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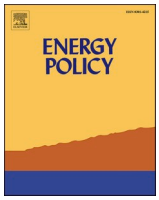

Public perceptions of finance options for retrofit shared-loop ground source heat pumps

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ABSTRACT

Heat pumps are a key part of the UK Government's decarbonisation strategy to achieve net zero carbon emissions by 2050. Shared-loop ground source heat pumps (GSHPs) offer domestic space and hot water heating at scale in medium-to-high-density areas where standard single-dwelling heat pumps are unsuitable. However, it is unclear whether homeowners would be willing to pay for them. This paper explores public perceptions of three shared-loop GSHP financing models. We used focus groups to understand homeowners' responses to each finance model, refined the models, and tested them in an online survey of UK homeowners. We found that while there is potential interest in joining a shared-loop GSHP network, there was distrust because the financial offers were perceived as unfair, disadvantaging some customers, and not offering long-term financial savings compared with a gas boiler. The standing charge for the shared loop was a major barrier. There was a preference for the shared-loop GSHP to be offered by a utility company, a need for personalised financial projections, and the option to delay joining. Our results suggest that to increase uptake, greater certainty around future decarbonisation incentivisation strategies is needed, along with regulation of financial models.

1. Introduction

To tackle global climate change, the UK has committed to achieving net zero carbon emissions by 2050 (HM Government, 2008). The residential sector accounts for around 17% of the UK's carbon dioxide emissions (DESNZ, 2023), with most coming from natural gas for domestic space and water heating (BEIS, 2022). As around 86% of English homes have a gas boiler (MHCLG, 2021), decarbonising electricity and moving towards low-carbon heating alternatives, is essential.

Across the globe, countries are embracing heat pump technology as part of their electrification strategies. In 2021, global annual heat pump sales increased by 13%. In 2023, over 2.5m heat pumps were sold across Europe (EHPA, 2024) but UK heat pump sales have risen more slowly. To address this, the UK Government introduced a policy aimed at converting 600,000 homes per year from gas boilers to heat pumps by 2028 (HM Government, 2020). While heat pump installations have increased annually from around 36,000 in 2020 to just over 60,000 in 2023 (Heat Pump Association, 2024), they are a fraction of what is needed to meet the 600,000 installations per year government targets (Climate Change Committee, 2023).

Financial barriers, such as high capital cost, are frequently cited for low uptake (Côté and Pons-Seres de Brauwer, 2023; Karytsas, 2018; Meles et al., 2022; Neves et al., 2021). Furthermore, the lack of public awareness around heat pump technology generates a lack of public trust in the information available (Karytsas and Choropanitis, 2017; Păunescu et al., 2023). This leads to concerns about heat pump performance, reliability and general maintenance (Bucke et al., 2022; Côté and Pons-Seres de Brauwer, 2023). Motivational barriers, such as the inconvenience of installation, play a role in dissuading homeowners from switching (Karytsas and Choropanitis, 2017; Snape et al., 2015). Crucially, physical barriers, such as internal and external space requirements for equipment, make heat pump installation challenging in higher-density, sub-urban mid-terraced homes and flats (Energy and Utilities Alliance, 2021; Gaur et al., 2021; Karytsas, 2018). Therefore, a different type of heat pump technology may be required for these homes.

One proposed solution is a shared-loop ground source heat pump (GSHP). This comprises a series of deep boreholes connected by shallow distribution pipework to heat pumps in individual homes. The boreholes are located in communal spaces, such as underneath the street. This meets the space heating and hot water demands of multiple properties rather than the more common setup of standalone GSHPs serving single properties. Shin et al. (2020) argue that there are cost-efficiency and

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resilience benefits to installing larger shared-loop GSHPs than numerous standalone GSHPs for the same number of homes.

While most shared-loop GSHPs are expected to be installed by social landlords (Heat Pump Association, 2023), there is a potential market for private homeowners, which make up over 60% of households across England and Wales (ONS, 2023). While a high proportion of private homeowners have positive views on switching to lower carbon heating systems, many are not willing to invest the effort required in making the switch (Okur et al., 2024), and there is uncertainty around how homeowners would consider paying for a shared-loop GSHP.

There are several common approaches to financing heat pumps in privately owned homes. For example, the Pay As You Save (PAYS) programme, prevalent in the USA, provides a long-term loan to cover the capital costs of low-carbon technology installs such as heat pumps and thermal upgrades to a home's building fabric. PAYS is funded by investment companies working in tandem with utility companies (Bianco and Sonvilla, 2021). Loan repayments plus interest are recovered through the homeowner's energy bill until the balance has been paid (Lin, 2018). The Green Deal was a UK-based version of PAYS, but was discontinued due to the high interest rates attached to the loans and inaccurate energy-saving predictions, meaning homeowners saved less on their energy bills than anticipated, and take-up was low (Bertoldi et al., 2021; Rosenow and Eyre, 2016). Similarly, in USA Property Assessed Clean Energy (PACE) programmes, costs are funded by investment companies and underwritten by state and local governments. The loan is attached to the property and the homeowner pays back the balance with interest through annual property tax levies (Less et al., 2022; Rose and Wei, 2020). Proponents of PACE state that these programmes, not being credit scored, make decarbonising through energy efficiency measures accessible to those on lower incomes (Rose and Wei, 2020; Winecoff and Graff, 2020). However, critics argue that unscrupulous lending practices have led to low-income homeowners committing to payments they cannot afford (Grind, 2017).

Heating system rental finance models have also been proposed, as a third of UK homeowners are likely to prefer renting rather than owning their low-carbon heating system (Schleich et al., 2021), and adding a maintenance package as a paid bolt-on service may also be popular (Côté and Pons-Seres de Brauwer, 2023). Indeed the UK boiler insurance industry is estimated to be worth around £519m (USwitch, 2024), suggesting many homeowners have a policy in place covering heating system repair and maintenance costs.

Heat pumps can be included in net zero consumption whole-house retrofits as part of the "Energiesprong" model. This is where the home's building fabric is upgraded and renewable energy technology, such as photovoltaic panels, are added and a set of performance standards are guaranteed (Brown et al., 2019a). The homeowner pays a set amount to their retrofit provider, which is no more than their current energy bill, and the retrofit provider pays the utility company on behalf of the homeowner. The retrofit provider recoups the retrofit cost in energy savings over time.

Finally, homeowners can pay for a Heat as a Service (HaaS) heating plan, which may include energy efficiency measures or low-carbon technology (Britton et al., 2021). Homeowners buy "warm hours" as part of an agreed comfort and well-being service package rather than simply buying units of energy (Britton et al., 2021; Holland et al., 2019). Proponents argue that heating plans offer homeowners cost certainty as a way to decarbonise (Holland et al., 2019), although HaaS has not been implemented at a sufficient scale to demonstrate that the heating system decarbonisation finance model is commercially viable (BEIS, 2021).

