Applying user-centred design to the service of installing renewable heating technology into UK social housing properties

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Applying user-centred design to the service of installing renewable heating technology into UK social housing properties

By
Natalie Jane Moore

A Doctoral Thesis

Submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy of Loughborough University
2013

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I would like to thank all my family and friends who have given me support and encouragement throughout the completion of my PhD; every kind word motivated me to keep going. There are a few people though whom I want to acknowledge personally, as without them I would not have been able to finish my PhD, let alone successfully!

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Abstract

Global climate change and energy use have gained significance as principal issues in Government policy, with energy and carbon reduction targets becoming increasingly ambitious. The European Union have committed to a 20% reduction in both energy use and greenhouse gas emissions and for 20% of total energy supply to come from renewable sources by 2020, compared to 1990 levels. The UK has committed to a 34% cut in energy use within the same timeframe. The domestic sector accounts for over a quarter of all UK CO₂ emissions and therefore poses an important area to address against the set targets. An overall stringent target has been set to reduce carbon emissions by 80%, against 1990 levels, by 2050 and it has been established that over two-thirds of the housing stock that will exist in 2050 is already built. Consequently, reducing household energy consumption and carbon emissions through retrofit measures is crucial.

This doctoral research was carried out as part of a 3-year, interdisciplinary project “Carbon, Control and Comfort” (CCC) [EP/G000395/1]. The aim of the CCC project was to assist social housing tenants in reducing their energy use and carbon emissions associated with heating practices whilst maintaining comfort in the home. Technologies utilising renewable energy are progressively being introduced into social housing, particularly for the provision of heating and hot water. In order to meet carbon reduction targets, the uptake and installation of renewable technology needs to be successful and occupants must be able to use the technology effectively. This research investigated the service of installing heat pumps into social housing properties, from both the landlord’s experiences and tenant’s experiences, with particular emphasis on the implications for older tenants, a key group of users. It aimed to develop an understanding of the service delivery from the tenants’ interactions with the landlord and the heating system, sought to identify any need for improvement of this experience and propose measures to address these issues.

Adopting a user-centred design approach, this research was conducted over three main phases comprising three empirical studies. A first exploration study investigated the current situation of heat pump installations in UK social housing
and the experiences of both landlords and tenants during this process. Through this understanding, the needs and wants of both landlords, as the service provider, and tenants, as the service recipient, were identified and potential areas that could be addressed to improve the service emerged. Key requirements for improved information, particularly relating to the introduction of the technology and its control, were identified from reviewing current service delivery processes.

A second study was carried out with stakeholders on both sides of the service, as a continuation of the user-centred design approach, to develop user requirements and ascertain the ways in which these key areas could be addressed. A set of recommendations was formed for the identified measures to improve the service. A particular key measure was prototyped, based on the requirements extracted from the first exploration study and further developed in the second study. This enabled an evaluation to be carried out through a third study, with end users assessing the prototype. This applied the final stage of the user-centred design process to the key touchpoint of the service delivery focused on as a result of the research, prior to implementation or further work.

As a final part of this thesis, the author reflected on the research undertaken against the aim and objectives set out at the beginning of the thesis. The discussion of the research at the end of the thesis indicated where contributions to knowledge lie. Firstly, this is evident in the greater understanding of heat pump installations in UK social housing this research provides an insight into and what may improve this service. The resultant recommendations for improvements to the service delivery provide a new contribution to the area. Secondly, applying user-centred design to the service delivery of installing heat pumps into social housing is a new way of approaching the design of this service process. In a relatively immature area of industry, installations to date have been heavily focused on the technical aspects of the system and so this research provides a valuable insight into the human aspects of the service delivery.
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<td>A</td>
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<tr>
<td>ALMO</td>
<td>Arms Length Management Organisation</td>
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<tr>
<td>ASHRAE standard</td>
<td>Standard subjective assessment of thermal comfort</td>
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<td>B</td>
<td></td>
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<tr>
<td>BRE</td>
<td>Building Research Establishment</td>
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<tr>
<td>C</td>
<td></td>
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<tr>
<td>CCC</td>
<td>Carbon, Control and Comfort (project)</td>
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<td>CERT</td>
<td>Carbon Emissions Reduction Target</td>
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<td>CESP</td>
<td>Community Energy Saving Programme</td>
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<td>E</td>
<td></td>
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<td>EU</td>
<td>European Union</td>
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<tr>
<td>H</td>
<td></td>
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<tr>
<td>Hard-to-treat homes</td>
<td>Properties which do not allow for cost-effective fabric energy efficiency measures</td>
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<td>L</td>
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<tr>
<td>Landlord</td>
<td>In this thesis, refers to any type of social housing organisation. In studies, it refers to the participant representing the social housing organisation</td>
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<td>LCBP</td>
<td>Low carbon buildings programme</td>
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<td>O</td>
<td></td>
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<td>Ofgem</td>
<td>Office of Gas and Electricity Markets</td>
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<td>R</td>
<td></td>
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<tr>
<td>Retrofit</td>
<td>(in context) To install new products or systems into a property already built</td>
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<td>RSL</td>
<td>Registered Social Landlord, which</td>
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Introduction

1.1 Climate change and the impact of domestic energy use

In order to address issues of energy security and abate pending detrimental changes to the earth’s climate, there needs to be greater adoption of alternative and sustainable energy resources. Global climate change remains a topic of conversation, debate and research, but the consensus demonstrated by increasing scientific evidence (Helm, 2008) and governmental policy (Bohringer et al, 2009; OPSI, 2008; Power, 2008) is that this is a critical issue to address today. Over more recent years, legally binding targets for reducing energy use and carbon emissions have become increasingly ambitious. The UK has been acknowledged as a significant contributor to greenhouse gas emissions and in response Government developed the Climate Change Bill, committing to an 80% cut in carbon emissions by 2050, against the 1990 baseline (OPSI, 2008). A more immediate binding target of reducing global greenhouse gas emissions by 20%, against 1990 levels, has been set to achieve by 2020, as part of the EU Climate Package (European Commission, 2012). Additionally, The UK Government’s Climate Act legally commits the UK to a more stringent reduction of emissions of 34% by 2020 against 1990 levels (Hamza & Gilroy, 2011).

Towards the end of 2009, awareness of concerns over climate change was heightened in the public domain due to media coverage of the Copenhagen Climate Summit. At the beginning of 2010, the Office of Gas and Electricity Markets (Ofgem), who are a governmental regulatory board for the national energy industry, reported findings from research with consumers. This research with the ‘Consumer First Panel’ involved 100 domestic customers from five locations across the UK and gave an insight into public opinion on energy and climate change related matters. The report stated that consumers care about the environment; that they believe everyone must ‘do their bit’ towards sustainable development (Ofgem, 2010). This indicates an understanding amongst the UK public that human behaviour has an effect on the environment and climate change and thus that changes in human behaviour could have a positive impact. Furthermore, the Consumer First Panel
asserted the importance of looking to the future to ensure resources do not run out (Ofgem, 2010).

However, a public poll from a similar period to the Ofgem publication reported a rising scepticism regarding climate change. Of the random sample of 1,001 adults interviewed, a quarter of people did not think global warming was happening at all and 74% did not believe climate change was a result of human actions. The percentage of those who did not believe climate change is a result of human activity had increased from 59% of people whom thought this way towards the end of the previous year (BBC, 2010). Whilst many people do have concerns about climate change and recognise the relationship between this and the use of fossil fuels, they often believe they do everything that they can or that the actions of one person is not enough to make a difference (Boardman, 2004). This has implications for policy and industry to better maintain impetus in the progression and awareness of sustainable developments and, furthermore, to direct the public in considering their energy consumption, if set carbon emissions targets for the UK are to be achieved.

The domestic sector in the UK is a major contributor to carbon emissions, with households accounting for over a quarter of all UK CO₂ emissions (Power, 2008; Utley and Shorrock, 2008; Boardman, 2007; Hamza & Gilroy, 2011). Household energy consumption has been recognised as a key area of behaviour that has the ‘greatest and potentially most negative impact on the environment’ (DEFRA, 2007), accounting for approximately 30% of total UK energy use (Power, 2008). Therefore, enabling reductions in carbon emissions from household energy use is crucial to have a substantial impact on achieving set targets. The buildings sector has been a key focus in Governmental policy at national and international levels; it is the sector with the highest cost-effective energy savings potential (Ekins & Lees, 2008). However, although building regulations and the design of technology can create the potential for greater energy efficiency of properties, the behaviour of occupants and their interaction with the buildings and technologies ultimately determines whether this intended energy efficiency is realised. Therefore, it is the public understanding and activities relating to energy use in the home that requires focus.
A need for public direction to understand and change consumer behaviour, to tackle climate change, is further supported by the Ofgem Consumer First Panel as, despite reporting an understanding of climate change and awareness of risks from the media, those involved claimed to have limited knowledge of the Government’s low carbon targets and felt that consumers should be made more aware. The panel presented an overall view that Government and the energy industry should be driving sustainable development and set an example to the public, providing more assistance in understanding how to save energy in their homes (Ofgem, 2010).

Latest legislation on building regulations and domestic greenhouse gas reduction targets mean that new-build houses will be properties with much greater energy efficiency. However, at least two-thirds of the homes that will exist in 2050 have already been built (Power, 2008; Ravetz, 2008). Therefore, the energy efficiency of the existing housing stock needs to be increased, in order to have a significant and meaningful impact on impending climate change. Making physical changes to properties, such as increasing insulation or fitting double glazing, or installing energy efficient technologies has the potential to improve the housing stock, but occupant behaviours have a large impact on actual energy efficiency realised. Therefore, human activity affecting energy usage in currently existing homes requires attention to promote changes in consumption.

1.2 Research Context

This doctoral research has been completed in contribution to a 3-year interdisciplinary research project “Carbon, Control and Comfort” (CCC), funded by E.On and the Engineering and Physical Sciences Research Council (EPSRC) under the RCUK Energy Programme (Ref EP/G000395/1). Several universities nationwide\(^1\) worked in collaboration with an aim to devise interventions that would assist social housing tenants to reduce domestic carbon emissions from their heating practices, whilst enabling satisfactory levels of comfort to be maintained.

\(^1\) Cardiff University, De Montfort University, Durham University, Kings College London, Leeds Metropolitan University, Loughborough University, University College London, University of Greenwich.
To develop appropriate, useful interventions, the CCC project took an action research approach, engaging end users from the outset. By involving users, a problem can be defined and addressed in context with a rich understanding of how a new product or system would fit into their lives and environment. Thus, this encourages maximum benefit for all stakeholders. User involvement is a widely accepted principle in the development of usable systems (Kujala, 2003; Maguire, 2001, McClelland & Fulton Suri, 2010) and the earlier it occurs the fewer potentially costly modifications are required to make something usable in retrospect.

The participants of the CCC research project were spread across two samples; one situated in North Yorkshire, England and the other in South Wales. These locations were chosen and participants were recruited through the CCC partners Leeds Metropolitan University and Cardiff University, as opportunistic samples in suitable proximity to the researchers at these two institutions, in order for them to carry out technical monitoring of home energy use and carbon emissions of the selected properties. The social research, carried out by Loughborough University and Kings College London, was conducted in parallel with the technical research, to evaluate any changes observed in the home energy use and carbon emissions as a result of the interventions developed.

This doctoral research utilised the CCC empirical study (with the author as one of the research team) with the sample in North Yorkshire as part of the initial exploration phase of this doctoral research and subsequently expanded to investigate further social housing providers in the UK, creating a wider-scale exploration study. The participants involved in the CCC project sample were all elderly tenants with ground source heat pump heating systems installed in their homes. Ground source heat pumps are one type of technology that utilises renewable energy as its source. These ground source heat pumps had been retrofitted in their homes. Retrofitting technologies that function using renewable energy into properties will result in sustainable, reduced domestic energy use and carbon emissions, when operated efficiently and so these homes provided a good sample opportunity to explore the issues.
A further target for the UK, as part of the EU Climate Package, is for 20% of total energy to come from renewable sources by 2020 (Youngs, 2013). Therefore, it can be argued that an increase of renewable technology installations is likely. But, these technologies need to be operated effectively to achieve sustainable energy efficiency, both in terms of energy consumption and operating costs for the householder. Installations of such technologies are increasing across the UK, particularly for space heating and hot water provision, and this is largely occurring in the social housing sector. As such, this emerges as an important field for investigation.

Another national, and global, trend is a general ageing of the population. With ageing, physical and psychological characteristics change and so interaction with environments and objects can change. There is existing research on older people and technology; the impact technology has on older people’s lives and the impact that issues concerning older people has on the design and implementation of technology (Hawthorn, 2000; TRIL, 2013). Social housing is an important provision for elderly people due to lifestyle and income factors. Furthermore, heating is an important issue for older people because of physical and psychological changes, lifestyle and income factors. Therefore, this domestic environment, the installation of heat pumps into social housing and this population in particular form an interesting and important area for research.

As such, the CCC sample in North Yorkshire and the research carried out for the project provides a foundation case study from which to develop this doctoral research. Conducting an investigation around these parameters places the CCC sample in a wider context, contributing to the project outcomes and addressing an issue that there has been little research on to date. This research looks at the service of installing heat pumps into social housing and, in particular, the impact this has on older people.
1.3 **Aim and Objectives**

This doctoral research adopts a user-centred design approach with the aim to explore and define the requirements and preferences of specific stakeholders in the social housing system when introducing heat pumps, to identify any means of creating a better service with a view to improving levels of uptake and efficiency of use of these technologies. The following objectives are the steps by which the above aim will be achieved:

1. Conduct a review of literature to develop an understanding of the parameters within the scope of this research and place this work within a broader context.

2. Through qualitative user-centred research methods, conduct the first part of an exploratory study to investigate user’s experiences of heat pumps and impacting behaviours in the home. This study serves to both inform this thesis and the Carbon, Control and Comfort project.

3. Extend the exploratory study with a wider group of social housing organisations, landlords and tenants outside the CCC project, to expand on Objective 2 and develop an understanding of the processes in place for installing heat pumps in a wider context.

4. Based on the understanding from the exploration study, identify key positive and negative aspects of current processes for installing heat pumps in social housing and highlight areas that could be addressed to potentially improve the service.

5. Carry out a second phase of explorative empirical study, using qualitative user-centred research methods, to refine user requirements and generate ideas for how to approach measures to improve the service of installing heat pumps in social housing.
6. As a result of the exploration phases of research and ideas developed, produce recommendations for service design improvements.

7. Conduct a third phase of empirical study to evaluate the key measures developed with end users.

8. Draw conclusions based on the research as a whole, evaluate the outcomes and critique the approach.

The aim and objectives of this work address the following research questions, which drive and shape this body of work:

1. What lessons can be learnt from previous experiences when retrofitting heat pumps into social housing?

2. What measures would help augment the successful introduction and adoption of heat pumps in future?

3. Can user-centred design add value when applied to the service of installing heat pumps in social housing properties?
1.4 Thesis Structure

The research completed to form this thesis is presented over 7 further chapters. In the following section, each chapter is described in a summary of its contents and structure.

**Chapter 2** reviews existing literature pertinent to the parameters within the context of this research and relevant fields of research. Discussion of the issues through a literary review places this body of work within a wider context and justifies the direction this thesis pursues. The chapter begins with an overview of the social housing system in the UK and further describes its role in domestic energy use and potential for carbon reductions. The review moves to discussing the ageing of the population, presenting the argument for focusing on elderly people, and the issues surrounding this cohort of people and the implementation of new technologies. Following this, application of renewable heating technologies is discussed, continuing from the issues outlined in the introduction. At the end of the chapter, conclusions are drawn from the review of literature and formulate the focus and course of the research to be carried out.

**Chapter 3** communicates the research strategy and approach applied to this work and describes the research phases carried out to achieve the aim and objectives defined in Chapter 1. A discussion concerning the purpose of research and important considerations for conducting research is firstly presented. Following, the research strategy for this investigation and user-centred approach is presented in more detail, depicting the stages of this process. The phases of this research encapsulate the studies conducted to form this thesis. Validity, reliability and ethical concerns of research are discussed at the end of this chapter.

**Chapters 4, 5 and 6** present each of the phases of research in turn; the first explorative phase of empirical research carried out, the second phase of research to refine requirements and develop solutions and the third phase of evaluation. Each of these chapters describes the methods employed, outlines the findings from the studies and discusses the results. Through these three chapters, the progression of
the research can be seen, how the outcomes of a study formulate the design of the subsequent study and conclusions are drawn.

The exploration research described in Chapter 4 identified the positive and negative aspects of current processes to install heat pumps into social housing. The findings highlighted that the service for heat pump installations has three main stages: introduction to the technology, installation of the system and use of the system. The information gathered from landlords and tenants identified the key service actors playing a part in the service who are influential on the installation experience. Findings demonstrated that communication between landlords, installers and tenants is an important area of the service to address, with information provision being a key issue.

Chapter 5 presents key areas and recommendations for improvement of the service, across the three main stages. These are:

**Introduction to the technology**
- Home visits to deliver sufficient information
- Community information events
- Delivering substantial and accurate information to set expectations
- Encouraging discussions between tenants and energy suppliers
- Training void officers, for properties where the heat pump is already installed, to provide sufficient and accurate information

**Installation of the system**
- Setting the system in consultation with tenants
- Delivering consistent messages to tenants during installation from landlords and installers
- Providing user-friendly information materials
- Ensuring tenants can operate basic controls
- Good levels of communication between landlords and contracted workforces

**Use of the system**
- Tenant representatives, including the landlord, a lead tenant or a tenant group, to deliver hands-on support in the community
- Providing one central contact for help services
- Using local workforces for maintenance suppliers
Ensuring information provided is consistent between landlords and contracted workforces
Training housing officers who visit tenants
Scheduling follow up visits or telephone calls with tenants post-installation
More effective and easily accessible internal resources and databasing for housing officers, energy officers and frontline staff
Training for frontline staff who are the first interaction point when a tenant calls or visits the landlord
Refreshed training periodically for housing officers in-line with staff turnover or updates to the process

This second phase of the research led to the development of information leaflets, created based on the criteria identified through refined requirements, as follows:
- Shorter length
- Simple, understandable language
- Pictures and labels for functions and symbols
- Sized to fit in the tenant handbook

The leaflets were ideally required to provide information about:
- How to turn the heat pump on and off
- How to change the temperature
- How to set the programme timers
- What to do in an emergency
- Clear contact information
- Energy tariff advice
- Best ways to ‘live with’ a heat pump

The final phase of the research in Chapter 6 evaluated these leaflets. This study found that, on the whole, participants responded positively to the leaflets and responses suggested it was a helpful tool in carrying out tasks. There were limitations to the extent this study could evaluate the leaflets in use, however, and responses also indicated that further work was required on the leaflets to fully satisfy user requirements.

Chapter 7 provides an overall discussion of the research. Firstly, this chapter presents a discussion of the understanding developed and outcomes of the research. This covers contextual issues informed through the research conducted and developed output. The success of the research outcomes in terms of their intended applicability and ability to address the aim and objectives as outlined in Chapter 1 is considered here. Subsequently, the application of the research in a wider context is
discussed. Following, the research is reviewed in terms of the approach applied and how the research methodology was conducted, the successes and limitations.

**Chapter 8** gives a conclusive overview of the research as a whole. Information and knowledge that this research contributes to academia and understanding of particular issues are demonstrated. The conclusion then outlines any opportunities for further work and applications this research may contribute to, if extended.

![Figure 1: Thesis structure](image)
2 Literature Review

The first objective of this thesis was to conduct a review of literature to develop an understanding of the parameters within the scope of this research and place the work within a broader context. In order to fulfil this objective, literature surrounding each area of focus which formulated this research was reviewed, to expand on the context set out in the introduction chapter. This is presented over the following chapter, to demonstrate the understanding developed and shaping of the research direction. The conclusion at the end of this chapter, in section 2.4, culminates the issues that emerged from the literature, to demonstrate the rationale for the scope of this investigation.

2.1 Social Housing in the UK

This section of the literature review encompasses information about the social housing sector in the UK; however, the focus is largely on social housing in England, within the scope of this research. Social housing is rented accommodation below market price for people on lower incomes (Bahaj, 2002). It is often referred to as affordable housing, as it provides secure, decent housing for people who do not have the means to buy a property or rent a home in the private market (McManus et al, 2010). This sector of housing is owned and managed by local authorities (councils) or registered social landlords (RSLs), which are either housing associations or Arms Length Management Organisations (ALMOs). Traditionally, affordable housing was council housing; properties built and managed by local authorities provided to those people most in need of housing, based on priority criteria.

Nowadays, not all councils own and manage their properties. Since the late 1980s, stock transfer became a central part of Government policy for social housing and has resulted in a much larger registered social landlord sector in England (Ginsburg, 2005; Malpass & Mullins, 2002). Part of the reason for the diminishing of council housing stock was the ‘right to buy’ scheme, where tenants could purchase their rented property. The other factor leading to the change in social housing sector structure was the ‘large scale voluntary transfers’ of local authority housing stock to
housing associations. This stock transfer really took hold in the early 1990s and has significantly accelerated since 1997 (Ginsburg, 2005).

Housing associations are independent, non-profit organisations but they tend to work closely with councils, taking referrals of people who have applied for and need housing. ALMOs are also non-profit organisations which manage and maintain housing on behalf of a local authority. They are usually set up by the local authority and ownership of the properties remains with them. With the establishment of stock transfers over recent decades, the social housing sector in England has become a smaller proportion of the total housing stock (Hills, 2007), yet it still accounts for nearly a fifth of domestic properties (Ravetz, 2008; Smith & Swan, 2012). Since the changes to the sector in the 1980s, housing provision has also become more tightly constrained and new lettings focus more on those most in need (Hills, 2007).

The structure and processes of a social housing provider in the UK may differ significantly from one to another, for instance due to factors such as geographical location, housing type or specialism for type of tenant. Therefore, the way in which a social landlord works with and for their tenants can vary in approach. However, it has been found that there are some commonalities across social housing organisations in the UK: a paternalistic relationship between landlord and tenant, a lack of choice over accommodation and rising tenant expectations (Cooper & Jones, 2009). With limited choice for the tenant over the location and type of property they receive, alongside their increasing expectations, providing choice over what services they receive (and how) may become even more important to ensure tenant satisfaction (Cooper & Jones, 2009). This has implications for the level and type of engagement with tenants to ascertain what they want and need. The engagement of tenants is crucial to social housing landlords, as their performance is measured by regulators, in part, by tenant interaction and satisfaction.

Social housing in the UK is subject to regulation, to ensure consumer protection and for economic reasons. The social sector receives private sector funding, a significant sum of which is made on the basis that the organisations are regulated;
therefore, there is a clear public interest in the social housing sector being regulated. The Cave Review published in 2007 recommended that the social housing sector should be regulated by a single, standalone regulator independent of government. As a result, the Tenant Services Authority (TSA) was established in December 2008. Reviews and a goal to reduce the number of quangos led to the abolishment of the TSA and the Homes and Communities Agency took responsibility for the regulation of the social housing sector in England as of April 2012 (Homes and Communities Agency, 2013).

This change in regulatory body has not, however, changed the fundamental goal of the regulator to protect consumers and the economy through setting and enforcing standards. There are other organisations which help in the regulation of the social housing sector and provide support for social housing organisations and tenants, such as the National Housing Federation. These are not discussed in further detail as the key point to note here is that the social housing sector is regulated and this drives changes and improvements within the sector. The primary tool for regulation of the social housing sector is through the implementation of a set of compulsory standards (DCLG, 2010). Standards relevant to this research are reviewed later in section 2.1.2, referring to the policies impacting energy efficiency and the thermal environment of social housing properties.

One core standard is relevant to mention at this point as it indicates how the regulation of social housing helps to improve the structure and processes in place. The Decent Homes standard was a 10-year programme implemented in 2000 to bring the condition of the housing stock to an acceptable level, based on particular criteria, by 2010 (Morrison, 2013). In an interim review and update of the Decent Homes Standard by the Department for Communities and Local Government it was highlighted that increased involvement of tenants in the appraisal and implementation of works to be carried out has seen real benefits. Tenants now have increased opportunity to be more involved in decisions about the management of their homes with the government encouraging tenant-led, community-based initiatives. Tenants can apply for funding for initiatives from the Tenant Empowerment Programme (DCLG, 2006).
2.1.1 Social housing tenants

There is a clear difference between householders in the social sector and householders in the private sector in terms of a lack of choice and control over their own home. When in need of a social housing property, a person or family enters a waiting list for housing and when a suitable property becomes available they are allocated to it. There is no choice for the tenant over the property and, on average, social housing tenants tend to have less space per person in their properties compared to other tenures and are more likely to be dissatisfied as a consequence (Hills, 2007). The rent for a social housing property is determined under a national regime, based on property value, local earning levels and property size (DCLG, 2006).

A person or family receives a social sector home under a tenancy agreement. Both councils and housing associations offer an introductory or starter tenancy for the first 12 months, as a trial for new tenants. Subsequent to this, tenants receive a longer-term tenancy. A council will offer a ‘secure’ tenancy and housing associations offer an ‘assured’ tenancy, whereby the tenant has strong rights and the option to purchase the property (Directgov, n.d.). Housing associations also offer an ‘assured shorthold’, which is a fixed-term tenancy, for example for 6 to 12 months. This increases the opportunity for the housing association to regain the property. Shorter or indefinite tenancies may have an impact on tenants’ motivations to improve their property, if they do not feel an attachment to the property or there will be a significant benefit to them.

As the provision of social housing has become more directed at those most in need, tenants are more likely not to be in employment and to have low incomes (Hills, 2007). It was reported that between 2008 and 2009 over half of the primary householders in UK social housing were economically inactive, with 31% of this being retired tenants (DCLG, 2010). In a report on the future of social housing, Hills (2007) states that tenants in the social housing sector are found to have higher rates of disability and are more likely to be aged over 60. The latest English Housing Survey, conducted regularly to monitor the status and condition of the housing
stock in England, quantified the amount of social renters aged 65 years or over at 29% of the social housing population (DCLG, 2010).

Social housing is always likely to be important for older people who, on average, have lower incomes than other demographics (Tinker, 1997). This may become of greater importance over coming years with the observed ageing of society, as illustrated in more detail in the following section 2.2. This is likely to have implications for lifestyle factors, such as disposable income and time spent in the home; consequently, comfort in the home, affordability and accessibility of products and services take precedence. Therefore, ascertaining the wants and needs of this population is important when considering the design of services in social housing. Thus, this supports the importance of the area of research this thesis is addressing.

2.1.2 Social Housing and Energy Efficiency

Buildings account for approximately 40% of energy demand in the European Union (EU) and it is estimated that energy efficiency measures currently accessible could cost-effectively save around 28% of this (Ekins & Lees, 2008). Buildings in the UK are subject to EU regulations. The primary legislation affecting energy use and energy efficiency in the buildings sector in the EU is the Energy Performance of Buildings Directive (EPBD) (Ekins & Lees, 2008). Introduced in December 2002, the EPBD aims to exploit the potential energy savings in the building sector. All new buildings covered by the EPBD have to meet minimum energy performance requirements and produce Energy Performance Certificates (Bio Intelligence Service et al, 2013). However, due to the wide variety in buildings across Europe, it is difficult to implement a common approach at EU level and transposition of the Directive into national law has faced difficulties and delays since 2002 (Ekins & Lees, 2008). By 2008, most Member States had created national law around the EPBD, but its implementation is not necessarily ensured (Ekins & Lees, 2008). Therefore, it can be said that while policy is attempting to direct change, in reality this is a slow process.

There has been much focus on the energy efficiency of dwellings in policy and regulation (Pilkington et al, 2011). As outlined in the introduction to this thesis, with
buildings accounting for a large proportion of total energy demand in the UK, achieving carbon reduction targets requires a significant contribution from the buildings sector with domestic dwellings as an area of focus (Kane et al, 2011; Skea, 2012). The domestic sector accounts for around 27% of all UK CO₂ emissions (Boardman, 2007; Hamza & Gilroy, 2011; Utley & Shorrock, 2008) and is an area considered very cost-effective to treat in terms of carbon abatement (Smith & Swan, 2012). The UK housing stock is subject to Building Regulations, with the first mandatory regulations in England being implemented in 1966 (Dowson et al, 2012). Since the energy crisis of 1973, continual revisions to Building Regulations have caused energy efficiency targets for all new buildings to be increasingly stringent (Dowson et al, 2012).

Since 2006, all new dwellings have been required to demonstrate design compliance using the Standard Assessment Procedure (Dowson et al, 2012). The Standard Assessment Procedure (SAP) was formulated by the Building Research Establishment (BRE) as the UK Government’s methodology for assessing the energy rating of dwellings (Murphy et al, 2010). Calculations are based on house type and layout of the property, along with heating and insulation measures installed (Wright, 2004). A SAP rating result is given on a scale of 1-100 (Dowson et al, 2012); a score of 80 and above represents an energy efficient home (Wright, 2004) with 100 representing net zero carbon (McManus et al, 2010). There is currently a target for all new buildings to be net zero carbon by 2016, with a more stringent target of 2015 for social housing dwellings (Jenkins, 2010).

A policy was initiated in 2007 to combat these targets for new housing. The Code for Sustainable Homes was introduced to manage a ‘step-change’ programme for improving the overall environmental performance of new-build housing (McManus et al, 2010). Codes are ratings, banded levels 1 to 6, which contain standards and requirements to be achieved in order to reduce carbon emissions and promote higher standards of sustainable design than currently set out by the building regulations (DCLG, 2013). The Code is not a set of obligatory regulations; however, the level 3 energy standard is now incorporated into the building regulations and,
moreover, affordable housing funded by the Homes and Communities Agency is required to be built to code level 3.

