climate change[51]. Escalating financial constraints due to the cost-of-living crisis may extend to overpower environmentally orientated aspiration.

Increasing household energy bills provide another potential motivation for action: to reduce energy outgoings. Between 2021 and 2022 the average household bill for gas and electricity increased by 46% [52]. The effect on public attitudes appears stark. For example, a one-off poll by YouGov in July 2022 reported 78% of those surveyed were either 'fairly worried' or 'very worried' about their household's energy bills[53]. Such concern could motivate adoption. Another one-off, experimental survey, this time by the UK government-founded Behavioural Insights Team[54], supports this positive outlook, suggesting:

- 44% of respondents (n=1,801) would choose a heat pump over a £2,000 gas boiler if heat pump installation cost was £2,000-£3,999;
- And 25% would still choose a heat pump over a gas boiler if the former cost £10-12,000, roughly approximate to current market prices.

To turn motivation into action requires sufficient capabilities to act. Across several fronts evidence suggests householder capability to act is reducing, resulting in a narrowing of the able to pay sector. Rising energy prices have contributed to record levels of inflation and an associated cost of living

[47] Richmond, J. G., & Hill, R. (2023). Rethinking local resilience for extreme heat events. *Public Health*, 146-148.
[48] BEIS. (2023). *BEIS Public Attitudes Tracker Winter 2022.*
[49] YouGov (2022) What impact is the cost of living crisis having on support for tackling climate change
[50] YouGov (2023) Climate Tracker
[51] https://yougov.co.uk/topics/politics/articles-reports/2022/10/12/what-impact-cost-living-crisis-having-support-tack
[52] Department for Energy Security & Net Zero (2023) Annual Fuel Poverty Statistics in England, p. 18
[53] YouGov. (2022, July). *Concerns about energy bills survey.*
[54] BIT (2022). *How much are we willing to pay for a heat pump*.

crisis. Whilst rising energy prices might be a motivator for some, for many others it has led to unsustainable energy bills and reduced their ability to adopt a heat pump.

Increased energy prices have driven many households into fuel poverty. The UK government estimates the number of households in fuel poverty in England will have increased from 3.16m in 2021 to 3.26m in 2022 when using the Low Income Low Energy Efficiency (LILEE) metric[55]. These numbers are provisional, modelled estimates, covering England only. Attempting to calculate the true number of households in fuel poverty across the UK is not easy. In December 2022 National Energy Action (NEA) released their own modelled figures. They estimated the number of households in fuel poverty in the UK increased from around 4 million in 2020 to 4.5 million in October 2021 and 6.7 million in October 2022. They projected 8.3 million households would be in fuel poverty from April 2023 when the Government's price support policies were due to end. NEA define a household as being in fuel poverty if it spends more than 10% of its income on heating. Following this metric, the UK government estimated that 8.8 million households would slip into fuel poverty from April 2023[56]. Meanwhile, the NatWest Greener Homes Attitude Tracker provides further evidence on the impact of the cost of living crisis on householder intentions to install heat related energy efficiency measures. In January 2023 they reported the number of homeowners across the UK planning to complete energy efficiency improvements in their homes over the next 12 months was decreasing, attributing this change to the rising cost of living[57].

The rising cost of borrowing is another constraint. On Thursday 18 May the Bank of England increased the base rate for the 12th consecutive time, with rates now fast approaching a 15-year peak.[58] The financial outlook for less well-off households is bleak. Only the wealthiest fifth of the population recorded an increase in their household disposable income in 2021/22 financial year while the least well-off fifth of the population has seen their household disposable income decrease over the last two consecutive financial years for which data is currently available (financial year ending in March 2022).[59] This points to the importance of Government support to ensure those who are less well-off are not left behind in the transition to heat pumps as a heating technology.

Public perception of heat pumps

Increased media coverage helps raise awareness. Increased coverage of heat pumps is therefore positive in principle. Beyond the overall number of articles increasing, we note increasing contestation over the value, purported benefits and associated challenges of deploying heat pumps for individual households and society as a whole.