However, finance options are more complex in a shared-loop GSHP system. Typically this is where the homeowner owns the heat pump in their home, but lenders fund installation and own the shared-loop GSHP infrastructure, with the aim of payback in 20–40 years from the standing charge paid by homeowners (Brown et al., 2024). There is a lack of evidence about public perceptions of financing these "split-ownership" systems. This paper examines public perceptions of three split-ownership financing models. We explore how demographics affect interest in getting a shared-loop GSHP, and how the upfront cost of a shared-loop GSHP affects beliefs about it. We hypothesise that as the costs increase, beliefs (attitudes, norms and perceived behavioural control) become more negative and intentions to get a shared-loop GSHP are reduced. We also analyse how attitudes, norms and perceived behavioural control predict intentions to change to a shared-loop GSHP.

2. Materials and methods

Our data collection formed part of a larger study to explore the feasibility of installing shared-loop GSHPs in a northern UK city. We adopted a mixed-methods approach of combining focus groups and a survey (Morgan, 1996) to investigate private homeowners' beliefs about paying for a shared-loop GSHP. We used focus groups to explore in detail how people responded to three shared-loop GSHP finance options and we used the insight gained to refine the financial options for the survey. We then conducted a UK-wide survey to measure people's responses to these revised finance options.

2.1. Focus groups

Four focus groups were held in October 2022. At the start of the focus groups, participants were shown a video which explained the shared-loop GSHP system and how it works, and told that it would cost about the same to run as a gas boiler. Discussions were informed by the Theory of Planned Behaviour (Ajzen, 1991) which describes how three sets of beliefs (attitudes, norms, and perceived behavioural control) predict behavioural intentions, which in turn predict behaviour. Discussions included beliefs about heat pumps and means of financing them, whether people feel able to engage with the shared-loop GSHP information and make a decision about changing their heating system, perceptions of their neighbours' beliefs and behaviours, and barriers to joining a shared-loop GSHP network. Focus groups lasted 1 h and were recorded and transcribed verbatim.

2.1.1. Focus group participants

Twenty participants were recruited from areas of a large Yorkshire city that would be suitable for a shared-loop GSHP (Table 1). Only people who said that they would be willing to pay to change their heating system to a heat pump were recruited for this study.

Table 1
Focus group participant demographics.

Variable	(n = 20)	%
Age	18–34	25
	35–54	55
	55–64	5
	65+	15
Gender	Males	30
	Females	70
Ethnicity	White British/White other	80
	Asian	10
	Black	10
Socio-economic group	A	5
	B	20
	C1	60
	C2	10
	D	5
Home ownership	Owner	95
	Renter	5
Landlord	Yes	10
	No	90
Willing to pay to change heating system	£0 to £1000	15
	£1000 to £5000	70
	£5000 or more	15

2.1.2. Finance packages

The finance options were developed by a financial institution that was working alongside a shared-loop GSHP company as part of the larger feasibility study. This included the upfront cost of the heat pump, repayment options, and standing charge. These costs were modelled as being feasible should an actual shared-loop GSHP development in these areas go ahead (Leeds City Council, 2023, p. 69). Participants were told that they live in an area suitable for a shared-loop GSHP, and if one were offered in their neighbourhood, at least 25% of households would need to commit to it for the network to go ahead. If they joined the network, their home would receive energy efficiency measures such as cavity wall and loft insulation, a smart thermostat and some draughtproofing. They were shown an infographic (Fig. 1) that illustrates how the shared-loop GSHP sign-up and installation process could work and provided three finance options (Table 2). Each option comprises two elements: (1) the capital cost of the in-home heat pump, paid through an **upfront payment** and/or monthly **surcharge**; (2) the cost to maintain the shared infrastructure, paid through a monthly **standing charge**.

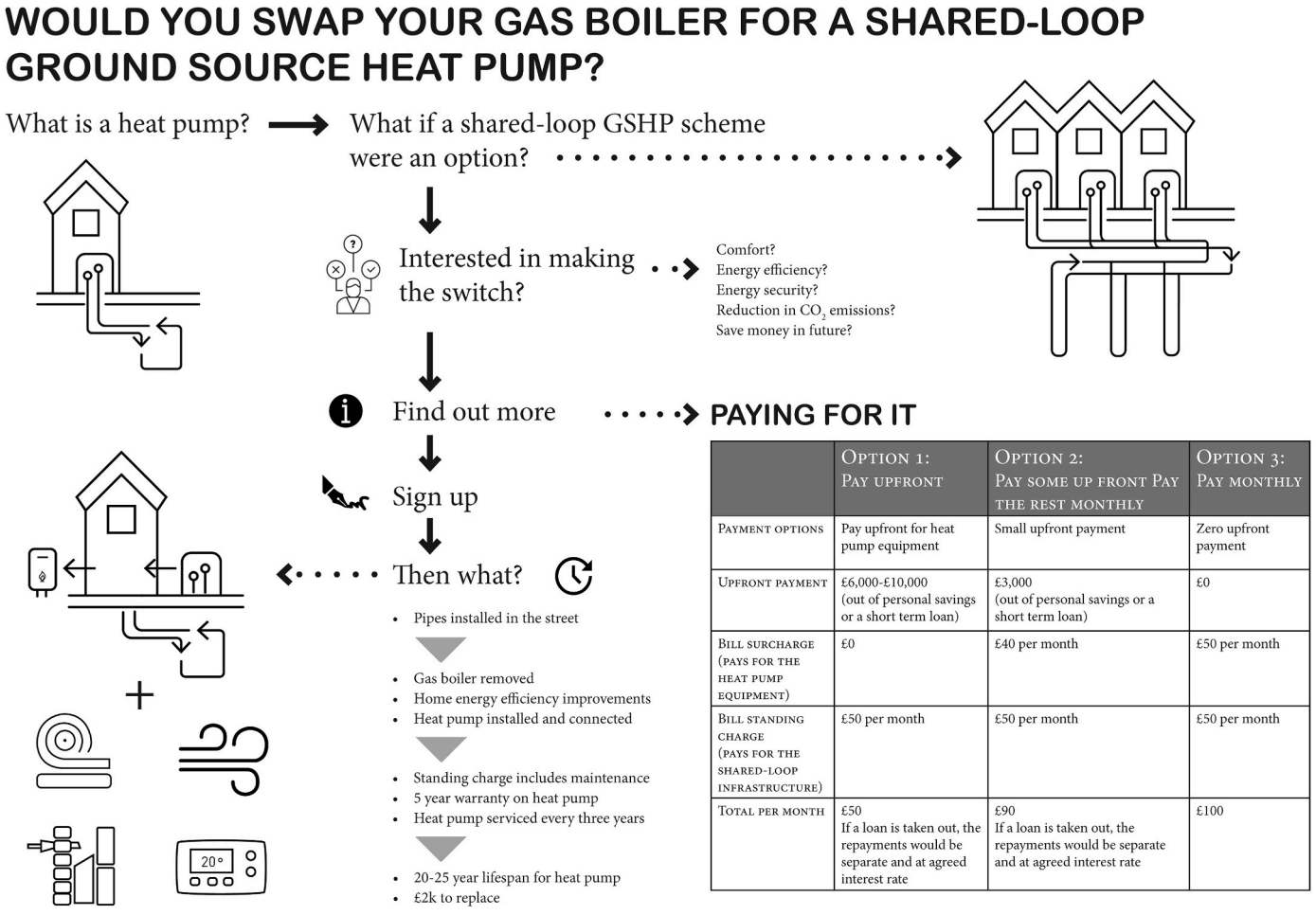
In Option 1, people pay £6000-£10,000 for their shared-loop GSHP; higher costs for larger homes. In Option 2, people pay £3000 up front regardless of house size, supplemented by a £40 per month bill surcharge, paid in perpetuity. In both these options the upfront payment can be paid directly or by taking a five-year loan through the shared-loop GSHP company at an annual interest rate of 3.29%. In Option 3, people pay nothing upfront and instead pay a £50 per month bill surcharge in perpetuity. For all options, the shared-loop GSHP infrastructure and maintenance standing charge is an additional £50 per month. These charges do not include the unit cost and standing charge for electricity used by the household (i.e. their electricity bill), and people are able to choose their own electricity supplier.