Despite regulations for better energy efficiency of all new buildings, such as through the EPBD, two key issues remain challenging. The first challenge is the increase in domestic buildings. The overall number of households in the UK is projected to rise over the next few decades, from an estimated 21.5 million in 2006 to 27.8 million in 2031 (DEFRA, 2009). This increase in number of households can be attributed to an observed expanding population and decreasing household sizes (Ravetz, 2008). It was stipulated that the UK Government was attempting to address an overall shortfall of housing by increasing building, potentially by 200,000 net units per year by 2016 (Power, 2008; Whitehead & Scanlon, 2007). This increase of output was to include around 30% affordable housing, both social renting and low cost home ownership (Whitehead & Scanlon, 2007). An independent assessment, the Barker review, recommended a need for increased levels of social housing in order to deal with the growth in need for social housing and the consequences of diminished stock due to the ‘Right to Buy’ scheme (DCLG, 2006).

It can be deduced that an increased amount of housing would most likely result in further energy consumption. This can be assumed from the indirect consequences of more housing, such as higher expectations of occupant comfort from the indoor environment, people working from home and greater instances of more electronic equipment (Cockroft & Kelly, 2006). The Energy Saving Trust calculated that ownership and use of domestic appliances doubled between 1971 and 2002 (Energy Saving Trust, 2006); it can be expected that more households would further increase the number of appliances in use.

The second of these challenges is that over two-thirds of the UK housing stock that will exist in 2050, the deadline for significant targets, is already built (Power, 2008; Ravetz, 2008; Wright, 2008). Therefore, the majority of the domestic building stock by 2050 will not be affected by this new-build legislation. It is proposed to raise the average SAP rating, the measurement of the energy performance of dwellings, of the current UK building stock to 80 by 2050, in line with modern building standards.
(Dowson, 2012). This proposed target indicates a need for focusing attention on energy efficiency in existing buildings and, therefore, retrofit measures will be crucial for the improvement of these dwellings. The following graph in Figure 2 shows current data of SAP ratings of the English housing stock and demonstrates the work that needs to be done to bring the existing housing stock up to a SAP rating of 80.

Figure 2: SAP ratings across the English housing stock (Dowson et al, 2012)

The UK has some of the oldest and most inefficient residential properties in Europe (Pendleton & Viitanen, 2011), as evident in the graph above (Figure 2) and even the developed world (Hamza & Gilroy, 2011). Only around one-fifth of homes in England have been built since 1980 (Pendleton & Viitanen, 2011). Thus, there are implications for the energy efficiency of housing in the UK for the foreseeable future. Housing in the social sector is already more energy efficient than housing in the private sector, with an average SAP rating of 57 against a SAP rating of 47 in the private sector (Ravetz, 2008). This may be attributed to the opportunity social housing offers in terms of economies of scale and the availability of grant funding to carry out work on a larger target of properties. In the private sector, it is the responsibility of each householder to initiate modifications to their home and to manage the outlay, as they own their property. In social housing, the landlord oversees management of a large amount of properties and is accountable for the cost of improvements; therefore, a widespread area of properties can be targeted and the responsibility and decisions lie less with the householder.
Furthermore, social housing organisations are under obligations to improve and maintain the standard of the social housing stock. A key standard driving national improvements to the existing housing stock in the social sector is the Decent Homes Standard (DHS). This standard was introduced in 2000, consisting of four key indicators known as the DHS criteria (Kempton, 2004), in order to bring all social housing rapidly to the standard level of current building regulations (Boardman, 2007). Under this policy, a home was deemed to be ‘decent’ if it meets the current fitness standard, is in a reasonable state of repair, has reasonably modern facilities and services and a reasonable degree of thermal comfort (Kempton, 2004; Wright, 2004). The latter of these criteria indicates the relevance of this research addressing thermal comfort and sustainability. The standard is driving improvements in thermal efficiency of the social housing stock and energy efficiency improvements are being implemented in order to meet the standard, including renewable technologies; therefore, an increase of renewable heating technology installations can be expected.

This policy set a target of ensuring all dwellings met the Decent Homes Standard by 2010 (DCLG, 2006; Ginsburg, 2005; Kempton, 2004). By the end of 2010, 92% of social housing met the DHS of being warm and weatherproof with reasonably modern facilities (Homes and Communities Agency, 2013). A Decent Homes Backlog Programme was established to provide further funding between 2011 and 2015 to help social housing organisations complete their programmes to meet the DHS (Homes and Communities Agency, 2013). To date, the social housing sector is likely to have moved closer towards the target of all existing dwellings meeting the DHS, but not reached it yet. However, there is a lack of available data on the extent of progress; this is an assumption based on the availability of funding and lapsed time period. Arguably, there is still Decent Homes work to be completed within the social housing sector.

As a consequence of infrastructure, management and policy drivers, the social sector is in a position to address their properties and increase their energy efficiency. As indicated by national performance ratings, they are already doing so. Not all homes are there yet though, indicating a need for continued improvement.
Whilst this may amount to a small percentage, this may represent thousands of homes and, therefore, thousands of people living in non-decent dwellings. Furthermore, it should be considered that the Decent Homes Standard is a holistic standard addressing the fitness of a property for inhabitancy; it is not predominantly driven by a goal to reduce domestic carbon emissions. Therefore, further work is arguably required to address energy usage and carbon emissions of the social housing stock in relation to other policies and targets.

2.1.3 The case for social housing

Undoubtedly, the private sector is a crucial area for change as it is the most substantial sector of housing. Approximately three-quarters of the UK housing stock is privately owned and nearly 90% of new housing is built in the private sector (Lovell, 2005); therefore, it is a significant area to address if energy targets are to be met. However, the remaining social housing, addressed in this research, presents a particular challenge. There are significant differences between social housing and private housing in terms of implementing home improvements and general perceptions of the role as householder. Therefore, the two sectors cannot be addressed effectively in parallel in any detail for the purposes of this research. Stakeholders perform different roles between social and private housing; responsibility and control lies with different people and therefore the research focus would be altered between the two sectors. For this reason, both cannot be investigated in this one body of work; the scope in this case would be too broad.

Firstly, it is noted that social housing was selected as the target population for this doctoral research because of its connection with the CCC project. As outlined in the introduction, the purpose of the CCC project was to assist social housing tenants in achieving thermal comfort in a sustainable, energy efficient manner. The interest in this area of research is an indication that social housing being improved through the Decent Homes Standard is not enough in terms of carbon reduction targets, as aforementioned. This doctoral research was carried out within the parameters of the CCC project, because of their connection, in order to contribute knowledge to the project and the wider research community in these areas; albeit,
the author of this thesis pursued a research area of distinction separate to the CCC research aim.

Furthermore, social housing provides the opportunity of economies of scale that do not exist within the private sector which can be exploited to address a wider target of properties at one time. This has been recognised in research as a valuable opportunity to increase the sustainability of a greater amount of properties at a greater rate than in private housing currently (Smith & Swan, 2012). For example, Jenkins (2010) proposes that to retrofit a large number of houses, focus should be on the social housing sector where there is an existing infrastructure of managing and refurbishing a wide-scale number of dwellings and, more so, in a way that is acceptable to the occupant (Smith & Swan, 2012). As is alluded to by Jenkins (2010), despite the opportunity social housing presents of a mass target population for greater improvements, it is crucial that each householder accepts, understands and interacts with improvements effectively for the benefits to be realised and investigating the status of this is important.

Existing low energy housing, which is defined as a property that exceeds current UK building regulations, is already largely within social housing. It was recently reported that approximately 47% of UK low energy housing developments were in the social sector, with around two-thirds of these being initiated by RSLs (Lovell, 2005). A study of 1000 private homeowners showed that 87% would pay a premium, up to around 2% extra, for energy efficient housing, and a further survey of 10,000 householders reported that the majority of those who were aware of energy efficiency features of their new home stated that this was an important factor in their decision (Lovell, 2005). This shows the opportunity and scope for potential low energy measures to be implemented in the private sector. The infrastructure and economies of scale existing in social housing can be exploited to exemplify the opportunities and possibilities (Smith & Swan, 2012), to lead a change in the wider buildings sector.

In addition to the potential social housing offers to address the problem in question in this research, it provides an opportunity for conducting the research itself.
Through a social housing organisation, larger samples can be targeted for empirical investigations in social housing. From this, findings can be extracted that may be applicable for use in a wider context.

2.2 An Ageing Population

The most significant development of the population over the next few decades and one of the major issues of modern times is certain to be a marked and rapid ageing of society (Burrows et al, 2011; Hamza & Gilroy, 2011; Metz & Underwood, 2005). This phenomenon has been recognised within much research for the last few decades, globally and across various domains (Hamza & Gilroy, 2011; Hogan & Hogan, 2002; Jacobzone et al, 1999; Willis et al, 2011). It is predicted that over the next 50 years the global population of older people will nearly quadruple (TRIL, 2009). There are several factors leading to the projected ‘age shift’, including people living longer (Hawthorn, 2000), the ageing of the ‘baby boom’ generation and a falling birth rate (Metz & Underwood, 2005; United Nations, 2007; Hamza & Gilroy, 2011). This shift to a greater population of older people has significant implications for the marketing and design considerations of products and services.

Older adults are currently most often classified in research and policy as people aged 65 and over (Gilly & Zeithaml, 1985; Hamza & Gilroy, 2011; Ormandy & Ezratty, 2012). Trends and predictions in demographic changes, however, indicate that people are living longer into older age. The life expectancy of men in the United Kingdom was 76 years in 2005 and is expected to rise to 81 years by 2030; of women it is predicted to rise from 80.5 years to 85 years over the same period of time. The average length of life beyond 65 years of age is currently increasing by 1 year per decade for women and 1.5 years for men (Metz & Underwood, 2005). Therefore, arguably, the lower age of what constitutes older adults may shift to an older age threshold to better reflect demographics in future. However, to contextualise and place this research amongst the wider research community currently, using the common segmentation threshold of 65 years is appropriate. Consideration of extended life expectancy is contextual knowledge which demonstrates the importance of this research focus. Additionally, the population is experiencing a falling birth rate. Due to factors such as availability of contraception,
expansion of higher education and greater career opportunities for women, people are starting families later in life, some are waiting longer to have a second child and are having fewer children overall (Metz & Underwood, 2005).

These two factors alone, of increasing life expectancy and falling birth rate, influencing demographic transition steer the population towards a greater ratio of older people to young. Globally, the population of older people is seen to be increasing at a rate of 2.6% per year, alongside a rate of 1.1% for the population as a whole (United Nations, 2007). In developed countries, it can be said that the population ageing is far advanced, with the number of older people outweighing the number of children since 1998 (United Nations, 2007). In 2001, the UK census showed that the population of people aged 60 years and over outnumbered those aged 16 and below (Eisma et al, 2004). This phenomenon is expected to emerge worldwide for the first time in 2047 (United Nations, 2007). Furthermore, the number of the ‘oldest old’, people aged 80 years and over, is increasing more quickly than any other segment of the population (Eisma et al, 2004).

Yet, to further contribute to this shift in population demographics, the ‘baby boom’ generation are moving towards retirement age. A ‘baby boom’ is a significant increase in birth rate over a marked period of time. The end of World War II triggered a baby boom in most countries, occurring most significantly in the USA but in the majority of Western countries, causing an increase in family sizes post-war. The United Kingdom experienced a two-stage baby boom; the second occurring due to the first baby boom generation having children. The peak of the first baby boom generation of people are currently around middle-age (Metz & Underwood, 2005); therefore, the ‘baby boomers’ of this era will become a large generation of older people in coming decades.

2.2.1 Ageing in Place
Not only is the population ageing, but increasingly the vast majority of older people want to live in their own homes (Mitzner et al, 2010; Tinker, 1997; TRIL, 2009) The phrase ‘ageing in place’ refers to older people being able to remain living in their own homes and not having to move into care or nursing homes as they get older
and their physical or cognitive abilities decline. In the UK, a concerted effort is being made to help older people remain living independently in their own homes, through policy (Hamza & Gilroy, 2011; Homes & Communities Agency, 2013) and the design of products and services to support older people living at home, such as assistive technologies e.g. (Alzheimer’s Society, 2012). In 1997, only 5% of older people were reportedly living in institutions in the UK whilst other countries, with higher rates at that time, were employing measures to reduce the amount of institutional care (Tinker, 1997). More recent research continues to outline the observation of ageing in place; for example, 74% of older people in the USA live independently in single-family homes or apartments, with only 4% of the same age living in institutions (Gitlin, 2003).

Furthermore, research over the last decade not only recognises the prevalence of ageing in place but promotes the benefits of it. Facilitating ageing in place is believed to improve the quality of life for older people, benefitting social and psychological well-being (Sixsmith & Sixsmith, 2008). For instance, Hamza & Gilroy (2011) consider the psychological links between place, possessions, memories and familiar environments and the impact this has on comfort and happiness. Autonomy and independence are highly valued by older people (Tinker, 1997; Burrows et al, 2011) and these aspects are perceived as evidence of a greater quality of life (Mitzner et al, 2010).

However, independent living at home is recognised as a challenge as it can bring difficulties in daily life. As people get older, ailments become more prevalent in psychological or physiological abilities (Perez-Toralla, 2008; Sixsmith & Sixsmith, 2008). Many measurable biological changes occur, such as to the nervous system, immune system, skeletal system and vision (Hipkiss & Bittles, 1989). This decline in physical, sensory and cognitive functioning has a significant impact on everyday life, affecting an older person’s ability to interact with their environment and live independently.

Furthermore, Huppert (2003) reports that the effects of declining abilities into older age can be exacerbated through new, demanding or complex situations.
Therefore, the environment and systems placed within it should be designed to minimise this potential. It has been reported that older people actively reconstruct their living space and modify their behavioural interactions with the environmental features in the home to cope with physical and cognitive difficulties (Gitlin, 2003). Identification of these behaviours could provide insights to develop a greater understanding of the needs and motivations of older people, to highlight existing design issues and filter into the better design of products and services.

Despite experiencing either physiological or psychological difficulties, or both, many older people have been found to feel little relation to representations of vulnerable old people. They also have been found to disengage with a view of old people as a homogenous group of people (Day & Hitchings, 2009). In fact, classifying older people as a single group of people can lead to a narrow stereotyping when diversity among older people is larger than among other age groups (Eisma et al., 2004; Hawthorn, 2000). These factors have implications for the design of products and services for older people living independently, to consider potential ailments or disabilities without pandering to a narrow, negative stereotype of a homogenous group.

A further benefit of enabling ageing in place is the impact this has on helping to relieve pressures on care systems (Sixsmith & Sixsmith, 2008). An expanding population of older people, particularly ‘oldest old’, creates social and economic pressures with an increasing cost of social care (Eisma et al., 2004). Enabling older people to remain at home living independently for longer will reduce the demand on care systems and associated socio-economic pressure. For the large majority of older people, activities occur within the home environment (Mitzer et al., 2010); people aged 65 and over spend more than 85% of their time at home while people aged over 85 years spend more than 90% of their time in the home (Hamza & Gilroy, 2011). It is widely supported that introducing technological solutions would help make everyday life for older people easier and facilitate independent ageing in place (Eisma et al., 2004; Mitzner et al., 2010; TRIL). However, they must both adopt the technology and be able to use it for it to be such a solution. An inability to use
the technology correctly or effectively would conversely have an adverse impact on the ability for ageing in place.

Arguably, the introduction of new, renewable heating technology has consequences for older people ageing in place and these implications may be to positive or negative effect. Renewable heating technology will be explained and discussed in more detail in section 2.3 of this literature review; however, at this point it is worth noting key attributes and the impact these have on ageing in place. Renewable heating technology has the potential to be a less laborious, more reliable, cheaper heating system than other heating systems currently in dwellings; the consequence of which is a more manageable, affordable heating system for older people. This implies that older people would find it easier to manage living independently, in adequate thermal conditions. On the other hand, if the technology is not understood and not used effectively then an adequate thermal environment may not be achieved and cost efficiency not realised; thus having the converse effect and older people being unable to manage the system independently living at home, either financially or in terms of thermal comfort.

### 2.2.2 Older People and Thermal Comfort
Thermal comfort is difficult to define in terms of what conditions equate to achieving it. In physiological terms, thermal comfort is experienced when the body maintains a core temperature of approximately 37°C and skin temperature of 32-33°C (Boardman et al, 2005). Temperatures and sensations on the skin are the main signals that are fed to the brain which led to an overall feeling of comfort or discomfort (Havenith, 2002). Fanger (1970) defines three conditions for a person to be thermally comfortable: the body is in heat balance; sweat rate is within comfort limits; mean skin temperature is within comfort limits (in: Parsons, 2003). The body is adaptable to maintain its core temperature but this is affected by external climate, environmental and behavioural influences. Furthermore, the objective, physiological parameters of what defines thermal comfort do not take into account the variation and effect of people’s subjective expectations. Therefore, a range of conditions may still be acceptable to a person’s thermal comfort state in different situations.
The ASHRAE standard defines thermal comfort as the “condition of mind which expresses satisfaction with the thermal environment” (Parsons, 2003). Although a standard, this definition allows for the variability and subjectivity involved in experiencing comfort. It includes a focus on the state of the mind and satisfaction, which are individualistic parameters. Comfort in any capacity is a partially subjective experience, dependent on a multitude of factors and the interaction of those factors. Thermal comfort is affected by a combination of environmental and individual, objective and subjective, parameters (Ormandy & Ezratty, 2012); it goes beyond health needs to personal preferences (Boardman et al, 2005).

There is a general opinion that older people have a preference for higher temperatures to achieve thermal comfort than younger people (Parsons, 2003). However, several studies have concluded that age has no significant effect on the ambient temperatures preferred by people. Rather than being a matter of preference due to age, it has been suggested that a lower metabolic rate, a less active lifestyle and clothing are reasons why older people would prefer higher temperatures rather than the effect of age (Parsons, 2003). Research has indicated that the ageing process contributes to an inability to adapt to the heat and cold (Khan et al, 1993). Furthermore, older people, particularly frail or disabled older people, spend more time in their homes than most younger, working-age people (Eisma et al, 2004) and tend to have a more sedentary lifestyle which makes them more sensitive to ambient temperatures and, thus, more susceptible to feeling the cold than younger people (Willis et al, 2011).

This is indicative of objective individual factors such as activity level, clothing worn, health status and gender all influencing thermal comfort. Environmental elements impact thermal comfort including air movement, temperature of surrounding surfaces, relative humidity, ventilation and air temperature (Ormandy & Ezratty, 2012). The home environment can also impact on these ecological environmental factors; for example, household status such as over-crowding or under-occupation can also affect thermal properties inside a dwelling.
For thermal comfort in the home, ambient air temperature is the key aspect for guidance on thresholds for safe limits to protect health (Ormandy & Ezratty, 2012). All of the aforementioned factors will vary across households and between individuals within households, over the course of a day and over longer periods of time (Ormandy & Ezratty, 2012). Particularly in such a dynamic environment as the home, these elements will not remain stable. However, guidance is required on safe limits and ambient air temperature thresholds provide this guidance (Ormandy & Ezratty, 2012). The World Health Organisation (WHO) guidelines on ambient air temperatures required for thermal comfort are not provided as a threshold for a satisfactory experience of comfort but because they are inextricably linked to health (Ormandy & Ezratty, 2012).

Excess winter deaths in the UK are a well-established phenomenon and largely affect older people (Wright, 2004). This is frequently attributed to effects of cold (Rudge & Gilchrist, 2005). Evidence indicates that a cold indoor climate has an impact on health; for example, Collins (1986) reported that in temperatures of 16°C there is a greater risk of contracting respiratory diseases and that blood pressure was observed to rise in older people at around 12°C and below. Results of a pilot study examining the existence of a relationship between older people’s health and fuel poverty risk supported this, also indicating that there may be a relationship between energy inefficient housing and winter respiratory disease among older people (Rudge & Gilchrist, 2005). Therefore, a case could be presented to drive energy efficiency improvements in housing based on public health risks (Rudge & Gilchrist, 2005). Research by the Environmental Change Institute into how carbon reduction targets can be achieved in the domestic sector highlights the immediate challenge of increasing the energy efficiency of housing to provide sufficient warmth for health and well-being in winter (Boardman et al, 2005).

Boardman et al (2005) state that people are normally sedentary for approximately two-thirds of their time spent in the home, irrespective of age or how much time is spent in the home. The World Health Organisation reports that there is minimal risk to the health of sedentary people in household ambient air temperatures between 18°C and 24°C. They also recommend that for people aged over 65 years,
the minimum temperature should be 20°C (Ormandy & Ezratty, 2012). Collins (1986) also reported 18°C to 24°C as the comfortable temperature range for people aged over 65 years.

It should be noted however that some individual differences warrant different indoor climates to the recommended guidelines, particularly due to health issues such as diseases and ailments prevalent in older people. For example, Osman et al (2008) found that the symptomatic health status of those suffering with Chronic Obstructive Pulmonary Disease was significantly worse when the ambient temperature failed to reach and remain at 21°C for at least 9 hours. Collins (1986) also suggested that at the upper temperature for thermal comfort of 24°C an older person suffering from hypothyroidism may feel cold. Notably, in these cases, higher temperatures are required for thermal comfort or to avoid detrimental health effects, indicating a need for increased thermal efficiency of properties to achieve this sustainably.

Shove & Chappells (2005) assert that expectations of the indoor environment are evolving and converging, around the world, around a concept of comfort that is immensely demanding to maintain. Focusing on comfort experience is extremely important from a climate change perspective, as the production of comfort around the world becomes more energy intensive (Wilhite, 2009). However, the diversity in preference and experience may suggest that there is an opportunity to move away from standardised recommendations for comfort, which would create a greater opportunity for a low carbon society (Skea, 2009).

It has been documented that further research needs to be done to explore how the demands of ageing intersect with the demands of living sustainably, with management of the thermal environment being a key issue (Day & Hitchings, 2009). The general public is being encouraged to use less energy to reduce carbon emissions, but little research has explored how the call for more sustainable heating practices applies in relation to issues in older age (Day & Hitchings, 2009). To reduce carbon emissions from the domestic sector in the UK, renewable heating technology is a technology being implemented, but it is relatively new. The
implication of introducing this technology into older people’s homes has not been addressed as a primary focus in the research arena and emerges as an important area for research.

2.2.3 Older People and Technology
Technology is infiltrating all aspects of modern day life (Burrows et al, 2011; Mitzner et al, 2010) and adoption of technology is becoming increasingly important for functioning in every day, modern society (Czaja et al, 2006; Hawthorn, 2000; Mitzner et al, 2010). Even as early as the mid-90s, it was purported that those unable to use computers and other everyday technology would be left behind (Morgan Morris, 1994) Predicting factors of general technology use have been found to include education, race, intelligence, computer self-efficacy, computer anxiety and age (Mitzner et al, 2010). Gilly & Zeithaml (1985) reported in their review of older consumers’ adoption of technology that research showed older people tend to be among the last to adopt a product, service or idea innovation and that age is related to attitude towards adoption of technology. Furthermore, research showed that compared to younger people, older people tend to be more cautious and to seek greater certitude before they act (Gilly & Zeithaml, 1985). These findings were reported nearly three decades ago, yet more recent research delivers a similar message, finding that older people are less likely than younger adults to use computers, the Internet and other technological products (Czaja et al, 2006; Willis et al, 2011).

However, is has been found that older adults are willing to use a wide range of technology to maintain social connections, gather information, be safe at home and to promote their personal health and wellness, if these technologies allow them to remain independent (Mitzner et al, 2010). This has particular relevance when considering older people and renewable heating technology in terms of safety, the promotion of health and wellness and enabling independence, as has been touched upon previously and becomes evident through the review of the renewable technology. Mitzner et al (2010) go on to report findings of surveys which demonstrate, however, that there is a ‘digital divide’ evident amongst older people.
Only a subset of the older population uses technology and the level of usage decreases as age increases (Mitzner et al, 2010).

Many older people have had little exposure to computer-based products whereas younger people may find it difficult to imagine life without technology (Eisma et al, 2004). It has been identified that older people are adopting and using technology more now than in previous years (Mitzner et al, 2010) but they are found to have more difficulty than younger people in learning how to use and operate current technologies. This is exacerbated by the effect of computer self-efficacy. Although older people may be keen to use technologies, they perceive that they may experience difficulty in learning how to use the system and that they would require more time to learn than younger people. This perception of an inevitable difficulty in learning how to use it creates a barrier to them using the technology (Czaja et al, 2006). Perceived ease of use and usefulness has an effect on the acceptance of technology (Eisma et al, 2004; Mitzner et al, 2010). Czaja et al (2006) and Eisma et al (2004) also report evidence of computer anxiety amongst older people. It has been found that older people portray less comfort using technology and less confidence in their ability to successfully use technology systems than younger people.

The stereotypical assumption is that older people have an aversion to adopting and using technology and this has, somewhat, been verified by research that has identified a lesser use of technology amongst older people compared to younger people (Czaja et al, 2006; Eisma et al, 2004; Mitzner et al, 2010), as evident through the preceding information. However, suitable and usable technologies may be of tremendous use to older people (Eisma et al, 2004) and Mitzner et al (2010) report that older people have shown that they perceive many benefits of using technology. Eisma et al (2004) identify that the amount of positive feedback from others is an influencing factor on technology use. A common benefit of technology frequently reported by older people was convenience. Older people reported liking technology if it reduced their own effort in performing household tasks (Mitzner et al, 2010). This is again a relevant insight in consideration of introducing renewable heating technology, in terms of the convenience it offers, particularly older people,
in the easier management of a heating system over solid fuel, as is explained in the next section of this chapter.

Czaja et al (2006) demonstrate that cognitive abilities, such as memory and speed of processing, are important to successful performance of technology-based tasks. Older people in particular have a limit to how much cognitive activity they can engage in simultaneously (Hawthorn, 2000). Designers must give consideration to how much of their cognitive load capacity the user should be expected to use in operating the product or system against what is required to apply to the actual task (Hawthorn, 2000). Furthermore, given the previously discussed deterioration of cognitive faculties predominant in older age (2.2.1 Ageing in place), this is a factor to consider in the design and implementation of new technological products with older people as end users. Other physiological ailments also need to be considered for older people using technology, such as vision and hearing difficulties that increase with age (Eisma et al, 2004; Hawthorn, 2000; Morgan Morris, 1994).

The UK Disability Discrimination Act requires that ‘reasonable steps’ be taken to ensure that systems are accessible to people with disabilities (Eisma et al, 2004).

As there is an increasing ageing population and increasing use and development of technologies, it is imperative to understand how to design technologies that support the needs and preferences of older people (Mitzner et al, 2010). Research has been and is increasingly being conducted in this area, through recognition of the importance of ensuring technology products are suitable and usable by older people (Eisma et al, 2004); for example, in the discipline of inclusive design and the development of items such as assistive technologies. ‘USERfit’ is a methodology and toolkit providing guidance on how to design improved assistive technologies. The distinct focus of this user-centred design handbook elevates the importance of the research area. While this thesis is not directly addressing the design of heat pump technology for older people, the investigations conducted here can be expected to extract insights pertinent to this domain. Furthermore, understanding the issues concerning older people and technology is valuable contextual information when considering the approach to achieving acceptance and use of a new domestic technology system.
This thesis takes interest, however, in the social and organisational factors around the adoption and usage of technology by older people: how does the service of introducing and delivering new technology aid the acceptance and usability of the product or system? Eisma et al (2004) highlight that it is important to be aware of the context of older people’s lives, to identify when technology should be introduced and when its introduction would have a detrimental effect on an older person’s quality of life. The introduction of renewable heating technology and stipulated benefits of it propose to enhance quality of life for all, with particular implications for older people of security, safety, affordability, manageability and facilitating independent living. However, the stability of the home environment is important and the introduction of technology can dramatically alter the life of a vulnerable older person, particularly if the installation is time-consuming and disruptive (Eisma et al, 2004).

2.3 Renewable Heating Technology

Over the following section, a review of literature is presented concerning energy use for domestic heating in the UK and the implementation of renewable heating technology. This includes an overview of available renewable heating technologies, in particular heat pumps, and the current status of heat pump installations in the UK. The implementation of heat pumps into the UK social housing sector was investigated through academic literature and desk-based industry related research. This consolidated an understanding of the present situation and identified where there were knowledge gaps for this thesis to be contributory to this arena.

2.3.1 Heating and Energy Use in the UK

Recent research shows that 38% of all energy use in the UK is for generating heat: space heating for homes and other buildings, hot water, cooking and a variety of industrial processes. For this generation of heat, the majority of the energy supply comes from gas, around a quarter comes from oil and coal and only 1% is from renewable sources (DECC, 2009). The majority of domestic energy consumption is for space heating, accounting for around 60% of household energy consumption in
2011 (DECC, 2012; Kane et al., 2011; Pendleton & Viitanen, 2011), with hot water as the second greatest requirement, accounting for approximately 15% of the demand (Fell & King, 2012). Affecting this energy consumption, as aforementioned, Shove & Chappells (2005) asserted that expectations of the indoor environment and the comfort within this are immensely demanding to maintain. Arguably, this notion applies in reference to thermal comfort and the demand on space heating at convenience will endeavour to be higher.

In support of this, Shorrock and Utley (in: Druckman, 2008) identified that average internal temperature preference has risen by approximately 6% between 1970 and 2001. Before the introduction of gas central heating in the 1970s, temperatures of 20°C or less were more commonly preferred and people used clothing to regulate thermal comfort more to avoid high energy costs. In contemporary times, people prefer temperatures of 23°C to 25°C, achieved through greater energy consumption for heating (Dowson et al., 2012). In addition, space heating is highly dependent on technical factors such as the type of dwelling, insulation levels and the efficiency of the heating system. Dowson et al. (2012) point out that the major issue of the existing housing stock is significant wastage of heat through poorly performing solid walls, single glazing and non-insulated buildings.

