IPPO INTERNATIONAL PUBLIC POLICY OBSERVATORY

Decarbonising Home Energy through Behaviour Change

How to Overcome Barriers to Consumer Green Purchase Decisions

Policy Recommendations and Realist Evidence Review

December 2023

How to Overcome Barriers to Consumer Green Purchase Decisions

The UK's goal of sharply cutting carbon emissions will only be met if householders buy heat pumps or other energy efficient interventions such as insulation. But **the UK is not on track** to achieve Net Zero and is far behind countries such as Norway, Finland, France, and Italy on metrics like heat pump installation. UK efforts to encourage green purchases have so far been mainly focused on improved technology or offering limited financial incentives - but these have not had the desired effect. A **new approach** is therefore needed.

Informed by behavioural science and international best practice, this review by the International Public Policy Observatory (IPPO) and the UCL EPPI Centre argues that making **interventions focused on behavioural and human factors**, and the contexts and systems that shape these factors, are likely to **increase the likelihood of consumers making green purchases**. We argue that a neglect of these individual and social contexts is partly to blame for the current low levels of take-up – and that addressing them can help motivate individuals when they are considering making a green purchase.

Drawing both on the review's findings and our work with stakeholders, IPPO makes the following key recommendations to national and local government to encourage consumer green purchase decisions:

IPPO's Recommendations to Encourage Green Purchases

Recommendation 1 – Establish and promote consistent incentive structures for green purchases.

The incentive structure for green purchases should be reformed to respond to the differing contexts which householders operate in. We recommend its restructuring to a wider, sliding-scale of income-based incentives including working with finance partners on green low-interest loans and mortgages for insulation.

Recommendation 2 – Set up Home Upgrade Agencies to co-ordinate consistent messaging and offer bespoke advice and pathways to householders.

The current incentive and regulation structure around decarbonising homes largely operates on a "one-size-fits-all" basis, limiting their reach and effectiveness. New agencies should be set up which use data-driven segmentation techniques common in marketing to provide tailored advice and financial support to consumers under the required wider incentive structure.

Recommendation 3 - Run a competition promoting innovative ways to minimise the disruption when installing heat pumps.

The review demonstrates that perceived disruption is one of the key barriers to consumers installing heat pumps. Governments should incentivise industry innovation through organising a competition to install heat pumps swiftly and with minimum interference for householders.

Recommendation 4 – Capitalise on the additional time available before the phase-out of fossil fuels in home heating in the UK by further prioritising insulation and an attendant programme of activity across society.

The UK government's extension of the window for the phase-out of gas boilers to 2035 provides a window of opportunity to further ramp up behaviour-focused activity on other aspects of home decarbonisation, especially on insulation.

A table setting out key findings and other policy recommendations from the review can be found overleaf on page 4.

About the Review

Actionable Evidence for Policy

The International Public Policy Observatory (IPPO) exists to provide policymakers with the evidence and knowledge they need to confront big strategic challenges, including achieving Net Zero.

As a result of our conversations with policymakers across government, IPPO was asked to review and produce actionable recommendations to encourage householders to make green purchase decisions, including on heat pumps.

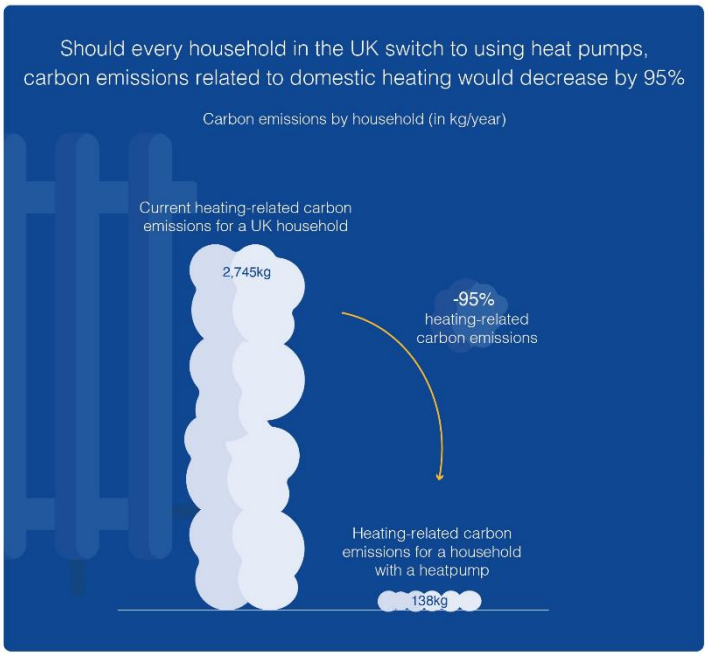
To do this, we convened roundtable discussions with experts from across government, the private sector, academia, and civil society. We produced and published a systems map, including a review of the strength of evidence on what drives these green purchases. And we collaborated with UCL's EPPI Centre to commission this Realist Review to ensure our recommendations to government were informed by the evidence.

The Need to Change Course

If the UK is to achieve Net Zero, a different approach is required to accelerate the decarbonisation of Britain's homes.

There is no route to achieving Net Zero without a radical reduction in carbon emissions from home energy use.

The below graphic demonstrates the transformative effect of radically increasing the take-up of heat pumps on carbon emissions in the UK.

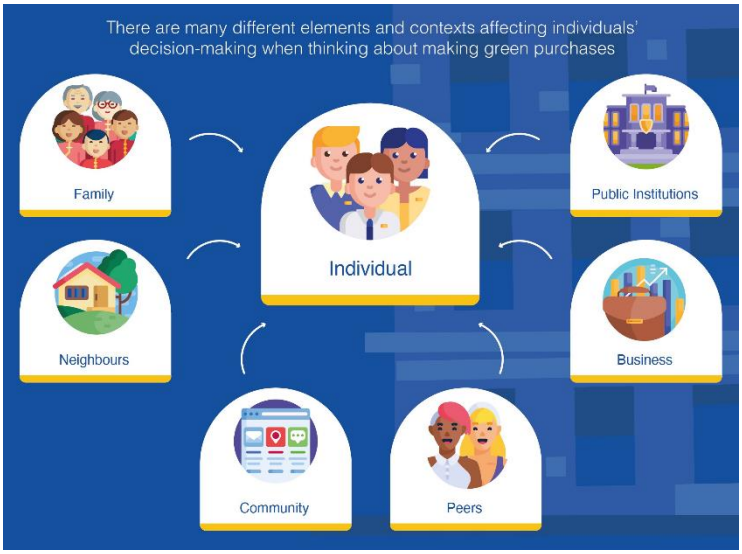


Why Do People Purchase Heat Pumps – or Choose Not To?

Building on our conversations with stakeholders from across society, the review looked at the why and how of householders' decision-making on green purchases including heat pumps. We assessed the existing evidence and made comparisons with other countries to look at what we could learn from them here in the UK.

Understanding Behaviour Change

Our review used the COM-B Model of Behaviour Change to understand that an individual's decision-making is influenced by numerous factors and contexts. This includes government policy, as well businesses and institutions, their local community, interpersonal relationships, and other individual concerns.



Policy Recommendations

Using this approach, we argue that making interventions focused on human and behavioural factors and contexts will be effective when encouraging consumers to make decisions about decarbonising their homes.

Our recommendations are based on a desire to influence the contexts which inform how individuals make decisions. We believe that intervening in these contexts can increase the likelihood of householders making green purchases.

Get in Touch

IPPO continues to work with national and local governments across the country to support the UK in reaching Net Zero. Want to collaborate with us? Get in touch at ippo@ucl.ac.uk.

Key Finding	Policy Recommendation
The upfront costs, running costs and non-financial costs of heat pumps such as disruption currently outweigh the benefits for most UK homes that have gas central heating and poor insulation.	Have a greater role for insulation *plus* heat pump and hybrids bundling as a home energy incentive to reduce the double disruption of insulation and installation. This condenses the disruption of insulation and installation into one event and recognises the role of insulation in heat pump efficiency and user satisfaction.
Poorly insulated homes are a barrier to access incentives to change home heating.	Work with finance partners for pump prime green low interest loans, mortgages for insulation. Work with providers to reduce non-financial costs concerns, such as refunds if not satisfied.
Climate change and environmental concerns are an important driver to behaviour change, but on their own are not enough. Future-proofing homes and reducing bills are also important drivers behind heat pump purchases.	Reform energy pricing to decouple it from the price of gas and harvest the benefits of renewable energy production with cheaper electricity. Support demand side flexibility Time of Use tariffs to support managing increased electricity demands. Support markets for renewable energy tariffs to incentivise switching from gas to electricity with lower bills. Promote reaching Net Zero as an ethical movement people can belong to. . Promote low carbon heat as the "new normal" for homes.
Instigating behaviour change to high value, high commitment green purchases requires multiple approaches. Interventions to promote behaviour change need to be targeted at multiple levels: at the individual, at the household level, and at the community and policy-regulatory levels.	Ensure consistency in government messaging and greater use of wider, structural interventions to reduce carbon. Use the extra time from the postponement of ending fossil fuels in homes to 2035 to "catch up" on insulation in line with other European countries. Change the first ECO+ central heating grant to heat pumps instead of offering first time or replacement gas central heating. Re-engage enquirers who dropped out of considering previous low carbon heating home incentives. Address structural and systematic barriers to heat pump purchasing.
Interventions targeted at lower incomes are not the highest carbon emitting homes.	Widen reach to middle and higher incomes with a sliding scale of income-based incentives.
Highly targeted interventions may not reach enough people to decarbonise homes or develop a competitive heat pump market.	Work with finance partners for pump prime green low interest loans and mortgages for insulation. Widen the reach of incentives to middle and higher income groups by working with finance partners for green low interest loans and mortgages.
Awareness of heat pumps is only weakly associated with purchase.	Work with retail to provide physical demonstration sites for heat pumps in electrical showrooms.
Installers play a crucial role as developers, designers, partners and consultants. Heat pump performance and satisfaction depends more on installation quality than users' behaviour.	Provide greater investment in capacity and skills-building and in the availability of heat pump installers as partners. Institute longer-term incentives for heat pumps installation to ensure an ongoing market for installation and a diversity of participants.
Advice by a credible messenger is a driver of purchases. However, scepticism of greenwashing stalls purchase decisions in the slower to adopt.	Fund and promote independent, tailored expert advice services which should be well-known and trusted.
There is a gap between the technical performance in measures of efficiency of heat pumps and measures of success that are important to users.	Consider reforming EPC certificates to more accurately reflect home users' heating behaviours in energy use against building fabric. Make home heating surveys part of the buying process as part of a "new normal" akin to other homebuying surveys.

Access the full report at theippo.co.uk

or download using this QR-Code:

Decarbonising Home Energy through Behaviour Change

Report of the UCL EPPI Centre

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Contents

1. Introduction

Changing Home Energy Use is a Social Intervention

The **decarbonisation of homes** by changing the way people heat their homes is **similar** in many ways **to a public health intervention**. It therefore **requires behaviour change** from individuals in different circumstances at varying stages of change or degrees of ambivalence.

A programme to do this will take **different forms and methods of implementation** in different contexts, including **collaboration** with many **different stakeholders** from different sectors and will be determined by and effect systems within systems. Like a public health intervention, the areas where interventions should be targeted are in different system-contexts in which people live, which shape them and are shaped by them (Bronfenbrenner 2000).

The Approach: a Realist Review

The review used a realist approach which sees the individual with their values and beliefs at the centre of a system, with their decisions and behaviours informed by the numerous influences around them: their families, their material circumstances, the communities in which they live, and where they work and the wider economic, political, cultural contexts. This approach is visualised in figure 1, below.