Participants were told that the heat pump installed in their home comes with a five-year warranty, they would be responsible for servicing it every three years, it has a lifespan of 20–25 years, and it would cost around £2000 to replace.

Table 2
Three finance options offered to focus group participants.

	Option 1: Pay all up front	Option 2: Pay some up front and the rest monthly	Option 3: Pay all monthly
Payment for capital cost (Paid using personal savings or a short-term loan[a])	Pay £6000-£10,000	Pay £3000	Zero upfront payment
Monthly surcharge to offset capital cost (paid in perpetuity)	£0	£40	£50
Monthly standing charge (Installing and maintaining shared-loop GSHP infrastructure)	£50	£50	£50
Total per month (Excludes energy bills)	£50	£90	£100

[a] The shared-loop GSHP company can offer a five-year loan with an interest rate of 3.29% to cover the upfront payment. Loan repayments are in addition to surcharge and standing charge.



	Option 1: Pay upfront	Option 2: Pay some up front Pay the rest monthly	Option 3: Pay monthly
Payment options	Pay upfront for heat pump equipment	Small upfront payment	Zero upfront payment
Upfront payment	£6,000-£10,000 (out of personal savings or a short term loan)	£3,000 (out of personal savings or a short term loan)	£0
Bill surcharge (pays for the heat pump equipment)	£0	£40 per month	£50 per month
Bill standing charge (pays for the shared-loop infrastructure)	£50 per month	£50 per month	£50 per month
Total per month	£50 If a loan is taken out, the repayments would be separate and at agreed interest rate	£90 If a loan is taken out, the repayments would be separate and at agreed interest rate	£100

Fig. 1. Illustrative infographic for shared-loop GSHP sign up and installation proposed for participants' local area.

2.1.3. Focus group data analysis

Recordings were transcribed verbatim and analysed using thematic analysis (Braun and Clarke, 2006) using the research question, "How do people respond to finance packages for a shared-loop GSHP?" An inductive approach was taken in which the codes arose from the data rather than by applying a pre-determined framework. Codes were grouped together with others of similar meaning and sorted into a thematic structure that best described the data. The criteria for a theme were that it is internally homogeneous, i.e. the codes and categories all shared a certain perspective, and that it is externally heterogeneous, i.e. that the themes were fundamentally different from one another. This stage was iterative, with categories merging and moving between themes until a grouping was identified that provided the most parsimonious data structure while capturing the full set of codes. One researcher (FF) coded the transcripts and undertook first-stage sorting. The other (KM) reviewed the thematic structure alongside the transcripts. Both the authors then finalised the themes. Quotes from the focus groups were selected on the basis that they best illustrate each point. The number of the focus group (FG1–4) is indicated in brackets after each quote.

2.2. Survey

An online survey measured responses to the shared-loop GSHP offer. At the start of the survey, participants were asked to watch a short video about shared-loop GSHPs (the same video played during the focus groups). Next, they answered a series of questions about their interest in, and willingness to pay for, a shared-loop GSHP. They were then told the cost of a shared-loop GSHP, and were randomised into one of three conditions: a cost of £6,000, £10,000 and £14,000. Finally, they answered a series of questions, based on the Theory of Planned Behaviour, on their beliefs about changing to a shared-loop GSHP and their intentions to do so.

2.2.1. Survey participants

There were 1373 participants. All were UK homeowners aged 18+, recruited via a panel organisation. Of those, 1052 provided their demographic details, listed in Table 3.

Table 3
Survey participant demographics.

Variable	(n = 1052)	%
Age	18–34	6
	35–54	32
	55–64	27
	65+	35
Gender	Males	47
	Females	53
Ethnicity	White British/White other	94
	Asian	3
	Black	2
	Mixed	1
Qualifications	GCSEs or equivalent	24
	AS/A level or equivalent	14
	NVQ 1–3 or equivalent	11
	Degree level	36
	Masters degree or higher	15
Working hours	30+ hours a week	40
	Working <30 h a week	16
	Not working	44
Financial status	Living comfortably	18
	Doing alright	47
	Just about getting by	26
	Finding it difficult	10
Area	Rural	24
	Suburban	57
	Urban	18

2.2.2. Survey analysis

Survey responses were imported into IBM SPSS version 29 for analysis. Descriptive statistics are reported, and group-based differences identified using appropriate statistical tests. For the linear regression, assumptions of normality, linearity, homoscedasticity, and multicollinearity were met.

2.3. Ethics

The study was reviewed and approved through the Leeds Beckett University research ethics process. Participants were provided with information about the research and had the opportunity to ask questions before providing written informed consent. Participants received an industry-standard incentive for taking part.

3. Results

First, we present findings from the focus groups, which provide an in-depth understanding of people's perceptions of the three split-ownership finance models. We then report the survey results on how a larger population respond to the finance models.

3.1. Focus groups

We identified four themes that describe how people respond to the finance packages: people's beliefs about heat pumps; cost and savings; deciding between the options; distrust and uncertainty.

3.1.1. Beliefs about heat pumps

Most participants had limited knowledge of heat pumps, and nobody felt well informed about either individual heat pumps or shared-loop GSHPs, and so were wary of committing to a long-term financial agreement. There was a lot of uncertainty about how suitable shared-loop GSHPs are, for example whether they would supply enough hot water. Many participants were reluctant to have a hot water cylinder, which they framed as an old-fashioned way of heating water and many were concerned about the space it would take.