The results suggest newspaper coverage of heat pumps is becoming more critical. In the first quarter of 2023, only 45.9% of newspaper coverage was positive compared to 67.3% in Q1 2022 and 57.1% in Q1 2021. The coverage also appears to be shifting towards technical aspects and pre-requisites for heat pump installation with hydrogen alternatives, building regulations and support schemes taking up a large share of the debate in media. This appears to suggest the debate is moving from a niche technology enthusiast space largely heightening benefits, to broader societal debate among more actors.

[55] BEIS (2023). The Annual Fuel Poverty Statistics in England
[56] BEIS (2023). The Annual Fuel Poverty Statistics in England
[57] NatWest. (2023, January). *Greener Homes Attitude Tracker January 2023.*

[58] BBC News (May 2023). Interest rates: how the rise affects you and your money.
[59] ONS (2022, March) Household income inequality

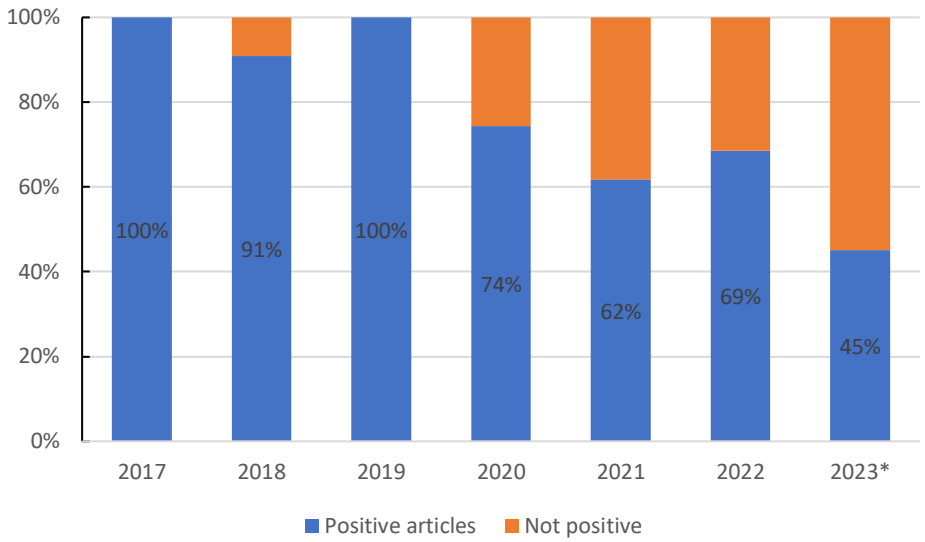

Figure 9: Proportion of newspaper articles discussing heat pumps in a positive light across 4 UK newspapers
* data for 2023 includes materials published up to end of March, i.e. Quarter 1.

2.5 User environment

Costs associated with installing and running heat pumps are widely regarded to be important barriers to heat pump adoption. Beyond this, fostering positive consumer experiences of installing and using a heat pump, beyond running costs, will be critical to mass adoption.

Everyday experiences

As the number of domestic properties using heat pumps as their main source of heating gradually increases, more data on user experiences is likely to become available. However, at present there is little aggregated evidence on consumer experiences with the adoption and use of heat pumps, while the evidence available focuses on specific sub-sections of properties, providing at best a narrow snapshot.

For instance, recent work by Nesta reports contemporary heat pump users are unsure about how the technology works, what operating expenses can be expected and what system and building specifications are required to deploy them[60]. Meanwhile, households' heating and hot water practices and preferences have been reported as undermining heat pump performance[61].

Running costs

How much a heat pump costs to run depends on: the price of electricity and gas and the taxes and levies placed on each, the seasonal performance of the heat pump, heat demand of the building including how energy efficient it is, and the practices of the building occupant. The costs of running a heat pump are therefore always context specific. Nonetheless, with a simplification of these

[60] https://www.nesta.org.uk/project-updates/improving-the-heat-pump-experience/
[61] Oikonomou, E. (2022) Understanding the drivers affecting the in-situ performance of domestic heat pumps in the UK. Unpublished PhD thesis. UCL. Available from: https://discovery.ucl.ac.uk/id/eprint/10150776/

variables it is possible to estimate running costs associated with a typical installation and therefore assess how associated costs have changed over time.