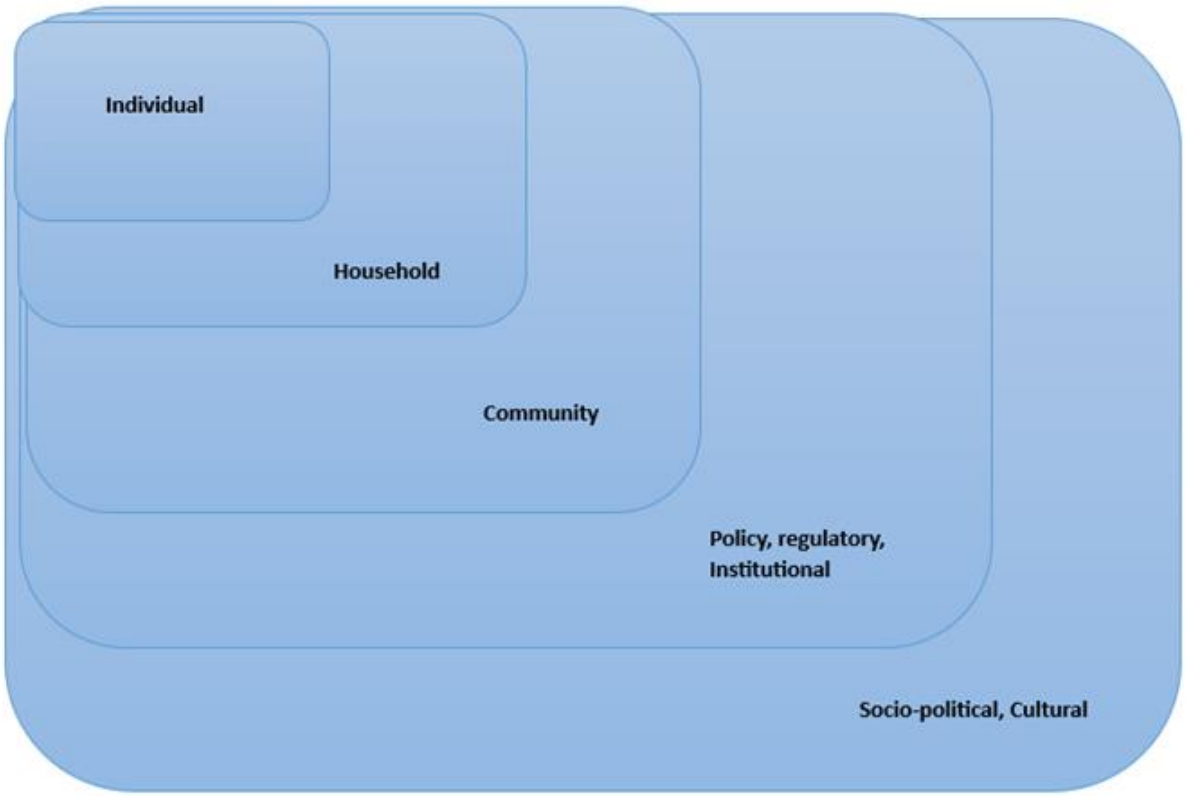


Figure 1. Socioecological framework for decarbonisation of homes

A realist approach to evidence synthesis is helpful where interventions are complex, and highly dependent on context and the actions and decisions taken by people when implementing them in getting to the desired outcomes. A realist review of effectiveness of a programme on a causal pathway from intervention to effect aims to capture what works for whom, under what circumstances, why and how.

The stages of a realist review start with a theory of change of how the interventions is expected to work and unpacking the underlying assumptions. It then populates this with evidence, revising, adapting and developing new theories with new lines of enquiry. Searches for evidence can be iterative, as theories of change develop, and can draw from many disciplines that can inform and enlighten stages in the causal pathway.

Understanding the ways in which **contexts vary** are crucial in understanding how intentions of interventions lead to actions through the resources and decision-making of the actors involved. Interventions are implemented into pre-existing social contexts which in turn can be influential on the final outcomes. Unpacking these relationships helps to understand how to get to intended outcomes and the factors that can intervene along the way (Pawson and Tilley, 1997: 70).

Contexts Shape Decision-Making

In complex social interventions, different actors are embedded in multiple social systems (Pawson et al., 2004). **Contexts** can be **structural**, such as the current state of the economic or institutional structures; **relational**, such as those mediating between different actors in their contracts, expectations and obligations; or they can be **cultural** and **political** such as in social norms, theories, beliefs, values, arguments, and the capacity for **agency** – that is the power to act and to choose and the boundaries of action. **Contexts shape people's decision making, and interventions attempt to**

change these contexts. Through understanding how context interact with mechanisms of action we can better understand how to get to intervention outcomes.

By following this approach, this realist review gives a detailed and rich account of the theoretical and empirical evidence for how a complex intervention should work under different conditions, with different stakeholders, and makes policy recommendations based on these findings.

Using the Com-B Model to Understand Behaviour Change

This review also uses the COM-B model of behaviour change. This approach was developed from a systematic review and synthesis of behaviour change theories and consensus study by more than 30 researchers in health psychology and implementation sciences. Their review identified 33 theories and 128 constructs and formed the basis for a "behavioural change wheel" (BCW)[1] consisting of three concentric circles (see figure 3.)

At the centre of the behaviour change wheel is the behaviour change of the individual, the "B" of the model, and the COM-B model proposes that there are three components to any behaviour change:

- Capability (C),
- Opportunity (O)
- Motivation (M).

To perform a particular behaviour, a person must want or need to carry out the behaviour more than other competing behaviours (M); feel they are both psychologically and physically able to do so (C); and have the social and physical opportunity for the behaviour (O). As each of these components interact, interventions must target one or more of these to deliver and maintain effective behaviour change.

The areas and ways in which interventions can be targeted are described further in the behaviour change wheel, which support the behaviour change conditions. These serve as the intervention or programme functions: interventions can persuade, restrict, restructure, model, enable, train, incentivise or coerce the individual. Policies that support can these programmes include guidelines, environmental/ social planning, communication/ marketing, legislation, service provision, regulation, and fiscal measures.

[1] Michie, S., Van Stralen, M. M., & West, R. (2011). The behaviour change wheel: A new method for characterising and designing behaviour change interventions. Implementation Science, 6(1).https://doi.org/10.1186/1748-5908-6-42

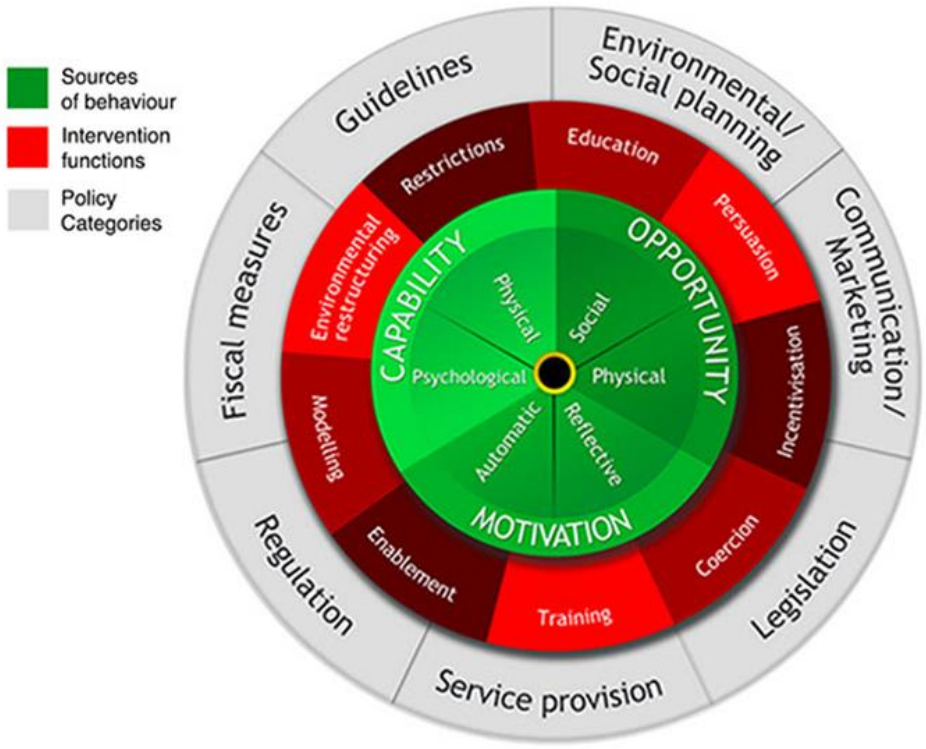
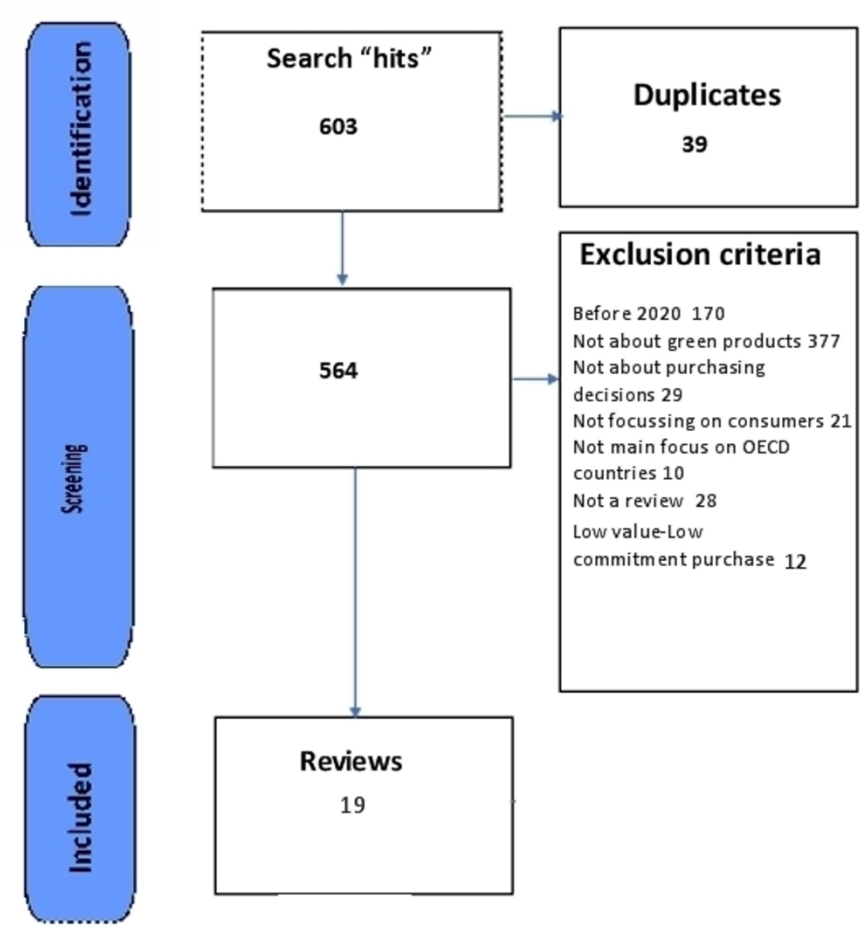


Figure 2. The Behaviour Change Wheel

2. Results of the Review

From the initial results of 603 records identified from bibliographic databases and grey literature that were screened against the inclusion criteria, 10 reviews were included as being focused on high value -high commitment, green purchasing decisions of consumers. These included electric vehicles, sustainable and green homes, home appliances, energy, with the remainder not specified.



C-O-M mechanisms of high-value high-commitment green purchases

We mapped the reviews findings against the COM-B framework for the mechanisms and drivers for green purchases as well as barriers, facilitators and factors that impacted on final outcomes. The correspondence between study and COM-B framework is in the table below. Four (n=4) studies found that all sources of behaviour change were necessary for high value- high commitment green purchases and all the reviews reported that several mechanisms at once were responsible for behaviour change. Green purchases were influenced by factors external to the individual as much as their personal motivations alone.

Study	Green Product	Motivation (automatic)	Motivation (reflective)	Capability (psychological)	Capability (Physical)	Opportunity (physical)	Opportunity (social)	Quality
Nie (2021)	GP	X						+++
Wilke (2021)	BioEc		X	X			X	+++
Zaremohzzabieh (2021)	GP	X	X	X				+++
Zawadzki (2020)	GP	X	X	X				+++
Zhao (2021)	GP	X	X				X	+++
Zhuang (2021)	GP		X				X	+++
Garcia-Salirrosas (2022)	GP	X	X					++
Bryla (2023)	EV	X	X	X	X	X	X	++
Sharma (2023)	GP			X		X		++
Barbu (2022)	GP	X	X	X	X	X	X	-
Kumar (2020)	EV	X	X	X	X	X		-
Caggiano (2022)	FEW			X	X	X	X	-
Chuweni (2022)	Res		X	X			X	-
Singh (2020)	EV	X	X	X	X	X	X	-
Testa (2021)	GP	X	X	X	X	X	X	--
Hazaea (2022)	GP	X	X			X	X	--
Ivanova (2023)	EV	X	X		X	X	X	--
Rashed (2023)	Res	X	X	X		X	X	--
Sharma (2021)	GP	X	X	X			X	--

EV Electric vehicles, GP green products, FEW food-energy-water, BioEc Bioeconomy (food, energy, materials), Res Residential buildings

Common Themes

Within this framework there were common themes that emerged. Within the motivation mechanisms, the drivers for behaviour change included personal ethics, fitting in with green routines, and a sense of moral responsibility. In reflective motivation, themes of drivers to change were the role of a credible messenger, and evaluation and expectations. Psychological capabilities were increased with knowledge, attitudes towards risk, and a sense of resilience and agency. Physical capability depended on

individual buying power, the capacity to make a purchase of this kinds, existing independently of motivations and opportunities.

Social opportunities to change to high value high commitment green products included the availability of marketplaces to engage in and physical opportunities to change required the supporting infrastructures for the new technologies or products. Higher quality studies tended to be about green products more generally and these found less sources of behaviour necessary for behaviour change. Higher value goods, such as electric vehicles and residential homes, tended to be lower quality studies, but also reported more sources of behaviour necessary to make the purchase.