> "It's like the days where we'd all run out of hot water." (FG1)

> "I don't want to go backwards so that I don't have hot water. 'You can't have a bath, actually, we all have to share this bath.' Absolutely not." (FG3)

> "I think one of the things that struck me was the amount of room you'd need for it and I couldn't think of where I would put it - whether it would be practical in my little house." (FG4)

There were concerns that having a heat pump, in particular a shared-loop system, might adversely affect property prices, although a few thought that a heat pump would be attractive to potential house buyers. Several talked about shared-loop GSHPs being best suited to new build homes where installation can take place as the homes are built, and space for a water tank could be designed into the homes. This would also remove the disruption of installing the shared loop,

> "I think if they are trying it, it might be a good idea with new builds. Because you haven't got all the upheaval." (FG4)

> "I just wouldn't want that disruption." (FG1)

There was also a reluctance to be an "early adopter" as people discussed how heat pump prices are likely to drop and technology improve over the coming years. Many assumed that there would be higher financial incentives offered in the future. They believed that installing a heat pump now could therefore mean paying more for an inferior product. These beliefs predisposed people to be more negative about

financial options to pay for a heat pump.

"I'd be thinking I'll wait five years because the kit will be 25% of the price by that time." (FG1)

3.1.2. Cost savings

Many participants were surprised at how much the shared loop and heat pump cost, and some were concerned about potential additional costs not covered by the finance package such as for redecoration. Participants compared this cost unfavourably with the status quo of staying with their gas boiler.

"I'm surprised that video didn't mention that the installation costs because what I know about heat pumps, the cost to install a heat pump in your house as opposed to just getting a new boiler in, is massive." (FG3)

Their discussions indicated that they expected heat pumps to save them money in the long term and that buying into a shared-loop GSHP is therefore seen as a transaction: you spend money to save money. Their response to the finance options was therefore framed in terms of overall financial savings.

"You've got to be able to show long-term savings are going to be really good otherwise no one is signing up to it." (FG1)

"One of the big questions is how long is the payback time, you know? It's capital expensive, but it's, I understand, cheaper to run. So when do you break even and when do you start to make a profit?" (FG4)

"I'd want to guarantee that in less than 10 years, I've got the money paid back." (FG2)

The length of time participants expected to stay in their homes influenced how quickly they expected this payback time to be. Those that planned to stay longer would be prepared to wait for longer before the savings they were making offset the cost of the heat pump.

"What if I decide to move out of that house for whatever reason then I've invested all of this money into a heat pump that I can't take with me." (FG2)

3.1.3. Deciding between the options

Participants' discussions revealed that when choosing between the options they tried to identify which option would generate the most overall savings. For options involving an upfront payment (1 and 2), some participants were reluctant to take out a loan; an approach applied to their everyday life rather than them being against taking out a loan specifically for a heat pump.

"I don't want to get into loans. That kind of thing. Because I mean, we budget quite well in our house so I don't want something else thrown into the mix." (FG3)

Some talked about how if they were being encouraged to join a shared-loop GSHP they should be offered an interest-free loan.

"I'm not taking out a loan if I'm gonna pay interest. Because all of a sudden your £10,000 becomes £12,000 because you're paying interest on the loan." (FG2)

Some talked about how people without a good credit rating might be unable to get a loan.

"I also think it's quite discriminatory in the sense of this is only going to be feasible for people with the luxury of a good credit rating or people that have got finances to be able to take out a loan rather than people that are maybe unemployed or people that are on benefits or other types of society which means that this may not even be an option for them." (FG1)

There was very little support for a monthly surcharge to reduce the upfront payment because participants were astonished that the surcharge continued forever, rather than lasting until the loan equivalent was paid off. They talked about this option as offering very poor value for money. A £10 reduction in the bill surcharge was not viewed as representing a fair exchange for the upfront payment.

"Interesting, so it doesn't drop when you, in effect, have paid for it?" (FG4)

"You're better off paying the lump sum in the long term." (FG3)

Many were concerned that having a permanent surcharge on your fuel bill would make it difficult to sell your property in the future.

"You're showing somebody this lovely house and they say oh yeah, you know, I'd like to buy it. And then you go but there's this that you have to pay for." (FG4)

Many participants talked about how they found the information about the finance options confusing. Several talked about how it is too generic, and they would want to have personalised examples of how much they would be paying against how much they were saving. Some highlighted how the figures given are not relatable to their individual circumstances, for example because the standing charge is higher than their current gas bill and so they would always be paying more. They had a lot of questions and were not sure who they could approach for advice.

"I wouldn't know who to go to, I don't know if I'll be liaising with my energy company or am I going to Yorkshire Water or am I speaking to the council? Who? What happens with the traditional energy bill? Do we just get cut off as customers - I don't know? I've got lots of questions. I wouldn't know who would be the first port of call." (FG4)

3.1.4. Distrust and uncertainty

A common response to the perceived injustice of paying a permanent surcharge in place of an upfront payment for the heat pump was to distrust the organisation behind the offer. Many participants were sceptical of the information provided and some talked about not trusting any organisation.

"I wouldn't sign up for it. It feels like a bit of a dodgy sales pitch, I think. I just don't trust it." (FG2)

"Because whether they're telling the truth or not, we're all kind of in a situation where we don't really believe anybody." (FG3)

Participants were wary of signing a contract that involved a standing charge that paid for the shared-loop GSHP infrastructure. Many assumed that because the organisation installing the shared-loop GSHP is a private company, the scheme is designed to make the organisation a profit. They were concerned that details would be withheld and they would find themselves locked into an unattractive financial agreement. Some were also wary of information from the government and highlighted previous examples of when advice was subsequently reversed, or about government projects that had eventually cost a lot more than projected.

"Everything at the minute, it just feels like you're getting swindled because nobody's really seems to be telling the truth. So I'd be like, 'Yeah, course it'll be cheaper.' You don't really trust anything that anybody's kind of saying to you to you." (FG3)

Their discussions suggest that they do not perceive the standing charge for a shared-loop GSHP in the same way as the standing charge for their gas supply, most likely because they can change their gas supplier, and therefore who the standing charge is paid to.

"Gas and electric, you can change your provider. Competition. You can be tied with this as well as some of the problems. So you're

signed in – it's not like gas and electric where you can shop around" (FG3)

The five-year warranty period on the heat pump also made participants wary. Several noted that their gas boiler has a ten-year warranty. Others wondered why a product with an anticipated lifespan of 20–25 years only has a five-year warranty. They noted that the heat pump should be serviced every three years, but the warranty only lasts five years, and wondered whether this was done deliberately so that any problems detected during the second service would not be covered by the warranty.

"I think that's a good lifespan. But yeah, I'm a bit dubious about if it lasts that long, why has it only got a five-year warranty you know, because you're basically getting one free service aren't you within, within, within its warranty and then you're gonna have to pay." (FG4)

Finally, participants disliked the uncertainty of needing a minimum number of people for the shared-loop GSHP to go ahead. They wondered if projects would be put on hold until enough people sign up, or whether people in a neighbourhood could be pressured to join, or if it would cause discord between neighbours.