Changes in the price of gas and electricity are the primary drivers of change in the contemporary running costs of heat pumps and result from Russia's weaponisation of gas supplies, a gas supply crunch and government interventions in domestic energy supply markets (e.g. the Energy Price Cap and Energy Price Guarantee).

Here we compare the costs of running a heat pump to a gas boiler. Figure 10 compares the varying annual cost of heating a typical home with either: a gas boiler with 87% efficiency; a low performing heat pump with seasonal performance factor (SPF) of 2.8; or a high performing heat pump with SPF 3.8. Heat pump SPF is dictated by the design and installation of the heat pump, as well as end user operation. Steps in the figure indicate historical unit price changes for the standard variable rate gas and electricity tariffs supplied by Octopus Energy (chosen due to the availability of historical data).

The analysis suggests that gas boilers became more expensive than efficient ASHPs from April 2022 onwards, when the Energy Price Cap was first raised, and more expensive than most eligible heat pumps under the BUS after the Energy Price Guarantee was introduced in September 2022. In our analysis, gas boilers are currently £89 per year cheaper than the least efficient heat pumps shown. This is set to continue until at least June 2023, the current end date for the government's Energy Price Guarantee scheme.

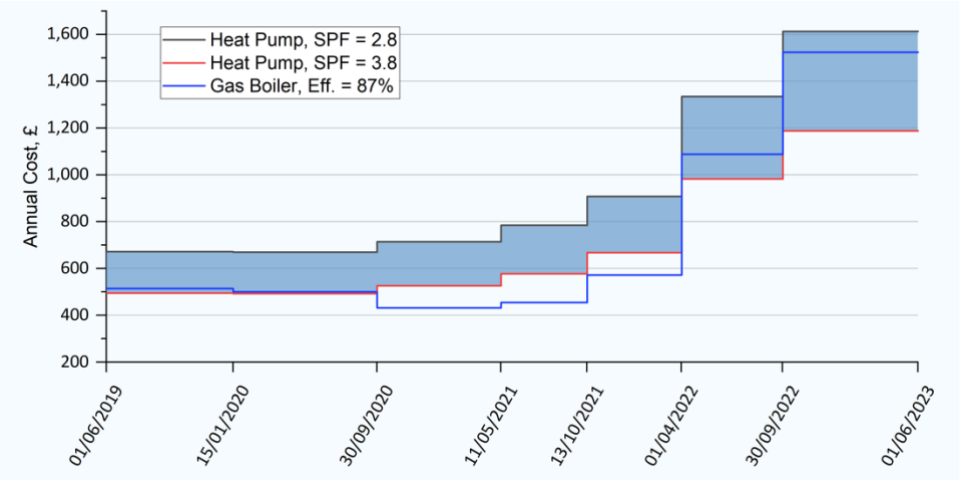

Figure 10: Comparison of Annual Running Costs, Heat Pumps Versus Gas Boilers[62]

To date, discussion of heat pump running costs have near exclusively focussed on the difference between domestic electricity and gas prices. Much less attention has been directed to operating heat pumps alongside domestic solar PV, where electricity produced onsite can be viewed as free or at least already written down.

[62] Octopus Energy domestic standard variable tariffs for London used to determine p/kWh for Gas and Electricity. Does not include standing charges for gas or electricity. Anomalous API tariff data for April 2022 to October 2022 replaced with data published by Octopus here. Minimum heat pump SPF for BUS is 2.8. Upper limit of SPF in Octopus real home data is 3.8 for air-source heat pumps (likely to be higher for ground-source). Gas boiler efficiency of 87% based on Nesta analysis. Typical heating demand of 12,615 kWh based on Nesta analysis.