Box 1. Key themes of Contexts-actors-mechanisms-moderators-outcomes

Contexts	Actors	Mechanisms	Moderators	Outcomes
Structural Infrastructure supporting green technology **Culture-Political** Social norms/ identity of environmental concerns Government and policy support **Relational** Buyer-seller Government-citizen Landlord-tenant **Agency** Regulations Economic climate	Buyers Sellers Regulators Technology innovators Investors Government Local authorities Agents Developers	**Problem identification** **Automatic motivation** Personal ethics Green routines Moral responsibility **Reflective motivation** Credible messengers Evaluation and expectations **Psychological Capability** Knowledge is power Risk, resilience and agency **Physical capability** Buying power **Social opportunity** Social space of markets Developing markets **Physical opportunity** Supporting Infrastructure	Scepticism and greenwashing Trust, reputation Beliefs in making a change, self-efficacy Information and advice from purchase experiences	Purchase Satisfaction Post purchase behaviours Raises awareness of green products Develops competitive markets for green products. Increased demand reduces prices Development and innovation of green products

Motivations for green purchases

The first step in this process towards the purchase of a high value, green purchase, is motivation which is activated by some lack, need, want or seeking a solution to a problem. Automatic motivation refers to those personality traits, tendencies, drives, beliefs and values, and self-identity, whereas reflective motivation refers to the evaluative, higher cognitive processes that link intentions to actions.

Automatic motivation

Personal ethics

The most commonly cited motivation for making green purchase lies in the personal ethics of the customer. Concerns for the environment was the strongest predictor of green purchase decisions in most reviews of green purchases and a person's concern

for the environment, for climate change and for environmental degradation, were problems that were believed to be at least partially solved by green purchases (Chuweni 2022) in having a belief in making a difference (Testa 2020) as was the perceived seriousness of the environmental issue (Sharma 2023). One review found an overall effect of environmental concern to customer purchase behaviour was 0.45, with a 95 percent confidence interval ranging from 0.39 to 0.50 (Nie 2021). A theory of Altruism's role in green purchase decision suggests that feelings of both guilt and pride lead people to behave in consistent ways with known personal norms (Hazaea 2022; Sharma 2023). Personality types that were of a nurturing attitude was associated with more concern for the environment and considering the consequences of actions on the environment (Bryla 2023). Only one study considered only personal ethics as a source of behaviour change alone, the remainder of the studies that reported on personal ethics as a driver of high value green purchases also reported other factors in combination with personal ethics.

Green Routines

If people were already engaged in green behaviours, then green purchases were more likely. The Barbur review also found that people who already had "green "habits were more likely associated with adoption of new green behaviours. Experiences of Green habits that were satisfying were self-reinforcing and in turn motivating for adopting further green habits and behaviours (Zawadzki (2020) Another review pointed to "consumer citizenship" that is, the rights and responsibilities such as recycling and waste disposal as indicative of green behaviours (Wilke 2021) . Performing green actions feels meaningful, and acting according to one's self identity increases subjective wellbeing (Zawadzki 2020) Green purchases were associated with high levels of self-congruity – that is when the green brand associations and self-image are aligned, the product becomes symbolic of self-identity (Kumar 2020, Sharma 2023).

Moral responsibility

A high level of moral responsibility for environmental concerns were associated with green purchase motivation in high income countries (but not for developing countries) in (Ivanova 2023). Beliefs in one's duty to society for green, sustainable behaviours was associated with a strong green identity and so people adopt green behaviours as it accords with their self-image. People with tendencies towards altruism, collectivism and social justice also tended to have a strong interest toward environmental concerns (Testa 2021) Green consumption or pro-environmental behaviours was in this sense a pro-social behaviour. (Zhao 2021, Zhuang 2021)

Two reviews also found that having children was associated with green purchases as parents were environmentally concerned for the future, and were further influenced by health and safety claims of the green purchases (Barbu 2020, Nie 2021)

Reflective motivation

Evaluation and expectation

Customers make comparisons of the price against the product's attributes to evaluate the products "worth" overall. Product attributes that could achieve lower operating costs, reduced energy consumption, lower CO2 emissions (Kumar 2020) life improvement (Barbu 2020) and well-being and comfort (Rashed 2023) were motivating factors for purchase. It follows, that customers must believe in the claims of green outcomes, to be persuaded in the value of the investment. Customers are more attracted to a company's credible ecological claims which demonstrate their efforts in corporate social responsibility in their green marketing and practices (Barbu 2020, Garcia-Salirrosas (2022). Trust in products and providers could be enhanced with ecolabels: labels, badges or certificates of green credentials which have been shown to increase brand preference, improves business Image, increases word-of-mouth recommendations, enhances credibility of the green product, increases satisfaction and

brand loyalty, value perception and is influential to getting to purchasing intention for green products (Garcia-Salirrosas 2022).

In Bryla 2023, expensive green purchase considerations like electric vehicles were likely to be better suited to an environmentalists' cost-benefit assessments, as sustainability values were more likely to be influential in their final decision, however a moderator to purchase outcomes was having a corresponding belief in the EVs performance and safety, that is, a belief in the green credentials of the product was a necessary but not sufficient drive for purchase.

Credible messenger

Potential customers must also trust the messenger for the green product claims to be credible. When it came to buying sustainable homes, the Rashed (2023) review found some professional groups more trusted than others by reputation (estate agents were the least trusted and architects were the most trusted as sources of information).

Scepticism about the environmental claims of green products was an important moderator acquired through prior experience and by association towards the credibility of the retailer (Hazaea 2022, Rashed 2023, Sharma 2023) and a perception of brand greenwashing was a barrier to purchase intention (Sharma 2023; Garcia-Salirrosas 2022).

Psychological capability

Knowledge is power

Knowledge forms part of the psychological capability to evaluate and act. Knowledge that was tailored to the individual was important for evaluating the product against alternatives (Caggianao 2022); knowledge through experience was an important predictor of purchase (Ivanova 2023) Indirect knowledge through product awareness and green product knowledge were both important predictors of purchase (Barbu 2020, Hazaea 2022), but knowledge was not necessarily indicated by the level of education (Barbu 2020, Ivanova 2023). A meta-analysis in Zaremohzzabieh (2021) found a strong and statistically significant association between environmental knowledge and consumer attitudes towards green purchases in Environmental knowledge 0.87 into consumer attitudes.

The lack of information and experience of new technologies increased uncertainty about high value high commitment green purchases as well as uncertainly about the environmental benefits (Kumar 2020). Ecolabels and certificates could decrease information asymmetry for buyers that comes with evaluating new technologies, but these consumer tools also need to include measures from the perspective of the end user such as comfort and wellbeing (Rashed 2023). Adoption of new technologies may need additional knowledge and learning that could exclude people who are more technology averse (Testa 2020); having access to knowledge mediated the psychological capability (Wilke 2021).

Risk, resilience and agency

Self-confidence to make decisions and agency to affect desired change was associated with green purchase intentions (Testa 2020). Self-confidence was related to perceived self-resilience against risks (Bryla 2023) Consumer confidence could be increased with the availability of protections against risks in the form of regulations and set rules of conduct (Barbur 2022). Consumer confidence in financial futures were based on evaluations of the wider economy and one’s exposure and resilience to the current economic climate (Bryla 2023) Confidence in any expected financial return on investment was associate with green purchase of “green real estate” in Chuweni 2022) On the other hand, economic uncertainty was a barrier to purchase when this intention was balanced against the high purchase price, long payback period, uncertainty over maintenance and repair infrastructures (Kumar 2020).

Physical capability

Buying power

There was less attention in the reviews paid to the physical capabilities of people to make the green purchase, but when mentioned, the most cited factor was people's financial capacity to make the purchase. Budget constraints was a strong predictive factor in any willingness to buy and their willingness to pay more for green products. A recognition of benefit and willingness to buy is in the context of other competing priorities (Bryla 2023, Kumar 2020). Price is an actual limit to the customers' ability to purchase irrespective of the products' attributes (Testa 2021, Wilke 2021). In the Caggiano (2022) review there was a recognition that energy saving behaviours could be difficult if faced with expensive energy saving equipment as part of the programme.

Opportunities – Social

The social space of markets

Social opportunities represent the external factors in the individual's social world that can influence the decision to purchase high value green products. Market and social factors were influential in household sustainability transitions beyond the attitudes and beliefs of the individual. Studies found that potential customers of high value green purchases who were environmentally aware and had the associate values and beliefs about environmental concerns experienced social and political barriers to purchase (Caggiano 2022).

The market offered social opportunities that were not only concerned with individual values but represented a belonging to a shared social identity of the environmentally conscious (Barbu 2020). Being seen to care enough to invest in a significant environmentally friendly technology represented an opportunity to signal belonging to this social group.

Market development

Value signalling of green goods through media, advertising, and electronic word of mouth (E-WOM) can enhance green purchase intentions (Hazaea 2022, Testa 2023), experiences after purchase can influence post-purchase behaviours, such as whether to recommend such purchases to others. Comments and opinions of peers and social circle were found to be highly influential in creating social pressures around green purchase (Testa 2023). A lack of experience, through a lack of social opportunities for purchase, can create a "recrimination cycle" into markets for new green technologies, where low customer demand due to lack of knowledge for green goods constrains the supply (and keeps prices high), and the low uptake is attributed to their unavailability (Rashed 2023, Testa 2023). Governments could play a role in new markets by stimulating adoption of new technologies with tax and economic incentives (Bryla 2023, Sharma 2023) and reassurances through setting shared standards in the form of eco labels, developing and supporting infrastructures and efforts in increasing awareness of new technologies and market developments (Bryla 2023).

Physical opportunity

Infrastructure

Potential customers expressed concerns that a major investment will not live up to the promised/ expected performance due to factors beyond the customers' control, such as a lack of physical opportunity to exercise that change due to a lack of supporting infrastructure (Kumar 2020).

One example was for electric vehicles customers “range anxiety” as a barrier to purchase, which refers to the concerns that the current infrastructure does not support electric vehicle charging could be a barrier to purchase for people considering electric vehicles.

Experiential learning

The physical opportunity to test or experience the product was influential in making the final decision to purchase high value-high commitment green products (Findrik 2023, Ivanova 2023) Experiential learning through gamification was a relatively new development focusing on competition and virtual experiences to enable energy use behaviour change (Caggiano 2022)

A Theory of change for green purchases

From this analysis of green purchases, we developed our theory of change using the COM-B framework for sources of behaviour change and a theory of a purchase decision process.

While motivation was a necessary condition for behaviour change, it was not sufficient; there first needed to be a problem to solve, a need or want to activate the motivation as a source of behaviour change and this was usually from a strong sense of environmental concern, a sense of personal responsibility combined with a belief that personal action can make a change, or be a solution to the problem. An individual’s capability to act on this belief in the form of knowledge and buying power was also needed. There must also be opportunities to act on these beliefs and enact their capabilities, which may rely on factors outside the control of the individual. Higher value green purchases needed multiple sources of behaviour aligned at each stage of the buying process.

Views and experiences of adopters of decarbonised home heating.

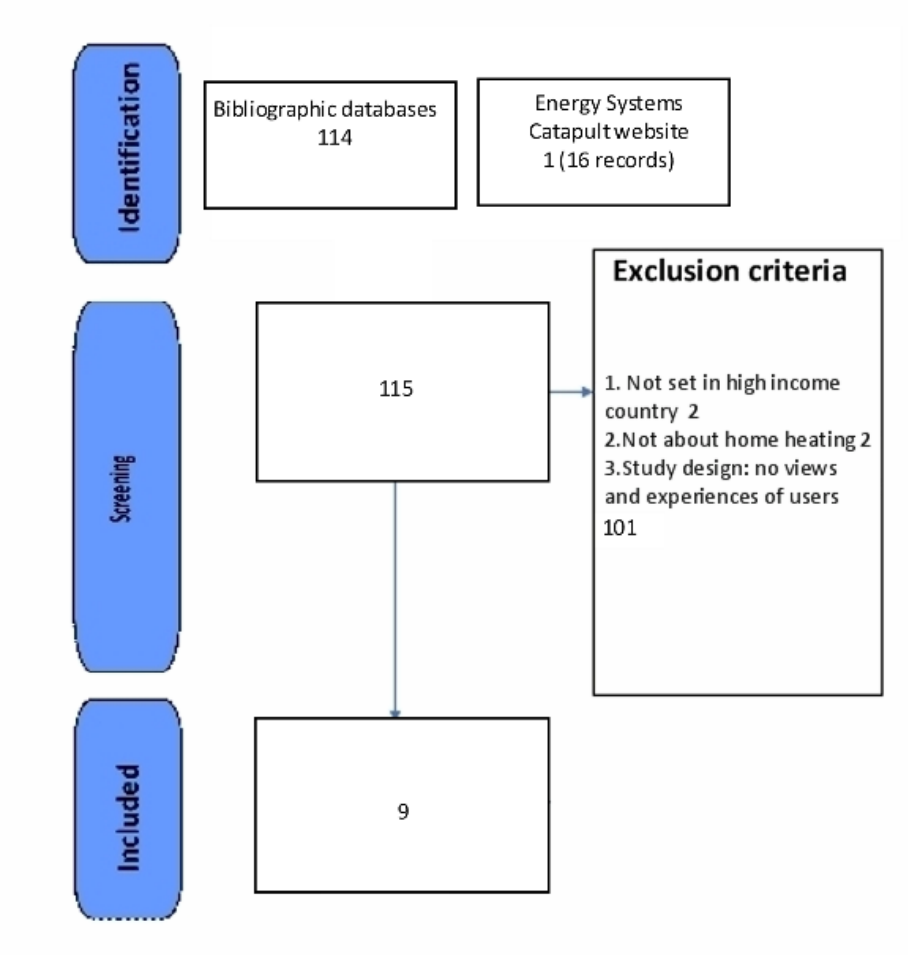
It was not always clear whether the included studies in the reviews measured the views of people who had made the purchase, or if they were measuring the intent to purchase or these purchase phases were presented interchangeably. The difference between getting from values to action, specifically environment values and belief-based intentions to practice or behaviour change, is well known and called the value-action gap (Gadenne et al., 2011), the intention – behaviour gap (Godin et al., 2005, Ozaki, 2011) the attitude-behaviour gap or the belief-behaviour gap (Kollmuss and Agyeman, 2002) . Motivations, capabilities and opportunities may all necessarily be present, but this still does not necessarily guarantee behaviour change.