The combined savings from insulation and heating efficiency improvements already implemented have reduced domestic space heating by an estimated 41.2 million tonnes of oil equivalent. Without these improvements it is estimated that energy consumption would have been twice as high as its current levels (DECC, 2012). However, the issue remains that the UK faces a major challenge to improve the thermal performance of its existing housing stock (Dowson et al., 2012). The reason for failure of reaching the Decent Homes Standard is often due to poor thermal comfort, because of outdated heating systems, low or no insulation, single glazing and draughty doors or windows (Hamza & Gilroy, 2011).

Global energy supply still predominantly relies upon fossil fuels, such as coal, oil and natural gas (Bahaj, 2002). Affluent regions of the world are accustomed to an economic and social lifestyle based on an abundance of energy and demand is
increasing (Bahaj, 2002). Much debate has ensued over the remaining availability of fossil fuel resources and this has long underpinned the need for more sustainable energy usage. Internal production of fossil fuels is decreasing in the UK (DECC, 2009), with coal and oil plant closures by 2015, posing a threat to security of supplies (Ofgem, 2009). The nation is increasingly reliant on imports, with the National Grid predicting that 70% of gas demand will be from imports by 2018 (National Grid, 2010). However, it is not just the diminishing of resources that poses a threat to energy security but geopolitical issues (Umbach, 2010).

Jenkins (2010) highlights that new concerns about energy security extend to natural gas, of which international trade is increasing. Russia holds more than 25% of the world’s natural gas reserves, coal reserves and 6% of oil reserves (Umbach, 2010), thus making Russia a dominant force in energy availability, delivery and cost. After the gas conflict in 2005-2006 between Russia and Ukraine, where Russia cut back gas deliveries affecting EU member states, security of energy supplies in Europe became of greater focus (Ofgem, 2009; Umbach, 2010). The energy regulator, Ofgem, has now warned that the UK is at risk of disrupted supplies (Ofgem, 2010). Increased reliance on imports puts the UK in a more vulnerable position, susceptible to unstable international markets and price fluctuations. Fuel prices can rise as a result of world markets or as a direct or indirect effect of policy (Boardman, 2004). Since 1998, energy prices have been increasing (Ofgem, 2009); major energy companies announced price increases to domestic gas and electricity nearly a decade ago (Boardman, 2004) and it is predicted that gas prices will rise a further 34% and electricity another 54% over the next decade (Ofgem, 2009).

Recent increases in energy prices have substantially added to the number of fuel poor households (Smith & Swan, 2012). For many years, fuel poverty was defined as a household which is required to spend more than 10% of their income on fuel to maintain an adequate level of heating (Bahaj & James, 2007). An adequate level of heating is outlined as achieving 21°C in the living room and 18°C in all other occupied rooms, as stated by the World Health Organisation (Bahaj & James, 2007; Boardman, 2010). The Department for Energy and Climate Change has recently released a new policy framework for tackling fuel poverty which redefines what
constitutes a fuel poor household. A household is now deemed to be fuel poor if their income is below the poverty line (taking into account energy costs) and their energy costs are higher than is typical for their household type.

It was reported in 2004 that the Government’s intervention to reduce, or rather eliminate, fuel poverty was inadequate and deprioritised for funding. It was claimed that the majority of reductions in fuel poverty households from 1991 to 2004 were due to higher incomes and lower fuel prices rather than greater energy efficiency (Boardman, 2004). Nowadays, ensuring all households are adequately and affordably heated is a priority of current UK energy policy (ECI), as is evident through the recent release of the updated strategy from DECC, “Fuel Poverty: A Framework for Future Action” with the revised definitions (DECC, 2013). Prior to this review, the 2000 Warm Homes and Energy Conservation Act stipulated a legal obligation in England to ensure that ‘as far as is reasonably practicable, persons do not live in fuel poverty’ by 2016 (Boardman, 2007; Guertler, 2012). As part of the consequential UK Fuel Poverty Strategy of 2001, a focus on vulnerable households and the implications of fuel poverty on health was a clear priority. An interim target of ensuring that no older householder, family with children or householder with a disability or long-term illness should be at risk of ill health due to a cold home by 2010 was prioritised (Guertler, 2012).

The number of households in fuel poverty is subject to uncertainty against the previous definition; however, research suggests this could be between 3.5 million and 5.5 million households (Guertler, 2012; Jenkins, 2010; Smith & Swan, 2012) which at the higher end is around 21% of the total housing stock (Smith & Swan, 2012). Fuel poverty in the UK remains a real problem in the social housing sector (Bahaj & James, 2007), with approximately 16% of UK households being fuel poor and living in social housing (Jenkins, 2010). As may be expected, fuel poverty has significant implications for the thermal comfort of household occupants and, as discussed previously, this has repercussions for health. Healy & Clinch (2002) reported a study which identified that over half of older people live in inadequate household temperatures during winter against WHO guidelines and there is a significant risk of people living in colder conditions in order to save money. For
example, over a third of older people admit to not heating their bedroom, bathroom or living room in cold weather in order to save money (Hamza & Gilroy, 2011).

However, research has indicated that being in fuel poverty does not necessarily directly result in people living in conditions that are too cold. It has been identified that some people in fuel poverty will still be warm because they buy and use a lot of energy (Roberts, 2008): they will heat their homes enough to achieve adequate thermal comfort, regardless of affordability. Yet, this of course puts them further into debt and further into fuel poverty. Whilst the occupant would not be risking their physical health through inadequate thermal comfort, this could have seriously detrimental effects on other aspects of their lifestyle with consequences to their health and wellbeing.

Higher energy prices are being experienced and, as outlined, are expected to rise; therefore, this can only be expected to exacerbate the fuel poverty issue. Older, retired people living in social housing largely have a fixed pension income, so achieving a higher income to combat higher fuel prices is not possible. The current ‘answer’ to fuel poverty has been through winter payments for vulnerable households to help with their energy bills (Jenkins, 2010). Winter Fuel Payments are paid to all people aged 60 or over, regardless of their circumstances (Hamza & Gilroy, 2011). These are payments of £250 to household occupants aged 60-79 and £400 for household occupants aged 80 and over (Hamza & Gilroy, 2011). Whilst helping to address fuel poverty, it is clearly not the answer with the current statistics of those remaining in fuel poverty. This leaves addressing energy efficiency as the critical path to eliminating fuel poverty, as is heavily encouraged by researchers. Jenkins (2010) proposes that fuel poor homes in the social housing sector may be a suitable area to concentrate on in attempting mass-scale retrofit schemes across the UK.

Two main factors continually presented as reasons for the UK housing stock being inadequate and requiring improvement are fuel poverty and domestic carbon emissions, as is clear over the preceding review. There is a synergy between the
two issues of abating fuel poverty and reducing carbon emissions which is recognised (Smith & Swan, 2012) and highlights the value of increasing the thermal efficiency of properties in addressing both problems simultaneously (Jenkins, 2010). Unquestionably, to tackle energy efficiency and thus impact fuel poverty and carbon emissions, new build properties can be built with this in consideration and to a better standard, as is now policy and regulation. However, as has been previously stated, over three-quarters of the housing stock in 2050 is already in existence and new build properties only add 1% to the housing stock each year (Hamza & Gilroy, 2011). For these reasons, it is suggested that energy efficient refurbishment or retrofitting carbon-saving measures on a large-scale is necessary (Jenkins, 2010; Smith & Swan, 2012).

### 2.3.2 Renewable Energy Technology

The Ofgem Consumer First Panel – outlined in Chapter 1 – consisting of members of the general public, highlighted key energy priorities as access to safe and secure energy supplies, reductions in carbon emissions and delivery of affordable warmth (Ofgem, 2010). To achieve carbon reduction targets, energy efficiency measures are to be invested in the built environment through energy supply systems and clean energy technology, such as renewable technology (Hamza & Gilroy, 2011). Renewable energy is derived from naturally occurring forces in the earth’s environment, named as such as they are not depleted through use (Energy Saving Trust, 2006). Furthermore, they produce few greenhouse gasses (Energy Saving Trust, 2006), thus, increased deployment of renewable energy technologies, in place of fossil fuels, would decrease carbon emissions.

Research indicates that the use of renewable energy would better prepare businesses for managing unexpected changes in energy prices, due to their lower energy use and operating costs (Henriques & Sadorsky, 2010). This principle is directly applicable in the domestic sector. In recognition of the opportunity renewable energy proffers in addressing the issues of energy security, carbon emissions and affordability, the adoption and utilisation of renewable energy is a core focus of the EU’s approach to addressing climate change (Helm, 2008) and a target has been set in the EU of increasing the contribution of energy supply from
renewable resources to 20% by 2020 (da Graca Carvalho, 2012) as part of the EU climate package. In the UK, a target of 15% energy from renewable sources has been set for within the same timeframe (DECC, 2009). With the level of renewable energy contribution recently reported at 3% in the UK, this emphasises the significant increase required in renewable technology installations in order to achieve targets.

Current research indicates that a key barrier to the implementation of renewable technology into properties is the upfront capital cost of the installation (Jenkins, 2010). Dowson et al (2012) outline the same, further stating that major barriers to energy efficient refurbishments include upfront cost, perceived hassle of installation, uncertainties over lower fuel bills and lack of knowledge over payback periods. These issues may all be applicable barriers to the private homeowner but a different dynamic exists in the social housing sector. Any upfront costs are the social landlord’s responsibility, so this does not surface as a barrier to tenant adoption of renewable technologies. Furthermore, payback on the installation of renewable technologies does not impact the tenant in terms of recouping expenditure; however, the tenant would be the person to receive the payback benefit of reduced fuel bill costs. The landlord does not receive the cost benefit in return for their capital investment. The benefit to the landlord is the fulfillment of their obligations, such as the Decent Homes Standard and the Code for Sustainable Homes, and there may be some monetary gain observed through lower maintenance costs. However, the barriers outlined of perceived hassle of installation and uncertainty over lower fuel bills may be of concern to social housing tenants.

Various grants and finance schemes have been available over recent years in order to reduce the cost barrier to installations. Since 2008, Government incentive schemes have been a key driver in reducing CO₂ emissions from the housing sector (Dowson et al, 2012). The Carbon Emissions Reduction Target (CERT) was the primary scheme from 2008-2011 which placed responsibility with large domestic energy suppliers to achieve carbon reduction targets from their customers. It was stipulated that 40% of this should be focused on the priority group of vulnerable households, including low income homes and pensioners over 70 years old.
(Dowson et al, 2012). The Community Energy Saving Programme (CESP) ran in parallel to the CERT scheme, which also placed responsibility with energy suppliers to provide funding to community partnership groups, housing associations and local authorities for retrofit measures to improve energy efficiency in low income and hard-to-treat homes. A hard-to-treat home is defined as one that cannot accommodate ‘staple’ or cost-effective fabric energy efficiency measures; for example, homes with solid walls or off the gas network (BRE, 2008). The CERT scheme reached far more homes than the CESP scheme, yet both addressed measures in homes regarded as difficult to treat (Dowson et al, 2012).

The Low Carbon Buildings Programme (LCBP) was a scheme run by the Department of Energy and Climate Change, offering grants for renewable technology installations to be done by public sector and charitable organisations. The scheme provided grants to approximately 20,000 projects between 2006 and 2010 (BRE Group, 2011). Organisations could apply for 50% of the project cost for an installation, to a maximum of £200,000, which could be applied to more than one building (DECC, 2009). This programme helped to drive renewable technology installations in the social housing sector through the assistance available with the upfront costs.

The LCBP closed for renewable technology for electricity production in early 2010, being replaced by the Feed-In Tariff (FIT) scheme. The FIT scheme has been running in the UK since 2010 and offers payment for electricity produced from renewable sources. Under the scheme, bonus payments are also given for surplus renewable electricity exported to the grid. This tariff has been in place in other countries and is the most prevalent national renewable energy policy in the world. It has already driven rapid and dramatic growth in renewable energy capacity in the European Union (Rickerson et al, 2007). It could therefore be assumed that the same trend will be observed in the UK over coming years. The LCBP was replaced altogether in Spring 2011 by the Renewable Heat Incentive (RHI). The RHI is the equivalent of FIT for heating production, offering payments for heat generated from renewable energy. Bonus payments are not applicable however with the RHI as there is no ‘National Grid’ to export heat to. However, as heating contributes a large part of
domestic energy use in the UK, payment for production offers a great incentive for transferring to renewable heating technology and thus an increase in installations will be observed.

The Green Deal is now the UK’s core energy efficiency policy (Dowson et al, 2012). This programme is an attempt to increase the implementation of retrofit energy efficiency improvements by removing the upfront capital cost. The cost is privately financed and repaid through a charge on the consumer’s energy bill. The initial ‘loan’ to retrofit energy efficiency measures remains attached to the property, not the occupier should they move on to a new property (Dowson et al, 2012; Guertler, 2012). It is hoped that the Green Deal will promote significant increases in retrofit energy efficiency measures but it has come under heavy criticism over its limitations and potential barriers (Guertler, 2012). It is clear however that the Green Deal has the potential to have an impact on reducing CO$_2$ emissions and to contribute to tackling fuel poverty (Guertler, 2012).

As evident, the key barriers to tenant adoption of renewable heating technology into their home are the perceived hassle of the installation and wariness over the benefit they will receive from having it put in. Achieving targets to mitigate the effects of climate change relies as much on individuals making the “right choices” as governments creating effective policies and suitable products being available (Hamza & Gilroy, 2011). This places the onus on the end user both in terms of making the choice to adopt low energy technologies in their home and to utilise the technology effectively. Whilst it has been illustrated that social housing tenants have less choice over their homes than private homeowners, they do need to accept the new renewable technology and run it efficiently. Dowson et al (2012) outline that retrofit measures may only be half as effective as expected if not installed and monitored adequately or due to subsequent inefficient use of heating.

Some renewable technologies currently being used to reduce energy demand from fossil fuels in domestic properties include: solar panels, which convert energy from the sun’s radiation; heat pumps, which convert heat energy from the ground, water or air; biomass boilers, which use plant material as fuel. Biomass is included as a
renewable source because the carbon it produces, from the burning of plant material, is reabsorbed. The material must, however, be obtained from a managed, replanted source. This thesis is focused upon ground source and air source heat pumps. These renewable technologies are already being implemented in social housing and particularly with the grants and schemes available as previously outlined the number of installations is increasing. For example, the CERT funding resulted in 2000 ground source heat pumps being installed over the 3 years it was in place (Dowson et al, 2012).

2.3.3 Heat Pump Technology

Heat pumps offer one of the greatest future carbon saving opportunities (Pendleton & Viitanen, 2011). There are two main types of heat pump: ground-source heat pump and air-source heat pump, which differ based on from where the renewable energy is obtained. Ground source heat pumps use the thermal energy stored in the ground and transfer this into energy to provide heating in buildings, as shown in Figure 3. A ground source heat pump may be installed in two different ways: an indirect circulation system or a direct circulation system. An indirect system works by circulating a water/anti-freeze mix through a buried sealed loop, with a heat exchanger transferring the collected heat energy from the ground to the heat pump refrigerant. Alternatively, a direct circulation system circulates refrigerant through a copper ground heat exchanger, giving good thermal contact with the ground (Energy Saving Trust, 2004). This, along with the elimination of extra components to the system, results in direct systems being more efficient. However, indirect systems are the most commonly used (Energy Saving Trust, 2004) and are the type of ground source heat pump focused on in this research.
Ground source heat pumps are beneficial to the environment as they use a renewable source of energy, exploiting the thermal energy available in the ground (Jenkins, 2009). To ensure the sustainability of its use, while meeting thermal requirements for a domestic property, ground source heat pumps must not deliver energy at a greater rate than the surrounding ground absorbs solar energy over a twelve month period. In cases where the system is reversed to provide cooling in the summer, the energy transferred to the ground may be stored to use in the winter; however this application is much less common in the UK (Energy Saving Trust, 2004).

Air source heat pumps work in a similar way to ground source heat pumps, whereby environmental heat is absorbed into a fluid, pumped through a heat exchanger and transferred to provide space heating and hot water, but heat is extracted from the outside air instead of from the ground, as shown in Figure 4. Heat can be drawn from the air at temperatures as low as minus 15°C (Energy Saving Trust, 2011). There are two main types of air source heat pump system on the market. An air-to-water system delivers heat through wet central heating.
system or an air-to-air system distributes heat through fans. An air-to-air system is likely to be for a space heating alone.

![Image of heat pump system]

**Figure 4: Air source heat pump system**

By using air or ground as the source, the start temperature is ambient therefore less energy is required to convert it to a higher temperature for domestic use. Thus a heat pump can result in reduced energy consumption and lower carbon emissions. It is this gap between the source temperature and the output temperature that determines the efficiency of a heat pump; referred to as the coefficient of performance. For instance the higher the ground temperature and the lower the output temperature, the better the efficiency of the pump. For this reason, ground source heat pumps can be more efficient than air source, as ground temperatures are higher and remain relatively stable. This enables operation, technically, to be maintained near to the optimal as designed. However, air source heat pumps are often favoured as they have a lower capital cost, cause less disruption on installation and require less space in a home.

The efficiency of a heat pump is affected, however, by several factors concerning both the installation and use phases and their performance heavily relies on a high level of thermal efficiency (Pendleton & Viitanen, 2011). Important considerations prior to and during the installation phase of ground source heat pumps, for example, include the design of the installation, the location of the pump and the size and orientation of the ground loop (Energy Saving Trust, 2004; Jenkins et al, 2009). As heat pumps require a high level of thermal efficiency to work effectively, the levels of insulation in the property greatly affects heat pump performance. Inadequately
insulated buildings are unsuitable for heat pumps; in a building with poor thermal efficiency, a heat pump may not be able to provide sufficient heat during very cold weather (Pendleton & Viitanen, 2011).

Ground source heat pumps and air-to-water air source heat pumps use a wet central heating distribution system, but run more efficiently by delivering lower temperatures for a longer period of time. Due to this, underfloor heating or larger radiators are more suitable for greater efficiency, providing a greater surface area to distribute heat. Compared to conventional boiler systems, the temperature emitted is tangibly lower to the occupant. As mentioned above, the coefficient of performance is determined by the difference between the temperature of the air or ground and the output temperature. This output demand is determined in the use phase, how high the occupant sets the temperature; therefore user behaviour becomes a critical factor.

The use of heat pump technology for the provision of space heating is one of the fastest growing applications of renewable energy in developed countries. For instance, there were annual increases of 10% in 30 countries between 1994 and 2004 of ground source heat pumps and in the USA, ground source heat pump installations have seen an annual growth rate of 12%, and mainland Europe is experiencing a rapid growth in installations, having established over 20 years of research and development. For example, despite a decline in the building market in Germany between 2001 and 2002, due to the economic climate, a slight increase in ground source heat pump installations was still observed (Lund et al, 2004).

However, the UK sits far behind in the uptake of heat pump technology. It is suggested this is due to poor insulation levels of the housing stock, a lack of suitable heat pumps and competition from the extensive natural gas grid (Lund et al, 2004). The UK is now increasing the use of heat pumps however, as since the early part of this decade it has been recognised the technology could have an impact on the key priorities of climate change and energy security, whilst presenting a financial benefit for occupants. However, relatively, the UK remains in a demonstration stage compared to the rest of Europe and USA (Omer, 2008).
2.3.3.1 Heat pump installations in UK social housing

Through regulations and UK targets, social housing has a recognised significant role to play in mitigating climate change and ensuring tenants wellbeing in their homes. A recent report from Sustainable Homes on behalf of the London Climate Change Partnership indicates the emphasis being placed on futureproofing the social housing stock against the effects of climate change; for example through works to improve water efficiency and flood risk measures (Sustainable Homes, 2013). Installing heat pump technology would be a measure to futureproof heating supply to the property for the foreseeable future, when there is uncertainty over energy supplies and costs in the immediate future.

Social housing landlords have a clear responsibility to ensure that the carbon emissions from energy use of social housing properties within their jurisdiction are reduced (Boardman, 2007). Retrofitting energy efficiency measures, such as heat pumps, aligns with the remit of the social housing sector to provide affordable housing. Any improvements to dwellings that would help to reduce fuel poverty risk are in-line with social housing providers’ mandate (Smith & Swan, 2012). An incentive for the tenant to take up the new technology is the opportunity it presents of reducing energy bills and improving thermal comfort. It is recognised that social housing providers are likely to be at the forefront of efforts to comprehensively refurbish existing UK housing to achieve sustainable emission cuts (Reeves et al, 2010).

One of the challenges faced by social housing providers in delivering heat pumps into their properties is being able to do so with minimal disruption to occupied homes (Smith & Swan, 2012). This is a widely recognised barrier to carrying out installations and has been a preventative issue, particularly with ground source heat pumps due to the anticipated space required and damage caused to gardens. There are examples of social housing organisations which have been encouraging implementation of renewable technology into their stock (Jenkins, 2010) and this is an increasing trend.
Penwith Housing Association completed the first project to retrofit ground source heat pumps into existing social housing in 2004. They reported that tenants were happy with the new systems and that results showed ground source heat pumps can provide space and hot water heating at an affordable cost (European Commission, n.d.). They also stated that one of the most significant outcomes of the project was the encouragement to other social housing landlords to install ground source heat pumps (European Commission, n.d.). This project was followed in the consecutive years by other social housing organisations running installation projects around the UK, several of which were identified for this investigation and became involved in this research. It is clear that heating system providers and social housing associations are promoting heat pumps and increasing installations (Energy for Sustainable Development, 2005; European Commission, n.d.). In all cases found, ground source heat pumps are outlined as beneficial for providing affordable warmth, a safe system, a long component life and requiring less maintenance than conventional systems (Energy for Sustainable Development, 2005; European Commission, n.d).

2.3.3.2 Review of heat pump installations in the UK

With the capital cost barrier removed for the individual householder and funding available for landlords in this sector, more installations can be carried out and monitored. However, a barrier remains with uncertainty over the technology: confidence in heat pump technology is important as it potentially offers the greatest carbon saving opportunities for future (Pendleton & Viitanen, 2011). Therefore, a substantial degree of trust and understanding of the technology is required if people are to adopt and use heat pumps in their homes, at the levels required for carbon reduction targets.

In a review by the Institute for Public Policy Research, Pendleton & Viitanen (2011) reported that more needs to be learned about the performance of heat pumps through more extensive trials (Pendleton & Viitanen, 2011) This indicates a level of immaturity in the market and a need for research to focus on heat pump installations, for successful wider implementation in future. Uptake of renewable heat technologies in households might realistically be expected to accelerate in the
2020s (Skea, 2012) efforts should, therefore, be placed now on better understanding heat pump installations in the UK, to increase the success of implementation at a greater rate in the near future. The social housing sector proffers the opportunity to carry out such extensive trials.

Much research to date has concerned heat pump performance purely from a technical perspective. The Energy Saving Trust recently conducted the first large-scale field study of UK heat pump installations that included user experience. The study monitored technical performance as well as customer behaviour, with the aim of informing industry stakeholders of improvements that could be made to installations (Energy Saving Trust, 2010). This project however incorporated a diverse sample, including privately owned properties and social housing dwellings, installations in new-build properties and retrofitted into existing properties (Energy Saving Trust, 2010). As previously suggested, there are differences between private homeowners and social housing tenants and, furthermore, there are differing issues associated with new-build and retrofit projects, which are not considered in this field study.

In the report findings, from the Energy Saving Trust’s UK heat pump field trial, outcomes indicate that, firstly, customer behaviour is a variable that was shown to impact performance. These behaviours and how they affect heat pumps are not explained however. Secondly, the report states that ‘many householders said that they had difficulties understanding the instructions for operating their heat pump. This highlights a need for clearer and simpler customer advice’ (Energy Saving Trust, 2010). This highlights a clear need for further work in the field of renewable technology to develop a better understanding of installations and usage.

Further work is additionally required as although research has identified a need for better information there is no support given in terms of what this advice should be, or how it should be presented to customers. A conclusion of the field study is that further investigation is needed, on an installation-by-installation basis, to record what has been done wrong or what has been done well and what could be done better, to improve future installations. This doctoral research is investigating cases
of heat pump installations in the UK social housing sector, to obtain information about the installation processes in place and various experiences of those processes. The findings from this will provide a rich understanding of the lessons that have been learned from existing projects, to disseminate into future projects.

As outlined through the descriptions in section 2.3.3 of this literature review, there are two main types of heat pumps being installed in homes: air-source and ground-source heat pumps. It is explained that there are differences between the two types of systems in terms of how they operate mechanically, their components, the scale of the installation infrastructure, and the energy source being converted to provide heat. However, this research is focused upon the service provided to tenants by landlords to install heat pumps in their homes. Considering this, other information in this review about the heat pump technology and installations also indicates there are substantial similarities between the two systems, key to the experience of an installation for tenants.

To install a heat pump, a tenant must be consulted with and provided information; this is true regardless of the type of system. The way in which the heating would be experienced in the home and the way in which the heating level should be controlled is the same for both types of heat pumps; they operate at lower temperatures for longer periods of time, whether the energy source is from the air or ground. The education around this for tenants to understand the operation of the heating is expected to be very similar.

During an installation process, tenants will interact with the landlord and those people carrying out the installation and these service provision aspects are the same for both types of system. Although there are differences between the systems in terms of the equipment that is installed and where it is located, a level of disruption would be inevitable for tenants in their homes and this is a key part of the service to be managed. The post-installation maintenance and support service would be the same for both the types of system as far as the tenant is concerned, in terms of communication and interactions with their landlord and any other maintenance stakeholders.
For these reasons, it is valid to investigate air-source and ground-source heat pumps together in this research at a service provision level. This is because, as is made evident above, similarities lie within the service provision aspects which are the focus of this research; the differences are largely technical concerns. As such, the research samples for empirical studies can combine the two types of systems.

2.4 Conclusions

It has been identified and accepted that the UK domestic sector is a significant contributor to carbon emissions, with the majority of domestic energy use attributed to heating and hot water. With greater expectations for occupant comfort, resulting in higher heating temperatures and increased demand for hot water (Cockroft & Kelly, 2006), domestic heating emerges as a crucial area to target for advancing carbon emission reductions. Technologies operating from renewable energy sources require less energy to function and produce minimal carbon emissions. Therefore, renewable heating systems are an option for heating and hot water provision which address the issue of reducing carbon emissions from these essential domestic needs.

As renewable heating systems, such as heat pumps, require less energy to operate, when used effectively, their running costs are lower. As such, they deliver an opportunity to abate fuel poverty, which is an issue across the UK, particularly in low income households. Grant funding has given social housing organisations the opportunity for numerous installations and, therefore, heat pump installations have been increasing in social housing. Social housing is important for older people, retired with low incomes.

Emphasis is being put on enabling older people to remain living independently in their homes and there is wide consensus that technological solutions are a way of facilitating this. Whilst heat pump technologies cannot be categorised as assistive technologies in the same way as other systems which support older people remaining independent, it can be argued they have an impact on ageing in place. Aspects of health that are related to environmental conditions can be impacted by
the quality of the indoor environment (Crump, 2011); therefore, increasing energy efficiency improvements in housing is being, in part, driven by public health implications (Rudge & Gilchrist, 2005). Heating is an essential requirement in UK homes for basic health needs, with particularly important considerations for older people. For instance, results of a study examined by Rudge & Gilchrist (2005) may indicate that there is a relationship between energy inefficient housing and winter respiratory disease among older people.

Installing heat pumps into social housing properties inhabited by older people may facilitate independent living by increasing the energy efficiency of the home and thermal comfort at a lower cost for the tenant. Furthermore, heat pumps provide a cleaner, easier to manage alternative to coal-fired systems that older people living in rural, off-gas areas have, which are laborious to use and maintain. Coal-fired systems become unmanageable for older people with disabilities; therefore, a heating system that is easier to manage, such as a heat pump, enables that person to remain in the property with satisfactory thermal comfort. Conversely, however, this would not be the case if the person is not able to use the alternative technology effectively.

A further advantage of heat pumps is that they also offer a sustainable source of energy obtained within the UK. With depleting fossil fuel supplies, alternative sources need to be exploited for longevity of energy provision. Currently, fossil fuel reserves are reducing within the UK and reliance on imports is increasing. Utilising renewable sources of energy within the country reduces energy security risks in terms of the high and volatile costs of imports or eradication of other fossil fuel sources used to produce energy.

Research recognises these issues of climate change, an ageing population and energy security as major challenges being faced this century (da Graca Carvalho, 2012). Research and UK energy policy also recognise the necessary goals of reducing carbon emissions, ensuring reliable energy supplies are available for consumers and ensuring that this energy supply is affordable (Skea, 2012). As outlined through this review of literature, renewable technology poses an opportunity to address the
implications of these matters through transforming domestic heating. However, effective integration of renewable technologies will require significant changes from a technical, economic and social perspective (Cockroft & Kelly, 2006). This research is an investigation of the social sector perspective and necessary requirements from this perspective for effective integration. The potential of any technology to augment energy efficiency is limited; the actual energy efficiency of a product is determined by the energy demand in the use-phase (Pierce & Roedl, 2008). Furthermore, the new system must be accepted in the first instance. Neither getting the technology right, nor making it affordable, is always enough to get new technologies adopted or used as intended (Webler & Tuler, 2010). Considering the design of the service when introducing and installing a heat pump system, therefore, becomes imperative to achieve successful uptake and effective usage.
3 Methodology

The aim of this thesis is reiterated at this point as the methodology chapter presents the author’s considerations in shaping the research, in order to fulfil the outlined purpose. Adopting a user-centred design approach, this thesis aims to explore and define the requirements and preferences of specific stakeholders in the social housing system when introducing heat pumps, to identify any means of creating a better service with a view to improving levels of uptake and efficiency of use of these technologies.