Little research has explored this potential to date. The impact of solar PV on heat pump running costs will depend on a variety of factors, not least the extent to which onsite electricity is produced at the times of heat demand. Domestic batteries could also play a mediating role. However, with nearly 1.3m domestic solar PV installations now installed in the UK and with the first quarter of 2023 recording the highest number of installations for 7 years, deploying heat pumps alongside domestic solar PV represents an interesting way to improve running costs and therefore heat pump economics more broadly.

3. Summary and discussion

Below we summarise the results of the review by thematic area, within a series of key messages, starting with technology deployment.

Heat pump deployment is increasing slowly

The rate at which residential heat pumps are being deployed is increasing, from low levels. Whilst this is promising, rates of deployment will need to accelerate if current government targets are to be met. There remains significant uncertainty about the total number of heat pumps deployed in the UK and little substantive publicly available information on where they have been deployed, in new build or within retrofit markets. Given the critical role ascribed to heat pumps by many analysts for helping to reduce emissions to zero in the residential sector, better reporting of deployment rates is vital.

Central policy instruments in the government's market-based approach have yet to be delivered

The rapid succession of heads of Government, chancellors, and Secretaries of State during 2022 created uncertainty over the government's commitment to heat decarbonisation and heat pump deployment. It has also delayed policy development. Of the four central policy instruments announced in the Heat and Buildings Strategy in October 2021 and designed to transform domestic heating via the deployment of heat pumps, only one instrument has been fully delivered (the Boiler Upgrade Scheme). Two instruments remain under consultation and lack a clear timetable to implementation (the Clean Heat Market Mechanism and boiler phase out dates). The final policy – rebalancing levies placed on electricity and gas – has yet to be consulted on. War in Ukraine and the global gas crisis has concentrated UK policy attention on energy security, narrowly conceived as a supply issue, to the detriment of demand-side solutions such as heat pumps, with potential to reduce energy demand and tackle the climate crisis.

Business model innovation is occurring despite market uncertainty

Recent activities of energy suppliers, namely Octopus, British Gas and Good Energy, indicate growing rates of business model innovation for heat pump deployment and emerging competition. This suggests strong confidence from some energy retailers in a future heat pump market, actively positioning themselves in the expectation of future rewards. At the same time increased recognition of 'MCS umbrella schemes' and efforts to clarify and standardise such schemes are increasing the sector's installation capacity by offering new routes for existing heating engineers to offer heat pumps alongside gas boilers.

The installer base is growing but capacity remains uncertain

The cumulative number of newly certified MCS installation contractors has grown steadily since 2021, reaching 3,370 by May 2023. However, there are currently only 1,593 contractors still registered and it is unclear how this figure has changed over time. Furthermore, because registration does not include the number of trained installers within each contractor – a number that would fluctuate over time – the total number of trained MCS installers is not clear. DESNZ estimates the total number to be around 4,500, although not all heat pump installers are MCS registered. Moreover, increased recognition and use of MCS umbrella schemes suggests the true number of heat engineers with capacity to engage in this emerging market may be underestimated. Hence, the UK may be on track to meet the HPA's 2023 suggestion that 6,800 installers are required by the end of 2023, although more pessimistic estimates suggest there could be less than half this

number. Looking forwards, the HPA states that its members have the capacity to train 40,000 existing heating installers to become heat pump installers each year. If true, this suggests there is sufficient installer training capacity to meet current and predicted heat pump demand in the near term. However, evidence suggests that retraining will be demand-led, and is therefore unlikely to help drive demand through increased competition between installers. To increase understanding of installer capacity, efforts to track the number of trained installers and MCS umbrella schemes will be vital.

Societal awareness is increasing

The latest data from BEIS' Public Attitude Tracker survey (March 2023) suggests awareness of heat pumps is increasing. Most notably, there has been a marked increase in the amount of knowledge respondents claim to have about heat pumps between Autumn and Winter 2022. If this trend continues, it suggests over half of the population are becoming more knowledgeable of heat pumps, likely the result increased energy prices following Russia's invasion of Ukraine and increased media coverage of heat pumps.