"It could cause problems. Yeah, if I said, 'oh yeah, I'm in' and my neighbour said they're not and you need two people." (FG1)

"Do they then say oh we've got 3% but we can't actually fit it until we've got 25% You know, that's another – so then are you waiting a year?" (FG3)

They also wondered about whether the standing charge would reduce if more than 25% of people signed up. The lack of clarity and potential perceived unfairness further added to the sense of distrust.

"If 25 of us sign up, we will pay £50 a month. Everybody else around this table signs up. That should go down. That should be pro-rata so if the whole street signs up, it's a tenner a month." (FG2)

As the focus group discussions revealed there were certain aspects of the finance options that were either unacceptable, or undesirable, the options were amended for the survey. Specifically, we removed the need to pay a bill surcharge forever, we removed the reference to a loan to pay for the upfront costs bearing interest, and added an upfront cost option of £14,000 in order to provide sufficient variability in the data to enable a regression analysis to be undertaken.

3.2. Survey

Survey participants' awareness of heat pumps was limited: 44% reported that they knew a little, 31% that they had heard of them but didn't know anything about them, and 6% had never heard of them. Only 15% reported knowing a fair amount and 4% that they knew a great deal. After watching a video to explain the heat pump and shared ground loop system, participants were told the following and asked if they would be interested in getting one (Box 1).

Over half (57%) reported being interested in getting a shared-loop GSHP. Younger age groups (18–34, 35–44 and 45–54) ($\chi^2 = 21.54$, $p = 0.003$), those working 30+ hours per week ($\chi^2 = 21.74$, $p = 0.016$) and those with a degree or higher qualifications were more interested ($\chi^2 = 28.82$, $p < 0.001$). Those who reported finding it very difficult to manage financially were least interested ($\chi^2 = 18.03$, $p = 0.003$). The area in which people live (rural, suburban or urban) did not have a statistically significant association ($\chi^2 = 3.68$, $p = 0.16$). See Table 4.

Participants were asked to select their preferred finance option, and then to state how much they would be willing to pay. The preferred option, Option 2, was to pay some money up front and make a monthly payment to the shared-loop GSHP company (23%). The modal amount they would want to pay up front was £2000 and median monthly amount was £100. Eighteen percent of survey participants preferred Option 3 and pay the shared-loop GSHP company monthly. The median monthly amount they would prefer to pay was £100. Option 1 was the

Table 4
Breakdown of financial options by survey participant demographic.

Variable	(n = 1052)	**Option 1 (n = 169)** %	**Option 2 (n = 245)** %	**Option 3 (n = 183)** %	**Not interested in a Shared-loop GSHP (n = 455)** %
Age	18–34	21	24	32	23
	35–44	15	20	26	39
	45–54	11	29	22	38
	55–64	17	24	13	46
	65–74	17	20	12	51
	75+	19	22	13	45
Gender	Males	19	22	20	39
	Females	13	24	15	47
Qualifications	GCSEs or equivalent	16	18	15	51
	AS/A level or equivalent	15	25	13	46
	NVQ 1–3 or equivalent	16	29	18	37
	Degree level	17	23	18	41
	Masters degree or higher	16	28	24	32
Working hours	30+ hours a week	16	27	21	35
	Working <30 h a week or not working	16	21	15	48
Financial status	Living comfortably	25	9	19	47
	Doing alright	18	16	24	41
	Just about getting by	10	24	28	38
	Finding it difficult	4	21	15	60
Area	Rural	19	22	18	41
	Suburban	16	23	16	46
	Urban	12	27	22	39
Total		**16**	**23**	**17**	**43**

Box 1
Information given to survey participants

Imagine that it will cost you £6000 to install a shared-loop ground source heat pump in your home (including a discount from a government grant). You can pay this amount up front (Option 1), you can pay some money up front and the rest monthly (Option 2) or you can pay it back monthly (Option 3).

least preferred option (17%) to pay £6000 up front, with most (89%) of those choosing this option reporting that they would use their own savings to do this. However, when participants were subsequently told they would pay a £50 a month standing charge for their shared loop system, 19% of participants said that they couldn't afford to pay it, 27% said that having to pay this level of standing charge would change their preferred finance option and 32% said that they would no longer be willing to go ahead with the shared-loop GSHP installation.

Those who were interested in a shared-loop GSHP were asked who they would prefer to buy it from. They could choose between the shared-loop GSHP company, the local council, a community energy co-operative, a utility company (e.g. British Gas, E.ON, Npower, EDF), or they could suggest another alternative. The percentage reporting each preference is shown in Fig. 2.

The 43% who were not interested in a shared-loop GSHP were asked why. Their responses were content analysed and we identified seven categories which are described and illustrated with quotes in Table 5.

Participants were asked to pick the things that would be most important to them if they were looking to install a shared-loop GSHP. There were 14 aspects to choose from (identified as important during the focus groups) and participants selected as many as they wished. The percentage of participants who picked each aspect is shown in Fig. 3. The three aspects most commonly selected were how much it reduced energy bills, that it gives enough heat and hot water, and waiting until their current system needs replacing.

3.2.1. The effect of cost on beliefs about shared-loop GSHPs

To measure the effect of cost on beliefs about shared-loop GSHPs participants were randomised to one of three conditions: that it costs £6000; £10,000; or £14,000. They were told the following:

> "We don't yet know exactly how much it will cost to install a shared-loop GSHP in your local area. Imagine that, including a discount from a government grant, it costs you £6,000/£10,000/£14,000."

They were then asked how much they agree or disagree with five statements, based on the Theory of Planned Behaviour. The statements are shown below, with each related theoretical construct shown in brackets.

- *People should change to heat pumps to protect the environment (attitudes)*
- *People should stop using gas in their homes (attitudes)*
- *My neighbours will be interested in getting a shared-loop GSHP (social norms)*
- *I could get a shared-loop GSHP if I wanted one (perceived behavioural control)*
- *I will change to a shared-loop GSHP (intentions)*

Table 5
Reasons why survey respondents would not be interested in a shared-loop GSHP.