To achieve the aim of this doctoral research, experiences of social housing tenants receiving and experiences of social housing organisations providing heat pumps needed investigation. A further focus of the thesis was to investigate the implications for older people in this situation. Through this chapter, the theoretical approach overarching this research and the structure of empirical study to achieve this aim is communicated. The purpose of this chapter is to review theoretical perspectives, methodological approaches and strategies, to consolidate an understanding of research design and define what is appropriate for this research.

The research questions this thesis aimed to address are outlined, which were formed through the review of literature and identification of the topic area requiring investigation. These questions further guided the methodology underpinning the research. The selected research strategy and methodological approach applied to this research is presented and reviewed, to substantiate how it addressed the aim and objectives outlined in Chapter 1. The research approach is outlined in the following diagram in Figure 5 to show how the research methodology was designed to inform the user-centred design process. It is considered that a preview of the research approach at this point will place the subsequent description of the research in context.
Figure 5: Research methodology for a user-centred design approach
The user centred design process is presented in more detail in section 3.4.1 later in this chapter. Each of the three main phases of this empirical research (Exploration, Refinement and Development and Evaluation) are presented over subsequent dedicated chapters, through chapters 4 to 6 as indicated in Figure 4, with the applied methods and analysis of each outlined in the relevant chapter. At the end of this chapter, methodological concerns over the robustness of the research and ethics are considered and discussed.

3.1 Research Design

Research design is the process by which a research study is formed. The means of analysing data is heavily dependent on the methodological approach taken and the anticipated type of outcome (Guest et al, 2012). The research approach taken and goal outcome may be referred to as the analytic purpose (Guest et al, 2012); in other words, the purpose for analysing data or the reasons why and how the research is being carried out. This is indicative of how the whole process of carrying out a research project should be considered from the outset. Several models and frameworks have been proposed over the years within the research community for composing research design. Selected proposed models are discussed here to indicate the elements considered for the design of this doctoral research.

Layder (2012) depicts a framework for the development of research design, shown in Figure 6. He outlines the importance of developing core research questions in defining the nature, scope and objectives of the research, giving clarity and momentum to the research from the start. Emphasis is placed on the combination of a problem focus and topic focus in forming research questions. Problem-driven questions are outlined as general, conceptual and explanatory; topic-driven questions are differentiated as more concrete: the ‘what’, ‘how’ and ‘when questions’ and so are descriptive in nature. A problem-focus initiates and is the driving impetus of the project, surfacing explanatory objectives and moving the research beyond a purely descriptive nature, while the topic questions elicit essential descriptive informational elements (Layder, 2012).
Maxwell (2005) concurs with the importance of developing core research questions, as shown by their central position within his research design model in Figure 7.

Maxwell (2005) argues that research design is not a fixed, sequential structure: it is an on-going process that involves going back and forth between the components of the design. He proposes that the researcher needs to assess the implications of goals, theories, research questions, methods and the threats to validity for one another (Maxwell, 2005). His model is therefore presented as an interactive model.
of research design, where there are interconnections and interactions among the different design components, as seen in Figure 7 above.

The diagram depicts the key components of research design as:

- Goals – the purpose of the study
- Conceptual framework – understanding of the contextual issues
- Research questions – defining what the research aims to find out
- Methods – how the research will be conducted
- Validity – assessing the correctness and trustworthiness of the research

Maxwell (2005) recognises these elements as similar to other research design frameworks proposed, but states that his differentiation is the interactivity of his model rather than a linear or cyclical approach.

Robson (2011) proposes a framework similar to Maxwell’s (2005) interactive model for designing research, shown in Figure 8. Robson (2011) places importance on the same components but surfaces sampling strategy instead of validity as a core component. He also places less emphasis on interactions between each of the elements than Maxwell (2005) but rather presents how the research questions are formed and how these then provide a basis to develop the research methods.

Figure 8: Framework for research design (Robson, 2011)
To determine research questions, Robson’s research design framework states that the conceptual framework and purpose of the research firstly need to be defined. The conceptual framework refers to the researcher’s understanding of the situation: theory about what is happening and why, what the aspects involved are and how they might be related (Robson, 2006). A review of literature establishes this conceptual framework, to develop an understanding of research problems and questions. The parameters of the research should be considered and the purpose of investigating them identified. From the determination of what is being looked at and why, the research questions can be formed to refine what exactly the aim of the research is: what questions are to be answered through investigation. Subsequently, a sampling strategy and methods can be decided upon and designed that will endeavour to address the proposed research questions, to fulfil the purpose of the research as a whole.

There are clear similarities between the perspectives on research design, in structure and design elements. Some differences lie in the emphasis placed on particular components, but overall the consensus is a strong importance on the research questions, the conceptual theory required to identify them and the role these play in defining the research process. Maxwell’s (2005) and Robson’s (2011) research design models both present the same perspective of forming and using research questions. Maxwell (2005) describes these as two triangles. The upper triangle indicates the need for a clear relationship between the goal of the research and the research questions and conceptual knowledge to inform the research questions. The bottom triangle is a representation that the methods used must be appropriate to enable the researcher to answer the research questions. Maxwell (2005) and Robson (2011) differ at this point, with Maxwell emphasising the need to deal with plausible threats to the validity of answers to the research questions and Robson (2011) concentrating on the sampling strategy being key in answering the research questions.

This work is inherently qualitative in nature, resulting from the research context, the research questions formed and fundamental purpose of the research. It is an investigation concerned with contextually rich information and understanding.
experiences. Qualitative data enables the examination of how and why questions (Silverman, 2010) because of the depth of information it can provide. Qualitative research methods enable the investigation of situations where little is known about what is there or what is going on (Gillham, 2000). Methods in qualitative research focus on obtaining evidence that enable an understanding of meaning. A qualitative approach is therefore suitable and, furthermore, required when the value of the data is not a measurable quantity but to identify and understand reasoning.

A quantitative research approach deals with the measurement and analysis of numerical data. Quantitative research is grounded in scientific philosophy, employing experimental methods to test a measurable hypothesis or phenomenon (Golafshani, 2003). In order to carry out such measurement in quantitative research, it involves the control or manipulation of variables in order to test a theory. A qualitative research approach aims to understand phenomena within a particular context, in 'real life' settings without manipulating the phenomena of interest (Golafshani, 2003). Strauss and Corbin (1990) describe qualitative research as any kind of research that produces findings which are not derived from statistical procedures of any means of quantification. Polaine et al (2013) describe a difference between quantitative and qualitative research in an alternative view, suggesting that quantitative methods are good for creating knowledge and understanding of a field but not very useful for turning knowledge into action. Qualitative research is more appropriate for using insights and helping shape the application of them (Polaine et al, 2013). A qualitative research approach is therefore, as stated, appropriate for this investigation, rather than a quantitative research design.

Guest et al (2012) summarise two approaches to qualitative data analysis, or effectively qualitative research: exploratory or confirmatory. Confirmatory approaches are hypothesis-driven, guided by specific ideas to assess and are less commonly used in social research. Exploratory approaches are content-driven and descriptive in nature. The themes are derived from the data collected and, most commonly, exploratory research involves purposive sampling as the researcher aims to find out about a particular context within specified parameters.
Robson (2011) interchanges the term qualitative with flexible when discussing research design. He outlines that a flexible research design enables proceedings of the study to form dependent on initial findings (Robson, 2006). In a new field of research, in a complex, social situation, a flexible design is appropriate. Exploration into the area is required to develop an understanding and this comprehension acquired defines what further research may be needed and how best to approach it. A flexible research design is appropriate when there is an issue the researcher seeks to understand, not involving manipulation of variables, to identify causal relationships or to compare groups. These aspects may occur, but emerge through the research progress (Robson, 2011).

3.1.1 Research purpose
The three possible purposes of research commonly put forward are to explore, to describe and/or to explain (Robson, 2011). In much research, the context is a new area, largely un-researched, in which case the focus on exploration is highly valuable (Robson, 2011). This is particularly the case for doctoral research, for which the area of investigation must be novel and unique, to establish and contribute new knowledge. As demonstrated through the review of literature, the context of this research is a relatively new field which has only recently been focused on in the UK. Understanding users’ experiences of heat pump installations better and in this particular demographic is relatively un-researched to the level of detail presented in this work.

Therefore, exploration is a key and valuable purpose of this research from which understanding obtained can inform policy, practice and industry. Even more valuable to these various outlets is the ability to describe and explain, through insights generated from further, comprehensive research. While Robson outlines these pertinent purposes of research, Layder (2012) discusses the difference between these purposes in relation to producing rigorous research. The purpose and importance of description in research is acknowledged but Layder (2012) suggests that this only “scratches the surface of social life by concentrating on how people conduct their lives”. Research should go beyond description to search for explanations of behaviour, shifting the perspective from addressing ‘how’ questions
to ‘why’ questions (Layder, 2012). It is proposed that this view of a phenomenon creates more scientifically adequate and rigorous research of interest, although it is understood in this approach that finding explanations is dependent on preliminary description (Layder, 2012).

The action perspective outlined by Robson (2011) proposes a further important purpose of research. In ‘real world’ research studies, an action perspective looks beyond exploration, description and explanation to facilitating action: to help change, influence or improve (Robson, 2006). This can be applied to this research, as it aims to go beyond description and explanation of a situation and to facilitate improvements to heat pump installations by influencing practice in social housing organisations. The research conducted to inform this thesis sought to explore, define and attend to the requirements of both the social housing provider and the tenant when introducing heat pumps into a tenant’s home.
3.1.2 Research Questions

As demonstrated in section 3.1, research questions are a core component of a research project. Robson (2011) states that the research question provides the key to most things when doing social research. The research question, or questions as in the case of large-scale research such as this thesis, drives the design and process of carrying out an investigation. For this reason, the research questions are reiterated throughout the thesis, to signpost which parts of the research and what their design and execution was based upon.

The research questions are reiterated at this point, to highlight how the research purpose and context shaped these questions and how these, in turn, guided the research approach and methodology. Through carrying out this research, the following questions were addressed:

1. What lessons can be learnt from previous experiences when retrofitting heat pumps into social housing?

2. What measures would help augment the successful introduction and adoption of heat pumps in future?

3. Can user-centred design add value when applied to the service of installing heat pumps in social housing properties?

Theoretical perspectives of research and methodological strategies are considered further in the following sections in order to reflect and identify what was appropriate to apply to this research and fulfil these research questions and objectives.
3.2 Theoretical perspectives

Theory gives direction to what we examine and how we examine it. Exploratory research approaches may be applied to generate hypotheses, build theoretical models from data or address a practical problem in the world (Guest et al, 2012). Guidance about what to study and how is always derived from some form of theory; be it existing literature, one’s own knowledge or other people. However it is initiated, this drives the belief that the identified topic and population of study are important. Applied research is to address and/or solve practical, ‘real world’ problems. Guest et al (2012) distinguish applied research from research centred purely on furthering knowledge. This is not the case for doctoral research; this distinction cannot be made, as a key purpose of the thesis is to contribute to knowledge. Nevertheless, this thesis is applied research as it serves to address a ‘real world’ practical problem through research.

Theoretical perspectives of research are ways of thinking about and doing research that are based on particular assumptions (Allsop, 2013). There is a divide within the research arena between two traditional philosophical research theories: positivism and interpretivism. These primary philosophies are discussed here to define the theoretical standpoint of this doctoral research. Both research philosophies are legitimate approaches to research enquiry; the approach and, therefore, methods should be most appropriate for the intention of the research (Gillham, 2000).

Positivism is the natural science theory of research (Gillham, 2000); the approach to empirical study is based on scientific theory to produce evidence-based knowledge (Allsop, 2013). Proponents of the positivist standpoint advocate that interpretations should be derived directly from data observed and that both data collection and analysis should be systematic and structured (Guest et al, 2012). The knowledge derived from study should be context-independent from a positivist view (Cibangu, 2013). This philosophy encourages the researcher to take an objective view, as far as possible (Gillham, 2000; Guest et al, 2012) resulting in detachment between researcher and participants. Positivist research is most often quantitative in nature from experimental research methods, to produce or test factual hypotheses with generalisable results (Gillham, 2000; Guest, 2012, Robson, 2011). Advocates of the
positivist philosophy dispute that research from an interpretive philosophy is too subjective in its approach (Guest et al, 2012). However, positivism has been criticised for its limitations and ignorance of the effects of researcher involvement and influence (Robson, 2011).

Post-positivism has emerged as a theoretical standpoint which is an evolution beyond positivism. Researchers taking this approach theorise that an objective reality exists and should be sought through scientific methods, as from a positivist view, but recognises the fallibility in what is known, in part through the limitations and influence of the researcher. Whilst the positivist view stipulates that researcher and participants are separate from each other for objectivity to be held, post-positivists accept that the researcher’s views and values can influence the research. Therefore, methods and conclusions should be examined to reduce potential bias and to establish reliability and validity (Robson, 2011).

Whilst the natural sciences, positivist viewpoint seeks generalisable results from empirical study, Gillham (2000) outlines the difficulty of achieving generalisation in the study of human behaviour due to the existence of too many elements that are specific to that group of people. Interpretivism is a theoretical standpoint which places interest and importance on the subjective understanding of deeper meaning within a context (Guest et al, 2012). Gillham (2000) emphasises the benefit of a subjective view as the researcher gets to know the subject’s world and what they are trying to do in it, stipulating that an objective view can ignore important data for an adequate understanding.

Stemming from hermeneutics, originally the study of biblical text, interpretivism extends this to the interpretation of meaning from non-religious text, searching for meaning from personal narrative or observation (Guest, 2012). Robson (2011) terms interpretivism as social constructivist research. The theory is described as focusing on how individuals construct and make sense of their world; how situations are interpreted (Robson, 2011). Robson (2011) proposes that researchers with this theoretical perspective find difficulty in seeing an objective reality, emphasising the importance of the subjectivity of an individual experience.
Again, the understanding of meaning is the central notion of interpretivism, lending qualitative research methods to be most appropriate and valuable to obtain multiple, subjective perspectives.

The interpretivist – social constructivist (Robson, 2011) or naturalistic (Gillham, 2000) – perspective largely involves non-experimental qualitative methods and places importance on contextual understanding to derive meaning. The interpretivist approach is often an emergent research design (Gillham, 2000). A naturalistic researcher needs to have an understanding of the research field through literature and data review but understands this may not be entirely relevant to their case of study. In this approach, the first stage is to review the context from which the research questions and means of investigation will emerge. In line with this, interpretivist research is inductive in nature: the researcher makes sense of what they have found after they have found it. In contrast, deductive research is associated with the natural science, positivist viewpoint, whereby the researcher designs experimental studies to test existing theory (Gillham, 2000).

From this review of the theoretical perspectives of research, it is clear that the research undertaken for this doctoral thesis is approached from an interpretivist perspective and inductive in nature. Understanding people’s experiences and opinions requires an investigation of subjective matter. Furthermore, in an area where there has been little research and the phenomenon of interest is relatively new, an exploration for contextual understanding is required and the research outcomes and process emerge as a result of what is found. Gillham (2000) outlines that the subjectivity associated with naturalistic, interpretivist research is not to ignore an objective view, but rather to identify the subjectivity behind the objective evidence. This emphasises the reason for conducting research with both the social housing landlords and the tenants in order to obtain a balanced research view of both objective and subjective substance.
3.3 Research Strategy

Different research strategies or approaches can be adopted to undertake inductive qualitative research, to provide rich understanding and explanation of a topic of interest. The traditional strategies for flexible research designs are each discussed in turn.

3.3.1 Phenomenology

Phenomenology is an approach to research data collection and analysis, founded on humanistic psychology. This approach to research is applied when the participants’ feelings and experiences are the focus of the empirical study (Guest et al, 2012). The premise of giving a voice to the people whose experiences and feelings are of interest is a traditional humanistic approach which has transferred to qualitative research approaches. This is evident through the type of open-ended questions and conversational research methods used in qualitative research to find out about a topic in the participants’ own words, unconstrained (Guest et al, 2012). A dynamic, conversational enquiry allows the researcher flexibility to probe and ask meaningful questions, based on responses received during data collection.

Guest et al (2012) argue that whoever the participant and whatever the topic, giving a voice to the research participant is part of the anthropological tradition and qualitative research which stems from phenomenology. In essence, this research is to an extent phenomenological, looking at the experiences, opinions and feelings of tenants when having a heat pump installed in their home and using the system. Robson (2011) concurs that phenomenological research focuses on understanding how humans view themselves and the world around them. He states that this research approach seeks to convey deep insight and understanding of the meanings of everyday life experiences.

This is in-line with the suggestion that this doctoral research is somewhat phenomenological in seeking to understand and vocalise the experience of participants. Robson (2011) further outlines that in phenomenological research, the researcher is considered inseparable from assumptions and preconceptions about the phenomenon of study and attempts are made to explain these biases and
integrate them into the findings of study. Further understanding of an objective nature was also studied in this research, by involving the service provider, to assist in supporting and explaining the phenomenon experienced and counterbalance researcher interpretation and assumption from investigating one viewpoint. These explanations of the phenomenological research approach underpin the need for qualitative research and, arguably, phenomenology is what qualitative research is today.

### 3.3.2 Grounded Theory

The central aim of grounded theory study is to generate theory form the data collected as the study progresses (Robson, 2006). Through the use of inductive and iterative methods, insights gathered are used to form theoretical models (Guest et al, 2012). As the name suggests, theories constructed are grounded in the data collected (Guest et al, 2012). Flexibility in the research design allows for methods to be applied systemically as appropriate, to produce data and progress the forming theory. Grounded theory study is particularly useful in new, un-researched areas where there is a current lack of theory or description and explanation of a phenomenon (Robson, 2006).

### 3.3.3 Ethnography

Ethnography is an exploratory research methodology based on the observation of participants. The aim of ethnographic research is to describe, interpret and explain the culture or social constructs of a group of people (Robson, 2011). The term ethnography has been used less accurately to describe methods adopted that involve user participation to gather insights but it is a particular, rigorous form of conducting user research (Polaine et al, 2013). Ethnography has its roots in anthropology and involves the researcher immersing themselves within the social group or culture being studied so that phenomenon observed can be described in detail (Robson, 2011). A key aspect of traditional ethnography is that the participant observation takes place over a longer period of time, such as a year or more (Polaine et al, 2013; Robson, 2011). A key concern over ethnography within the research arena is the risk that researchers becoming immersed in the situation and
involved with the subjects being observed may disturb and change the natural setting (Robson, 2011).

3.3.4 Case-based research
Case-based research is discussed in a greater level of detail, as this was selected as the most suitable strategy for this research. Case-based research is an empirical enquiry that investigates a contemporary, complex, holistic situation within its real-life context (Yin, 2009). It does not involve manipulation of the situation variables but provides an in-depth understanding of predefined parameters to enable insight into the various factors involved and the interactions between those factors. The benefit of case-based research is the level of detail that can be obtained to explore, describe and develop theory (6 & Bellamy, 2012) as outlined as the key purposes of research (section 3.1.1). Case-based research is the study of a single case or few cases in considerable depth and as comprehensively as possible (6 & Bellamy, 2012). It is a research design or strategy, however, not an approach to data collection (Schrank, 2006).

The comprehensive study of case-based research and consequential level of detail is obtained through researcher involvement and the depth at which the researcher can investigate a case. The greater depth of understanding and familiarity of a case through researcher involvement can lead to greater insights and the ability to identify issues of importance, which were not apparent prior to commencing the research. Furthermore, Darke et al (1998) propose that case-based research is suitable for exploration of areas where existing knowledge is limited, as is the circumstance in this research context as demonstrated through the literature. Case-based research has a flexible structure; therefore it is applicable to the explorative nature of this research, where outcomes cannot be hypothesised or predicted. Case-based research more easily accommodates changes during the research process (6 & Bellamy, 2012) so research studies may be designed based on reflection of previous findings. The field of investigation and parameters forming this body of work result in a unique population sample. It presents an important area for study, as outlined through the review of literature; however, it relies on a small cohort from which to extract a research sample. Therefore, this enquiry looks at
one case in depth with supporting cases informing the research and providing wider contextual understanding and validation.

The case itself refers to a situation, individual, group or organisation of interest (Robson, 2011). Gillham (2000) agrees with the broad application of the term ‘case’, but further breaks down the definition into greater detail, outlining a case as:

- a unit of human activity embedded in the real world
- which can only be studied or understood in context
- which exists in the here and now

(Gillham, 2000)

6 & Bellamy (2012) define a case as sufficiently internally complex to study interacting factors and sensitive to context. These definitions of a case are attributable to the situation being investigated in this work. With multiple stakeholders involved and delivery of a product and a service with varying processes and interactions, it is internally complex and interacting factors can be examined. Furthermore, a deep contextual understanding is required to address the posed research questions of this work. Gillham (2000) further outlines that case-based research seeks a range of evidence to answer the research questions. He proposes that one source of evidence is unlikely to be sufficient and that use of multiple sources of evidence, each with strengths and weaknesses, is a key characteristic of case-based research.

Case-based research does have recognised limitations. Conducting case-based research means that the research cannot be extensive; there cannot be a large amount of data or large number of cases to analyse; therefore, it cannot be generalised. It produces more specific insights, the applicability of which to other contexts cannot be predicted. It is susceptible to generating insights and contributing knowledge that are only relevant to the particular case (6 & Bellamy, 2012). However, the potential for information being too specific and generalisation issues resulting from small, specific samples should not be taken too rigidly to prevent a contribution to theory. The sample may be specific but the insights generated do have the potential to be identified in other cases or areas (6 &
Furthermore, Flyvbjerg (2006) and Gillham (2000) support the value of case-based research through the impact just one case may have. Flyvbjerg (2006) outlines the ability of a case to provide falsification: one of the most rigorous tests a scientific proposition may be subjected to. Because of the in-depth approach of case-based research, insights may be produced which identify something that does not fit with other cases or a hypothesis and as a result the whole proposition must be revised or rejected (Flyvbjerg, 2006). Gillham (2000) describes the value or impact one case may have in research by outlining how phenomena of a single case must be paid attention to because they happened: they cannot be argued against or ignored and may provide important information for theory and knowledge.

3.4 Methodological approach
The purpose of this research, as described in section 3.1.1, was to explore and understand users’ experiences and opinions in order to comprehend their needs and any opportunities to facilitate change for improvement. Therefore, user involvement in the research to ask them about their personal experiences and opinions was imperative. This investigation adopted a user-centred design approach in order to enhance user involvement in the process, for a better focus on the users’ requirements, to address research questions 1 and 2. Applying a user-centred design framework also identified the viability of this approach for a service context, addressing research question 3.

3.4.1 User-centred design
Put simply, Pheasant (2002) defines the objective of user-centred design as to achieve the best possible match between the product and its user, in the context of the task that is to be performed. Shackel & Richardson (1991) previously depicted a similar explanation of the principle interacting components of any user-system situation, surfacing the influence of environment on the user, tool (or product as above) and task, as shown in Figure 9. Good design is dependent on solving the
dynamic interacting needs of these components (Shackel & Richardson, 1991) or creating the best fit to satisfy them, as Pheasant (2002) describes.

![Figure 9: Interacting components to consider in user-centred design (Shackel & Richardson, 1991)](image)

Expanding on this definition of the intention of user-centred design, Pheasant (2002) summarises that:

“if an object, a system or an environment is intended for human use, then its design should be based upon the physical and mental characteristics of its human users.”

A discussion of user-centred design usually goes hand-in-hand with the term usability; a user-centred design process is to increase the usability of a product or system. Usability is now widely recognised as critical to the success of an interactive system or product (Maguire, 2001). If a product or system is poorly designed and not intuitive, users may find it difficult to learn or complicated to use. This may result in under use, misuse or an inability to use the product or system and frustrated end users (Abras et al, 2004; Maguire, 2001). This traditional ergonomics or human factors perspective has evolved over the years to go beyond suitability and usability in terms of physical and cognitive fit, to include consideration of emotional, social and cultural dimensions (McClelland & Fulton Suri, 2010).
Abras et al (2004) define user-centred design as a broad term to describe design processes in which end users influence how a design takes shape. This reflects how the philosophy and process of user-centred design, to consider the requirements and capabilities of the end user during the design process, has been applied across wider contexts of product and system design. The process for user-centred design is outlined below in the diagram in Figure 10.

Figure 10: User-centred design process

It is noted by Pheasant that the physical and mental characteristics of the human users demarcate design as far as possible, determined by the methods adopted and information gathered (Pheasant, 2002). This demonstrates two key points: the importance of the methods used and the importance of the involvement of users.

3.4.1.1 User involvement
User-centred design is both a methodological philosophy and a collection of methods which have one key aspect in common: the design process involves users. Usability is only possible and only definable with regard to a particular user group, doing a particular task in a particular context (Coleman, 2007). The International
Standards Organisation concurs with this definition, stating that usability is “the extent to which a product can be used by specified users to achieve specified goals with effectiveness and satisfaction in a specified context of use” (Bevan, 1995). The extension of this definition to incorporate ‘satisfaction’ emphasises the importance of end user perception.

Thus, the involvement of end users is an important feature in the development of any products or systems, to help ensure what is developed for users will actually cater to their wants and needs. Clarke (2009) states that a barrier to adoption of new products is design without the specific needs and abilities of the user in mind. Taking into account Karat’s (1997) view that usability is not simply limited to the interface, but that it encompasses how the artefact fits into a complex environment, Clarke’s principle can be extended to the holistic service surrounding a product design and delivery. Involvement of the user from the outset is an optimal means of identifying their wants and needs. The International Standards Organisation further supports this by recommending the active involvement of users to understanding user and task requirements (Kujala, 2003). This complex environment extends out to incorporate the service surrounding a product.

A study of ‘older people and winter warmth behaviours’ found that participants emphasised the existence of diversity amongst the older population, but acknowledged the generation as a whole to have different lifestyles to younger people (Day & Hitchings, 2009). This emphasises that the involvement of end users is necessary to identify commonalities and differences in the range of behaviours and preferences of a user group or groups, to feed into the development of products and services for these users. In this case, as indicated by Day and Hitchings (2009), the involvement of the older population as end users is important to understand their experiences and perceptions, as diversity in this user group is apparent, and to dispel any potentially mistaken pre-conceptions of the elderly.

For researchers and designers, involving older people in the development of products and services provides a rich information base, providing insights into their personal experience, and opportunity to observe and gain an understanding of the
physical and social changes which occur in later life. These changes translate into altered needs and aspirations (DesignAge, 1997). Difficulties of involving older people in research processes have been identified; for example, research has shown that drop-out rates are higher amongst older participants (Chatfield et al, 2005). Attrition of elderly participants can create bias in study samples and affect the reliability and validity of the findings (Bhamra et al, 2008). Bhamra et al (2008) identified that attrition in research is affected by factors such as being older, being cognitively impaired, having lower socio-economic status and being less well-educated; all of which may be present in the participant sample in this research of older people in social housing.

Research has been successfully conducted with the involvement of older people (for example: Czaja et al, 2006; Day & Hitchings, 2009; Mitzner et al 2010). It has been proposed that approaches to retaining older people in research should be flexible and incorporate personal gestures (Bhamra et al, 2008). A means of retaining older people in research studies is emphasising the importance of the study and the participants’ involvement. This can be done by sending participants letters from the researcher thanking them for their participation (Bhamra, 2008). Through the research being endorsed by the social housing organisation and the participants being contacted by the landlord rather than the researcher directly, this potentially increases the perception of importance and validity of the research as the social housing landlord has agreed to it through recognising it as beneficial.

It has been found that older people are cooperative in participating in research as they are “aware of the reciprocal nature of the collaborative process”. There is an understanding that if they are involved and have the opportunity to provide information about their lives and what they like and want; the design of products and services is more appropriate and thus they receive some gain (DesignAge, 1997). Again, through the social housing organisation being the primary contact recruiting for the research studies, this indicates to the tenants that their landlord is aware of the research being carried out and their input will be heard by their landlord.
3.4.1.2 User-centred design philosophy

Summarising the user-centred design approach discussed above, Pheasant (2002) presents the following set of 8 key principles of user-centred design which encapsulate its benefit, value, process and, moreover, appropriateness to this work. These principles are defined below:

1. It is empirical

It seeks to base the decisions of the design process upon hard data concerning the physical and mental characteristics of human beings, their observed behaviour and their reported experiences. It is distrustful both of grand theories and intuitive judgements – except insomuch that these may be used as the starting points for empirical studies.

2. It is iterative

It is a cyclical process in which a research phase of empirical studies is followed by a design phase, in which solutions are generated which can in turn be evaluated empirically.

3. It is participative

It seeks to enrol the end user of the product as an active participant in the design process.

4. It is non-Procrustean

It deals with people as they are rather than as they might be; it aims to fit the product to the user rather than vice versa.

5. It takes due account of human diversity

It aims to achieve the best possible match for the greatest possible number of people.

6. It takes due account of the user’s task

It recognises that the match between product and user is commonly task-specific.
7. It is systems-oriented
It recognises that the interaction between product and user takes place in the context of a bigger socio-technical system, which in turn operates within the context of economic and political systems, environmental ecosystems, and so on.

8. It is pragmatic
It recognises that there may be limits to what is reasonably practicable in any particular case and seeks to reach the best possible outcome within the constraints imposed by these limits.

This list of principles clearly outlines how the user-centred design process is an approach which can be applied to address the interactions between people, tasks and objects in a width breadth of product and system contexts. This thesis is looking at the interactions between people and products of a system but applies the user-centred design philosophy, approach and methods to an even broader, service context.