In the following section we review and synthesise the views experiences of people who have experienced installation of heat pumps in their homes, we examine their experiences against the COM-B framework for green purchases of heat pumps specifically. We focus on heat pumps as the current most accessible alternative to gas and oil heating available to domestic customers at this present time. “Hydrogen ready” boilers are to be launched in the UK 2025, but the hydrogen fuel to run them is not currently available to domestic customers.

For this section we ask the following review questions:

What are the views and experiences of people who have installed heat pumps? What are the COM-Bs associated with decarbonised heating adoption in the UK?

We review 19 case studies from a single UK trial of heat pumps in homes, Electrification of Heat (EoH) demonstration project. In addition to this UK trial, we included a rapid search for empirical studies that included users’ views and experiences of heat pumps from an additional 8 studies



Study characteristics – Heat pump users' views and experiences

Outside of the BEIS demonstration project, participants in the studies of heat pump users' views and experiences were from Finland, Scotland, Switzerland, Canada, Ireland and 2 studies from the United Kingdom. The study design of the included studies were case studies, surveys of users and qualitative interview studies. The small number of studies that include users' perspectives confirms this review project's scoping review of reviews finding that much of the earlier research on heat pumps has focused on the heat pumps' technical performance and the nature and extent of literature on user-technology interactions came later, from 2022 onwards.

Study characteristics - Electrification of Heat trials

The Electrification of Heat demonstration project aimed to install heat pumps in a range of different housing types in different parts of the UK, measuring performance and satisfaction of participants. The project was funded by BEIS and started in Autumn 2020 with first results published in 2021. The recruitment of participants was through purposive, quota sampling from three delivery organisation providers, EoN, OVO and Warmworks in three regions of the UK, it included all housing types and the majority used mains gas heating; the methods and conditions of recruitment varied for the three companies. Exclusions were if the property was listed, was not owned by the resident, did not have Wi-Fi, or did not want to use energy monitoring, was deemed to be vulnerable, or heat demand was too high due to thermal (in)efficiency or the property was too large, out of area for the quota, or the quota was met for that type of property. Some properties were not included because of the higher costs involved in upgrading the property due to heat loss, commonly in solid wall insulation in pre-1919 stone built properties, pre-1991 timber frame properties, or window replacements for single glazed sash windows, but this was a small proportion of those initially invited to participate.

Participants in the trial tended towards the higher income brackets, with a large proportion (at least 35%) of households with a heat pump installed had a household income over £50,000, higher than the UK average where only about 29% of households earn over £50,000 per year before tax and slightly older than the national average. The average cost per property was £14,800 and included the heat pump, additional measures and labour costs. Effectiveness was measured in terms of heat pump performance and customer satisfaction.

All 12 case studies were considered low quality for their study design and relevance to the review as the focus and purpose of the trials was the demonstration of the effectiveness of heat pumps and customer satisfaction rather than a formal evaluation. The case study reports included quotes from participants in the study selected by authors for illustrative purposes and represent a small sample of the whole study.

Study	From	To	Motivation (automatic)	Motivation (reflective)	Capability (psychological)	Capability (Physical)	Opportunity (physical)	Opportunity (social)	quality
EoH (2020) 1940's flats Newcastle	Storage heaters	ASHP, hybrid, GSH	X	X	X	X	X		-
EoH (2020) 1950s mid terrace	Combi gas	ASHP	X		X	X	X		-
EoH (2020) 1950s semi	Combi gas	ASHP	X	X			X		-
EoH (2020) 1960s Semi	Direct electric	ASHP		X	X	X	X	X	-
EoH (2020) 1980's mid terrace	Combi gas	ASHP	X	X	X		X		-
EoH (2020) 2010 detached	Gas	ASHP	X	X	X		X	X	-
EoH (2020) pre 1919 mid terrace	Gas	Hybrid		X	X	X	X	X	-
EoH pre 1919 mid terrace (2022)	Combi gas	ASHP		X	X		X	X	-
									-

Sources of behaviour for Electrification of heat case studies

As we found for the high value high commitment green purchases, behaviour change was activated by multiple of sources. Personal finances and the physical capability to make high value purchases was a major factor in the high value high commitment green purchase COM-B model, but in the Electrification of heat case studies this was not a consideration given that the cost of installation was met by the demonstration project.

The automatic motivation of personal values of environmental and climate change concerns appeared less often than for the high value high commitment green purchases, and while they did feature in most case studies, these values and concerns were combined with the view that their gas boiler would have to be replaced sooner or later, which provided the opportunity and motivation to consider heat pumps as an alternative. At the time of the trial, gas and oil boilers were expected to be phased out by 2025, after which it would be illegal to install in new build properties (but not existing homes) as part of the Future Homes Standards (2019). Marketing and recruitment

materials for the demonstration project also suggested that the benefit of participation included “futureproofing” their homes. [2]

Reflective motivations of participants weighed up the benefits against non-monetary costs (as the consideration of monetary costs had been averted) this included the disruption of having a new type of heating system installed and was often discussed by participants. Disruption was also the most common reason given for non-participation at 47% reasons given for non-participation.

The social capability of needing a developed, competitive marketplace with availability of experienced and knowledgeable installers was critical to the satisfaction of the instal. In these case studies the installer played a critical role as a trusted expert, educator, designer and as a partner in problem solving and featured in almost all the experiences. But again, this experience of the availability of knowledgeable, skilled installers may have been a feature of the demonstration than representative of the UK market currently.

The physical capabilities of the demonstration projects’ homes to install heat pumps were circumvented by the selection criteria to quotas of property types, costs and extent of the install and the experiences of the participants may not be representative of everyone in the UK, particularly for larger homes, poorly insulated homes and private sector rentals, or more complex installations. Cost considerations for the trial providers included the heat pump unit, home adaptations and labour, but not the costs of running or maintenance to the participant after installation. Follow up after installation did not run over a wintertime where one might expect higher energy demand and participants be able to give a full evaluation of cost comparisons.

COMB-B sources of behaviour change in all heat pump users

Motivation automatic

Personal ethics
In the electrification of heat demonstration, the desire to reduce one’s carbon footprint was usually combined with the need to replace the boiler eventually in any case. Disruption was the most often given reason for non-participation, unless there was an imminent need to replace the boiler, suggesting that people could be more tolerant of the disruption but only if there was an imminent problem or need to. Marketing materials often promoted the heat pumps’ green credentials and appealed to potential participants’ personal ethics. The electrification of heat demonstration project recruitment materials promoted the idea that it would be “futureproofing “one's home, as well as the heat pump being free and being environmentally friendly. Marketing materials that promoted the environmental benefits of heat pumps were associated with user product awareness in other case studies (Parrish 2021(. Marketing materials promoted the social and environmental benefits of heat pumps for social housing residents (Calver 2022) but surveys for this group cited costs and comfort and the main reasons for their satisfaction. There were differences in personal ethics as motivations as a sources of behaviour change comparing Finland, where heat pump take up is high, to the UK where it is comparatively lower. For Finland, motivation for heat pump use was primarily about comfort and costs compared to the UK where motivations to change were environmental concerns and government incentives.

[2] Since these case studies, this deadline to gas heating installation in new homes and those off the mains gas grid has been extended to 2035.

Concerns about the environment as a motivating factor and source of behaviour change was not as pronounced as one might expect in other studies. For example, in Bucke 2022 only 53% of the users were concerned about climate change.

Surveys of willingness to pay found users willing to pay more for a home heating systems with high environmental sustainability compared to low compared to a significant non-willingness to pay for high comfort, but only moderate environmental sustainability and moderate installation hassle (Meles 2022). This is likely due to the idea that needs for comfort are already met for most people on gas central heating, so this calculation amounts to paying more for what they already have but getting less for environmentally sustainability and increased installation hassle.

Green routines - Green ambitions
People already engaged in green behaviours, were concerned about climate change or the environment and were open and willing to do more; this was an indication of a greater willingness to pay. This source of behaviour change was reported in the electrification of heat trials but was not mentioned by heat pump users in other studies.

One environmentally concerned resident calculated that, although the amount of energy had been reduced, the costs of energy were considerably higher for the same period. Nevertheless, the resident was said to be delighted that their carbon footprint had been reduced (BEIS, 2020, EoH - flat 2000). Another resident considered the heat pump the next step in their "journey" to reduce their carbon footprint, having already purchased an electric car, installed rooftop solar PV, done insulation upgrades and installed smart heating controls but also noted the disparity in price per unit of energy (BEIS 2020, EoH - 1950s semi), another resident considered installing solar after having the heat pump installed *"Now that we are a more electricity based household, we are also considering adding some solar panels in the future* (BEIS 2020, EoH - pre 1919 mid terrace).

Moral responsibility
Beliefs in a moral responsibility to change heating was less prominent in the case studies than for other green purchases; only one case study participant was said to be enthusiastic that people should consider installing a heat pump (BEIS, 2020).

In one study, some responsibility was suggested to lie outside the capacity of individuals, as individual had limited influence on external and structural domains, and it was the role of the government to "do more" (Bucke 2022) while UK industry respondents suggested the government should do more to raise awareness of heat pumps, and other respondents in the same study said this should be the responsibility of both industry and government working together (Martiskainen, 2021).

Motivation reflective

Credible messengers
Several of the Electrification of heat project case studies stated that government funding of the trials was reassuring and suggested that the demonstration project could be trusted. One participant linked the government involvement in the project to the expected quality of work.
"We wanted to have the work done properly", (EoH, 2020 - pre 1919 mid terrace).

Evaluation and expectations
One case study reported increased energy usage, this had a knock-on effect of increased bills as the electric storage heaters and immersion heater for water did not meet the resident's needs. This case study participants were vulnerable young adults in social housing, and potentially people on a low income. This was also found in Calver (2022) that fuel poor participants who had been underheating their homes felt the greatest impact of increased use of heating, which had not been anticipated. Participants who did mention increased energy costs in the EoH case studies all seemed aware that this was due to the disparity in the charges for types of energy rather than increased energy use. One participant in the case studies pointed out that

they had not yet used the heat pump over winter to compare like for like for bills (BEIS 2020).

For people on electric storage heaters the change to heat pumps was met with greater satisfaction action in terms of comfort and slightly reduced bills, however an unintended consequence of the change from direct electric heating was increased bills for some as they had been underheating their homes before the switch (Calver 2022, Freyre 2022). On the other hand, people switching from electric storage heating also cited non-financial benefits such as the radiators being safer for children and people with limited mobility (not being so hot to touch), a reduction in black mould and condensation and not having to constantly things and "fiddle" with the heating settings. (Calver 2022) The benefits of switching to heap pumps suggested that people who had electric storage heaters were switching from heating that did not meet their needs to a heating system that did, and these benefits were not necessarily unique to heat pumps. Participants who had considered changing from gas boilers to a heat pump had researched the possibility of changing and then decided against it, finding them unaffordable and unsuitable for their property in terms of their looks and size (Bucke 2022).

Measures of heat pump performance from the users' perspective were based on the capability of the heat pump to deliver to needs in terms of costs and comfort (Oikonomou 2022)

Capability (psychological)

Knowledge is power
Participants who had some technical knowledge, for example by working in a related industry, also had low awareness of policy incentives of grants and loans, and for organisations who could give free advice about them e.g. Energy trust (Bucke 2022). People in Canada who were aware of government incentives when prompted were not any more likely to buy a heat pump, compared to people who were aware of incentives without being prompted, suggesting that promoting an awareness of policies and incentives was not always enough to encourage heat pump purchases (Corbett 2023). An existing commitment to finding out more about heat pumps may have explained the difference between promoted and unprompted knowledge and the association with purchase. A lack of awareness of heat pumps – what they were and who they worked was not confined to end users, but also architects, builders, property developers, installers, and policy makers, (Martiskaine 2021).