Cost	
• Heat pumps are too expensive. • Heat pumps are more expensive than a replacement gas boiler. • Heat pumps do not make financial sense. • Prefer to wait for the price of a heat pump to reduce. • Not planning on living in my home long enough for the heat pump to pay for itself in energy savings.	*"Can't afford it. Many other things priority at the minute."* *"That's far too much money, especially as we had to have our gas boiler replaced last year for around £3.5k."* *"It will take too many years to recoup the cost of the pump."*
Concerns about suitability	
• Unsure whether a heat pump is suitable for my home, • I don't believe claims about heat pump effectiveness. • A water cylinder would take up too much room in my home.	*"All of the professional advice received suggests a heat pump will not heat the house to an acceptable ambient temperature unless insulation is 100% effective."* *"This type of heater does not work!"* *"Don't have anywhere for a water tank."*
Concerns about the shared elements	
• I don't want to share a shared-loop GSHP with neighbours. • Concerns are about whether the shared-loop GSHP could supply enough heat for everyone.	*"Don't want anything to do with my neighbours."* *"I would always want total control of my heating costs, and total control of my heating, I may have a heat pump in the future but it would be my own."*
Insufficient information	
• I want more details about heat pumps. • I want to speak to a friend or family member with experience of using them. • I want to see them working before committing.	*"I don't really know enough about them and I would like to speak to real people who have invested in one and get their opinion once they have been using it for a while."*
Too much hassle/happy with existing heating	
• Installing a heat pump would be too disruptive. • Happy with existing heating arrangement and don't see the need to change.	*"It is too much hassle to install one."* *"I'm happy with gas."*
It's not the right way to decarbonise	
• Believing that heat pump technology is not sufficiently tested. • Heat pumps are not the best solution.	*"I don't believe the technology is proven. There aren't enough engineers to support the new technology in case of issue, and it relies a lot on electricity- where does everyone think this electricity will come from?"*

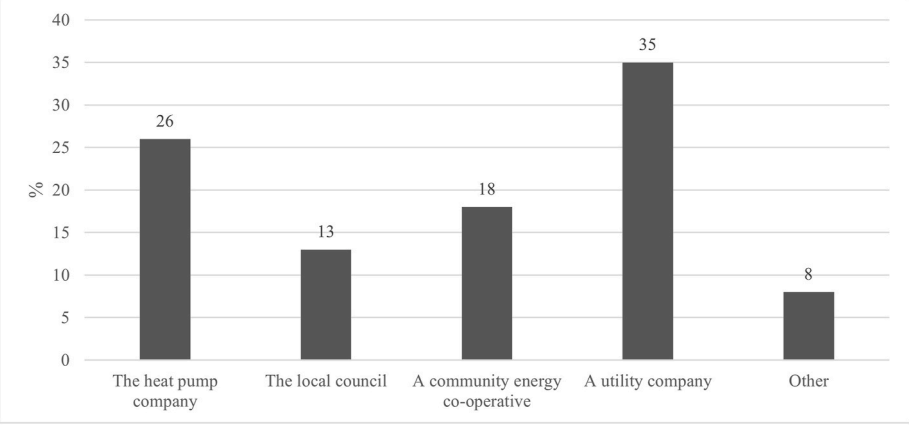


Fig. 2. Preferences for who to buy a shared-loop GSHP from.

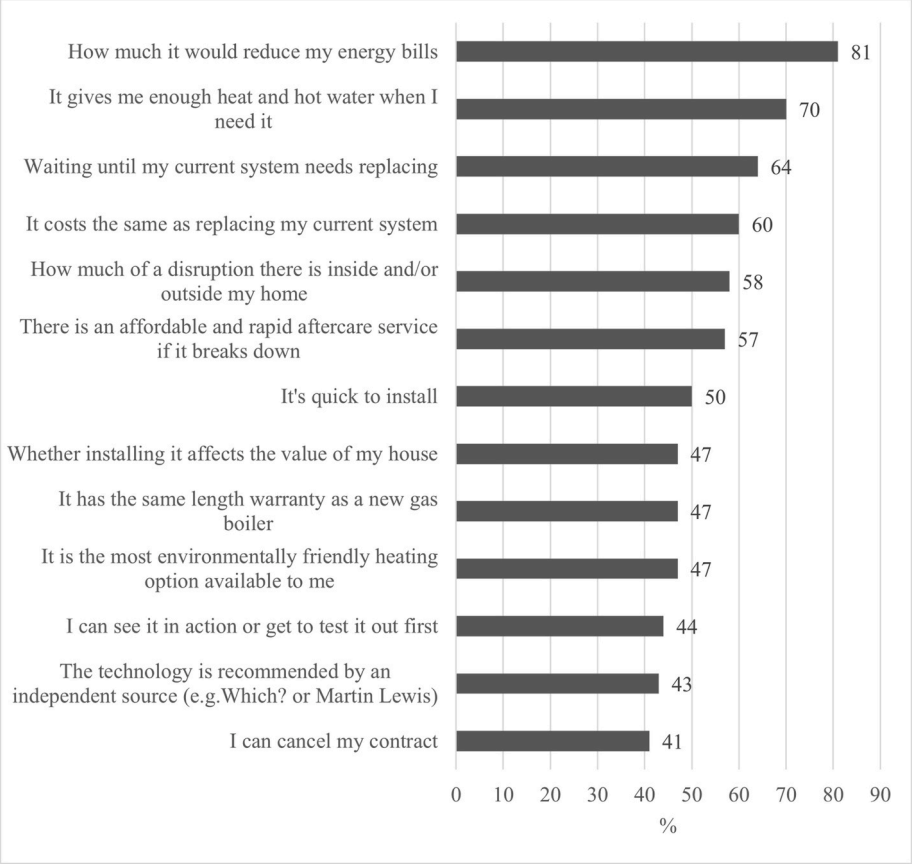


Fig. 3. The percentage of participants who selected each aspect as important.

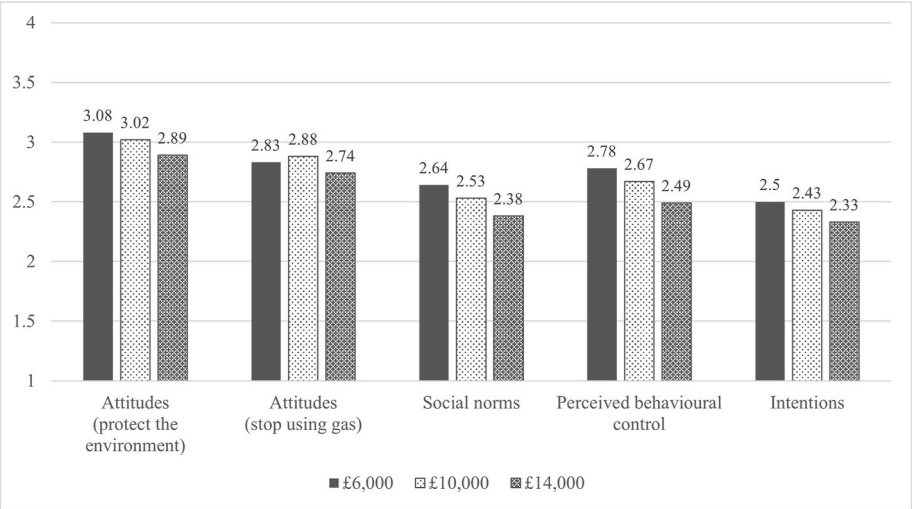


Fig. 4. The effect of cost on beliefs about shared-loop GSHPs.