3.4.1.3 Designing for Services
Social housing organisations are service providers. In managing social housing properties, landlords provide many different services to tenants, such as property maintenance and consumer advice. Installing a heat pump system into a social housing property is a service delivered by the social housing provider to the tenant. It is not just the handing-over of a product; there are surrounding service elements such as tenant consultation, assistance with usage and maintenance of the product which will all impact on the usability of the system for the tenant. The experience had by social housing tenants throughout the service delivered by the social housing landlord may ultimately have implications for their willingness to accept the new heating system, use the system correctly and the likelihood of recommending it to other tenants.

This section of outlining the methodological approach is deliberately labelled ‘designing for services’ and not ‘service design’. Service design is an emerging and growing discipline (Nieminen, 2011); it is becoming established in industry and
academia (Vaajakallio et al, 2009). Service design is recognised as an interdisciplinary approach, which has emerged over the last couple of decades, focusing on the design of interactions between users and the supply system that form a service (Sangiorgi, 2009). Pacenti (1998) defined this perspective of service design as the design of the area, ambit and scene where the interactions between the service and the user take place (in Sangiorgi, 2009).

Although services themselves are intangible, service design addresses the ‘service interface’ – also referred to as ‘service encounters’ or ‘touchpoints’ – which encompasses the tangible or visible parts of the service which result in its existence and delivery. These tangible points of interaction are made up of people, products, information and environments that will support the user experience (Sangiorgi, 2009). The Copenhagen Institute of Interaction Design (2008) outlines service design as “an emerging field focused on the creation of well thought through experiences using a combination of intangible and tangible mediums” (Stickdorn & Schneider, 2010).

As a developing discipline, there is no single, refined definition of service design. The UK Design Council’s definition however, states that “Service design is all about making the service you deliver useful, usable, efficient, effective and desirable” (Stickdorn & Schneider, 2010). The principles of service design are appropriate to the creation or review of any service and the redesign of existing services is just as much an important area for innovation as new services (Berry & Lampo, 2000). Whilst the definition of service design is as yet undefined, the principles of its process are clear.

The first principle of service design is that it is user-centred. For a service to function, participation of the user, or customer, is imperative (Stickdorn & Schneider, 2010). For the service to be successful, the user needs to be able to perform their role effectively. Therefore, it is important to gain an understanding of the situation from the perspective of current and potential customers (Stickdorn & Schneider, 2010), to ensure the service is designed to satisfy their requirements and preferences. When designing a service, as much information as possible should be
gathered about the context in which the service will be implemented (Morelli & Tollestrup, 2007).

The second principle of service design is that it is co-creative (Stickdorn & Schneider, 2010). Involvement of users should not just be at the beginning or the end of the design process. Involving users at the beginning to investigate a situation alone allows potential for designers’ own biases and preferences to be introduced. If users are only brought in at the end to validate a design, this can result in costly and time-consuming changes needing to be made. By involving users throughout the process, as is advocated by the service design approach, and giving them the opportunity to participate in the design stage, a user’s perspective can be maintained and this helps to ensure designs are suitable for the users. Co-creation is the term used to refer to a level of user involvement that means the users participate in the design stage, producing design ideas themselves.

Whilst service design is evidently a user-centred approach in its philosophy and methodology, the second core principle of it being a co-creative process is what differentiates the service design methodology from the traditional user-centred design approach. In some contexts, co-creation is not possible and to robustly adhere to a design methodology the core principles must be followed. In this research context, the participants were elderly and inaccessible to the researcher prior to the research because of the social housing context. It was not felt that the participants would be to open to heavily-participative, co-creation methods, given the participants’ age and familiarity with the research and interest in taking part in such activities. Consequently, the third research question of this thesis was to identify the viability of applying a user-centred design methodology to the design of a service; can user-centred design add value when applied to a service where co-creation and, therefore, true service design is not possible?
3.4.2 Research Methodology

Having established the user-centred design approach, presented in Figure 10, above, the detailed methodology for the research is considered here. A case-based investigation consisting of three main phases and empirical studies which enable the fulfilment of the user-centred design stages was used, in a process which suits the service context, as shown in the diagram below in Figure 11 (a reduction of Figure 5).

![Research Methodology Diagram]

Figure 11: Research methodology for a user-centred design approach

The first study (reported in Chapter 4) was an exploratory empirical study with multiple social housing organisations, in order to ‘understand and specify the context of use’. User-centred design advocates the need to fully explore the needs and desires of the users and intended uses of the product, through involving actual users, in the environment in which they would use the product (Abras et al, 2004). Therefore, this study was an exploration carried out through contextual interviews with landlords and tenants. The diagram below in Figure 12 depicts this research study and how it was informed through the CCC research sample and participants recruited for this doctoral research alone. Through this exploration research, user requirements were identified.
The second study (reported in Chapter 5) was to refine requirements and develop solutions based on the outcomes of the first exploratory phase. This second phase of the research was effectively an iteration within the user-centred design process, as indicated in Figures 5 and 11, to conduct further exploration and definition of requirements with a more specific focus, based on the outcomes of the first study. The landlord and tenants from the Gloucestershire part of the sample were involved in the second study as the case study being investigated across the research. The refinement of requirements and development of solutions was executed through conducting focus groups with stakeholders on the service provision side and stakeholders on the service recipient side, as indicated below in Figure 13.
The final phase of this research (reported in Chapter 6) fulfilled an evaluation stage of the user-centred design process. The solutions developed were evaluated by users from the Gloucestershire case study, to ascertain the suitability of what was developed against the user’s requirements. A prototype was distributed to tenants along with a questionnaire to review and evaluate the design.

Gable (1994) proposes that case-based research is suitable to firstly define constructs and develop theory and then test by survey research methods. This sums up how the research methodology outlined above comes together, to maximise user involvement and create solutions that are as user-centred as possible, to increase the likelihood of success. The details of each research phase are described over the following chapters 4, 5 and 6 presenting the methods applied, research findings and a discussion of the research outcomes of each study.
3.5 Reliability & Validity

The search for answers to the research problem questions driving the research is the key to scientific rigour. This search for explanation beyond description of a situation or phenomenon produces research of more substantial adequacy and interest. However, understanding explanations relies on the provision of preliminary accurate and reliable description (6 & Bellamy, 2012). 6 & Bellamy (2012) outline that principles of scientific rigour should be demonstrated throughout all phases of a research process and in the reporting of a research project; adequacy and reliability should be evident, for example, in the research questions, the design of the research and the methods of data collection.

Qualitative research investigating user’s opinions and experiences lends the data to be subjective in nature. Reliability and validity have important implications for the success of subjective measures (Noyes & Baber, 1999). Reliability refers to the internal consistency of a measure, meaning the ability to repeat a research process and obtain the same results. Validity refers to whether the method of research measures what it was intended to (Noyes & Baber, 1999). These measures exist independently of each other, but increased instance of both increases the rigour of the research. Golafshani (2003) outlines that reliability and validity are treated separately in quantitative research but are not viewed separately in qualitative research. In fact, the terminology reliability and validity tends not to be used in qualitative research (Golafshani, 2003; Robson, 2011).

Researchers adopting qualitative, flexible research designs avoid the terms reliability or validity, or even propose they are not relevant in such research (Guest, 2012; Robson, 2011). Morse (1999) argues that to state these terms are not applicable in qualitative research is to infer that qualitative research cannot be reliable or valid (in: Robson, 2011 pg 155). By the definition that scientifically rigorous research must be reliable and valid, if qualitative research is not reliable and valid and it cannot be rigorous science. Robson (2011) points out that, whilst an extreme interpretation, this argument poses an important consideration for presenting scientifically rigorous qualitative research. Straus and Corbin (1990) discuss this in their earlier writing by
proposing that the “usual canons of good science” require redefinition in order to fit the realities of qualitative research.

This implies recognition that the aspects of reliability and validity in research should not be dismissed but rather redefined to be more relevant to qualitative research design. Researchers taking a qualitative, flexible approach to their study have replaced the terms of reliability and validity with other terms such as credibility, dependability, confirmability, trustworthiness (Guest, 2012; Robson, 2011). These terms place more emphasis on the confidence of the truth and accuracy of the research findings and whether the research process is consistent and carried out with attention to the conventions of qualitative research (Guest, 2012). Whilst reviewing and recognising other researcher’s application of terminology and opinion in this research arena, Guest et al (2012) argue that the terminology reliability and validity should be kept in qualitative research, whilst recognising their limitations.

Researchers have discussed the implications or need for reliability and validity in particular regard to case-based research. The issues raised are very much in-line with those concerning qualitative research. For example, 6 & Bellamy (2013) state that case studies must meet certain standards of reliability and validity but that it is unclear what these standards are in order to demonstrate that they have been met. Denzin & Lincoln (1998) use alternative terms such as dependability and confirmability to refer to the concept of reliability, in the same sense as other qualitative researchers who redefine the term using similar terminology to more appropriately fit the nature of the research.

A limitation of case-based research is that it does not involve a large participant sample or volume of data. It is, therefore, susceptible to producing insights particular to that case and the relevance of this in other contexts is unclear (6 & Bellamy, 2012). This, as with qualitative research explained above, has implications for the replication of research if applied to other cases. In this regard, the term reliability as applied in quantitative research is not suitable terminology. Within and across social contexts great variance can be observed, so empirical research is difficult to replicate. However, if regarding the rigour of research in terms of
credibility and trustworthiness, it is important to demonstrate that data were obtained and analysed in ways that were pertinent to the research design and data were accurately used to produce research findings (6 & Bellamy, 2012)

Small samples and a lack of being able to replicate the research or generalise findings is not to dismiss the value of a case-based research, however. 6 & Bellamy (2012) purport that researchers may overstate the particular nature of case-based research in such a way that it sacrifices the possibility of contributing to theory. However, as Gillham (2000) outlines and as described in section 3.3.4 reviewing case-based research, a single case holds value in contributing to theory through falsification of a phenomenon or highlighting the existence of a phenomenon previously not recognised but which cannot be ignored.

Darke et al (1998) highlight that the reporting of case-based research can be difficult and has often been considered to be lacking in rigour. In order to increase validity within case-based research, 6 & Bellamy (2012) outline a strategy applicable to interpretive, qualitative research in general. They describe checking back with participants to ensure that the data collected accurately captured the subjective meaning and that the inferences made by the researcher from the empirical study make sense in the context of their experiences. This was achieved in this research by the format of the research methods. An empirical study of contextual interviews followed by further exploration with participants in the same case through a focus group and, subsequently, more contextual interviews enabled a validation of insights and greater contextual understanding.

An audio or video recording of data collection during these studies ensures that all information and a greater level of detail are captured and retained for the duration of a research project. This not only adds value to the research process by enabling flexibility in carrying out conversational research methods, but provides support to substantiate the validity of the research. Inaccuracy or incompleteness of data reduces the validity of what the researcher reports. Therefore, a recording of the data with all details captured ensures the researcher has all the information available
to work with rather than just their own note-taking or memory, which could result in data being omitted if not registered at the time.

**3.5.1 Pilot studies**

A pilot study is a small-scale version of the intended process of carrying out a major research study. It can also be known as a feasibility study because the purpose of the small-scale study is to assess the feasibility of the planned protocol (Robson, 2011). It is an opportunity for the researcher to practise and prepare for conducting an empirical study. It also allows for a pre-test of particular research measures, such as an interview guide or questionnaire (van Teijlingen & Hundley, 2001). One of the key reasons conducting a pilot study is important is that this pre-testing may give prior indication of difficulties or the research: where an instrument is too complicated or inappropriate, where protocols may not be suitable or where failures may occur (van Teijlingen & Hundley, 2001).

Conducting a pilot study cannot guarantee the success of a major study. A pilot study being conducted successfully cannot create an assumption that the main study will also be as successful. Although it can give an indication of the likely success or failures, they are based on small samples and cannot be extrapolated to the main study with accuracy. It can, however, reduce the risk of failures by identifying any potential areas early on. By pre-testing the feasibility and practicality of a research study process, any issues may be identified enabling them to be addressed and modified where necessary prior to commencing the main study.

There are aspects of case study research that can make piloting more difficult to do (Robson, 2011). Robson (2011) suggests that for case-based research piloting is less crucially important. If only one case is to be considered or there are such particular features of the selected case that an appropriate exemplary equivalent could not be referred to, then a pilot study would not be suitable (Robson, 2011). In this research, a pilot study was conducted where practicable but not in all parts of the research. This is due to such particular parameters of the research making the sample, albeit important, relatively small and equivalent representative samples
difficult to obtain without detracting from the main study, which was of greater importance to the research process.

3.6 Ethical considerations

Ethics are a critical consideration of every social research project (Noyes & Baber, 1999). Ethical issues inevitably arise in all research involving people and should be taken into account in the planning and conducting of any research project (Robson, 2011). Ethical guidelines regulate the behaviour and activities of researchers in all projects in order to protect the rights and well-being of research participants (Layder, 2012). Researchers must be aware of the ethical guidelines relevant to their area of work and, as far as possible, adhere to these (Philips & Pugh, 2000). If for any reason guidelines are deviated from it must be justifiable as imperative to the research purpose and accepted by the appropriate ethical regulatory body (Layder, 2012; Robson, 2011). As a fundamental principle of ethical research, no individual should leave a study in a worse state, mental or physical, than when they started (Noyes & Baber, 1999).

A core principle of ethical guidelines in all manners of research is fully informed consent (Layder, 2012). The participant should always be made aware of what is being asked of them, the purpose of the research and its intended outcome or outputs. This ensures ethical issues of deception and potential harm are minimised or eliminated. As part of the informed consent, participants should be made aware of any potential risks and understand they have the right to withdraw at any stage without question or any repercussions. It would be unethical to impose psychological barriers to withdrawal mid-study as their involvement may have proved unexpectedly stressful during the course (Robson, 2011). The participant must be provided the opportunity to ask any questions and clarify any aspect of the research with the researcher, prior to agreeing to participate or during the progress of the research and the participant should not feel any pressure to take part. Consent is obtained by the participant signing a form, which outlines the key points they should be aware of to ensure they understand all aspects.
In longitudinal research with a flexible design it is questionable how far the consent obtained initially can be applied, whether it remains valid, as the research develops (Layder, 2012). With changes in methods across the research development, consent should be obtained against each, to ensure that the participants are aware of what is being asked of them in that particular study. Although case-based research, this work also involved a new population of participants per study. Some participants were involved in more than one phase of the research, however, the methods employed changed to best investigate at each phase. Therefore, it adhered to best practise ethical guidelines to provide new information sheets and obtain consent from everyone, at every phase.

As part of the informed consent obtained, participants should be reassured of the confidentiality and anonymity of their participation. Anonymity is the protection of participants’ personal identity. Personal details of the participants should not be made available to anyone outside of the research team and should be protected as far as possible. Pseudonyms, often in the form of a code, are used to replace the participants’ real name and identity to create anonymity; however, data management becomes imperative to ensure the effectiveness of such a system, Bell (2010) purports. Successfully managing anonymity and data supports the confidentiality of the research information obtained (Layder, 2012). The assurance of confidentiality and anonymity can be verified by data management techniques such as storing files and information on a password protected computer and keeping paper records in locked cabinets when unattended.

Aside from practical considerations around participant consent, a core principle of ethical research is protecting participants from any undue physical or mental harm. Participants must be treated with consideration and respect, minimising any intrusion into their privacy, allowing their freedom of choice over how much or little they participate in the research and in fairness with regard to any compensation or incentives received (Layder, 2012). Participants should be treated equally and not caused any embarrassment; they should not feel pressure to participate and should be in no way misled over the intention of the research (Layder, 2012).
Ethical principles and regulations also serve to protect the safety and well-being of the researcher. Risks for the researcher are particularly problematic when carrying out work with previously unknown people, in difficult environments or investigating sensitive topics (Robson, 2011). The majority of the empirical research for this work was conducted in participants’ homes or unfamiliar locations. For some of the data collection the researcher was chaperoned which reduced any safety risk; however, a proportion of the data collection was conducted alone by the researcher. Risk in these cases was minimised by ensuring supervisors were aware of the location and times of appointments and contacted after visits. This did not breach confidentiality of the participants’ details as they were kept within the immediate research group. Face-to-face investigations with social housing landlords were not chaperoned. However, this was not deemed a high risk to the researcher, as data collection was carried out in an office at the social housing organisation’s premises or an office at Loughborough University where, in either case, other staff members were in the vicinity. If the researcher felt uncomfortable in any situation, they would end the session prematurely, politely thanking the participant for their time, and leave immediately.

This doctoral research was carried out in compliance with the ethical guidelines of Loughborough University and sought the approval of the Ethics Committee at the university. The participants involved in the research were over 65 years of age, which meant they were within the category of involving vulnerable people in research. As such, a ‘Full Ethical Submission’ was required to satisfy ethical requirements concerning how the research would be managed. This covered the issues outlined above: informed consent, confidentiality and anonymity. In addition, it was required that the researcher had a check carried out by the Criminal Records Bureau and obtained certification that they posed no risk to the participants. Furthermore, because the majority of the empirical research was carried out in the participant’s own home, a clear plan was outlined for how this would be conducted to protect both the privacy of the participant and the safety and well-being of the researcher. The ethical considerations and practices for each of the phases of research are outlined in each relevant chapter, in chapters 4 to 6.
Another aspect to consider regarding ethical practice in research is ethical responsibility. Researchers need to be aware of their responsibility to report any suspected illegal behaviour or activity observed when carrying out empirical studies to an appropriate authority. In any instance of this occurring, the agreement of participants’ anonymity is negated as this issue takes precedence (Robson, 2011). Similarly, other situations where concern is caused over someone’s physical or mental well-being should be brought to the attention of the researcher’s supervisor or a relevant authoritative figure; for example, if professional misconduct causing grief to another is observed by the researcher (Robson, 2011).

The researcher should also be aware, however, and distinguish between what is actually unethical and what is disturbing or concerning in view of the researcher’s own values and expectations (Robson, 2011). Caution must be exerted in reporting questionably unethical behaviour by seeking the advice of supervisors. The researcher is not in a position to enforce what constitutes ethical behaviour from their own personal standpoint. Therefore, any potential concerns observed should be discussed with supervisors and reviewed or investigated by a suitable authority. These issues may arise in research such as the studies for this thesis carried out in the home environment, where disparity may be observed in social interactions and behaviours.

It could be argued that there are ethical issues to consider in this work beyond practical research ethics. When carrying out work that potentially may redesign a service or change an organisation’s operations, this may impact various aspects of an organisation and this impact could be negative. For instance, in designing services for improved user experience, if this involves streamlining processes, it should be taken into consideration whether this will ‘design out’ someone’s role. Ethically, the impact of the research in the broader social context should be considered throughout.
4 Phase I: Exploration

To achieve the overall goal of this research, an assessment of the current services across social housing organisations of installing heat pumps into their properties was needed to form a foundation of understanding. The first research question of this thesis is:

- What lessons can be learnt from previous experiences when retrofitting heat pumps into social housing properties?

The answer to this research question could be partially informed through a review of literature, the first objective of this thesis, the results of which have been presented in chapter 2. This doctoral research aimed to apply a user-centred design approach to the heat pump installation service, following the research design described in chapter 3. The first stage of the user-centred design framework is to ‘understand and specify the context of use’, through the involvement of users. An initial research study was conducted to obtain the perspectives of both the service providers (landlords) and the service recipients (tenants) of heat pump installations, to explore and develop a deeper, contextual understanding of the service delivery and users’ experiences of heat pump installations. The insights gathered from the exploratory empirical research led to the fulfilment of the second stage of the user-centred design framework, to specify the user and organisational requirements. To inform this research, the requirements were focused around any potential improvements that could be made to the service.

The following diagram, Figure 14, is a depiction of how this exploration phase of the research applies to deliver the first two stages of the user-centred design approach, as described above.
The existing literature in this area surveyed and presented in chapter 2 indicated that people’s understanding about the system when having a heat pump installed is an issue and related to this may be the information that they are provided. A more detailed investigation is needed to explore these issues further and identify any other related issues: positive or negative experiences and where improvements could be made to the installation service.

4.1 Exploratory research methods

As outlined above, the purpose of this phase of the research was to investigate and understand people’s views, behaviours and opinions. Therefore, qualitative research methods were required that would enable rich, in-depth information to be gathered. The insightful information most valuable in this part of the research could be established through open conversation and the development of contextual understanding. Particular research methods lend themselves better to obtaining this sort of information and at a greater level of depth. Research methods are reviewed in this section and the most suitable method selected for this research study outlined.

Interviews are a well-established method of conducting research to obtain rich, detailed information (Gillham, 2000). In order to be carried out effectively and obtain this greater level of detail, they are a time-consuming method of data collection (Gillham, 2000). Interviews, therefore, are a less appropriate research method for a large sample of participants (Courage & Baxter, 2005; Gillham, 2000). They are an option to be used with large samples but would require a lot of time, resource and cost which is likely impractical, particularly for a lone researcher.
With smaller participant samples, however, interviews are a suitable research method for empirical study, to obtain a rich understanding of a situation.

The most important form of interviewing in case-based research is semi-structured interviewing (Gillham, 2000). A semi-structured interview is one which has a level of predetermined questioning, usually open-ended, and format prepared, but allows for changes and additional questions during the interview as it progresses. Semi-structured interviewing enables the extraction of reasoning and meaning behind responses, giving researchers the ability to clarify responses. Interview questions which are open-ended also allow the opportunity for probing issues further, as they arise, and digression into issues that the researchers had not pre-empted (Richards, 2005). For these reasons, semi-structured interviews are advantageous for gathering comprehensive data to develop an understanding of a given situation.

Contextual interviews are a type of interview method that allows an in-depth understanding of the participants and situation to be gained. The interviews are conducted in the environment or context in which a product or service occurs. This can elicit more specific details about the situation or phenomenon under investigation and a familiar setting often makes a participant more comfortable discussing their thoughts and behaviours (Stickdorn & Schneider, 2010). By conducting interviews within the contextual environment, it also allows the researcher an opportunity to gain a holistic understanding of the person-environment fit, by observing social and physical factors (Gitlin, 2003).

The contextual setting for this research was social housing tenants’ homes. By situating data collection with tenant participants in their own homes, the researcher may be limited in the amount of exposure to the environment they can have during the interview session (Gitlin, 2003), both in time and access, but it helps people to convey their experiences and personal context in more detail (Stickdorn & Schneider, 2010). It has been reported that the study of home life requires face-to-face interaction for a comprehensive understanding (Gitlin, 2003). Home visits should be time-limited, however, so as not to be too onerous or intrusive for the participants.
Telephone interviewing has become a more popular research method over the past decade (Gillham, 2000) as an alternative to face-to-face interviews, contextual or not. Arguably, this is more so the case due to the advances which have been and continue to be made with technology. The introduction and evolution of mobile phones and smartphones means that a telephone interview can be carried out in any location convenient to either party, allowing for greater flexibility over availability. Where face-to-face interviews are not practical, for example due to geographical location or participants being widely dispersed, conducting an interview over the telephone is appropriate (Gillham, 2000). This removes the contextual richness from an interview setting and can be harder to facilitate; however, richness in the participants’ responses remains. While telephone interviews can be harder to keep going than with face-to-face interaction, they can be recorded which allows the researcher to focus on responding (Gillham, 2000) and keeping a natural flow of conversation going, without worrying about extensive note-taking.

Telephone interviews are still a time-consuming method of data collection because of the conversation they allow to take place, providing opportunity to capture depth in the data and emergent issues. However, they are less time consuming than face-to-face interviews, because this method does not involve any need to travel to a location to meet the participant. As such, the cost of face-to-face interviewing is removed by conducting telephone interviews (Gillham, 2000). Telephone interviews work best in small-scale research approached in one of two ways: if the researcher knows the respondents and arranges an interview at a time that suits them or by telephoning first to inform the respondent about the interview and arranging a convenient time to hold the interview phone call (Gillham, 2000).

When preparing interviews, the amount planned to conduct should be considered. With a greater amount of data collected, a greater amount of insights can be obtained and the robustness of the research is enhanced. However, the researcher should be mindful of the data set planned and consider analysis stages for the study to assess the feasibility of the empirical study. Gillham (2000) outlines that for every
one hour interview carried out an audio recording of this would require approximately 10 hours of transcription and a similar amount of time for analysis.

Questionnaires are a less time-consuming method of data collection for both the researcher and the participants. They are a less onerous method for the researcher in terms of practically carrying out the research and subsequent analysis time; there is no requirement for transcription to factor in. For the participants, questionnaires can be quicker to complete than an interview and may be done at their leisure and convenience; they do not have to be completed in one dedicated period of time. However, although questionnaires are less demanding than interviews, people are less likely to respond to a questionnaire. Questionnaires would be suitable in a situation where face-to-face interaction is impractical, more detailed information is not necessary or to gather data from a larger sample in a shorter timeframe. In the exploration phase for this research, a smaller sample set is involved; therefore, interviews are a plausible method of choice. Furthermore, for an exploration study to develop a rich understanding of a situation, detailed information is required and face-to-face interaction is the best means through which to achieve this. Questionnaires are appropriate when straightforward ‘closed’ questions are to be asked (Gillham, 2000).

Interviews have successfully been used as a qualitative research method with older people in many other studies eg. Kriglstein & Wallner, 2005; Day & Hitchings, 2009. Contextual interviews were selected as the appropriate research method for both the CCC project research and the exploratory research for this thesis, to enable a greater level of understanding to be obtained, through semi-structured questioning and observation of the environment. In cases where face-to-face interaction was less practical, due to geographic location or time availability of the participants, telephone interviews were opted as an alternative research method. This was because they offered the next best opportunity to achieve a substantial level of detail in responses, despite the contextual observational element being removed. Telephone interviewing was more appropriate with the social housing landlords as the contextual aspect was less necessary. This method was used as little as possible
with tenants, only when the distance to travel to conduct a face to face interview was far less practical and more costly.

The exploration study comprised of interviews with employees from social housing organisations and social housing tenants, either through a contextual interview or a telephone interview. The study was formed using data collected for the purpose of the CCC project in addition to data collected through methods designed by the researcher purely for this thesis. Over this chapter, the methods designed for the CCC project and the methods designed to inform this thesis are presented separately for clarity what was collaborative work and what was solely the researcher’s responsibility. It is noted that the researcher has a significant role in the collaborative CCC project work in terms of methodology development, data collection and analysis, as well as this doctoral research. The tenant data were analysed as one whole set and the landlord data were analysed as a set, with findings presented for each group. Analysis procedures are discussed further in section 4.3.4.

Due to the different purposes of the CCC project and the research to inform this thesis, the interview guides prepared differed between the CCC tenant participant sample and the rest of the tenant participants. The CCC interviews covered broader issues concerning domestic heating and comfort that were not within the remit of this thesis’ focus with some additional questions specific to the heat pumps in the relevant properties. The interview guide for the remainder and majority of this doctoral research consisted of questions entirely relevant to the service of installing and using heat pumps. The interviews were, however, semi-structured so no interview would be identical, while based on the same format and eliciting the same topics of information. Therefore, the questions for the CCC project sample that elicited relevant information produced information which could be analysed in the wider data set of other social housing landlords.

A third interview guide was prepared for the landlord interviews, as the information to be obtained had different contextual relevance and involved a different perspective on the process. All interview guides are available in the Appendix: the
CCC tenant interview guide is in Appendix A, the interview protocol for the rest of the tenant interviews for this thesis is located in Appendix B and the landlord interview guide is available in Appendix C.

The following diagram, Figure 15, outlines how the research study was formed; where research was carried out purely for this thesis and where research from the CCC project contributed towards this thesis research.

![Diagram](image.png)

**Figure 15: Samples contributing to the exploration phase research**

The research for the CCC project was carried out first and the data analysed for the project deliverable. This gave the researcher an initial opportunity to immerse in the data to begin developing contextual understanding and surface initial requirements for the heat pump installation service. The remainder of the empirical research was conducted subsequently, validating what had been found in the first set of interviews and further informing the understanding and requirements. The geographic areas involved in the research outlined in Figure 15 above are further explained as the research sample in the following section.
4.2 Exploration phase study

4.2.1 Sampling

As drawn out from the literature reviewed in Chapter 2, the topic of interest in this research was the installation of heat pumps into social housing properties and the effect of this on older people. The methodology presented in Chapter 3 outlined the intention to investigate this from both the perspective of the service providers and the service recipients, landlords and tenants respectively. Therefore, two samples of participants were required: social housing landlords and older social housing tenants living with a heat pump heating system. It was attempted as far as possible to recruit landlords and tenants from the corresponding social housing organisation to get a balanced view of each situation investigated.

The CCC project included a social housing provider in North Yorkshire as a case sample, as shown in Figure 15, which provided access to homes with ground source heat pumps installed. This provided the foundation sample of participants. The remaining social housing organisations involved in the exploration phase were recruited by the researcher as an opportunistic sample. Through desk research and networking, social housing organisations that had installed heat pump systems into their properties were identified and contacted. The social housing organisations were selected as a suitable representation of the topic being studied and, furthermore, this allowed approaches and experiences from various geographical locations to be reviewed to present a broader picture, as indicated in the subsequent map in Figure 16.
The map in Figure 16 illustrates where each of the samples was located in England. The larger circles represent the locations where landlords and tenants who were interviewed in this study were situated. The red coloured circles represent where only the landlord was interviewed; the orange coloured circles represent where both the landlord and tenants were interviewed. The number of tenants interviewed across these social housing organisations was not evenly distributed as outlined in section 4.2.1.2, so some organisations were better represented by tenants than others. An additional smaller circle is on the map pinpointing the Isle of Wight. This location is not listed in the sampling information but is relevant to note. The landlord interviewed located in the London area carried out a heat pump installation project in properties they manage in the Isle of Wight and it was this project and tenants living here that the landlord discussed in their interview. Unfortunately, the tenants here could not be interviewed for this research; therefore, this location is marked as an area to note, rather than as a sample area.
4.2.1.1 **Landlord Participant Selection**

The participant representing the social housing landlord was a specifically selected employee of the social housing organisation to interview and obtain information from about the heat pump installation service provision. The employee interviewed needed to have knowledge and understanding of the process for installing heat pump systems in the properties in order to give comprehensive insights. Through desk research and networking conducted to identify suitable social housing organisations, an appropriate contact was found and they were approached to locate a relevant employee to interview. A recruitment letter was sent to the contact found which outlined the purpose of the research and the requested involvement of the participant. In the majority of cases, the approach from the researcher was speculative with no prior engagement, based on which organisations found through desk research fit the necessary criteria. Therefore, participation was purely on an opt-in basis and the sample was opportunistic.