Risk, resilience and agency
Some people were able to cope with the disruption if installation more than others. People with health issues, with limited mobility, stayed at home most of the time (due to physical and psychological reasons), or with caring responsibilities for children or elderly reported the disruption "challenging", "unsettling" and "overwhelming" (Calver 2022). There was a balance to be struck between informing and unsettling residents unduly, letting people know in advance that there would likely be disruption resulted in some people dropping out. Installers in this study were then instructed to try and present the installation a more positive light.

For people in homes rented from the local authority that were changing from electric storage heaters to heat pumps, there was little agency to express preferences, or know more about the switch *"They didn't ask me what, they just said they were going to come and fit it"* (Calver 2022).

Disruption to the home was a leading reason for non-participation in the Electrification of heat demonstration project, with 47% giving this as a reason for non-participation, unless there was an existing need to replace the heating system in which case, people appeared to be more tolerant of the prospect of some disruption in the home. Even though the heat pump was free, the idea of the level of disruption was still too much for many potential participants. The concerns over increased bills as a reason for non-participation, was a comparatively low proportion of 6%.

In a willingness-to-pay experiment, installation hassle was negative and statistically significant. People who were generally positive about heat pumps, were more likely to have high incomes, and were more likely to install them, still expressed a strong aversion to the installation hassle (Meles 2022)

Noise tolerance and sensitivity

There were mixed reports of level of noise with some saying that they didn't hear it at all while other said it was more noticeable than they had expected. There was no discernible pattern in terms of type of housing for who experienced noise, and this may have been more related to individual sensitivity to noise, tolerances and expectations.

Several of the case studies reported that they were aware of noise from the heat pump, but that this was not a problem for them or their neighbours (BEIS 2020 EoH 2000 flat, EoH 1930s detached, EoH 1930s semi, EoH 1940's flats, EoH 1950s mid terrace)

In some cases, the noise was said to be at a level one got used to (BEIS 2020 EoH 1960s Semi, EoH pre 1919 mid terrace), while one case study stated that the noise was noticeable only when the window was open (BEIS 2020 EoH 1980's mid terrace). One case study said the indoor unit was noisier than expected (BEIS EoH 1950s mid terrace) whilst another had an ultra-quiet model installed (BEIS 2020 EoH pre 1919 mid terrace) and so did not hear anything at all.

In the other studies, few users reported on the experience of noise at all. Noise disruption to neighbours, if not oneself, was a concern in Bucke 2022. In another study many of the participants reported "troublesome" noise from the pumps at some point (Parrish 2021).

A*esthetics and preferences*

The size, look and feel of the heat pump unit was a consideration for some people, but there were no reports of a rejection of the heat pump due to the aesthetics. For some people, the heat pumps one sees abroad on holiday was their only reference, and these heat pumps compared favourably to larger heating and cooling units often seen on top of hotels. (BEIS 2020 EoH 1930s semi, EoH 1950s mid terrace) Some respondents said that the heat pump would be more noticeable in a small garden (BEIS EoH 1930s semi, EoH pre 1919 mid terrace (2022) Another case study mentioned the look in the garden compared to the benefit to the environment, suggesting that the user had to make a balanced calculation of this feature with a corresponding benefit. (BEIS 2020 EoH 1980's mid terrace) and one case study found that being noticeable in the garden was a positive aspect (BEIS 2020 EoH 2010 detached).

The indoor unit was larger than expected for one case study (BEIS EoH 1930s detached)
One case study found that although the radiators were deeper and longer than expected, this was still a good look (BEIS 2020 EoH 1950s mid terrace)

Capability (physical)

Buying power

Where users were considering purchasing heat pumps, the upfront costs and higher bills consistently outweighed beliefs about the environmental benefits (Bucke 2022, Meles 2022). One study that looked at reasons for adoption of heat pump found that the total upfront cost has the largest influence (42%) on the respondents' choice of home heating alternatives, followed by the billing savings attribute (23%). Respondents were willing to pay more for heating system if there were reduced energy bills (Meles

2022). Reasons given to replace heating were said to save money on bills (45%), and second to this was that they would do this to switch to a more environmentally friendly heating system (35%) (BEIS 2020b).
Up-front costs were more of a barrier than perceived increases in running costs for UK users. A perception of increased running costs was given as a reason for non-participation in only a small proportion of respondents in the EoH case studies 6% (BEIS 2020). The motivations of users of heat pumps in Finland were much more oriented around reduced running costs than for users in the UK, who were more likely to be motivated by concerns for the environment and the availability of government subsidy.

Opportunity (Physical)

Supporting Infrastructure

The studies included in this review can be assumed that participants had the physical opportunity to change their heating as their property had the infrastructure to support having heat pumps installed. The case studies from the electrification of Heat demonstration project represent a small sample of those people who were originally recruited, and at least some of these were triaged out of the sample due to physical constraints to the installation. Nearly all of the participants in this demonstration project had adaptation in their homes to install the heat pumps, and these costs were met by the trial providers. Often, this was replacement of radiators, changing pipework to wider gauge pipes, but adaptations also included partial retrofit of radiators and pipework, fitting an ultra-quiet model installing hot water tanks, installing heat batteries where there was limited space, hiding indoor units in specially built cupboards, acoustic, noise reduction strategies. At least one case study changed from the original plan of installing a heat pump to a hybrid because of space constraints (BEIS 2020 EoH pre 1919 mid terrace). Several homes in the electrification of heat demonstration project had a heat battery installed due to space constraints many of which were flats that lacked space for a hot water cylinder (LCP data 2020).

Dissatisfaction was usually associated with the quality of the installation rather than the heat pump itself. Customer examples of dissatisfaction statements were “higher energy consumption than expected”, “bad setting”, “noise”, “cold indoor temperature”, “leakages”, “not enough hot water”, “air in the radiators” (Freyre 2021)

Adaptation and personalisation

Some users said they wanted greater controls over settings, but heat pumps operate in quite a different way than gas boilers, and it was not always clear that this was understood by people. Some case studies reported on programming the controls for flexible tariffs, but they also experienced challenges in doing so (BEIS 2020). Some participants described interactions with the heat pumps and settings in similar ways to the ways one could control a gas boiler such as controlling when it comes on when they are out all day at work (BEIS 2020 EoH 1940's flats), one couple saying that they find the system so easy to “turn off and on” they haven't yet used the timer (BEIS 2020 EoH 1950s mid terrace) while another resident says that he no longer has to use a timer because the thermostat automatically turn the heating off and on base on his desired temperature (BEIS EoH 1960s Semi).

Opportunity (social)
Social space of markets
Successful installation, and customer satisfaction of heat pumps was dependant on the geographical availability, and the extent of engineer skills and soft customer facing skills of the installers.
The availability of skilled and expert installers were critical to the success of the Electrification of heat demonstration projects and the installers fulfilled several roles and skills in the process apart from installation, this Included design and configuration (BEIS 2020 EoH 1950s semi) minimising disruption to home life during the installation (BEIS

2020 EoH 1950s semi, EoH 1980's mid terrace, EoH pre 1919 mid terrace) leaving everything clean and tidy after them (EoH (2020) pre 1919 mid terrace) worked with users to solve problems as they arose such as mitigations to noise (BEIS 2020 EoH 1950s mid terrace, EoH 1950s semi), informing customers of the process (BEIS2020 EoH 1960s Sem) giving reassurance with advice and suggestions (BEIS 2020 EoH 1930s semi, EoH (2020) pre 1919 mid terrace) and making the resident an equal partner in the design and decision-making (EoH (2020) 1940's flats) were all commented on and valued by participants.

Outside of the demonstration project, experiences with the availability of installers were more mixed. Installers fulfilled the role of trainers and educators for many participants, but users didn't always interact with the Heat pump system as intended. In one case study. The engineers found that people were not confident in changing their settings, even though they had been shown how When following up to requests to change home heating setting, they found the unit still on factory settings. (Calver 2022). There could be difficulties in sourcing engineers in remote areas (Bucke 2022) and there were delays to installation due to supply chain issues in the Electrification of heating demonstration projects causing delays of weeks, sometimes months which could be frustrating for residents (BEIS 2020 EoH 1940's flats) . Although at least some of the disruption in the demonstration project was caused by timing and restrictions of the Covid 19 pandemic.

For residents who were dissatisfied with their installation pointed to installers not having the knowledge or confidence in the technology, including installation and setting and were not able to answer residents' questions on how to change settings and this reduced confidence in the ability of the installer. In the same study, people who were satisfied with the installation were keen to recommend to others, and conversely, equally as eager to tell people about a poor installation experience. (Freyre 2021). In a comparison between Finland and the UK, the training for UK installers was considered limited, mainly due to the lack of demand for heat pump holding down incentives for small to medium business to invest in the education and training of new installers. (Martiskainen 2021)

Summary

For potential customers of heat pumps, the beginning of their purchasing journey begins with an identification of a problem and/ or need to set in motion a motivation mechanism of change. There needs to be an awareness of heat pumps in the first instance as a potential solution, followed by a period seeking out more specific and relevant information to evaluate. Heat pumps and insulation are high cost-high commitment purchases, but they are also a new technology that few people have direct experience of and are significantly different from the technology that they are replacing. In the case of the Electrification of heat trials case studies, some of this purchase decision process has been circumvented by most of the participants having been approached and recruited to participate in the trial and arguably the most significant consideration of costs is also bypassed as the unit and installation is provided at no cost to the participant as part of the trial.

3. The Context in the UK Nations and Regions

The next section explores the current structural, relational, cultural-political contexts and the UK policy incentives and interventions that intent to alter these contexts and systems in which people make their decisions, and the mechanisms of change as the sources of behaviour. We consider the potential threats to policy incentives and interventions in how these contexts and moderators to these mechanisms can influence final outcomes. We also compare key contexts and indicators in selected European countries of similar economies and climates.

What is the current UK and region contexts for the decarbonisation of homes? What are the aims and intended outcomes, format and what functions the policy interventions?

Contexts	**UK, England and Wales Intervention** s	**Actors**	**Mechanisms**	**Moderators**	**Proximal Outcomes**	**Distal outcomes**
Structural : current domestic heating sources- Oil, Gas, Electric Electricity production mix- Gas, coal, wind, nuclear, solar National grid capacity Dwelling stock quality and condition **Cultural-political** Desire for home ownership Population density Target to achieve net Zero Energy policies Cost of living **Relational** Government-citizen Homeowner-mortgage bank-Insurer Landlord-tenant Resident-local authority **C**ompetitive Electricity markets **Agency**	Boiler Upgrade scheme (BUS) England, Wales Eligibility £5000 for an air source heat pump or Biomass (if off gas mains) or £6000 for ground source, up to 45kWth, excludes hybrids **Overlapping intervention** UK wide ECO+ Retrofitting and replacement gas boilers heating Broken heating, 1 time central heating Insulation with gas boilers People living in homes with an EPC Rating of D or below and living in lower council tax bands. OR low income group Aim: to reduce fuel poverty, reduce carbon emissions by reducing energy demand Some costs met by suppliers	Resident homeowners Private landlords MCS certified Installers Grant application administrators Local authority Regulators District network operators	Activates **physical Capability** mechanism by Increasing *buying power* Increases **Social opportunities** By *developing markets* **Automatic motivation** Presented and described as low carbon, clean heat Post purchase behaviour informs future participants **Reflective motivation** awareness of low carbon heating. Experiences of heat pumps informs *evaluation and expectations* against alternatives. Activates *credibility of the messenger*- through the support of government and accreditation of installers. **<u>FROM PILOT PHASE</u>** Evaluation of alternatives purchasing phase: **Motivation – reflective** Individualised advice and tailored	Insulation of home, EPC- no outstanding recommendations for loft or cavity wall insulation. Date of home (pre-1930 as single wall) Pipework Radiators Size of home availability of electricity from carbon-free renewable energy to reduce carbon emissions from switch knowledge and skills of the participating installers Degree of trust in Government (Microgeneration, Certification Scheme (MCS) standards.) Scepticism/ Greenwashing Availability of participating installers in locality Proficiency of new users with the system	Take up of grant Scale of take up of grants Satisfaction with heat pumps Reduces carbon emissions by household Increases public awareness of low carbon heating Improved air quality in the home **Rebound effects** Supplemental heating from Wood burners **Negative outcomes** Unexpected Energy bill increases Lack of knowledge transfer to subsequent users Poor experiences and dissatisfaction capture public attention.	Reduces carbon emissions Develops low carbon markets for Heat pumps Increased demand reduces unit costs **Negative outcomes** Guaranteed business reduces competition and quality of services SME's cannot compete with incumbents and withdraw from the market- reduces competition Long wait times to access alternative home heating due to limited market Increased electricity demand increases energy prices due to grid constraints

Economic climate Regulation Energy security			information and messaging			

4. Factors Influencing the Success of Policy Interventions

Factors – Contexts: homes with different forms of heating

Homes on mains gas

Most people (80%) in England and Wales are on mains gas (ONS 2022), which is currently 3x cheaper than electricity. Gas central heating systems are highly effective at heating homes, even poorly insulated ones. As a result, it may be difficult persuade people of a need to change based on a financial cost benefit calculation as they will be the least likely of the three main heating types to see cost savings from switching to electric heating. The lifespan of a well-maintained gas boiler is around 15-20 years so the window of opportunity when the user has a need to consider alternatives is a small one. A BEIS survey of public attitudes asked people what their reasons would be for changing their home heating system and 55% said this would be if their current system needed replacing or was deteriorating (55%) with only 21% saying they would consider changing their heating system whilst it as still working (a further 20% did not have a choice as they rented) (BEIS 2020) Replacement alternatives to gas central heating cost considerably more and the date to end the installation of gas boilers in new homes has been postponed to 2035.