Mean responses are shown in Fig. 4. Cost has an effect on all psychological predictors of behaviour: increasing costs makes attitudes towards shared-loop GSHPs more negative ($F(2) = 3.15$, $p = 0.022$), reduces social norms ($F(2) = 6.45$, $p = 0.001$), reduces people's beliefs that they could change to a shared-loop GSHP ($F(2) = 6.77$, $p < 0.001$), and reduces their intentions to do so ($F(2) = 2.52$, $p = 0.04$). A post-hoc analysis revealed the differences arose when the cost was £14,000; there were no significant differences between costs of £6000 and £10,000. Cost did not affect attitudes towards stopping using gas ($F(2) = 1.45$, $p = 0.12$). A linear regression indicated that all four variables predicted intentions to change to a shared-loop GSHP ($F(4,1014) = 299.8$, $p < 0.001$). Perceived behavioural control (Standardised Beta = 0.31) was the strongest predictor, followed by norms (Standardised Beta = 0.28), attitudes towards shared-loop GSHPs (Standardised Beta = 0.22) and attitudes towards stopping using gas (Standardised Beta = 0.13), all $p < 0.001$.

In addition to cost, beliefs differed with some demographic characteristics. Those age 55–74 had lower social norms ($F(7) = 4.36$, $p = 0 <$

0.01), perceived behavioural control ($F(7) = 3.40$, $p < 0.001$) and intentions ($F(7) = 3.40$, $p < 0.001$) than the 25–44 age groups. Those with higher qualifications had more positive attitudes towards shared-loop GSHPs ($F(5) = 3.14$, $p = 0.008$). Those who are better off financially (living comfortably) have higher perceived behavioural control than those less well off ($F(4) = 4.85$, $p < 0.001$). Gender and type of area where participants live (rural, suburban, urban) did not affect beliefs.

4. Discussion

This paper explores UK homeowners' responses to three split-ownership shared-loop GSHP finance options. Focus groups provided insight into their understanding of and response to the options and the barriers to uptake. A survey tested responses to the options from a larger group of UK homeowners.

4.1. Acceptable financial terms for joining a shared-loop GSHP

Our research has identified how and what participants would be willing to pay to join a shared-loop GSHP. The finance options presented use a split-ownership model in which the homeowner owns the heat pump but the ground loop infrastructure is treated as a shared utility, incurring a standing charge (Howard and Crook, 2021). In focus groups, participants were willing to buy into a split ownership model but not under the conditions presented in this study's three finance options. Instead, they suggested that the capital cost options need to be perceived as fair and as offering value for money. This requirement for social fairness extends beyond shared-loop GSHP members to the heat pump company, their investors and those responsible for installing and maintaining the infrastructure, so that they do not make large profits at the members' expense. An unequal distribution of cost, profit or cost savings and resources could cause resentment or envy amongst members. Dworkin (1981) posits that an "envy test" establishes whether the division of resources is equal. The test fails if one person prefers what their neighbour has been allocated. Therefore, participation as a shared-loop GSHP member could introduce an informal sense of distribution egalitarianism to the network. Any financial options that fail the envy test could be perceived as unattractive and generate discord.

For survey participants, who were not told that a monthly surcharge continues forever, a lower upfront capital cost and a monthly surcharge was preferred (40% of those open to a heat pump). Reducing the upfront payment helps overcome the high-cost barrier to heat pump uptake (Karytsas, 2018). People can more easily pay from their own savings rather than the less popular idea of taking out a loan. However, in the options explored in the focus groups, a perpetual surcharge meant that people would pay more over time than if they were to pay upfront, so it was perceived as unfair and unattractive. In addition, focus group participants disliked the idea of linking the loan to their property. Indeed, linking energy efficiency debts to properties has had negative consequences in the US as mortgage lenders actively avoid lending to buy homes where PACE schemes are available, making homes unattractive to potential buyers (Rose and Wei, 2020). Stopping the surcharge at the point of capital cost repayment could alleviate this inequality.

People open to taking out a loan to pay for upfront costs perceive that it is unfair to add interest, as it penalises them for making sustainable choices while the shared-loop GSHP company profits from their interest payments. This may be a valid concern as, in the USA, high interest rates added to PACE loans made the schemes popular with mutual funds and insurance companies as they offer lucrative returns with green credentials (Grind, 2017). One criticism of the UK's Green Deal was that the interest rates attached to loans were higher than standard bank loan rates at the time, making the proposition unappealing to homeowners (Bergman and Foxon, 2020). Rosenow and Eyre (2016) suggested that rates of between 2 and 3% would be appropriate for loans of this sort. However, participants considered the interest rate of 3.29% proposed in this study to be too high, even though it was about half the rate available for a personal loan at the time of data collection (Bank of England, 2022). They wanted any loan offered to be interest-free. Therefore, there may be scope for not-for-profit distribution cooperatives similar to those in USA PAYS programmes, which reinvest profits into the system (Lin, 2018).

Nearly a third (30%) of survey participants open to shared-loop GSHPs preferred an ongoing monthly surcharge to an upfront payment to pay for the capital cost of their in-home heat pump. In a similar study, Schleich et al. (2021) also found that this approach appealed to about a third of their participants. This highlights the importance of offering a range of finance models, suitable for people with different personal circumstances (Côté and Pons-Seres de Brauwer, 2023).

Participants were surprised at the high standing charge for a shared-loop GSHP. Despite being unaware of how much standing charge they currently pay to their energy providers; they assumed it would be substantially less than £50 a month. Standing charges are historically unpopular (Bennett et al., 2002), and this contributes to the sense of distrust and profiteering felt by participants towards the shared-loop GSHP company. Our participants' discussions indicate that the standing charge structure fails the envy test (Dworkin, 1981) as infrastructure costs should be divided between members, so that as the network grows over time, the standing charge decreases. Therefore, to maintain distribution egalitarianism, participants are more likely to consider a dynamic approach to standing charges.

4.2. Who is interested and who is not

Survey participants were more knowledgeable about heat pumps than a previous UK Government survey suggests, as only 6% had never heard of heat pumps in this study, compared to 61–75 % in the Government survey (BEIS, 2020). Against this backdrop, more than half of our survey participants (57%) were willing to consider changing their gas boiler for a heat pump, which is broadly similar to previous research (Meles et al., 2022; Poblete-Cazenave and Rao, 2023; Strazzera et al., 2024). These people tend to be younger and more highly educated, as noted in previous studies (Balcombe et al., 2014; Mahapatra and Gustavsson, 2009). While previous research has found that heat pump uptake is higher for people in urban areas (Poblete-Cazenave and Rao, 2023), we did not find any differences based on living in a rural, suburban or urban area.

Despite being willing to consider changing, our participants did not know how to access trusted information about heat pump performance, reliability and maintenance. This, together with motivational and physical barriers, like the level of disruption and not wanting a domestic hot water cylinder, means people would be hesitant to join a shared-loop GSHP. However, the main reasons behind people not wanting to make the switch relate to financial barriers, i.e., the cost, and not wanting to pay to join while their gas boiler is working well. While in other studies (Krikser et al., 2020; Strazzera et al., 2024), participants were told that if they switched they would save money on their monthly energy bills, in this study, focus group participants were told that their energy bills were likely to stay the same. This challenged their perceptions, as most people expected that a low-carbon heating system would lower their energy bills and save them money after a reasonable payback period. As the equipment is more expensive to buy than a gas boiler, costs the same to run, and they need to pay for additional insulation, people do not feel that switching represents value for money. The assumption of spending money to save money does not hold for shared-loop GSHPs, at least in the finance options in this study, which is problematic as the most important thing to UK homeowners deciding about changing their heating system is savings on their energy bills (Schleich et al., 2021).