Table 1: Social housing organisations recruited for the exploration study

<table>
<thead>
<tr>
<th>Landlord participant code</th>
<th>Geographic location</th>
<th>Type of organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA</td>
<td>North Yorkshire</td>
<td>Council</td>
</tr>
<tr>
<td>LB</td>
<td>Cornwall</td>
<td>Housing Association</td>
</tr>
<tr>
<td>LC</td>
<td>Cornwall</td>
<td>Housing Association</td>
</tr>
<tr>
<td>LD</td>
<td>London</td>
<td>Housing Association</td>
</tr>
<tr>
<td>LE</td>
<td>Lincolnshire</td>
<td>Housing Association</td>
</tr>
<tr>
<td>LF</td>
<td>Nottinghamshire</td>
<td>Housing Association</td>
</tr>
<tr>
<td>LG</td>
<td>Gloucestershire</td>
<td>Council</td>
</tr>
</tbody>
</table>
4.2.1.2 Tenant Participant Selection

Tenant participants were also an opportunistic sample, recruited through the social housing organisations, once the organisation had agreed to take part. After the employee of each social housing organisation was interviewed, it was broached with them whether any of their tenants would likely be willing to participate in the research. It was anticipated that by building a rapport with the social housing provider and their interest in the project through conducting the first interview with them that they would be more receptive to their tenants contributing to the research. Those landlords who responded positively were subsequently contacted with recruitment information tailored to the tenants.

Three quarters of tenant participants in the North Yorkshire sample were already recruited as part of the CCC project. As stated, relevant data collected in the research for the CCC project was used to inform this doctoral research. As such, the first set of tenant interviews conducted in the research, which were also for the CCC project, was carried out prior to the social landlord of this organisation being interviewed. All subsequent tenant participants were recruited for interviews by the housing provider after the landlord had been interviewed. This meant that landlord data collection and tenant data collection across social housing organisations were carried out in parallel, dependent on when participants for either sample were recruited and available. The employee contact at the social housing organisation was supplied with an information sheet for tenants giving details of the study. They informed the tenants about the researcher and study and requested the participation of the tenant. Contact details of tenants who consented to take part were subsequently provided to the researcher, to arrange an appointment for an interview, either as a home visit or by telephone dependent on which was possible.

The tenant participants were treated as one sample rather than a set from each of the social housing organisations, because recruitment meant that tenants interviewed were not representative of all the social housing organisations investigated and not evenly distributed across those that were represented. Any differentiations between the social housing organisations that would affect tenant
experiences were considered during data analysis and is acknowledged in the discussion of findings, where any comparisons need to be highlighted.

For the purposes of this study, older people were defined as over 65 years old because, as outlined, this is the commonly accepted threshold across the research community and it is the standard retirement age in the UK. The original intention of this study was to only recruit older participants to investigate their experiences. As discussed in the literature, there are issues around older people and the adoption or ability to use new technologies and it is a critical factor to their health and wellbeing that they have a satisfactory level of warmth in their home. However, participant recruitment for this particular age group alone proved more difficult than expected; therefore, the age bracket for investigation was widened.

Any willing tenants with a heat pump installed were recruited to participate and, as such, not all participants were over 65 years of age. It was determined that this provided an extra level of detail to the research, enabling the researcher to identify commonalities and differences between the experiences of those under 65 and those over 65, to determine if there are issues specific to the older population when installing heat pumps. This applied to all subsequent parts of this research. An exact age was not obtained from all participants but where a clear judgement could be made the participants were defined as over 65 or under 65. Where a clear estimate could not be made of whether the participant was over or under 65 years old, no data was reported. The sampling information for tenants is presented following in Table 2.
### Table 2: Social housing tenants recruited for the exploration study

<table>
<thead>
<tr>
<th>#</th>
<th>Tenant code</th>
<th>Geographic location</th>
<th>Age</th>
<th>Gender</th>
<th>Sample</th>
<th>Heat pump system type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H_1_M</td>
<td>North Yorkshire</td>
<td>69</td>
<td>M</td>
<td>CCC</td>
<td>Ground</td>
</tr>
<tr>
<td>2</td>
<td>H_1_F</td>
<td>North Yorkshire</td>
<td>69</td>
<td>F</td>
<td>CCC</td>
<td>Ground</td>
</tr>
<tr>
<td>3</td>
<td>H_2_M</td>
<td>North Yorkshire</td>
<td>69</td>
<td>M</td>
<td>CCC</td>
<td>Ground</td>
</tr>
<tr>
<td>4</td>
<td>H_2_F</td>
<td>North Yorkshire</td>
<td>69</td>
<td>F</td>
<td>CCC</td>
<td>Ground</td>
</tr>
<tr>
<td>5</td>
<td>H_3b_M</td>
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<td>North Yorkshire</td>
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<td>M</td>
<td>CCC</td>
<td>Ground</td>
</tr>
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<td>North Yorkshire</td>
<td>no data</td>
<td>F</td>
<td>CCC</td>
<td>Ground</td>
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<td>F</td>
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<tr>
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<td>Thesis</td>
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</table>
4.2.2 Recording data

In a face-to-face qualitative interview, participants are encouraged to engage in a relaxed discussion, to promote open responses. Therefore, the method of data recording aims to be unobtrusive (Richards, 2005). Most often, research interviews are recorded on audio media. A small Dictaphone recording the session is an unobtrusive method, if positioned where it will not distract participants. Participants need to be made aware of the Dictaphone to comply with ethical boundaries, but this means of recording the session allows for the discussion to flow with minimal interruption, as can be caused by the researcher making written notes. Audio recording is also appropriate for telephone interviews.

For both face-to-face and telephone interviews, audio recording provides a more comprehensive documentation for better analysis subsequently, as all of the dialogue will be recorded. If only note-taking, some things may be unheard or overlooked. Obtaining an audio recording minimises the need for extensive note-taking; however, it cannot be fully relied upon and some notes should be recorded at the time of the interview, as a contingent measure. Telephone interviews allow greater opportunity for note-taking, as the need for a constant visual engagement with the interviewee, to maintain a comfortable rapport, is removed.

4.2.3 Method

In the following sections, the different methods used for the stages within the exploration study are outlined. Firstly, piloting of the method is discussed then following are the methods adopted in the main study. The method for the CCC project is described as the first part of the main study. This is separated because it applied to a specific group of the participants and was conducted as part of the wider project research, which was carried out collaboratively, but the relevant outcomes contributed to this thesis. The methods designed and conducted solely by the researcher for this thesis are then outlined. The method for investigating social housing landlords is described then the method for investigating tenants’ experiences with heat pump installations is described.
4.2.3.1 Pilot study for the exploration phase tenant interviews

A pilot of the CCC research method was carried out with characteristic participants of those to be recruited for the exploration study. The pilot participants were not direct representatives of the exploration study sample but two key criteria were comparable: they were older people aged over 65 years and the interviews were carried out in the participants’ homes, as intended in the main study. They were not social housing tenants and they did not have heat pump heating systems; however, at this stage of testing the method it was felt this was not a drawback. Being a social housing tenant and the heating system in-situ was more relevant to the question content. Although testing question content is important, and this was done to a degree, greater value was placed on the demographic and exposure to interviewing in a participants’ home, to determine best use of language, questioning style and best practise of conducting research in a private, domestic environment.

Two pilot interviews were conducted with two female participants aged over 65 by the author of this thesis and CCC project research associates. The interviews lasted approximately one hour and were carried out sat around a table in the participant’s living room. A trial of the interview gave the researchers an indication of how to appropriately direct the session for a comfortable, natural flow of conversation. The run-through with a representative participant indicated how clear and understandable the questions were in terms of language used and delivery by the researcher. It also highlighted how the opportunity for probing responses into emergent issues may arise and how to manage this during the interview. The pilot session also enabled the researchers to determine how long to allow for discussion of the topics, to ensure the interview remained within the allocated time-frame. By going through the interview in context, this allowed the researchers to consolidate the session protocol, determine suitable dynamics between the researchers and gain confidence in directing the discussion.

In the preparation of the interview procedure, the researchers had created an interactive note-taking technique, using A3 paper and stickers of topic-related icons; for example, there were pictures of a radiator and a thermostat as shown below in
Figure 17 (see Appendix D for the full set). These were designed by one of the CCC project researchers.

Figure 17: Icon stickers designed for CCC interviews

This was to establish a focus during the interview and annotate data collected around these key aspects during the discussion. It was anticipated that this would maintain an informal approach to the interview, help make it more engaging and trigger responses from the participants. It was also thought this would help with subsequent analysis of the data. However, during the first pilot interview, it quickly became apparent that this concept was unnecessarily onerous and did not add value to the discussion. Responses emerged naturally, the participants did not need prompts and the use of the tool may create a distraction and curtail discussion around issues not pre-empted by the researchers. The interview quickly formed into a flow of conversation, with simplified note-taking by the researcher appropriate to quickly record information.

An interview guide for the CCC research was prepared with a set of questions to structure the interview and cover all topics needed for the CCC project, which was piloted. The pilot interviews demonstrated that this was an effective means of directing the conversation in a logical manner, whilst allowing opportunity at any point for digression, either led by the participants or led by the researchers to probe unpredicted information. The interview guide was modified prior to the main
exploration study for the CCC sample in North Yorkshire and first set of tenant interviews for this thesis, to incorporate questions specific to heat pump properties. The original CCC tenant interview guide is available in Appendix A. The specific questions for heat pump properties were not piloted as the other CCC sample interviews were assessing domestic heating and comfort practices in general in properties with other types of heating system.

The other tenant interview guide was produced for the remainder of the main exploration study sample, where participants were not involved in the CCC project also (available in Appendix B). This was because the CCC interviews involved more general questions around heating and comfort practices in the home that were not within the scope of this research study focus. The focus of this research was centred on the process and experiences specifically of heat pump installations and usage of the system rather than a broader investigation of thermal comfort behaviours and, as such, the ability to answer the questions was restricted to heat pump users. Therefore, as with the interview guide for the CCC project participants with heat pumps, the main exploration study interview guide for this thesis could not be usefully trialled to test the question content with anyone who was not a social housing tenant with a heat pump installed.

These specific criteria were required of participants for the exploration study, as outlined. The review of literature and further investigation of the field indicated there was not an extensive population fulfilling this criteria from which to recruit participants. Difficulties of recruiting participants for empirical study were also considered, such as a lack of interest or not wanting researchers to visit their home. Furthermore, in this particular case, other research projects targeting the same population was considered as there is heightened research interest in this area and a limited population to recruit from. Hence, it was determined that any data that could be obtained from people who fit the criteria was more usefully applied in supporting the main body of research rather than the pilot sessions. The pilot study with representatives of the demographic and in the intended environment for the empirical study was a valuable exercise, however, to prepare for all of the interviews in the exploration study.
The interviews were semi-structured and each interview could have presented useful information that warranted subsequent interviews to be reviewed and modified. The nature of qualitative research means it is dynamic and responsive as the research progresses (Krueger, 1998); therefore, the method may be refined during the exploration study. However, in preparation for the contextual interviews, the pilot interviews for the CCC project data collection provided an opportunity to practise the technique of conducting semi-structured interviews with older people in their home environment. Research skills were pre-tested through this for how to deal with new unanticipated information and how to allow the interviewee enough opportunity to provide information, whilst ensuring all the core questions were covered and within the appropriate timeframe. This piloted technique was useful for all interviews to be conducted for this research phase.

4.2.3.2 Method for CCC Research

The first stage of the exploration study to collect data from social housing tenants was with those in the North Yorkshire social housing sample recruited for the CCC project (social housing organisation A for this doctoral research). This involved a more extensive interview to obtain the breadth of information required for the wider research in the CCC project. The interview lasted approximately one hour and was conducted by the CCC project Research Associate and the researcher of this thesis. A signed consent form was obtained at the beginning of the visit, after the participants had been given an opportunity to read the information sheet.

The interview consisted of questions regarding the heating system, thermal comfort behaviours of the occupants, the occupants’ lifestyle and their opinions of their environmental behaviours. A guide of questions was produced in order to help give the interview direction and structure, which can be seen in Appendix A. This was a semi-structured interview however, to allow for digression and discussion into emergent issues. To maximise the information captured in the interview, one researcher led the interview by asking the core questions and some probing
questions while the other researcher took notes, also interjecting with questions where it was appropriate for further clarification or development on a response.

### 4.2.3.3 Method for Landlord Interviews

An interview was carried out with a representative from the social housing organisation, either face-to-face or over the telephone where a meeting was impractical. The interviewee had significant knowledge of the process the organisation goes through to install heat pump systems in their properties. An interview guide was prepared with a list of questions to cover specific information, but the discussion was semi-structured allowing for emerging points. The questions were formed to investigate the following:

- which renewable technology has been installed
- drivers for decisions about the technology and suppliers
- drivers for installations: place and time
- how the system was introduced to tenants
- what information they were provided with
- how the system works
- post-installation maintenance and communication with tenants

This is available in Appendix C.

An overview of the study was delivered verbally by the researcher at the start of the interview session and the interviewee was given another opportunity to read the study information sheet, if the interview was in person. A signed consent form was completed at the beginning of the session in face-to-face interviews; where the interview was conducted over the phone, the consent form was posted to the interviewee to sign and return in a provided stamped, addressed envelope prior to the interview.

A Dictaphone was placed in a suitable position between the interviewer and interviewee, to record the conversation clearly yet unobtrusively. The interview progressed over approximately one hour, following the guide of questions.
produced. The questions covered the experience of installing heat pump systems from the landlord's perspective, identifying how and why choices are made and the opportunities and barriers they face. The researcher took notes throughout the session, ensuring crucial information was recorded, providing a backup to the audio recording.

4.2.3.4 Method for Tenant Interviews
An interview was carried out in the tenant’s or tenants’ home for the majority of participants, lasting approximately 30 minutes to 1 hour. Where a face-to-face interview was not possible, a telephone interview was carried out; this method was used for only one participant due to practicalities of travel. An interview guide was designed with questions covering the key pieces of information that this research study aimed to investigate. The questions were formed to investigate the following:

- how the tenants were approached in advance of having a heat pump
- why they had one installed
- what happened in the tenant’s home when it was installed
- the tenant’s perception of this process
- the tenant’s experience of having this technology for a heating system.

The guide can be seen in Appendix B.

An information sheet specific to this data collection study was written and delivered to tenants with a cover letter at the recruitment stage, by the social housing provider. Another information sheet was given to the tenants to read at the start of the session to provide them with an opportunity to refresh their knowledge of the study or ask any questions before commencing the interview. The consent form was signed at the beginning of the interview, after the researcher gave a verbal brief of the purpose of the interview.

The interview followed the structure of the interview guide that was produced, allowing for further discussion over any issues that emerged during the conversation. The discussion was recorded on a Dictaphone, with the tenants’
permission, and the researcher also took notes throughout. It was the participants’ choice where the interview took place within their home, but it was an informal situation – usually in the living room – to enable the discussion to take place in a relaxed, comfortable environment.

4.2.4 Analysis
With a study involving such small samples, the results cannot be generalised as they would not be representative of an extensive population; the data can only be treated as a case-based investigation at this level of research, to draw any conclusions. However, the user-centred, contextual methodology provided rich data for a deeper understanding of the situation. Employing a thematic analysis was an appropriate method of evaluating the data as it organises and describes data in rich detail while indicating emerging patterns within the data (Braun & Clarke, 2006). Other methods of analysing qualitative data, such as NVivo computer analysis tool, are available, but were considered to be unnecessarily onerous with such a small sample size so were not used in this analysis. Analysis of the data by the researcher involved retains richness of the data. By typing up interview notes subsequent to each session, this also allowed the researcher an opportunity to reflect on the data collected and begin familiarisation with the information for later analysis.

User-centred design specifies an exploration of the context of use in the first stage. This study was designed to explore the context of heat pumps installations into social housing properties. However, there is little guidance on how this exploration should take place. A thematic analysis of the data produces insights around themes that establish an understanding of the context and surfaces requirements. In a service it is important to understand the process and where requirements fit within this process; therefore consideration of the positive and negative aspects of the service, practicalities and limitations of the service is important to keep in mind during analysis. This assists in a pragmatic understanding and communication of the key aspects to address.

Through the thematic analysis of the exploration study research data and production of insights and requirements in a service process, the positive and
negative elements of current services to install heat pumps were identified. These highlighted potential areas for improving the service; the lessons learned from the various social housing organisations investigated here can be carried through to inform the recommendation and development of service improvements. Thus, this answers the first of the research questions of this thesis and leads into addressing the second research question in the next phase of the research.

Identifying the actors who, directly or indirectly, have an impact on the service or system is an aid for shaping the problem (Morelli & Tollestrup, 2007). Actor mapping is a useful tool that gives a representation of roles and interactions between them, within the service context. This network of actors can be used in generating a model of a new system or it can be used to represent an existing system. Therefore, it is a helpful tool in identifying who should be considered in the design of a service or system and who may have an influential part to play. As part of the analysis of the data recorded in this study, actors emerging as playing a role in the service delivery or receipt were noted.

4.3 Findings

The findings from the exploration study are presented in this section over three parts. Firstly, the findings from the research conducted with social housing landlords are outlined; then findings from research with social housing tenants are given. Subsequently, the findings from both data samples are discussed as a whole and key positive and negative aspects of current services to install heat pumps in social housing are highlighted.

4.3.1 Findings from landlord interviews

The research findings from interviews with representatives of the social housing organisations are presented in this section. Interviews were carried out with a total of seven landlords from six geographic regions in the UK. The key issues which emerged from the analysis of the interviews with these social housing landlords are highlighted in the table below and presented in further detail subsequently. The key issues were formed through the thematic analysis process that identified insights.
and themes relating to decision-making or the heat pump installation process which influenced the service provision to tenants or the landlord's opinion on tenant experience. These insights inform the understanding of the tenants' experiences and any limitations to the current service provision or provide rationale for why the current service is delivered the way that it is. Through these selected findings, the first research question of this thesis could be addressed:

- What lessons can be learnt from previous experiences when retrofitting heat pumps into social housing properties?

The findings are presented in the table in order of importance for this research, which was determined by the level of relevance to tenants’ service experience and identification of user requirements, through either frequency of emergence in the data or prominence of the issue. Therefore, issues that were mentioned by all the landlords or were discussed as being of key importance to the service delivery are presented as the highest priority. Findings further down the table provide useful contextual understanding about the service but are not directly related to defining user requirements for an improved service; however, they represent organisational requirements for the service delivery. Definition of organisational requirements is a part of the user-centred design process, as indicated in Figure 9, in order to identify limitations and balance end user requirements against what is possible.
<table>
<thead>
<tr>
<th>Key issues (in order of priority)</th>
<th>Emerging themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information provision</td>
<td>• Consistently a difficult issue</td>
</tr>
<tr>
<td></td>
<td>• Tenants told not to touch controls</td>
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<td></td>
<td>• Written information inconsistent and need improving</td>
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<tr>
<td></td>
<td>• Setting expectations</td>
</tr>
<tr>
<td>Introducing heat pump technology to tenants</td>
<td>• Initial approach by letter</td>
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<td></td>
<td>• Home visits</td>
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<td></td>
<td>• Requests for repeat visits</td>
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<tr>
<td>Effect of community</td>
<td>• Neighbours influence promotion of heat pumps</td>
</tr>
<tr>
<td></td>
<td>• Neighbours influence usage of the heat pump</td>
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<tr>
<td></td>
<td>• Community information events were beneficial</td>
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<tr>
<td>Selection and impact of contractors/workmen</td>
<td>• Importance of the standard of service</td>
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<td></td>
<td>• Impact of location of maintenance</td>
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<td></td>
<td>• Tenant contact</td>
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<tr>
<td>Tenant choice</td>
<td>• All tenants had a choice about having a heat pump</td>
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<tr>
<td></td>
<td>• Refusals were experienced</td>
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<td></td>
<td>• Barriers to adoption</td>
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<tr>
<td>Tenants as service recipients</td>
<td>• Tenants referred to as customers</td>
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<td></td>
<td>• Introducing the technology was ‘selling the technology’</td>
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<tr>
<td>Effect of age on installation</td>
<td>• Age did not affect service delivery</td>
</tr>
<tr>
<td></td>
<td>• Older tenants were a target population for heat pump installations.</td>
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<tr>
<td>Reasons for installation</td>
<td>• Property-driven: off-gas properties</td>
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<td></td>
<td>• Benefits over other heating system options</td>
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<td></td>
<td>• Fuel poverty</td>
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<td></td>
<td>• Legislation/ obligations</td>
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<td></td>
<td>• Tenant need/request</td>
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<tr>
<td>Funding</td>
<td>• Necessity for installations being possible</td>
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<tr>
<td></td>
<td>• Determinant for amount and timing of installations</td>
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<tr>
<td>Type of system installed</td>
<td>• Varied opinion on the systems available</td>
</tr>
<tr>
<td></td>
<td>• Property and cost drive the choice of technology</td>
</tr>
</tbody>
</table>
Information provision

One of the most consistent insights across all the landlords interviewed was the issue of tenant education. All landlords outlined this as one of their biggest difficulties in properties installed with a heat pump. By tenant education, the landlords were referring to being able to teach tenants how to use the heat pump and them understanding how it works in order to be used effectively. Landlords recognised this issue in terms of being able to verbally communicate how the heat pumps work and experiencing variance amongst tenants whether they fully understand the heat pump technology or not.

Participant LD highlighted that in response to tenants thinking something was wrong because the radiators weren’t hot:

“We learned to educate it’s a different type of heat and way of heating the home.”

(Participant LD)

Participant LE stated:

“A lot of the teething problems were about how to use the actual systems and that’s more about education of the tenants… They’re very used to having a physical fire or physically turning the heating up to feel warmer whereas it’s been a very different educational process with them to try to get them to understand.”

(Participant LE)

Often it was found that problems occurred with the functioning of the systems when tenants tried to alter the settings and through not understanding how to do so correctly. It was common amongst the interviewed landlords that all promoted setting the heat pumps themselves and telling tenants not to touch the controls.

“Tenants were tempted to go in and start taking the tops off the heat pumps and trying to work out and fiddle with it and we could tell that they were… and they were getting very high fuel bills because they weren’t using the systems properly and there’s actually no reason why they’d have to touch the system at all.”

(Participant LE)
There was an inconsistency over written information provided by the various landlords. Some landlords appeared to deliver more substantial written information when introducing the heat pump technology to tenants. For example:

“We did them an information literature leaflet that told them all about the process of the drilling, the process of what the heat pump was, how the heat pump worked, how it would heat their home and what the expectations from the heat pump would be.” (Participant LC)

“We give a pack. They are given, there’s a fact sheet basically about how to use it and what the actual system is and useful numbers… they are left with a user guide as such… But generally it would be the manual that does come from the manufacturer but then we do put some supplementary stuff in about general energy saving, top tips if you like for using it.” (Participant LE)

However, written information to help tenants with usage of the system was consistently highlighted as an area for improvement by landlords.

“We did give them information how to use it and how the technology worked… I think that could’ve been improved upon, that was a slight downfall.” (Participant LC)

“At first tenants were offered the full manual. This was too complicated and not fair on the tenants.” (Participant LA)

“We haven’t got as far as a piece of paper or booklet to give to tenants, but want to be able to.” (Participant LA)

“They were given information but it wasn’t enough – we hadn’t done many by then. The person who installs it explains it to them.” (Participant LD)

Participant LE reported that they have improved the education process through having
“a better handover process from development through to the housing management staff, who are now trained quite well in exactly how the systems work.”

However, they still state

“there is more that we can do with the tenants, definitely.” (Participant LE)

**Introducing heat pump technology to tenants**

All seven landlords outlined that they wrote to tenants initially to introduce the offer of having a heat pump system to them. This was followed up by a visit the tenant’s home in nearly all cases, except participant LB outlined that they would host a community information event and visit tenant’s homes afterward on request.

All seven landlords reported that when they introduced the technology to tenants they would give them verbal information about the heat pump system: how it worked, what to expect during the installation, how the heating worked and other expectations such as costs. The landlords did not explicitly cover what, if any, written information was provided at the introductory stage when the tenants were deciding about having the heat pump installed.

**Effect of community**

Landlords were aware of the effect of neighbouring tenants or others in the community on each other’s perceptions and usage of the systems. The landlords reported an awareness of tenants talking to each other about their heat pump systems. Some landlords reported that tenants were able to visit another tenant’s home that had a heat pump installed, to see contextually what the installation was like in a home. Participant LD explained that through tenants seeing other tenants with heat pumps

“they could see it wasn’t that ugly or it didn’t cause too much hassle and maybe it resulted in a hotter home or savings depended on how they were using the system before – they could see the benefits”. (Participant LD)
Participant LA highlighted that:

“Those who knew they were getting it were keen to get it… Most of the people who are keen to have it know somebody in the group of people who have already got ground source heat pumps in the council stock – cousins and friends, and they’ve heard, seen, heard stories about the sort of comfort people have and the sorts of costs people have and they’re keen to have the same thing.”

(Participant LA)

Landlords sometimes found tenants initially refused to have a heat pump but contacted the social housing organisation wanting to have one installed after seeing their neighbours experience with one (Participants LC and LG). Tenants were also found by landlords to influence each other’s usage of the system.

“tenants were discussing amongst themselves… they changed settings after comparing with each other” (Participant LA)

“Tenants have been going to help the neighbours if there’s any teething problems. The community pull together if there are any problems.” (Participant LE)

Participant LD described how their organisation utilised the community in helping the service delivery and tenants understand using the heat pump system:

“There are community contacts – four or five people based in the community had training on using the system, so tenants could knock on their door for assistance, to check issues before getting the engineer out.” (Participant LD)

Participant LA has seen this occurring amongst their tenants and wants to formally utilise it because:

“Neighbours have been very pleased and willing to tell new tenants of their experience with a ground source heat pump, giving advice.”
“A formal group of ‘tenant experts willing to give their time to people who would like to learn better and have questions…Tenant to tenant is a lot better than [landlord] going in as the authority telling them what to do…Friendly advice rather than ‘you will behave in a certain way’ which is possibly how it would be perceived if it’s the council giving the information rather than somebody in the same position you are.” (Participant LA)

Some of the landlords interviewed reported that they held community information events to introduce the tenants to the heat pump technology and explain it to them, as outlined above. Here the effect of community would be apparent through the opportunity it presented for discussion amongst tenants.

**Selection and impact of contractors/workmen**

Landlords interviewed highlighted the responsibility they have or felt in supporting the communities under their jurisdiction by employing local companies for work to be done. Most landlords commented that they tried as far as possible to employ local contractors; however, at the early stages of installing heat pumps, not that many suppliers dealt with the systems. Participant LD reported that they chose their contractor by putting it to tender but that fundamentally they were looking for a supplier who would:

“match our standards and minimise hassle to residents”. (Participant LD)

Participant LG discussed contracted workmen in the same light indicating when the workers did not meet their expected standards it resulted negatively on the service experienced by tenants. They further stated that they used another local contractor because they were used to working in the tenants’ properties and interacting with the tenants, at a standard expected by the landlord. Participant LA reported that they received negative comments from their tenants as a result of the installers’ attitude. The installers were traditional plumbers and had negative feelings about the heat pumps as they found them difficult to work with and this negativity was passed on to the tenants in their homes.
Participant LB stated that they wanted to support the local economy but had to choose a contractor from further afield over a local contractor because of the difference in anticipated timeframes to get the work done. The local contractor stated they would take 2-3 weeks over the work whereas the competition would take just a few days. Participants LE and LF both reported the difficulties of working with contractors situated further away when maintenance problems arose and response rates were slow because of the distance.

“We were using suppliers that could have been for example in Devon or even abroad and when we first had a lot of them installed we did have teething problems and to get someone who had to come up from Devon or even abroad to fix an issue was very difficult because we had tenants going without heating or stuff like that.” (Participant LE)

On the whole, landlords reported that tenants phoned the social housing organisation if they had a problem or query. The landlords were aware however that tenants received communication from the installers working in their homes. Participant LA highlighted the issues they encountered by providing tenants with phone numbers for contractors as well as the social housing organisation.

“We used to have issues; some tenants would call [the supplier], some would call [the installer/maintenance contractor] and some would call us…they would use any number they could find.” (Participant LA)

**Tenant choice**

All seven landlords interviewed outlined that their tenants had a choice whether they had the heat pump installed or not. All tenants in the social housing organisations interviewed were first approached about having a heat pump by writing to them and visiting them at their home; some landlords ran community information events for tenants to attend together to find out more about the heat pump systems. According to the landlords, the tenants had the option to refuse having one installed in their home and in some cases there were refusals. Those tenants who refused to have the heat pump installed were followed up in most
cases to have further discussions with them, but the landlord had to make a judgement call when a refusal was not going to change their mind and they had to continue with the other installations.

Participant LC stated that “tenant refusal rate was so high against oil”. Speaking about how they dealt with refusals from tenants, participants outlined how they tried to encourage tenants to have one installed but would reach a point at which they would have to agree not to put one in, indicating the tenant was not forced to have one and their choice remained.