This arrangement of one dominant mode of energy provider is particular to the UK compared to other countries where take up of heat pumps has been more successful, such as in Finland. The starting points for transition to heat pumps for Finland was from diversified modes of domestic energy sources such as oil, wood and district heating; for Sweden this was a transition from oil, which was and is far less common in the UK.

This contrast can be seen in the different motivations for heat pump purchasers in Finland and the UK, with purchasers in Finland being motivated by reduced running costs and comfort compared to motivations in the UK of environmental concerns and the availability of government subsidy. The differences of motivations reflect diverse starting points of the two countries, with a Finland user changing from solid fuels to a more efficient and lower energy using heat pump, compared to the UK switching from an effective, (if not efficient) and comparatively cheap to run gas central heating system. In addition, heat pumps are not usually the sole source of home heating for homes in Finland with most homes with a stove for burning wood for supplemental heating or home saunas.

Activating motivation to change for people with a gas burning heating system to a low carbon one will likely need to appeal to motivations of personal ethics of concerns for the environment and a strong desire to reduce carbon footprint as well as evaluation that there may be a future need if gas central heating are to be superseded by low carbon alternatives and a reduction in, or help with upfront costs.

There are barriers for people on mains gas, who privately rent but who are motivated by environmental concerns and are willing to pay, as they will need permission from the landlord for any major changes to the property. Tenants who live in homes that do not have central heating may, with the permission of their landlord, apply for gas central heating grant under the ECO4/ ECO+ scheme but this would be for a new gas central heating system

People who rent their homes privately tend to be younger and stay less time in their homes before moving on. As heat pumps are not easily portable, private renters are unlikely to wish to make such an investment for the benefit of the landlord's property. On the other hand, there is little incentive for landlords to replace one working system with another unless strongly motivated by their personal ethics and rationalising that heat pumps will become the norm rather than exception in the future and will add the property values and its desirability for rent and/ or investment. Any requirement to retrofit rental homes with energy efficiency measures could make new build homes more incentive an investment compared to retrofitting older homes. However, the requirement and deadline for landlords to bring their properties up to an energy efficiency standard of C or above by 2028 has also been postponed.

Homes that run on LPG and solid fuels

For people with LPG or oil, there may be a greater motivation to change their heating compared to mains gas as they will already be paying more for their heating. For people on these types of heating, environmental concerns, the promise of costs savings and the improved efficiency and performance may align to activate their motivation to change. Many homes off-main grid tend to be older, in rural locations and built with traditional methods (single, solid wall construction), but few homeowners of these types of property will be eligible for ECO+ and will need to meet the cost of insulation themselves. Even a high take up of electric heating from this group may not achieve the desired outcomes of reduced carbon from homes as overall, they are responsible for a small proportion of the GHG emissions from domestic heating.

Homes that run electric heating systems

Heating systems that use electric are almost all storage heating, which charges heaters off peak at nighttime to use cheaper energy to discharge heat during the day. OFGEM (the UK regulator) reports that just over half of all non-gas households use electricity as their primary heating source (OFGEM). Electric storage heaters tend to be less popular with their users (OFGEM Insights) compared to other heating sources as they are often inadequate at meeting needs for comfort of warmth or the desired amount of hot water. Homes that run on electric are more often on lower incomes and more likely to be defined as fuel poor, in social housing or in the private sector. The fewer households that use direct electric heating are more likely to be in the private sector than in social housing. Users of electric heating are already familiar with green routines in time of use tariffs and would benefit from the greater efficiencies of heat pumps. However, people may increase their energy use because of the improved efficiency and effectiveness of heat pumps in heating and availability of hot water, this may have the negative outcomes of increasing bills for vulnerable groups and fuel poor.

Homes with no central heating

Home with no heating system at all represent a very small proportion of the UK homes at around 1% of housing stock (Housing census 2021). This group of households are eligible for the UK ECO+ scheme for homeowners and private renters if they have never had a central heating system before, are on certain kinds of benefits or their application approved by the local council. This scheme offers a grant to cover the costs of a full, gas central heating system. Homes with no central heating represent a potential increase in homes with gas central heating if households take up the grant.

Dwelling stock- condition and quality

The most recent Government incentives for insulation (ECO+) eligibility has been extended to homes with an energy efficiency rating (EER) at D-G and in lower council tax bands as well as to low-income groups.

In the UK, people on middle to high incomes are more likely to be in EPC Band D and below. Only 39% resident homeowners were in EPC Band C and above compared to socially rented homes which were amongst the most energy efficient. Housing association and local authority dwellings were more likely to be in band C and above (65% and 59%, respectively).

It costs more on average to improve the energy efficiency rating for owner occupied and privately rented homes than for local authority and housing association homes (on average £7,872 and £7,430, greater than the £5,345 and £5,158 respectively) (English Housing Survey 2020).

Therefore, the populations that fall between these two interventions (in England and Wales, and UK wide) are people in middle and higher incomes that live in larger or higher value (higher council tax banded), older, less energy efficient homes that also produce the most carbon emissions and represents the majority of the dwelling stock in the UK (ONS 2022).

Relational contexts and impacts on outcomes

Relational contexts between different actors influence and constraint's people's capacity for action, bounded by rules, expectations and contractual obligations.

Between buyer and seller: Information asymmetry

Heat pumps operate very differently to what most people are familiar with, so while it is suggested that customers "shop around" is not always easy to know what to shop around for, there are currently limited numbers of installers available to ask for advice, and no independent service currently that can tailor advice to individual circumstances. This may impact on potential users' capability to evaluate the cost benefits of heat pumps against alternatives at the information seeking stage.

Evaluation, Expectations

There may be considerable after-care needed to fine tune the system to work properly. People reported needing support to understand how to use the system.

The review of views and experiences showed considerable trust in schemes that were run by the government, as this was seen as an endorsement and Certification of service providers acted as a kind of guarantee. On the other hand, the number of schemes that have been rolled out then withdrawn, or paused has been confusing to potential adopters. After the "early adopters", the "early majority" would need the new technology to prove itself first and mixed messages from trusted institutions may encourage them to wait a little longer.

There was a corresponding view that individuals were not the only ones responsible for change, did not have the capacity to decarbonise alone and the government should "do more" to address wider structural, causes of carbon emissions and their solutions (Bucke 2022)

Factors - Moderators

Our COM-B framework synthesis of green purchases identified several moderators to policy interventions to decarbonise homes. These factors intervene on the causal pathway from intervention to outcome. These factors can affect the direction of effect, or the strength of the outcome of reducing carbon emissions from home in the short term and the UK reaching net Zero by 2035. These were the scale of take up, evaluation and against alternatives (insulation), scepticism and competitive marketplace.

Scale of take up

The numbers of people meeting the eligibility criteria of being resident homeowners or private landlords in well insulated homes may be too few to reduce carbon emissions from domestic homes enough to meet the net zero targets.

Evaluation against alternatives

The costs of insulation emerge as a competing alternative to low carbon heating for reducing energy demand and lowering carbon emissions. Improved insulation can reduce costs by reducing home energy demand to reach the same level of heating and comfort. Doing both, insulation and switching to electric heating, would benefit both the householder and the power system, in that the increase of demand for electric power from the grid would be managed or reduced by each home. However, the costs to households of doing both can be prohibitive and are greater for homes with greater needs.

Scepticism

The eligibility for the Boiler upgrade scheme is that homes have an EPC certificate issued in the last 10 years which did not have any recommendations for loft or cavity wall insulation. Proposals from the Department for Energy Security and Net Zero suggest that removing this stipulation will make the application simpler and encourage more applicants. Removing this stipulation may encourage more applicants, but as heat pumps operate at lesser intensity and at steadier temperatures than gas and oil, there is some agreement that adequate insulation is necessary to ensure heating at a comparable level of comfort, achieve optimal efficiency that is, without having to increase the size, upfront costs and running costs of the heat pump. The risk of removing this condition is that heat pumps installed without adequate insulation will create poor experiences and a reputational risk to the new technology. On the other hand, information that is tailored to individual circumstances, through individual home heat loss surveys, the use of data about similar properties and circumstances can enable the user to assess and evaluate more accurately their needs and environmental, climate change goals.

Scepticism in the electrification of home heating may increase if is not part of a wider programme to decarbonise other sectors. The belief in the efficacy of action to decarbonise home heating by switching domestic heating to electric, may be eroded without a corresponding increase in production of electricity by clean and renewable fuels.

Factors - Mechanisms

Mechanisms as moderators

We also found several mechanisms that were not overtly targeted by current policy interventions that we identified in the framework synthesis. These mechanisms were increasing psychological capacity through knowledge, addressing people's evaluations of risk, and their resilience and agency, increasing people's physical opportunities to change through supporting infrastructure.

Psychological capability

Knowledge is power

Awareness of heat pumps in the general UK population was low, as of 2021 the BEIS public attitudes tracker found that 57% of consumers had some awareness of heat pumps, and only 4% felt they knew a lot about them. People were more likely to be aware of solar renewable heating than other kinds of renewable heating systems (84%) (BEIS 2020). One survey found that awareness of independent and free advisory services who provide knowledge and advice was low, even for participants with some technological knowledge (Bucke 2022).

In the participant recruitment survey for the electrification of heat demonstration project, awareness of heat pumps was higher and more evenly spready across 5 levels of awareness from no prior awareness at all (17%) to extremely knowledgeable (13%), with trial participants tending to be more knowledgeable that the general population.

In other European countries similar in climate and domestic energy mix, such as Germany, rising sales has been attributed to increased awareness in the general population of the need to change to climate-friendly, efficient heating (BWP 2023), however the proportion of retrofits has slowed to below target levels.

In the UK, the Boiler replacement scheme (which replaced the Domestic Renewable Heat Incentive (DRHI), with an upfront payment rather than a repayment over time) was poorly promoted with more homeowners and tenants having heard of the previous scheme (42% compared to the one that replaced it 22%). This lack of awareness did not seem to be due to a lack of interest or agreement that the government should play a role, as the same report shows that nearly two thirds of people felt that the "government should help with funding or subsidising energy efficiency measures (Kingfisher 2022)

Risk, resilience and agency

For potential purchasers of heat pumps the significant upfront costs for a new technology represents risk. There are few opportunities to see a heat pump working and little opportunity to try heat pumps before purchase. Residents' awareness of organisations that could provide advice was reported to be low, even in people with some knowledge about alternative heating systems (Bucke 2022)
In the sources of behaviour change for high value high commitment green purchases, risk could be assessed in an anticipated return on investment. For participants in the Electrification of heat demonstration project, the return on investment was often expressed as "futureproofing" their homes, which was also included in the recruitment marketing materials as a benefit of taking part. This view was in a context of UK policy commitment to phasing out of gas boilers for new properties. In one case study the resident took this to mean spare parts for the old gas boiler would become more difficult

to get hold of (BEIS 2020 EoH - 1930s detached) while others explicitly saw the future as one without gas as the main source of heating "*All houses are going to convert to low carbon heating technologies at some point – we've future proofed our home"* (BEIS 2020 EoH - pre 1919 mid terrace).

Physical opportunity

Infrastructure

The experiences of people who had heat pumps installed as part of a UK wide trial showed that almost all homes required adaptations including changing pipework to wider bore, larger radiators fitted, noise mitigations or adaptations due to lack of space.

People are more willing to accommodate the disruption if there is an imminent need to replace the current heating system, such as "when the current one breaks down or starts to deteriorate" 55% compared to 19% who would consider replacing a working system (BEIS 2020) , are informed in advance of what to expect (BEIS 2020) , or are able to vacate the property while the work is going on (BEIS 2020, Calver 2022). However, this may not be an option for everyone, particularly households with health issues, families with young children and elderly occupants (Calver 2022)

Disruption may be reduced by increasing the insulation of homes so that heat pumps do not have to work harder to compensate for heat loss. Hybrid systems offer a midway choice between all electric heat pumps and all gas retaining the gas hot water functions and requiring less disruption for installation as much of the infrastructure remains the same while retaining the option to upgrade to fully electric at some point in the future.

5. International Comparisons

The following section compares contexts of key home heating and national energy indicators, polices and incentives for selected European countries of similar economies and climates.