Our findings show that cost affects psychological predictors of shared-loop GSHP uptake, particularly as the cost increases to £14,000, and while homeowners would like to make choices that protect the environment, they prioritise cost and cost savings over their environmental values. Likewise in other studies, while homeowners are

motivated to adopt heat pumps for environmental protection or energy independence reasons, multiple financial barriers play a greater role in disincentivising them (Balcombe et al., 2014). Although, including other non-financial motivators like improved comfort could improve heat pump uptake (Meles et al., 2022). Steg (2016) argues the importance of highlighting the collective costs and benefits when asking people to pay more for environmentally friendly products or services. Similarly, our research suggests the need for a greater environmental narrative alongside other non-financial motivators to encourage UK homeowners to switch to a shared-loop GSHP in the absence of financial benefits from doing so.

We also found that people are unwilling to switch to a shared-loop GSHP while their gas boiler is working, meaning they reactively consider alternatives when their boiler needs replacing. For example, only around 14% of homeowners reported that they would be replacing their boiler next year (Meles and Ryan, 2022). This represents a small number of homes randomly located across the UK that have a window of opportunity to join a shared-loop GSHP at any given time. Once the homeowner makes their choice, the opportunity will not naturally occur again until that boiler fails in another 10–20 years (The Heating Hub, 2023). This could create a "chicken and egg" situation, as homeowners will not proactively join a shared-loop GSHP network until their boiler breaks but a shared-loop GSHP scheme will not go ahead until a threshold level of participation is reached.

4.3. Implications for policy

Several of our findings have implications for energy policy. First, participants' reluctance to install low-carbon heating unless it saves money strengthens the Climate Change Committee's argument that electricity needs to be cheaper so that the running costs of heat pumps are lower than gas boilers (Climate Change Committee, 2024). Options to address the unfavourable cost ratio between gas and electricity prices include moving the levies that are currently applied to electricity prices to gas, applying a carbon tax to gas, or offering discounted electricity tariffs to shared-loop GSHP homeowners (Brown et al., 2024). Furthermore, our results suggest that the narratives around energy efficiency need to change so that they include addressing climate change as well as reducing fuel bills (Fylan et al., 2016).

Second, our results show that homeowners considering investing in low-carbon technology need greater certainty about future costs and incentives. They are savvy about energy costs and are likely to switch when it is most advantageous to do so (Reeves and Rai, 2018), particularly as heat pump and energy costs are high, and there is no penalty for delaying adoption (Chronopoulos and Siddiqui, 2015). Therefore, they want personalised projections of how much it would cost them to join and stay on a shared-loop GSHP network. Judson et al. (2015) suggest that installers acting as intermediaries would be well placed to offer a tailored service, which in turn could increase uptake (Brown et al., 2019b). However, there may be limits to how accurate a personal projection could be, particularly if it is based on a home's energy performance certificate, as these can overestimate energy consumption (Few et al., 2023). Despite homeowners being unlikely to switch without knowing the anticipated heating and hot water costs, there is a risk of repeating Green Deal mistakes if projected cost savings exceed actual cost savings. People also believe that government incentives are likely to increase over time, discouraging them from taking early action. However, while the shared-loop GSHP industry expects in-house heat pump costs to fall by up to 50% over the next 20 years (Howard and Crook, 2021), this relies on shared-loop GSHPs becoming more commonplace. This is further complicated by uncertainty around where shared-loop GSHPs sit within the UK's heating strategy (Brown et al., 2024). Arguably the lack of policy certainty creates a vicious cycle that perpetuates homeowner hesitation, which holds back adoption rates and keeps shared-loop GSHP capital costs high.

Third, we found that people would prefer to buy their shared-loop GSHP from a utility company, which is in line with Schleich et al. (2021) but contrary to Brown et al.'s (2024) findings where people trusted their local council to connect them to a shared-loop GSHP. This suggests people may prefer to trust familiar local options with in-depth technical knowledge, over central government, as they are more flexible and better suited to local programme delivery (Mallaburn and Eyre, 2014). However, distrust also stemmed from the monopolistic nature of a shared-loop GSHP network, as while homeowners could change their electricity supplier, they would be wedded to the shared-loop GSHP company via its infrastructure. Public reassurance could be improved through policy measures such as a charter of guarantee to protect homeowners from unscrupulous heat pump company actions and regulate the dynamic standing charge.

5. Conclusion

To explore UK private homeowner perceptions of three shared-loop GSHP financing models, we used a mixed-methods approach of conducting focus groups and a survey. The finance models tested included two parts: paying for the in-home heat pump equipment up front or as a surcharge through monthly instalments, and a fixed standing charge to maintain the shared-loop infrastructure. We identified four themes from the focus groups that described how people responded to the finance models: people's beliefs about heat pumps; cost and savings; deciding between the options; distrust and uncertainty. After refining the financial models based on the focus group findings, over 1300 UK homeowners completed an online survey to tell us how they felt about the revised financial options. Our results indicate some of the challenges shared-loop GSHPs will face should they become a strategy to decarbonise heating and domestic hot water in the UK's medium-to-high density privately-owned homes. People are likely to be deterred by the higher capital and running costs than a replacement gas boiler. However, the standing charge for the shared loop is likely to present a major barrier to uptake, both in terms of the cost and the need for the charge to be perceived as fair for early and late joiners. Also, people expect loans to finance the upfront cost to be no-or-low interest. Greater certainty around continued shared-loop GSHP investment and incentivisation would help address the reluctance to commit to this technology. Our results suggest purchasing options fronted by utility companies would provide homeowners with a trusted single point of contact to ask questions, build knowledge and awareness while understanding how a shared-loop GSHP would work for them. Furthermore, implementing consumer protection policies that focus on the monopoly-based structure of shared-loop GSHP networks could help to build trust and improve take-up.

The strengths of this study include the mixed-methods approach: qualitative work on the initial finance proposals allowed us to refine the offer and testing a more acceptable set of options with a large sample UK homeowners. The limitations are that the focus group participants were all from a single UK city, and not all survey participants were living in an area suitable for a shared-loop GSHP. Future work could explore the gap between what finance packages homeowners are prepared to accept and what investment companies are prepared to offer, and how the UK Government could bridge this gap.

CRediT authorship contribution statement

Kate V. Morland: Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Investigation, Data curation. **Fiona Fylan:** Writing – review & editing, Writing – original draft, Software, Methodology, Formal analysis, Data curation, Conceptualization.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The participants of this study did not give written consent for their data to be shared publicly, so data beyond that included in the article is not available.

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