“Once we’ve explained what it’s about to them and they’ve said no, I don’t trouble them anymore because they’ve made up their minds.” (Participant LB)

“There was an old lady who we speak to who she still goes out every morning to the coal house to get her coal and we were saying to her wouldn’t it be better if, you wouldn’t have to have this if we put a heat pump in and she, no, she prefers to have it the way she wants it.” (Participant LE)

Refusals or barriers to adoption were reportedly either due to the tenant being happy with the current system that they have or because the tenant was wary of the new system. Wariness emerged more as a barrier to adoption than refusal to having the heat pump installation.

“Maybe it is something about the fear of the unknown. They’re very used to having their heating a certain way.” (Participant LE)

“Elderly tenants were a little bit more wary of it, they didn’t understand it quite so well.” (Participant LC)

Participant LA reported that some tenants looked at heat pumps on the internet to help inform their decision whether to have a heat pump installed. This indicates there may be alternative sources tenants use for information about heat pumps other than the landlord, but this particular finding did not emerge in the majority of
the interviews; therefore is not considered further in user requirements. A theme that was consistent across the landlord interviews was tenants communicating with each other as an alternative source of information, both in the decision process and usage phases of heat pump installations.

**Tenants as service recipients**
The landlords referred to tenants in a manner that portrays the relationship between them as a service provider and service recipient. When the landlords talked about approaching tenants about having the heat pump they spoke in terms of ‘selling the technology’.

Participant LB described the benefit of heat pump technology as

“A win-win where the environmental improvement comes as a free extra with getting a better service for the customers”. (Participant LB)

**Effect of age on installations**
Across the landlords interviewed, they reported that there was no real difference in the way they approached tenants or delivered information about having a heat pump dependent on the tenant being an older person.

Participant LF stated that they approached everyone in the same way about having a heat pump and how to use it:

“Issues are the same for everybody with a new technology… We assume that people knew nothing and took it from there.” (Participant LF)

Participant LE suggested that their older tenants perhaps received more personal attention and “hands-on guidance’ during the process to ensure they understood, but on the whole age did not affect the landlord’s service. Participant LC highlighted that older tenants were more wary of the heat pump technology, but this did not appear to mean they delivered the service any differently; they communicated with anyone further who needed more help and a better understanding.
Age did play a factor to some extent in that landlords reported that older people were a priority or more likely to be in properties where heat pumps were installed. Many of the landlords reported a significant proportion of their tenants were older people, many living in off-gas properties. These tenants were a priority for landlords in order to reduce tenants’ bills, reduce the labour for the tenant in maintaining and using the system and providing them with more sustainable, adequate levels of thermal comfort. Participants LB and LG, for instance, highlighted these needs:

“The first few sites we did with ground source heat pumps were for sheltered housing or places where there were elderly tenants and a lot of them just couldn’t cope with solid fuel.” (Participant LB)

“There’s lots of tenants, certainly our elderly tenants, they’re not at work and therefore they’re housebound 24/7” (Participant LG)

**Reasons for installing heat pumps**

The initial decision for all landlords of where to install heat pumps was mostly determined by the property, not the occupants. Heat pumps were chosen as the heating system technology for properties in rural areas off the gas network, according to all seven landlords interviewed, to deliver affordable, sustainable heating. Across the data set, the majority of landlords ran heat pump installation programmes on a community-scale to impact multiple properties at one time. For example, Participant LD described that they determined the project by property:

“We decided to retrofit a whole street. Everyone in that street got the retrofit. So it wasn’t resident selected.” (Participant LD)

Economies of scale was also reportedly sought after by tenants according to two landlords:

“We talked to the tenants groups about it and what they said was well we would like you to come and do all the work in our area at one time, rather than do one
Heat pumps were deemed favourable against alternative, conventional systems of solid fuel, oil or storage heaters in terms of benefit to the environment and the tenant’s management and cost of the system. Participant LB outlined that other traditional options were not very good; in particular they outlined that oil-fired systems were becoming expensive to install and more expensive for tenants to run. Storage heaters were also a system commonly being replaced by heat pumps. It was consistently reported that storage heaters have problems of requiring advance planning for when the heat may be needed, delivering heat at the wrong time, running out of energy when needed most in the evenings, not being responsive to conditions and being expensive to run.

Fuel poverty was a key driver for installing heat pumps, as an issue that appeared to be congruent with properties being off the gas network. Participant LD highlighted that during the research interview, the community-wide project to install air source heat pumps was in an area identified as being in extreme fuel poverty:

“People either didn’t turn their heating on at all or they just lived in one room, so we knew it was quite severe before.” (Participant LD)

Participant LE outlined a retrofit project they ran:

“We’ve got about 200 properties that are going through, trying to meet the Decent Homes Standard. As part of that, Lincolnshire’s a very rural area and a lot of the properties are off gas. So we have very high fuel poverty issues.”

( Participant LE)

An extract from the literature review was the need for landlords to adhere to legislation and obligations in terms of housing standards and energy efficiency. This was a further driver for the heat pump installations. For example, in reference to air source heat pump projects, Participant LF outlined:
“Developers see it [air source heat pumps] as a cheap, renewable option to get codes 3 and 4.” (Participant LF)

Participant LE outlined that the Code for Sustainable Homes has driven installations:

“Most places would insist that it had to meet code 3, which generally does consist of one renewable energy source.” (Participant LE)

Heat pumps also became the chosen option to install where systems were not working and needed replacing in off-gas properties.

“We needed to replace a lot of systems. Some of them had come to the end of their lives….And when we looked into it, to reline a chimney was about about 2,500 which we would have to have done. We would also have had to put a new heating system in the solid fuel, we would have had to provide, to follow, legislation, somewhere safe for people to put their coal, like a coal bunker and ash pans and things like that. And when it was costed out, it wasn’t much difference.” (Participant LG)

The replacement of systems was seen to be driven by both the need to replace the equipment and tenant needs.

“We’re replacing oil boilers… the last couple of years is the first time that I’ve had tenants phoning me up saying ‘I just cannot afford to fill up my oil tank’ um ‘I haven’t got £600, £800 to fill it up, what am I going to do?’ and we’ve had that situation quite a few times…[reports the necessary work and costs for oil replacement]… So again you’re into the 6-7,000 [pounds] which is what it would cost for a heat pump.” (Participant LG)

The tenants did play a part in the decision process for installing heat pumps. Some landlords interviewed highlighted a driver for installing heat pumps being because of tenants struggling with the cost of their current system or coping with their current
system. Solid fuel was a priority to replace with heat pumps because of the environmental impact of these systems but also the difficulty of managing them for the tenants, particularly for elderly people.

“We’ve had situations where tenants living in maisonettes have had solid fuel and they’re carrying buckets of coal upstairs at 10 o’clock at night to top up their heating system… we want to take people out of the dark ages.” (Participant LG)

**Funding**

Across all social housing landlords, it was ascertained that installation programmes for retrofitting heat pump technology was entirely dependent on funding being available. In all cases thus far, this has been reliant on grants and external funding to subsidise the capital cost of installations. The funding available was a determinant for the amount of installations that could be done and the timing of when they could be done. For example:

“We needed grant funding. There’s no way we could’ve…well we certainly couldn’t have done so many.” (Participant LG)

“It depends on what funding is being brought in what projects can be done”

(Participant LF)

Participant LC pointed out the importance of funding availability on being able to carry out installations. Speaking of tenants who were offered a heat pump but refused on the basis they were happy with their oil systems, Participant LC reported:

“As soon as the price of oil started to rise, which it’s done at the moment, people are saying well hang on a minute we want ground source now. Well of course, in our situation at the moment, the funding isn’t there and the LCBP [Low Carbon Buildings Programme] funding isn’t there now. So basically we’re stuck, they have to stay with oil at the present moment in time.” (Participant LC)
**Type of system installed**

There was a mixture of opinion amongst the landlords interviewed over the suitability of systems between ground source heat pumps and air source heat pumps. All recognised that air source heat pumps are cheaper to install in properties than ground source heat pumps. Two of the participants interviewed, LD and LF outlined that only air source heat pumps were installed in their properties because amount of space required or the level of disruption associated with ground source heat pumps.

When speaking of ground source heat pumps, Participant LF described it as

"unlikely for retrofit – too difficult, too much disruption. Unless the only ground being dug up is like a car park." (Participant LF)

Participant LF further highlighted that digging up gardens was an issue for tenants; the gardens are their ‘pride and joy’. Participant LD stated that they installed only air source heat pumps

"Due to the space around the properties; we couldn’t get ground source heat pumps in there… Space ruled out ground source heat pumps and we weren’t going to get gas into the community… so we were down to individual property solutions, which for heating led us to air source heat pumps.” (Participant LD)

Other landlords have installed a mixture of air source and ground source heat pumps, finding either to be a viable possibility. Participant LB in particular outlined the need to dispel these perceptions around ground source heat pumps needing a large garden space to be able to install the groundwork and causing too much disruption.

"One of the things we particularly pioneered here was the idea of using boreholes for ground source heat pumps… when you look at the guidance documents that are published, particularly documents that were published 2 or 3 years ago, they
very often repeat myths about some of the technologies that really need to be exploded…

… before we did this, everybody said well you can’t drill a borehole in somebody’s garden… perceived as a very messy, disruptive operation…

… a little bit of disruption that can be tidied up and left looking like it’s never happened; provided that the contractor is careful about how they manage that, it’s in fact nothing like as disruptive as one might imagine.” (Participant LB)

Other participants interviewed (LA, LC, LE and LG) have used the same technique for installing ground source heat pumps on an individual property basis.

Landlords consistently reported the fact that air source heat pumps are cheaper to install which makes them a good option for individual property retrofit, to cater for off-gas properties in a more sustainable, economical way and reach the Code they are required to achieve in their properties. The landlords interviewed agreed, however, that ground source heat pumps are a better performing system than air source heat pumps and that air source heat pumps are not necessarily the best option for the UK. It was outlined by landlords that, although air source heat pumps can operate at temperatures sub-zero, to a point, they have to work the hardest in the coldest weather, when they are needed the most.

Participant LG explained that:

“because the grant funding has dried up with the new government, we haven’t done any more ground source since, we’ve switched to air source. And that’s not through choice, we would prefer to do ground source if we can.” (Participant LG)
4.3.2 Findings from tenant interviews

In summary, 34 tenants were interviewed, from 5 geographical locations. The sample include 14 males (41%) and 20 females (59%), with 20 participants (59%) 65 years or over, 10 under 65 years (29%) and 4 not specifying their age (12%).

The interviews with tenants provided insights relating to their usage of the heat pump system, their understanding of the heat pump system, their opinion of the heat pump system and opinions of the service. The themes identified in the data are presented in the following findings to depict the positive and negative aspects of the service relating to these factors. The key issues emerging from the research findings are shown in the following table and presented in further detail subsequently. The findings are presented in order of importance for the development of this research by outlining the aspects causing mostly negative or mixed experiences as this identifies where there is a user requirement for improvement; the most positive experiences are outlined to demonstrate where lessons can be learned from current processes as opportunity for future services and contextual issues are drawn out which support the contextual understanding for service development.

Table 4 indicates the key themes identified and relevant insights extracted from the data. The themes are presented according to the installation process, with a priority from the data identified (1, 2 or 3, with 1 being the highest priority issues to be addressed.) The 'experience impact' alongside denotes which aspects were positive and which were negative, to highlight aspects of importance and where areas may require improvement. Where the experience impact is labelled ‘influence’, this identifies findings that provide information which influences the experience of use of having a heat pump, rather than a direct service experience. This information provides contextual understanding which may impact how the service is delivered, but is not a positive or negative aspect of the service itself.
## Table 4: Tenant exploration study findings

<table>
<thead>
<tr>
<th>Key issue</th>
<th>Emerging themes</th>
<th>Experience impact</th>
<th>Priority level</th>
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</thead>
<tbody>
<tr>
<td><strong>Issues pre-installation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information provision</td>
<td>• Verbal information</td>
<td>Mixed experience</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>• Lack of helpful written information</td>
<td>Negative</td>
<td></td>
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<tr>
<td></td>
<td>• Messages communicated</td>
<td>Mixed experience</td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>• Initial introduction by letter</td>
<td>Positive</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>• Home visits by landlord</td>
<td>Positive</td>
<td></td>
</tr>
<tr>
<td><strong>Tenant choice</strong></td>
<td>• Perception of choice</td>
<td>Mixed experience</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>• Barriers to adoption</td>
<td>Positive</td>
<td></td>
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<tr>
<td><strong>Issues during installation</strong></td>
<td></td>
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<tr>
<td>Disruption during installation</td>
<td>• Low level of dissatisfaction</td>
<td>Positive</td>
<td>2</td>
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<tr>
<td></td>
<td>• Unexpected problems dealt with</td>
<td>Positive</td>
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<td></td>
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<tr>
<td>Impact of contractors</td>
<td>• Customer service in the home</td>
<td>Mixed experience</td>
<td>2</td>
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<tr>
<td></td>
<td>• Communication with tenants</td>
<td>Mixed experience</td>
<td></td>
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<tr>
<td><strong>Issues during use</strong></td>
<td></td>
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<tr>
<td>Understanding of the system</td>
<td>• Radiators not being hot</td>
<td>Mixed experience</td>
<td>1</td>
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<tr>
<td>Control of the system</td>
<td>• Wariness of using controls</td>
<td>Negative</td>
<td>1</td>
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<tr>
<td></td>
<td>• Understanding of controls</td>
<td>Negative</td>
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<tr>
<td></td>
<td>• Use of thermostats</td>
<td>Positive</td>
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<td></td>
<td>• Vulnerability</td>
<td>Positive</td>
<td></td>
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<tr>
<td>Impact of previous system</td>
<td>• Better satisfaction compared to previous systems</td>
<td>Positive</td>
<td>3</td>
</tr>
<tr>
<td>Use of technology</td>
<td>• Varied technology use</td>
<td>Influence</td>
<td>3</td>
</tr>
<tr>
<td>Warmth preferences</td>
<td>• Varied temperature settings</td>
<td>Influence</td>
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<td></td>
<td>• Individual differences</td>
<td>Influence</td>
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<tr>
<td>Use of windows</td>
<td>• Keeping windows open</td>
<td>Influence</td>
<td>3</td>
</tr>
<tr>
<td>Use of additional artefacts for</td>
<td>• Use of the electric fire</td>
<td>Positive</td>
<td>3</td>
</tr>
<tr>
<td>warmth</td>
<td>• Use of a blanket</td>
<td>Influence</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Use of clothing</td>
<td>Influence</td>
<td></td>
</tr>
<tr>
<td>Overall satisfaction</td>
<td>• Mostly dependent on warmth in the home and cost of the heating</td>
<td>Mixed experience</td>
<td>2</td>
</tr>
<tr>
<td>Community effect</td>
<td>• Communication between tenants</td>
<td>Positive</td>
<td>2</td>
</tr>
</tbody>
</table>
Information provision

There were evidently different stages at which tenants were provided with information about the heat pump system. Tenants were first provided with information when the heat pump technology was introduced to them while being approached about having a heat pump system installed. Subsequently, information was provided during the installation process. There was variance found in the data between tenants from different locations in the sample whether they received written information when they were approached about having a heat pump installed. The majority did not report having written information at this stage but verbal information provided.

Tenants consistently reported being told that having a heat pump installed would be cheaper than their current system and save them money when they were approached about having a heat pump system installed and this was the key driver for their decision to have it installed. Other reasons included the environmental benefit, cleanliness of the heat pump system or a lack of choice because their current system was no longer functional.

A level of dissatisfaction was exhibited by tenants who claimed that the information they were given when they were approached about having a heat pump was inaccurate after experiencing having the heat pump installed. This was largely in relation to information provided about cost expectations; the social housing landlord who visited tenants giving information on the monetary savings they would get through having a heat pump not being realised in use. It was also found to be in relation to the installation process carried out. For example:

“He said you get it very cheap; well I don’t think so.” (Participant H_B)

“How much cheaper it would be and everything, but he was telling lies, I’m afraid.” (Participant H_6b_M)

“Well the information they gave us was completely wrong… He told us in 2 days it would be done, well 6-7 weeks it took.” (Participant SD_A_F)
There was variance in the reports from tenants about the information they were provided with at the installation about how to use the heat pump. Some tenants reported being provided information and being satisfied with this but the majority reported either no information being given or that the information they had they did not understand. Tenants who reported they had information that they did not understand had been provided with a full manual from the manufacturer.

Tenants repeatedly reported not being given any information about how to operate the heat pump, which clearly caused negative feelings amongst the tenants.

“No, no they don’t give booklets out he said. They don’t give you instructions, that’s what I was told.

Q: did they show you anything?

“No. They did it all and I said ‘what are you doing now’ he said ‘you don’t need to know love, it’s set and that’s it.” (Participant H_5b_F)

“I said to them is there any leaflet or a booklet on this to… how to look after it or adjust it? Oh no. We don’t give you them, he said. He said people mess about and they all go wrong. So he said we don’t give you them… I asked for a book… a leaflet to tell me how it worked…But I never got one.” (Participant H_6b_M)

Participant CH_B used to sit on the Board at their social housing organisation and now is part of the forum of tenants; therefore, they have more informed knowledge of both the organisation side and the tenant side of services and experiences. CH_B was part of the pilot scheme, approached to have one because they worked so closely with the social housing organisation, and very satisfied with their heat pump. With their greater level of knowledge of what occurs at the social housing organisation, they were able to comment that the organisation carry out a lot of customer satisfaction surveys and were receiving mixed feedback. In CH_B’s opinion:
“A lot of people who don’t like it, older people, they really do need educating because they don’t know what they’re doing with it; that’s the trouble.”  
( Participant CH_B)

CH_B highlighted that they thought the social housing organisation should:

“Hold a half day seminar or something and teach these people how to use the thing.”

The majority of tenants provided evidence that they received information from the installers or contractors during or post installation and that they learned how to use the controls from them.

“He [maintenance] wrote them [control instructions] out and I stuck them up on the heat pump.”  (Participant H_5b_F)

Control of the system

Half of the tenants in the sample had a digital control panel on the internal heat pump unit; these were all the properties in North Yorkshire. This heat pump system does not run on a programmed timer; it is ‘on’ all the time and regulated for the heating to switch on or off by internal and external thermostatic sensors. The property temperature setting is altered through use of the digital display and buttons on the panel on the internal unit. The other half of the heat pump systems seen in the sample and discussed in the contextual interviews had programme timers and the temperature setting was controlled by a thermostat dial device.

All tenants who had a thermostat control device reported being able to use it. Participant CH_B, for example, spoke confidently of being able to control her heat pump but it was evident this was in terms of using the thermostat for changing the temperature and not any other part of the equipment such as the programme control panel.
“When it was put in, they set it up, the time, for me and I wrote it up on the wall in the little alcove, in the cupboard where the equipment was… There is a lot of equipment in the cupboard which obviously I don’t understand, there’s a terrific amount, but on the hall wall there is a thing I can turn on or off…[Q: is that a control panel with buttons or like a dial thermostat?]…a thermostat…and in the winter I’ve got it switched on to 20°C” (Participant CH_B).

Tenants consistently reported that they were wary of using controls, either the digital control panel on the heat pump unit in the case of the North Yorkshire participants or the control panel of the remaining properties.

“I told them to set it up for me because I didn’t dare touch it and they did.” (Participant NL_C)

“It’s not clear at all when you’ve just got to touch and everything so delicate… Turn it too quick… it just goes mad on you. So I think, oh, the best thing I can do it just leave that alone once it’s set… And that’s why I’m saying, if there was a thermostat inside…” (Participant H_6b_M wanted a conventional thermostat in the home)

Some tenants reported being told not to use the heat pump controls and were not provided with information of how to do so; this was largely in the case of the North Yorkshire properties.

“It’s the fact you can’t control it. That’s what I don’t like. Can’t turn it off when we want”. (Participant H_I_F).

“He [maintenance] said ‘will you take a bit of advice love?’ so I said ‘Yeah I won’t touch them anymore’”. (Participant H_4b_F, after using controls and causing a problem with the system)
Tenants who felt they did not know how to control the heat pump or were too wary to use the controls and were dependent on the landlord to operate the system for them, which was mostly in the case of tenants in the North Yorkshire properties, highlighted an issue of vulnerability as a consequence. Participant H_5a_F described when her lack of control of the heat pump resulted in her having no heating or water.

“He’d gone and I thought, gosh, what’s the matter with me? I’m cold. And then I thought, well, stone cold. So I rang this thing up at [the landlord], the repairs, you know? I said you just had [unclear] I said, clean the valves and tested the smoke alarm, I said and everything is stone cold – no water, no nothing…I said the light on the thing through the back, it’s flattering. The green light… anyway, she rang me back twice and I finally got him when he’s coming back. And she said I’ve really told him off. He’d forgotten to switch it back on.”

As a result of this the tenant requested to be shown how to turn the heat pump on and off and reported feeling happier that they could do so. Other tenants interviewed reported asking installers or engineers who visited their property for information on how to use the controls. It was evident that tenants received information post-installation about how to use the heat pump system once they had been using it for a period of time. In cases, it was evident that finding out about how to control the heat pump at a later stage impacted their running costs.

“The first year I had it done erm it did cost a lot of money in electricity,…and then until I learned how to control it, down a bit, it went down a bit less like you know.”

(Participant NL_A).

**Introduction to the system**

All tenants interviewed reported that they were approached about having a heat pump by a representative of the social housing landlord through a letter first, followed by a home visit. A mixture of response was given about the level of information provided at this stage; this is presented separately as the first important theme that emerged.
No tenants reported any dissatisfaction with the approach the landlord took to introduce the technology to them. Some of the tenants’ responses indicated that the level of service they received at this point had an impact; they would remember the interaction they had with the representative.

“I can’t remember the name of the person who came, very nice, very polite, brought leaflets”.

Dissatisfaction from the introduction to the system was reported in relation to the information provided and whether this was deemed accurate by the tenants, as outlined earlier.

**Understanding of the system**

Variance was observed across the tenant data set of how well they understood how the heat pump system worked. Some tenants attempted to explain in their own words how it worked.

It was found that there was a mixture of understanding regarding the radiators and the heat emitted from the system. Some tenants understood that they had larger radiators because the heat pump runs at a lower temperature; some reported that they thought it was an issue that the radiators weren’t ‘hot’.

“We thought at first well this isn’t getting very hot. You see the radiators weren’t getting very hot. But then when we were taught how to use it, we were ok.”

( Participant CH_A)

Some tenants identified that the radiators being a lower temperature meant that they were safer. The responses from tenants appeared to reflect information that they were provided by either the landlord or installers.
**Tenant choice**

Tenants reported that they did have a choice about having the system installed and this finding was consistent across the each of the various social housing organisations the tenants were renting from. Tenants explained they were written to by the landlord to say they were being offered a heat pump. Some responses from tenants indicated however that it did not completely feel like a choice; for some it felt it was inevitable.

Those who felt they did have a choice about having the system installed made their decision based on what the representative of the social housing landlord told them when they introduced the technology to them.

Q: Why did you choose to change from your current system to have the heat pump put in?

“I believed what they told me, that it would reduce my bills and give me a better quality of heat.” (Participant CH_B)

Those tenants who felt it was an inevitability that they would have a heat pump installed and that they had no option were those who either had problems with their current heating systems or believed it would be done at a later date if not at the time of being approached.

“The bloke from the council came and told us we had to have a new chimney breast put in but he said we aren’t going backward, we’re going forward, so we’re coming in with this new heating.” (Participant H_B)

“They told me either have it done this year or we’ll probably be back next year. I thought well let’s get it over and done with because I’m still at work so I thought if we do need any renovating done, painting or touching, I’ve still got plenty of money to throw about to touch it up.” (Participant SD_A_F)

“Yeah it seemed like it was going to happen sooner or later, so we might as well do it now.” (Participant SD_A_M)
“My central heating actually went wrong, as I had multi-fuel fire central heating and they said they were obsolete and that they were putting ground source heating in.” (Participant CH_C)

A barrier to adoption was highlighted by tenants of being wary of the heat pump system. Several tenants reported it was something they knew nothing about and that they were unsure when approached. This was obviously a barrier to adoption to be considered and not a direct cause for refusal as all the tenants in this research had a heat pump installed, despite any initial wariness or concerns. Wariness was abated by the information provided and the service delivery from the landlord.

“I was a bit wary, thinking ‘ooh I don't know’...Because it was something new and because I hadn’t heard or seen anything about it, I didn’t know anything. I mean he was very good. Erm, and he didn’t rush it, you know, he sat and he went through it. And so I agreed. Because my husband was at work, he left it in a clause that when I’d spoken to my husband if we changed our minds we could go back and just stay the way we were.” (Participant NL_B)

Community effect
Tenants repeatedly reported that they communicated with their neighbours about the heat pump systems. They either spoke to each other about having it installed in the first place or how to use it. Some tenants reported that their neighbours operated the heat pump controls for them to change the temperature, if the neighbour understood better or had more confidence in using the system. Information highlighted in some interviews indicated that tenants were aware of how their neighbours used their system, what temperature it was set to or roughly how much it was costing them.

“We talk to each other about different things and learn from one another... We did talk to each other, there’s 6 bungalows here and we talked to each other and we thought it was a good idea.” (Participant CH_A discussing the choice to have a heat pump installed and learning to use it.)
Impact of contractors
It was evident from the tenant interviews that the contracted workmen played a significant role in the service delivery. They were the people in the tenants' home daily carrying out the work and in regular contact with the tenants.

“We had more of a relationship with them [contractors]” (Participant SD_A_M)

Tenants reported communicating with contractors when they visited their property during or post installation, to find out about the system and how to use it, as outlined previously.

Overall satisfaction
There was a mixed response across the tenant data set in terms of their overall satisfaction with the heat pump. Tenants mostly gave responses of being satisfied in terms of the heating it provided in their home.

“I think it’s marvellous…I like the saving I get from it, the reliability, I can control it if I want to and it keeps the house at a temperature of 21°C in the winter” CH_B

“When you come in, the heat is already there.” (Participant NL_B)

“As soon as you walk through’ t door you can feel the heat there.”
(Participant H_A)

Dissatisfaction with the heat pump was in the majority of cases due to the cost of running the system. This was mostly found to be the case with tenants in the North Yorkshire properties.

“He said this is a fantastic new energy saving system which will cut your energy bills by half… It’s green and it will cut your bills by half, afraid not, we are talking about double which is not what he said in the first place. If we’d known what we know now we’d no way would have had it installed, ever.” (Participant H_I_M)
**Disruption during installation**

There is always disruption to a degree with heat pump installations with the work being done internally and externally to the property and tenants indicated that they were aware of this being the case.

“It was a mucky job… the garden was the worst affected… people have got to be prepared.” (Participant CH_B)

The majority of tenants interviewed were not dissatisfied by the disruption by workmen keeping things as clean as possible and minimised the disruption as far as possible; they stated they had no problems living at home during this time.

Participant NL_C claimed that the workmen 'looked after her' and it was clear from the interview she had a good rapport with the workmen; this tenant had just returned home from hospital and did not feel the installation caused her any problems.

Some tenants reported more difficulties living at home while the heat pump was installed when the installation was carried out during winter months. This was because when the heat pump is installed the previous heating must be removed and the house becomes cold. The house is without heating for as long as it takes to install the new heat pump system and tenants reported it taking a few days to heat the property up once it had been switched on.

Some tenants described unexpected problems occurring during installation. Dissatisfaction in this event was managed by the tenant feeling the problem was dealt with suitably.

“They hit a water cable and it flooded a little bit, but they were very good, they brought in the pumps and pumped it out and they left everything as it was.” (Participant CH_A)
Greater difficulty was caused by unexpected problems resulting in delays of the installation work. When this occurred in winter months in particular, this created problems of no heating for periods of time during cold weather.

“It was supposed to be done in September… we went on holiday in September and when we came back it was supposed to be done, obviously it was delayed and after all the freezing cold…”

Q: Did they do any of the work before Christmas?

“Did they put the fire in before Christmas? [asked daughter] Because I had no heating whatsoever. I had a coal fire but I got a hole in the chimney so everytime I lit the fire the smoke would come through. I’d absolutely no heating.”

Q: How long was that for?

“Just all when it was cold, so yeah it wasn’t very nice” (Participant H_C)

“The main problem was when they were putting all the pipes in, in the airing cupboard. ‘Cause it took all day and it was freezing cold. And it was all into the evening; it was about 6ish when they finished, 7 o’clock. And you can imagine the house was freezing cold… It was winter and they had all the doors open coming in and out” (Participant SD_D)

Redecoration in the home was sometimes required as a result of the heat pump installation, particularly with wet systems where new radiators and piping needed to be fitted. Participant H_A reported that he was in the middle of redecorating his property, which was also clear on observation during the interview, but that he was told by the landlord not to proceed with any redecoration work until after the heat pump had been installed, due the mess that would be caused. Participants H_2_M and H_2_F, a couple, highlighted that they redecorated after the heat pump was installed. They had been informed they would be given vouchers for redecoration, however they did not know how much the value of this was before doing the work and overspent.
Use of additional artefacts for warmth

Tenants consistently stated that they did not use the electric fires that were installed with their heat pump for regular additional space heating; if used it would be for an occasional ‘boost’, but this was only reportedly used by few tenants in this instance. Some tenants reported that they used the electric fire on a setting which displays artificial flames, for the light and comfort that it provides.

“It [the heat pump] is comfortable and sometimes I put the fire on, but I only put the colours on you know, the fire part, I don’t put the booster on to send any heat out, it is just for background feeling, and that makes the room feel warm.”

( Participant H_4b_F)

Some tenants were observed to have, or reported having, additional electric or oil heaters in the home. The couple H_3b_F and H_3b_M reported occasionally using an oil heater in the evening for example, but this was not a common finding across the data set. Some tenants, such as H_5a_F keep an oil or gas heater in the home for in case of emergency such as a power cut resulting in a loss of heating from the heat pump.