Country	Energy characteristics	Residential characteristics	Access to resources characteristics	Policy contexts	Heat pump penetration
Finland	**Energy Characteristics** **Main fuel for heating** - In 1970, 90% of its space heating supply came from timber and oil. District heating most, accounted for 40 per cent of the supply mix, with electricity 21 per cent, biomass 21 per cent, oil 11 per cent, heat pumps 6 per cent, and gas only 1 per cent. **Energy production mix** - Oil 24% Gas 7% Nuclear 19% Coal + others 13% Renewables 38% **Per capita Carbon** - 9.31 **Per capita carbon ranking** ranking - 57	**Residential characteristics** **Home energy Loss** - the average consumption level of buildings completed in the 1960s is 195 kWh/m2 , while the figure for those completed in the 2010s is half of this, or 100kWh/m2 . **Age of homes** - Market Pre - 1946 1946 - 1980 1980 - 2000 Post - 2000, 9.6 48.7 29.7 10.7 **Quality of dwelling stock** Housing stock, apartment 47%, single family house, 38%, row house 13% owner occupancy 62%, state subsidised rental 11%, free market rental 23%, right of occupancy 2% other 2%	**access to resources characteristics** **House price to income** - Price to Income Ratio: 7.93 Mortgage as Percentage of Income: 51.12% Loan Affordability Index: 1.96 **Residential energy costs** - Domestic electricity prices in the IEA including taxes pence per kw 19.16 **Home ownership** - 69.50 percent in 2022 from 70.30 percent in 2021.	**Policies and incentives** **Type of incentive** - Grants and tax deductions Up to €4,000. In 2022, tax deduction for oil burner replacement up to 60% and max €2,400. 45 to 60% of renovations and heat pump installations are also tax deductible. **End date to Gas?** Yes [info] In accordance with the Act approved in 2019, coal-fired power and heating generation will be banned as of 1 May 2029. Since 2014, heat pumps must be installed in every new home, while a government subsidy covers up to 20% of the costs of switching:	**Heat pump take up** **Penetration Heat pumps in home**s - Heat pumps per 100,000 people 24,159 1.4 million heat pumps already provide about 20 percent of heating Note: “To avoid damage, the air source heat pump should not be used as the sole source of heating in winter, as they can freeze easily.
France	**Energy Characteristics** **Main fuel for heating** - Gas 34%, Oil (+ kerosene, bottled gas) 24%, Solid (coal, wood) 4%, Electricity 28%, District 10% **Energy production mix** - Oil 29% Gas 16% Nuclear 42% Coal + others 2% Renewables 11% **Per capita Carbon** - 5.18 **Per capita carbon ranking** ranking - 19	**Residential characteristics** **Home energy Loss** - Home temperature loss after 5 hours (with temperature of 20 °C inside and 0 °C outside) 2.5 percentage stating they are unable to keep their home adequately warm 4.8% **Age of homes** - Market Pre - 1946 1946 - 1980 1980 - 2000 Post - 2000 28.7 37.0 23.9 10.4	**access to resources characteristics** **House price to income** - Housing overburden rate comparison (2020, Eurostat) 5.6% Price to Income Ratio: 10.87 Mortgage as Percentage of Income: 72.04% Loan Affordability Index: 1.39 **Residential energy costs** - Domestic electricity prices in the IEA including taxes 2022 pence per kw 17.63 **Home ownership** - 64% in 2020	**Policies and incentives** **Type of incentive** - New building: No grants Renovation: Grants +low VAT5,5% for hydraulic HPs –/!\ ATA till VAT 20% Energy efficiency subsidy scheme Building codes and standards Carbon price Existing ban on fossil fuel heating **End date to Gas?** Yes	**Heat pump take up** **Penetration Heat pumps in home**s - Heat pumps per 100,000 people 5,815
Germany	**Energy Characteristics** **Main fuel for heating** - Gas (piped), 35%, Oil (+ kerosene, bottled gas) 35%, Solid (coal, wood) 4%, Electricity 16%, District 10% **Energy production mix**	**Residential characteristics** **Home energy Loss** - Home temperature loss after 5 hours (with temperature of 20 °C inside and 0 °C outside) 1	**access to resources characteristics** **House price to income** - Price to Income Ratio: 9.17 Mortgage as Percentage of Income: 64.35% Loan	**Policies and incentives** **Type of incentive** - Grants ATA €15,000. Up to 5%. Energy efficiency subsidy scheme Carbon	**Heat pump take up** Penetration Heat pumps in homes - Heat pumps per 100,000 people 1,962

	- Oil 34% Gas 27% Nuclear 6% Coal + others 17% Renewables 16% **Per capita Carbon** - 9.42 **Per capita carbon ranking** ranking - 6	**Age of homes** - Market Pre - 1946 1946 - 1980 1980 - 2000 Post - 2000 24.3 46.5 23.1 6.1 **Quality of dwelling stock** - housing built before 1946 Germany (24%) sub-standard homes : 12.0%	Affordability Index: 1.55 people living in households that are paying more than 40% of their income on housing – known as overburden – (9.0%). **Residential energy costs** - Domestic electricity prices in the IEA including taxes 2022 pence per kw 28.31 **Home ownership** - 49.5%	price # Existing ban on fossil fuel heating From 2023 to 2030. Up to 25% for heat pump. 5% bonus for GHSP. 10% for replacement of fossil fuel boiler. ATW €15,000. GSHP €18,000. **End date to Gas?** Yes existing ban on fossil fuel heating	
Ireland	**Energy Characteristics** **Main fuel for heating** "Natural gas was the main home heating fuel, but its use varied widely between urban households (53%) and rural households (4%). In contrast, 53% of rural households used kerosene as their main heating fuel compared with 21% of urban households. **Energy production mix** - Oil 45% Gas 35% Nuclear Coal + others 9% Renewables 12% **Per capita Carbon** - 8.29 **Per capita carbon ranking** ranking - 68	**Residential characteristics** **Home energy Loss** - Ireland's housing stock has been identified as being amongst the least energy efficient in Northern Europe. - A study of Ireland's housing highlights the dominance of detached houses (43%), 72% of which are rurally located and are predominantly heated with fuel oil. Around 26% of households living in rented properties used electricity as their main heating source compared with 7% of households in owner-occupied properties. **Age of homes** - Pre - 1946 1946 - 1980 1980 - 2000 Post - 2000 13.3 22.9 20.7 22.0	**access to resources characteristics** **House price to income** - Price to Income Ratio: 7.39 Mortgage as Percentage of Income: 54.81% Loan Affordability Index: 1.82 **Residential energy costs** - Domestic electricity prices in the IEA including taxes 2022 pence per kw 25.13 **Home ownership** - Ireland averaged 72.83 percent from 2003 until 2022	**Policies and incentives** **Type of incentive** - up to €3,500 for an air-to-air heat pump, or €6,500 for an air-to-water heat pump. The first step to getting your heat pump grant is a Technical Assessment Government funded schemes have been introduced to incentivise the uptake of thermal retrofit measures in the domestic Irish market **End date to Gas?** Yes The installation of oil burners will be banned in all new builds in Ireland, and from 2025, the installation of all gas burners will be banned.	**Heat pump take up** Penetration Heat pumps in homes - Heat pumps per 100,000 people 1,209
Netherlands	**Energy Characteristics** **Main fuel for heating** - natural gas accounted for 90% of residential heating demand, **Energy production mix** - Oil 36% Gas 46% Nuclear 2% Coal + others 7% Renewables 9% **Per capita Carbon** - 9.54 **Per capita carbon ranking** ranking - 33	**Residential characteristics** **Home energy Loss** - Home temperature loss after 5 hours (with temperature of 20 °C inside and 0 °C outside) 2.4 **Age of homes** - Market Pre - 1946 1946 - 1980 1980 - 2000 Post - 2000 18.9 41.9 26.4 9.5	**access to resources characteristics** **House price to income** - Price to Income Ratio: 6.63 Mortgage as Percentage of Income: 45.97% Loan Affordability Index: 2.18 **Residential energy costs** - Domestic electricity prices in the IEA including taxes 2022 pence per kw 40.11	**Policies and incentives** **Type of incentive** - Grants, ATW €1,950 – 3,750. Subsidies have been extended beyond 70 kW to max. 400 kW in 2023. Carbon price From 1 January 2022. GSHP €3,750 – 5,100. HHP €1,950 – 3,000. Other policies The Dutch Hydrogen Strategy and Green Gas Roadmap	**Heat pump take up** Penetration Heat pumps in homes - Heat pumps per 100,000 people 2,392

				define plans to accelerate large-scale production and use of low-carbon hydrogen, and a variety of bioenergy-based gases, including biomethane. **End date to Gas?** Yes he Dutch cabinet has issued a ban that from 2026 homeowners must install at least one hybrid heat pump when replacing central heating electric heating system pump or connection to the heating network	
Norway	**Energy Characteristics** **Main fuel for heating** - electricity (85%), 11% of heat comes from district heating, with municipal waste the primary source of fuel (60%) Gas 1%, 2% other, 1% biofuels **Energy production mix** - Oil 31% Gas 16% Nuclear Coal + others 4% Renewables 48% **Per capita Carbon** - 8.30 **Per capita carbon ranking** ranking - 64	**Residential characteristics** **Home energy Loss** - Home temperature loss after 5 hours (with temperature of 20 °C inside and 0 °C outside) 0.9 **Age of homes** - Market Pre - 1946 1946 - 1980 1980 - 2000 Post - 2000	**access to resources characteristics** **House price to income** - Price to Income Ratio: 8.22 Mortgage as Percentage of Income: 58.30% Loan Affordability Index: 1.72 **Residential energy costs** - Domestic electricity prices in the IEA including taxes 2022 pence per kw 25.17	**Policies and incentives** **Type of incentive** - Grants, Up to NOK 10,000 (€1,000). Bonus introduced in 2022 for combination of brine-to-water-heat pump, accumulator tank, and water-borne heating system NOK 15,000 (€1,500). Subsidies for new buildings since there is no incentive for heat pumps in the building regulations. Carbon price Existing ban on fossil fuel heating Subsidies for many years, no end date given **End date to Gas?** Yes [info] *existing ban on fossil fuels*.	**Heat pump take up** Penetration Heat pumps in homes - Heat pumps per 100,000 people 29,745
Poland	**Energy Characteristics** **Main fuel for heating** - ELECTRICITY. 2% NATURAL GAS. 9% DISTRICT HEATING. 41% SOLID FUELS. 47% OTHER. 1% **Energy production mix** - Oil 28% Gas 17% Nuclear Coal + others 42% Renewables 13% **Per capita Carbon**	**Residential characteristics** **Home energy Loss** - percentage of the UK stating they are unable to keep their home adequately warm 5.1% **Age of homes** - Pre - 1946 1946 - 1980 1980 - 2000 Post - 2000 19.1 43.0 22.7 11.4	**access to resources characteristics** **House price to income** - Price to Income Ratio: 11.48 Mortgage as Percentage of Income: 106.69% Loan Affordability Index: 0.94 **Residential energy costs** - Domestic electricity prices in	**Policies and incentives** **Type of incentive** - Clean air. Grants renovations ATA A+: €930/€ 1,650/€2,300. ATW A++: €4,100/€5,950/€7,450. GSHP A++: €5,930/€8,600/€10,750.	**Heat pump take up** Penetration Heat pumps in homes - Heat pumps per 100,000 people 1,491

	- 7.70 **Per capita carbon ranking** ranking - 20	**Quality of dwelling stock** - substandard homes (6%)	the IEA including taxes 2022 pence per kw 13.95	SHW €1,060. ATW €1,060. SHW €1,060. Grants vary depending on income in three levels. Energy efficiency subsidy scheme Building codes and standards 2018 - 2029. Last date for signing contract - 2027. Grants new builds: ATW €1,060. Grants for photovoltaic system with the energy storage: - ATW with hot water tank, - SHW with integrated hot water tank. Energy efficiency subsidy scheme Building codes and standards 2021 - 2023. Last date for signing contract - 2023. **End date to Gas?** No	
Sweden	**Energy Characteristics** **Main fuel for heating** - District heating 50%, biofuels 18%, electricity 29%, oil 1%, gas 1% **Energy production mix** - Oil 18% Gas 3% Nuclear 29% Coal + others 4% Renewables 45% **Per capita Carbon** - 4.49 **Per capita carbon ranking** ranking - 63	**Residential characteristics** **Home energy Loss** - Home temperature loss after 5 hours (with temperature of 20 °C inside and 0 °C outside) 1.2 **Age of homes** - Market Pre - 1946 1946 - 1980 1980 - 2000 Post - 2000 22.7 47.7 12.3 4.6	**access to resources characteristics** **House price to income** - Price to Income Ratio: 8.68 Mortgage as Percentage of Income: 62.49% Loan Affordability Index: 1.60 **Residential energy costs** - Domestic electricity prices in the IEA including taxes 2022 pence per kw 17.31 **Home ownership** - **Home ownership** Rate in Sweden decreased to 64.20 percent in 2022 from 64.90 percent in 2021.	**Policies and incentives** **Type of incentive** - The Swedish Tax Agency. ROT-deduction for labor cost (Repair, Conversion, Extension). Not applicable for newbuilds or if a house is younger than five years only applicable to repair to same standard as new. Tax deduction ATA 30% tax rebate on labour costs, up to max €5,000/year. GSHP 35% of the total cost for an installation considered to be labour. 30% of that then the rebate ex: 0.35*€18,000*0.3= €1,890 rebate. ATA, ATW 30% of total cost considered to be labor then 30% of that in rebate and max €5,000.	**Heat pump take up** Penetration Heat pumps in homes - Heat pumps per 100,000 people 22,727