Motivation for adoption should be increasing but the 'able and willing to pay' market is shrinking

Rising household energy costs, due to Russia's invasion of Ukraine, are likely to have made heat pump adoption a pressing financial concern, with the potential to save money on historically high energy bills a potential motivation for those able to afford the upfront cost of a heat pump. Societal concern over climate change has grown steadily over recent years. The evidence suggests that those most concerned about climate change are part of higher social grades, who are also more likely to be able to afford the upfront cost of a pump. However, the able and willing to pay market is shrinking. Rising energy prices and inflation widely reported as 'a cost-of-living crisis', have reduced the financial capacity of households to act. Evidence shows that UK households planning energy efficiency improvements in the next 12 months was decreasing in January 2023 due to increased costs.

Costs associated with running a heat pump compared to a gas boiler have reduced but remain highly uncertain in the long term

Domestic energy prices have risen from historical lows during the early days of the pandemic to unprecedented levels following the global post-pandemic economic recovery and Russia's invasion of Ukraine. Since January 2019 the Energy Price Cap has set a maximum price that energy suppliers can charge consumers per kilowatt hour (kWh) used, whilst the Energy Price Guarantee (EPG) has limited average household energy bills to £2500 annually with government making up the shortfall in retail prices. With each price fluctuation, the comparative cost of operating a heat pump compared to a gas boiler has changed. Our analysis suggests that efficient heat pumps became cheaper than gas boilers from April 2022 onwards, when the energy price cap was raised to just under £2,000. Nearly all but the worst performing heat pumps become cheaper to run than gas boilers with the introduction of the EPG in October 2022. However, the extent to which heat pumps will stay cheaper following the end of the EPG is unclear and depends on the price of electricity and gas under the Energy price cap.

4. Conclusion

With few standardised indicators available, assessing how the UK market for residential heat pumps is developing is not easy. This review has been informed by a review of the literature and nine scoping interviews with experts from across policy, practice, and academia. This approach allowed us to build up understanding about which elements of the socio-technical system were perceived as important and why. These interviews also provided experts insights into what key elements were thought to have changed and how, in response to multiple disruptive events across geopolitics, politics, markets, and society.

It is hard to come to any conclusion other than recent disruptive events having influenced the transformation of UK residential heating and the emerging market for heat pumps. However, it remains beyond the scope and ambition of this project to link disruptive events to specific developments in this formative market. Whilst some causal links can no doubt be made, the identification of such variables serves little purpose, when disruptive events are likely to cause a series of interactions between elements of systems as they co-evolve. More important is understanding how incumbent heating systems based largely on fossil-fuel combustion are being challenged and potentially replaced by electrified systems based principally on heat pumps and where there are opportunities to intervene to accelerate progress.

The review supports our initial assumption: recent disruptive events have influenced how the UK market for residential heat pumps is developing, creating a variety of opportunities and challenges, whilst also introducing new risks to the government's preferred market-based approach. A few elements are worth highlighting in conclusion.

Review of the available data suggests two distinct opportunities.

- The war in Ukraine and the resultant global energy crises was a missed opportunity for the UK government to develop a strategy for reducing domestic energy demand, tackle reliance on domestic gas boilers and deploy heat pumps.
- Heightened societal awareness of and interest in heat pumps is a further opportunity that could be seized to accelerate the market. If government is serious in its ambition to decarbonise heating via heat pumps, this heightened interest needs to be capitalised on through clear consistent messaging positioned within a substantial government-backed advice campaign.

It also points to several challenges and risks having emerged because of recent disruptive events, including most notably:

- The decline in new house building starts risks undermining the expected uptick in heat pump deployment from 2025 when the Future Homes and Buildings Standards is currently expected to kick in;
- The delay in legislation for core government instruments, such as the Future Homes and Buildings Standards or the Clean Heat Market Mechanism, resulting from ministerial churn risks undermining policy ambition; and
- Inflation and the associated cost-of-living crises has reduced those households willing and able to pay, with a concomitant challenge of having to support an increasing number of households unable able to afford the upfront cost of heat pumps.