				End date to Gas? Yes Gas heating will no longer be used in new homes from 2025. Instead new homes will be fitted with low carbon heating systems	
UK	**Energy Characteristics** **Main fuel for heating** - Gas (piped) 82% , Oil (+ kerosene, bottled gas) 7%, Solid (coal, wood) 1%, Electricity 9%, District 1% **Energy production mix** - Oil 32% Gas 41% Nuclear 8% Coal + others 5% Renewables 13% **Per capita Carbon** - 5.60 **Per capita carbon ranking** ranking - 17	**Residential characteristics** **Home energy Loss** - Home temperature loss after 5 hours (with temperature of 20 °C inside and 0 °C outside) 3 (highest heat loss) **Age of homes** - One in five houses in the UK (21%) were built prior to 1919, the second-highest proportion in Europe Market Pre - 1946 1946 - 1980 1980 - 2000 Post - 2000 UK 37.8 39.7 15.6 6.9 **Quality of dwelling stock** - The UK has the highest proportion in Europe of housing built before 1946 at 38% 15% of all English homes failed to meet the Decent Homes Standard	**access to resources characteristics** **House price to income** - England has the most people overburdened by housing costs in Europe – with the least well-off suffering the most England is home to the largest number of people living in households that spend more than 40% of their income on housing in Europe, at 11.3 million. (international housing stock audit 2023) **Residential energy costs** - Domestic electricity prices in the IEA including taxes 2022 pence per kw 30.72 **Home ownership** - 65.2 % (2018) **Avg. cost heat pumps** - Increased ASHP costs are due mostly to non-equipment costs, such as more demanding installation requirements, labour, overheads, commissioning and distribution costs (Sissons, Wiley and Williamson, 2022).	**Policies and incentives** **Type of incentive** - Boiler Upgrade Scheme. Grants Renovations, New builds ATA £5,000 (€5,804.29). Carbon price From April 2022 until April 2025. ATW £5,000 (€5,804.29). GSHP £6,000 (€6,916) **End date to Gas?** Yes, End to Oil and gas in new builds by 2035	**Heat pump take up** Penetration Heat pumps in homes - Heat pumps per 100,000 people 564

Summary

Overall, the home infrastructure in the UK to support heat pumps is perhaps more challenging than in other European countries as UK homes are older, less well insulated and more likely than other countries to have mains gas as the dominant form of energy for heating homes. There are fewer opportunities to minimise disruption by installing only in new builds as there are fewer new homes being built by comparison to other European countries of similar climates. Home owners have less disposable income taking into account mortgage to loan ratios and also pay more for installations of heat pumps due to the additional adaptations to their homes to accommodate them. They also pay more than most for their electricity per KW. Aside from Poland, the UK is unusual amongst this group of selected countries in not currently restricting the installation of fossil fuel home heating in new builds.

6. Conclusion

We have shown how applying a framework of behaviour change to developing a theory of change can help with logically thinking-through the pathway from intervention to outcomes and how different contexts can influence and constrain decisions making and choices.

The review of reviews of high value high commitment green purchases and the review of users' experiences of heat pumps showed multiple sources of behaviour change were necessary, with the social capabilities and opportunities for change largely outside of the individual's control. We find the sources of behaviour change are interdependent along the purchasing pathway from an identification of a problem, needs or wants to social opportunities to share experiences that loop back in post-purchase behaviour into the information seeking phase of people about to consider their purchase.

- **Problem identification**

The identification of a problem, need or want was influenced by a horizon scan for future problems or needs, creating a need to invest in the future. The home heating baseline with people on gas central heating more likely to be see a problem or need in their personal environmental concerns and if they needed to replace their system either now or in the near future or that the mode of heating would one day not be available.

- **Motivation** - Automatic

This source of behaviour change included individual values and beliefs about climate change, environmental concerns, personal and moral responsibilities, and self-efficacy, a belief in oneself and in the product to solve the identified problem. For people who had existing green routines, that is environmentally friendly habits, automatic actions are associated with further green ambitions. Green actions are satisfying and self-reinforcing for those concerned about climate change and the environment. Positive attributes of green products align with self-identity and a sense of belonging.

- **Motivation** - Reflective

Evaluation and expectations.

People evaluate the products attributes to its worth overall, considering financial and non-monetary claims. For the High Value green purchases this included the products green credentials, but also its performance and safety.

A credible messenger

The source of information or promotion or signs of accreditation helped provide assurances of the green products claims, quality and performance, especially for green goods of high value and high commitment.

- **Capability** – Psychological

Knowledge is power

Knowledge through experience was a predictor of purchase, as was indirect knowledge through certificates and eco labels from a trusted source, but these consumer tools needed to include measures from the perspective of the end user, such as comfort and wellbeing.
Product knowledge and not level of education was a predictor of purchase. Knowledge of policies and incentives, when prompted, was only weakly associated with purchase of heat pumps.

Risk, resilience and agency

This source of behaviour change was related to self-confidence and self-efficacy. This could lie in confidence in the future to make high value purchases now rather than later, confidence that the new technology will deliver on the solution to the identified problem or needs, and confidence in understanding the technology and in adapting and personalising it to their needs and goals.
It also related to people capacity to cope with difficulties, such as a disruption to home life of an installation of a new kind of heating system.

- **Capability** - Physical capability

Buying power

People's financial capability to make the purchase was a brake to any motivations, capabilities or opportunities to adopt new technologies. Higher value, high commitment purchases needed multiple sources of behaviour change as well as the financial capability to initiate purchases. While and important factor it was not always the first reason for non-purchase, with the disruption of installation of heat pumps being given as a main reason for non-participation, even in potential users with high environmental concerns and the financial capability to purchase.

- **Opportunity** – Physical

Infrastructure
Potential purchasers calculated whether they would be able to meet their needs and goals due to a lack of physical opportunity presented by a lack of supporting infrastructure. For users of electric vehicles this was seen most clearly in "range anxiety" that there was inadequate infrastructure in the availability of charge points which could restrict its use, and that could influence purchasing decisions. Unlike for electric cars, purchasers of heat pumps had little opportunity to trial the item, and concerns over meeting comfort needs and running costs and suitability of the heat pump for their particular circumstances influenced purchase decision's.

- **Opportunity** – Social

Social space of markets
Green purchases that aligned with one's values and goals signalled belonging to a social group, or a shared identity. It provided social opportunities to gain and share experiences with others; to provide a source of interest and discussion. Recommendations and shared experiences were influential in information-seeking for new technologies.

Developing markets
Developing markets could be positively or negatively self-reinforcing with limited markets providing limited choices of experiences, leading to a "recrimination cycle". Perceived low customer demand can limit the incentives to business to invest in capacity building the skills of installers, while the

unavailability of skilled installers creates negative experiences in installation experience and supply chain delays.

Post-purchase behaviours

People's satisfaction and willingness to make recommendations depended largely on the experiences of the install more than the performance of the heat pump.

Threats to policies: moderators

- Highly conditional, or targeted interventions may reach too few people to achieve the desired outcomes.
- Evaluation against alternatives- given the context of the UK dwelling stock, insulation of homes emerges as an alternative high value high commitment purchase to low carbon heating.
- Scepticism - customer experiences are more mixed outside of trials and demonstrations where costs are met, and qualified, skilled installers are available.
- Competitive marketplace - The short term, fund-limited availability of grants to change home heating to low carbon alternatives may enable only the larger companies to invest in the training and certification of staff, the time costs of applying for the government grants, and to be able to meet the upfront costs of installation before reimbursement and the type of installations that are profitable to do within the time and funds available.

Contexts

There was considerable variation in the types of home heating used, types of incentives offered, quality of housing stock and disposable income of citizens after housing costs, that could explain differences in heat pump take up outcomes. Comparative analysis of policies and interventions in other countries for lessons learned in promoting heat pumps should also consider the contextual differences that influence policy and intervention outcomes.

Key Findings and Recommendations

This review argues that the decarbonisation of home energy should be treated in similar multi-faceted way as to a public health intervention. In light of the review's findings and its work with stakeholders, IPPO recommends that government:

- Establish and promote consistent incentive structures for green purchases;
- Set up Home Upgrade Agencies to co-ordinate consistent messaging and offer bespoke advice and pathways to householders;
- Run a competition promoting innovative ways to minimise the disruption when installing heat pumps; and
- Capitalise on the additional time available before the phase-out of fossil fuels in home heating in the UK by further prioritising insulation and an attendant programme of activity across society.

The full set of key findings, recommendations, and policy goals of the review are set out on page 4.

Discussion

The widespread adoption of heat pumps (or any other low carbon home heating that comes available) is highly contextual, and the pathway from intervention to outcome can vary according to

their baseline or starting point – that is, the source of heating that they are switching from and the home it will be heating. Benefits were more pronounced for people starting from a home heating of direct electricity or with no central heating in terms of comfort but with a potential unintended consequence of increasing costs for the most vulnerable: people who were fuel poor and were underheating their homes to begin with. People using oil to heat their homes also see benefits of cleaner home heating, convenience and lower running costs. However, the great majority of people in the UK are on mains gas and already enjoy comparatively lower bills than other type of heating due to the difference in price for gas compared to electricity. High upfront costs, higher running costs switching from gas to electricity the additional costs of refitting and the disruption of the install while still living in the property slows the uptake of heat pumps for existing homes.

In the international comparisons of selected European countries contexts, we found that UK differs from the other countries lauded as having greater success in heat pump adoption in important and influential ways: The majority of homes heating in the UK is from mains gas, which has a high rates of satisfaction and relatively cheap compared to some of the highest per KW rates for electricity in Europe, the UK has older homes which tend to be less well insulated, and lower rates of new building so much of the adoption will need to be retrofitted, which is more complicated and disruptive in terms of adaptations and changes needed to existing home infrastructure, and so more expensive to install than gas boilers.

This is also seen in other countries with a high rates of home heating from mains gas; in Germany, the rates for scale of heat pumps for retrofits are lower than necessary to meet low carbon targets in 2045. There is a similar picture for the Netherlands, which is currently focussing on new builds as these are homes that are better insulated even though this represents a smaller proportion of the overall housing stock. Nonetheless, even these countries with a high reliance on gas have set near end dates to the use of fossil fuels for heating in new buildings.

Disruption was a feature of heat pumps not found in other high value green purchases and this was the main reason given for non-participation in the UK electrification of heat demonstration projects even when all other costs were met. The disruption of installation could be particularly challenging for people who stayed at home most of the time, such as people who cared for children or the elderly or people with health conditions or disability. People could be more tolerant to the disruption if there was a definite need, such as replacing the boilers and believing that gas would one day no longer be available; the investment then, in terms of money and inconvenience, would be “futureproofing” one's home. Disruption could also be more tolerable if people knew what to expect, again installers played a critical role in providing clear accurate information to the user.

The model of behaviour change for high value, high commitment Green purchases show that higher value green goods needed more than a concern for the environment as their motivation and was coupled with calculations of cost and benefit and a view that the goods would be the standard one day, that purchasing now was an investment in the future. The model showed that there were multiple sources of behaviour change and not all of these were in the control of the individual such as the increase of clean renewable energy to meet the increased demand for electricity after the widespread adoption of heat pumps: that is, reducing carbon emissions individually, would then aggregate to reduced carbon emissions from everyone. People’s experiences of heat pump both good and band were fed back as recommendations or warnings into people’s deliberations in their information seeking phase, through neighbourhood conversations and increasingly, social media or electronic word of mouth (E-WOM).

The review of user's experiences found that installers were key to the success and fulfilled multiple roles as designers, customers services, after sales care, planners, plumbers, electricians, carpenters. Whether a users’ experiences were good or bad largely depended on the quality of the install, and the knowledge, skills, experience and the availability of the installer.

UK incentives are frequently changing, short term, and in some instances, conflicting. The current incentives for replacing gas boilers with heat pumps is a fixed budget incentive on a first come first served basis, targeted at homeowners with homes with good insulation and take up has been low. On the other hand, the Energy Company Obligation (ECO) or ECo+ incentive is available for people on low incomes or related benefits, aims to replace a broken boiler with a new gas boiler or a new gas central heating if there had not been central heating there before. The UK had originally set an end date to the use of fossil fuels for heating in new builds for 2025, but this has now been postponed until 2035. For the UK context, insulation of homes and so reducing demand for energy will likely be necessary, not only for the efficient use and correctly sized installation of the heat pump, but to manage the increased demand on the national grid of a mass switch from gas to electricity.

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