Some of the older female participants reported using a blanket to cover their legs when sat on the sofa. Tenant H_3b_F stated she used this to keep warmer due to a draft in the living room. Other female tenants, for example H_6b_F and H_5b_F use a blanket as they have circulation problems and feel cold, particularly in the evening time.

Effect of previous system

Tenants who previously had a coal-fired heating system appeared to be, largely, the happiest with having a heat pump system. Most tenants found the heat pump was cheaper to run than a coal-fired system, with the current price of fuel. Even more consistent was the positive response to heat pumps against coal fired systems in terms of how much easier a heat pump is to manage and how much cleaner the system is in their home.
“The house is more better. We used to suffer with our chest and things like that, because of all the smoke.”

Q: So the ground source heat pump creates better air in the house?

“You can tell by that cord there, the telephone where the cord is, can you see how black it [the wall] is? Everything was black. Everytime you took your clothes off, soot come out.” (Participant H_B)

There was a mixture of opinion for tenants who changed from storage heaters to a heat pump. Tenants in the North Yorkshire sample who went from storage heaters to the heat pump without a thermostat control felt they had less control over the new system.

**Use of technology**

A variety of technology use was observed across the data set. Participants were observed to own entertainment equipment, such as a television. Some participants were observed to have a computer, with only a handful mentioning use of the internet; for example participant SD_A_M reported he researched heat pump systems on the internet.

Age did not emerge as an impacting factor on technology use observed in this research sample, on the basis that no difference was reported in equipment ownership or usage. Examples of technology use reported by tenant participants indicated that being of older age did not necessarily reflect an aversion to technology. H_6b_M was a participant over 65 years of age and was one of those who reported computer and internet usage; participant H_4b_F was 79 years of age and reported playing on her Nintendo DS regularly.

“I have got engrossed in that…”

Q: What’s that?

“[Nintendo] DS… I play solitaire on it mostly, and I have just been sat nearly 3 hours playing solitaire” (Participant H_4b_F)
Warmth preferences

The temperatures within the properties of tenants interviewed was not information directly sought in the interview questions but emerged during conversation about the tenants’ heating. The participants who provided this information showed that there was a range of temperatures across tenants’ properties, from 17°C to 25°C. It also indicated that some tenants monitor their home temperature; for instance, participants H_6b_M, H_6b_F and H_4b_F were observed to have a thermometer in their living room.

“I used to have it at about 20 degrees, I can turn it back now to about 17 and less since it’s been insulated.” (Participant CH_A)

“25 it says now” (Participant H_6b_M)

Individual differences were evident across the data for preferences for warmth and temperature regulation. Tenants reported how activity in the home affected their experience of temperature in the home, such as when doing household chores. It was often reported that clothing was used to regulate temperature dependent on activities. Some tenants highlighted their preference for a cooler bedroom and keeping windows open to create a cooler temperature in this room.

Participants reported health issues which affected their experience and preference for warmth in the home. For example, several tenants reported being on Warfarin medication for blood circulation problems; participants on this medication reported feeling the cold more.

“The wife takes Warfarin and she feels the cold” (Participant H_6b_M)

“I’m alright through the day when I’m moving about, when you sit at night, it’s cold” (Participant H_6b_F)
Use of windows and doors

A number of tenants were told not to open windows or doors in relation to having the heat pump system (For example: H_1_F, H_5a_F, H_5b_F, H_6b_M). Only some of these were given a reason of why this was the case, referring to the way the heat pump works. All of these tenants were in the sample from the same geographic location.

“…. they said well they were made for Norway and of course they are cold all the time so we can’t open any windows or doors, every time you open the door it all goes out, and how can you not open any windows and doors, I mean I like my bedroom window open at night, I always do so I am very hot, erm, and they more or less said we should have listened to what they said…..” (Participant H_1_F)

Despite these instructions, the tenants were still found to open windows at night in the bedroom to keep it cool, in summer and alongside activities like showering or cooking. Other tenants in the sample did not report being instructed to keep doors or windows open but reported behaviour of opening windows.

Q: What do you do if it gets too hot in the house?
“I go outside, I stand outside… Oh yeah I open windows, I open back door.”

(Participant NL_C)
4.3.3 Heat pumps installed

To contextualise findings from the interviews about the heat pump installations experienced by tenants, images of some example heat pumps are included here. Across the sample, in the majority of cases ground source heat pumps were the systems installed in the tenants’ homes; however, an air source heat pump was included in this sample and further aspects of the research are likely to include references to air source heat pumps. There was also a variety of manufacturer and supplier between the different social housing organisations. However, the size and placement of systems was comparable across the sample.

Figure 18: Air-source heat pump - indoor unit on wall (left), two size examples of outdoor units (right)

Figure 19: Ground source heat pump - indoor unit
4.3.4 Service actors

As highlighted in the analysis section previously, identifying the actors who impact on or are affected by the service of installing heat pumps is important to identify. Whilst this research focuses on the core relationship between the social housing landlord and the tenants, other actors play significant roles in the service and, as such, are included at various points of this thesis. The following diagram, in Figure 17, depicts the main actors identified as part of this service. There may be other actors involved, but these were selected as those which emerged in the study either through data obtained or observation. The lines between actors signify where there is potentially direct communication between them.

![Figure 20: Service actors map](image)

The manufacturer, installer, provider, installation contractors and maintenance actors may all be the same one organisation but each role is identified here as a variety of situations were seen in this study. As stated, the thesis is focused on the core relationship between the landlord and tenant and the service experience between these two actors. The research, however, highlighted the significant importance of the installer in the delivery and experience of the service. Therefore they were actively sought after for the second phase of this research, as they play a significant role in communicating to tenants when the heat pumps are installed. The
installers help to inform the tenants about the systems and how to use the controls, as evident in the information provided in the exploration study.

4.3.5 Service touchpoints

From the research with landlords and tenants, an understanding of the service process was developed. The following diagram, in Figure 21, depicts the high level service process identified. It shows the three key stages of the installation service and interactions between the service providers and service recipients, to clarify the remit of the service and the touchpoints reviewed in this research. ‘Installers’ in this diagram refers to any contractors carrying out the installation work in the tenants’ homes.
<table>
<thead>
<tr>
<th>Introduction Stage</th>
<th>Installation Stage</th>
<th>Usage &amp; Maintenance Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Initial letter from landlord</td>
<td>• Home visits from landlord</td>
<td>• Home visits from contracted or in-house maintenance teams</td>
</tr>
<tr>
<td>• Home visit from landlord</td>
<td>• Installation work carried out in and around the home by installers</td>
<td>• Tenants telephone landlord with any queries or problems</td>
</tr>
<tr>
<td>• Survey at home by installer</td>
<td>• Verbal information from landlord and installers</td>
<td>• In some cases, tenants contact the contractors (installers or</td>
</tr>
<tr>
<td>• Verbal information from landlord and installers</td>
<td>• Written information about the heat pump system (not provided in</td>
<td>maintenance) directly with queries or problems</td>
</tr>
<tr>
<td>• Written information about the heat pump system (not provided in all cases)</td>
<td>all cases)</td>
<td>• Tenants discuss usage with neighbours, friends and family</td>
</tr>
<tr>
<td>• Community information event held by landlord (not provided in all cases)</td>
<td>• Tenants telephone or speak in person with landlord about queries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>or problems</td>
<td></td>
</tr>
</tbody>
</table>

Figure 21: Service touchpoints identified through exploration research
4.4 Discussion of exploration study findings

The findings and extracted positive and negative aspects found through the empirical research provided the information to establish user and organisational requirements. A potential for bias was considered in the empirical research with landlords, in case of the organisation not wanting to be represented in a negative way. It is noted that landlords interviewed were found to be open in their responses as much about failures as successes, thus lessons learned can be extracted and heeded as trustworthy information.

It is clear from the research that heat pump technology is currently a beneficial option for properties in rural, off-gas areas as an alternative to solid fuel, oil or storage heaters. The heat pump technology provides a cleaner, more manageable system that has the potential to provide better thermal comfort and save the tenants money and deal with fuel poverty. Currently, heat pumps do not make such a suitable alternative to gas central heating systems. Although there are energy security concerns around gas supply, current costs in the UK mean that heat pumps do not have such a cost-saving benefit against gas systems and the energy efficiency of modern gas central heating is much better than the alternative fossil fuel systems of coal or oil.

While age did not seem to play a significant factor in how landlords approach and educate tenants about the heat pump installations, it was clear that older people were a target population for having a heat pump installed. This is because heat pumps provide a cleaner, less laborious option for heating than solid fuel. The findings from tenants did not highlight any significant differences between the experiences of the installation service between tenants over 65 years old and under 65 years old. Health related issues reported which affected their experience and preferences of warmth from the heating system were more prevalent amongst older participants.

On reflection of the findings from both landlords and tenants, installations carried out during the winter period cause a negative experience. It was ascertained through this investigation that the process of putting a heat pump into a property
involves removing the heating system in-situ and the installation of the heat pump takes from several days to a couple of weeks. This means that the tenant’s home is without heating for a period of time. Furthermore, once the heat pump has been installed, it takes a few days to fully heat the fabric of the property and run effectively. During the winter period, this makes a home cold to live in while having a heat pump retrofitted if remaining in the home during the installation, as is common practise.

Landlords provided alternative heating during this time by distributing oil burners or electric heaters, but this is not entirely adequate for a planned, non-emergency situation. Also evident in the data with both landlords and tenants was the potential for unexpected problems and delays during installation. This cannot be predicted but should be considered before commencing installations and factored into the timing of them, as it would exacerbate problems of no heating during the wintertime. Whilst this lends towards a recommendation that installations should not be carried out during winter, it is recognised through the data that installation opportunities are currently heavily reliant on the availability of funding; therefore, this has implications for funding providers and the timescale of which they offer grants and schemes.

The heavy dependence on funding on the ability to install heat pumps into social housing properties means that the timing and opportunity to carry out installations is not always at the landlord’s discretion. This emphasises the need for successful uptake from tenants at the time of it being offered to them. The research indicated some tenants refused at first but later wanted a heat pump installed, after seeing the success of them in neighbours’ properties, yet with funding no longer available they were unable to then have one installed.

Community information events appeared to be a successful approach for landlords to inform tenants about the heat pump systems, in their opinion. This type of approach enables a discussion between the landlord and tenants and tenants talking to each other in an informal, informative environment. It was evident that tenants influence each other’s opinions and usage of heat pumps; therefore, community
events may assist in wider-scale promotion and acceptance of the technology, particularly with timing being critical, as outlined above, relating to funding availability. An event such as this would be less demanding on resources by addressing many tenants together rather than individually and present opportunities for practical demonstrations or greater question and answer discussions that may surface and iron out more issues at an earlier stage. However, it does not allow for obtaining perspective of individual contexts and needs. Therefore, a community event cannot be in place of a home visit to ascertain suitability and other factors concerning the property and tenant but is added value to the service for further information.

Control of the system, or lack of, is potentially the most important finding from the research where tenants have difficulties, which impacts their ability to use the system effectively and with confidence. However, it is not listed as the top key issue in the tenant findings section. What surfaced in the research was that the information provided affected this issue; the lack of understandable written information to assist tenants with using the controls created or exacerbated the problem. Therefore, information provision emerged as the most important issue to address from the research findings. Because this was a precedential issue from both the landlords and tenants interviewed, the case was presented for information materials to be the priority focus of the continuing research.

Whilst written information materials emerged as the primary user requirement to address, other themes which emerged most consistently in the research related to issues concerning communication. This broader topic encompassed several of the themes identified in the research and touchpoints across the service. Therefore, aspects of communication were also addressed in the continuing research as the intention was to recommend measures which would improve the holistic service.
4.5 Summary of exploration phase

This study was designed to address the first research question of this thesis which, as a reminder, was:

- What lessons can be learnt from previous experiences when retrofitting heat pumps into social housing?

Through the contextual interviews with tenants and landlords a better understanding was acquired and lessons learned through their experience were identified. Objectives 2 and 3 of this thesis were achieved through the execution of this study, as evident in the study and findings reported and discussed above.

Objective 4 was to identify key positive and negative aspects of current processes to install heat pumps into social housing and highlight areas to address for improvements to the service. This was achievable through the data and understanding developed from the first study. The key positive and negative aspects are drawn out here, to illustrate what user requirements this thesis continues to address, achieving objective 4. This fulfilled the second stage of the user-centred design process and, consequently, informed objective 5: the second study carried out and presented in chapter 5.

Key positive aspects of current processes to install heat pumps

- Tenants were satisfied when workmen took care in their properties during the installation, covering flooring and furniture and cleaning homes and gardens thoroughly.
- Neighbours communicate about the heat pumps and help each other in using the system.
- Home visits and personal explanations helped the tenant make a decision about the technology and use the technology.
- Large-scale community installations are beneficial for both landlords and tenants. For landlords, it reduces the cost by having the equipment required in one place for a period of time to work on several properties. Tenants also prefer the work to be done on mass at one time, to minimise the disruption to their community or street.
Key negative aspects of current processes to install heat pumps

- Lack of, or inadequate, written information materials were supplied
- Inaccurate messages delivered during the ‘selling of the technology’ or setting unrealised expectations
- Tenants were provided with a lack of control or understanding of control panels
- There was no heating during winter months when installing during this time period

As outlined in the discussion above, in section 4.4, communication was a key aspect drawn out as an issue across various elements of the service and user requirements were identified through the emerging themes in the research of which elements needed further addressing to improve the service. The key user requirements were for improved communication in written information materials provided and verbal communication from landlords and installers.

It is clear that there are three main stages to the service of installing a heat pump system.

1) the ‘introduction’ stage, where tenants are approached about having a heat pump, informed about the technology and make the decision about having it installed,

2) the ‘installation’ stage at which the physical installation is carried out and the tenants informed how to use the system,

3) the ‘usage and maintenance’ stage, encompassing the tenants’ on-going use and experience of the heating system in everyday life and the on-going service the landlord provides in assisting tenants with the heat pump, maintaining the system or repairing any faults.

It is with consideration of the structure of these three stages that this research continues to address the service. The ensuing study, presented in chapter 5, investigates further the aspects within these stages that affect and could improve communication, in particular written information materials delivered.
In the purchase decision process, search behaviour is motivated in part by perceived risk and the consumer’s ability to acquire relevant information with which purchase uncertainty can be addressed. Marketing theory suggests that consumers use information sources to reduce the uncertainty associated with services (Murray, 1991). This principle may be applied in this context but with a substitution of the word ‘purchase’ for ‘acceptance’. A heat pump system is new technology that the majority of people know little about, yet an installation into someone’s home makes it an essential part of their everyday living. This is likely to increase caution over the risk involved, as was evident in the research with tenants reporting their wariness over the technology describing it as “something knew” and that they “knew nothing about”.

As a result they will seek for better understanding of the system from whichever sources of information are available. This argues the need for more appropriate and adequate written information materials as a tangible, retainable point of reference for the tenants to obtain information. Furthermore, the better the information provided about the holistic service at the introduction stage, the more the risk and uncertainty is reduced as the tenants can be reassured that all aspects of the system installation, usage and maintenance are taken care of and that the tenant will be supported. The more uncertainty and perception of risk is reduced the more likely tenants would be willing to accept the system into their home.

This thesis is looking at the core service provided from the social housing landlord to the tenant when installing a heat pump. But, as shown above, other actors will have an influence on this process and the experience. The next phase of this research investigates communication aspects of the service with a primary focus on written information delivery. It involves the social housing landlord, the installers and the tenants as it was identified that the landlord and installer are both the key communication channels interacting with the tenants directly.
5  Phase 2: Refinement & Development

Presented through Chapter 4, the exploratory phase of research depicted a contextual understanding of heat pump installations in social housing. By interviewing tenants and landlord representatives of multiple social housing organisations, the positive and negative aspects of current installation practises were identified. From this, areas that could be improved by the design of the service delivery were highlighted.

Applying user-centred design to a service adds a degree of complexity, as described in chapter 3. The first exploratory phase (chapter 4) produced a rich understanding of the installation service and highlighted areas that could be addressed to improve the service. A whole service and all of the touchpoints creating its delivery cannot be addressed at one time, particularly within a scope such as this doctoral thesis. A key aspect was highlighted in the first study that could be further addressed to improve the service: communication, with a particular focus on written information materials. Communication was highlighted as an issue and across various touchpoints and interactions, the breadth of which were surfaced by exploring the holistic service as far as possible, with the landlords and tenants. This first phase of exploration research, therefore, covered the first two stages of the user-centred design process: firstly, to understand the contextual issues, service process and experiences and, secondly, to define user requirements from the research findings.

The defined requirements were at this point high level and broad, due to the scope of the investigation of a service. The area of communication was an overall requirement to address, with various touchpoints identified that needed designing or improving. Whilst the first exploration phase provided rich and detailed insight into the installation service, the level of detail around the requirements was not sufficient to address the touchpoints, particularly from a user-centred approach perspective. Therefore, this second phase of research is titled ‘refinement and development’ and involves a second iteration of more focused exploration before progressing to the design stage.
As outlined prior, the scope of a service means that not all touchpoints can be addressed at one time. The key touchpoint felt, on the whole, by both landlords and tenants to be inadequate or lacking was written information about the heat pump system and how to use it. This touchpoint was a tangible part of the service delivery and, applying the philosophy of this research, required a user-centred approach to develop it. As such, the second phase of research was to understand the contextual issues and define the requirements of this particular touchpoint. The broader view of the communication aspects of the service was maintained and further investigated also in this second phase, to refine the requirements of other relevant service aspects and develop recommendations for improvement. This wider view of the service maintained at this stage also placed the development of the written information within the service context and any limitations.

Whereas the first study established an understanding of the context and what could be done, the second study was to augment a refined understanding of how something could be done to address key problem areas. A user-centred study was therefore designed involving the service recipients and the service providers of heat pump installations in social housing properties to address the identified areas for improvement. The purpose of the study was to form a deeper contextual understanding, generate ideas for potential improvements to aspects of communication in the installation service and to obtain insights and user generated ideas for requirements of how these should be developed. The focus of study with tenants in particular was to develop requirements and ideas for the information materials for their usage.

One of the social housing organisations that participated in the first exploratory phase of this doctoral research continued their participation for this second phase of research through to development of the physical touchpoint. The continuation of their involvement established this organisation as the case for this research investigation. This phase of research was in order to fulfil objective 5 of this doctoral thesis, outlined below as a reminder, and was an iteration of the first three stages of the user-centred design process.
Objective 5 of this thesis was to:

- Carry out a second phase of explorative empirical study, using qualitative user-centred research methods, to refine user requirements and generate ideas for how to approach measures to improve the service of installing renewable technology in social housing.

The following diagram, Figure 22, is a depiction of how this second phase of the research applies as iteration within the user-centred design approach.

![Figure 22: Refinement and Development phase of the UCD approach](image)

This chapter firstly describes the method employed to further explore and define requirements for the communication-related issues and written information provision. As with the first study, following the user-centred design approach, this involved both the service recipients and service providers to obtain a balanced perspective. The findings from this empirical study are reported and discussed to outline the progression into developed solutions. The recommendations for improvements to the design of the service to install heat pumps into social housing homes are subsequently presented.
5.1 Research methods for refining requirements

A second iteration of exploration was carried out, as previously described, in order to enhance the user focus and refine requirements in the development of solutions. To refine requirements to a greater level of detail, a significant level of depth was required in the research to elicit substantial and useful information, particularly in relation to the design of information materials. Achieving this richer understanding would be most productively extracted through discussion between multiple users. A survey research method at this stage would be inappropriate. Although it may enable the questioning of a large sample and collate wide-scale viewpoints, richness of the data and the ability to probe and clarify would not be possible, which were important factors at this stage. Interviews allow the collection of rich data to extract further insights but this would be a time-consuming method to gather fewer viewpoints (Courage & Baxter, 2005). Furthermore, interviews would be individual and would not enable discussion between participants. The benefits of discussion are that it facilitates idea generation and the reaching of a consensus between participants over issues.

Focus groups are used to gain insight into people’s views, perceptions and attitudes on a given topic (Litosseliti, 2003). A focus group creates a platform to bring together a selection of participants to contribute to a debate on a particular set of issues, whilst enabling the researcher to investigate and explore group norms and views (May, 2001). As such, they provide the opportunity for open discussion and rich data collection from several people: they are beneficial for investigating users’ points of view and feelings. Therefore, focus groups are a suitable method to find out about users’ experiences. The term focus group is sometimes interchanged with workshop in practice. However, the difference is that workshops are a group setting in which to teach or inform participants whereas focus groups are to listen and gain information in a non-threatening environment (Litosseliti, 2003).

Focus groups are a useful method for eliciting user requirements (Lofthouse & Lilley, 2006; Maguire, 2001) and identifying issues which need to be addressed. Although the aspects to address were derived from the first phase of interviews, further viewpoints and greater detail can be gathered which may validate previous findings.
or introduce further insights. To assist the development of solutions, the presence of several viewpoints and the collaboration possible in a focus group setting allows for greater discussion over ideas and can fuel development or quickly discount implausible ideas by eliciting further requirements. As Maguire (2001) outlines, participants in focus groups can stimulate ideas in each other and the discussion that ensues consolidates a collective perspective.

Litosseliti (2003) proposes that focus groups are applicable at different stages of research, from exploratory questioning to assessing a developed programme of activities. It is also suggested that this method is beneficial for examining participants’ shared understandings of everyday life and the everyday use of language and culture of a particular group. Furthermore, this method is useful for generating ideas through discussing different angles of a problem and potentially reaching solutions. For the aforementioned reasons, a focus group is an appropriate method for refining requirements and extracting user perspectives on potential solutions.

A phenomenon that is apparent in focus groups but rare in other forms of data collection is an internal inconsistency in responses: people can change their opinions during the course of the discussion after listening to other people’s points of view (Krueger, 1998). This may be considered a flaw of focus group research but in real-life settings people’s opinions do not remain constant. Therefore, it can be deduced that participants are responding in a normal and natural manner. The reason for the change in opinion, however, is important to identify: for example, did the person really change their personal view or did the forcefulness of another person result in the change? (Krueger, 1998).

Focus groups are a time-consuming method of obtaining data collection, requiring preparation time, travel time and time to conduct the actual session. However, they are a less time-consuming method of gathering several points of view at one time, by enabling the input of several participants in a shorter time frame than is possible with conducting individual interviews, and allow for collaboration and discussion. The number of participants in the group should not be too large though, as this can limit input from individuals and restrict the flow of discussion. Too many
participants can also be difficult to assemble and moderate on the researcher’s part (Krueger, 1998). There is not a definitive amount of participants of which a focus group should comprise but it is recommended that they should be kept to between eight and twelve participants (Lofthouse & Lilley, 2006).

Focus groups are a qualitative research method providing rich information and the consequently discursive nature of the method means that a semi-structured format is most appropriate. A systematic structure can be followed, however, to encourage focused, useful discussion. The session should begin with questions that allow participants to become familiar with the subject matter by recollecting personal opinions and listening to others. This should be followed with key questions that elicit the information the study aims to obtain. Lastly, the session is summarised with the participants for clarification on both the participants’ and researchers’ part.

For the reasons outlined above, it was decided that a focus group was applicable as the primary method of data collection and more beneficial than only further interviews or a wide-scale survey. However, whilst interviews were not deemed suitable as a sole research method for this phase of study, they can be appropriate used in conjunction with focus groups. Focus groups are more onerous: they are more time-consuming and can require participants to travel to another location. This can be impractical for people for a variety of reasons, such as disability or an inability to drive. Both of these examples are more likely to be the case for older people. In the recruitment for this study it was found that some tenants responded that they could not attend the arranged focus group but wanted to participate in the research.

Although carrying out interviews with individuals who could not attend the focus group would not involve the important aspect of discussion and collaboration, contextual interviews could add to the level of depth of information gathered in the focus group. They could be used to validate the focus group results through the outcomes being reviewed by other people that fit the population sample. The interviews could be used to identify requirements to review against those extracted from the focus group and observe in context. Conducting interviews with those
who could not attend the focus group ensured valuable viewpoints were not dismissed on the basis of practical issues.

5.2 Method: Exploration to refine user requirements

5.2.1 Sampling
This study involved one of the social housing organisations that participated in the first exploration phase: organisation LG (the participant code applied in the first study in chapter 4). Social housing organisation LG had already installed heat pumps of various types: ground-source, air-air source and air-water source heat pumps, on a wide scale. Approximately 125 systems had been installed in their social housing properties over the last few years. At the same time as installing in their socially rented properties, due to the availability of funding and the practicality of equipment being on site, they also took the opportunity to install heat pumps into privately rented properties in the same locations as the social rented properties. This meant that organisation LG was a suitable and interesting example case with extensive experience of installing heat pumps into a variety of properties.

The social housing organisation were already aware of the need for better tenant information about heat pumps, for them to have a better understanding of how they work and to use them more efficiently. This partly emerged as the result of an independent report that the BRE (Building Research Establishment) were commissioned to carry out, to assess a sample of air-source heat pump installations for their quality and effectiveness. BRE reported that there was a lack of understanding amongst tenants about how their heating system worked and that providing better information could address this (BRE, 2011). The results of this report were in line with findings from the explorative interviews for this doctoral research, which involved tenants with ground-source heat pumps.

Consequently, organisation LG had contracted an external, independent energy agency to carry out research and improve the information provision. The social housing organisation contacted the researcher subsequent to their involvement in the first study to inform about their plans and suggested collaboration between the
energy agency and this doctoral researcher in going forward. This provided an opportunity for this researcher to carry out a case-based investigation through a user-centred design process and offered greater support with the recruitment of participants. Therefore, this organisation was selected as an opportunistic sample case. Although the work was done in collaboration with an energy agency, the researcher designed the method for the user research. A representative from the energy agency co-led the empirical research and produced an output report to the social housing organisation; however, the focus group, interview structure and questions to be asked in both methods were developed by the researcher and the results were analysed by the researcher.

When conducting the contextual interviews with participants for the exploration phase, it was broached at the end of each whether they would be willing to contribute to any future study for the research. A rapport was built with the organisation and each of the participants during the interviews in the first study, particularly because of being face-to-face interviews, which helped in the recruitment process for this second phase.

5.2.1.1 Participant selection
This study consisted of three parts, requiring participants from both the service recipient side and the service provider side. The service recipients, tenants, were recruited for the focus group through the social housing landlord (service provider). The researcher wrote a covering letter and an information sheet outlining the study and expectations of the participants. This was forwarded to the social housing organisation and distributed by them under their own covering letter to tenants with a heat pump installed in their home. The introductory letter for recruitment of participants was sent to tenants from the social housing landlord because of the relationship of trust between them and the landlord’s duty to protect the tenants’ personal details. Furthermore, it was anticipated this would return better response rates. For these same reasons, a representative at the social housing organisation was provided as the contact to respond to. The researcher’s contact details were also available on the information sheet, should the tenants wish to contact the researcher directly for any further information.
It was determined crucial that users involved in this phase of the research were existing users, not potential users. With such new technology in question and a demonstrated lack of understanding amongst experienced tenants with a heat pump installed, as evident in the review of literature and findings of the exploration phase, it was deemed unsuitable to recruit a random selection of tenants of the social housing organisation to participate. It was essential to ensure that all participants were heat pump users. Furthermore, in focus group research, specific responses based on experience are given more weight (Krueger, 1998) therefore the contribution of tenants with a heat pump was more likely to provide substantial, valid information.

A level of experience with this specific technology was required to be able to relate to the service, the areas identified for improvements and to contribute ideas about how to tackle these improvements that the tenants would find beneficial. Those who had been through the existing service would know what would have improved the experience for them at various stages of the process. Novices would be very unlikely to have enough prior understanding to be able to give substantial insights. Thus, the sample could not be random as participants had to fit particular criteria. Only tenants with a heat pump received the recruitment letter and it was therefore an opportunistic sample from this sub-set of tenants, in that participants were recruited on the basis of responding positively to attend from targeted requests.

Table 5 shows the sample information for the participants who were recruited to represent the service recipients in the focus group; the first and main part of the tenant data collection for this research phase. Whilst the target audience to be recruited was tenants, in the group of eight participants, six were tenants of the social housing organisation and two were a relation of a tenant. One was the partner of a tenant with a heat pump, who lived elsewhere but had experience of the heat pump system, and one was the daughter of an elderly tenant with a heat pump. The daughter attended both as a user of her mother’s heating system and also to support her mother in contributing to the focus group itself because of her physical ailments.
The researcher had less control over the recruitment because this was done by the social housing organisation, as explained earlier, beyond the content of the recruitment documents and specifying participant requirements to the social housing organisation. Interaction at the point of recruitment was between the social housing organisation and the respondents. It was determined that the relations could appropriately contribute to the discussion as stakeholders who use the system and have experience of spending time in the properties with the systems. Participants 4E and 5F had been involved in the previous phase of this research, interviewed in their home about their heat pump experiences. This helped to validate the reliability and accuracy of the findings of the first phase of research through the repetition of them discussing their experiences.

Exact ages of the participants were not obtained when collecting data but it was determined whether they were under or over 65 years old. This age was the lower limit of what classified the population of older people, as outlined in the literature review section 2.2, being studied in this research. Therefore, it was appropriate to determine which participants were in this category and which were not, to determine any differences between the demographics in their responses.

<table>
<thead>
<tr>
<th>Code</th>
<th>Gender</th>
<th>Heat pump system</th>
<th>User Type</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.A</td>
<td>Female</td>
<td>Air-Air Source (ducted)</td>
<td>Tenant</td>
<td>Over 65</td>
</tr>
<tr>
<td>1.B</td>
<td>Female</td>
<td>Air-Air Source (ducted)</td>
<td>Daughter of I.A</td>
<td>Over 65</td>
</tr>
<tr>
<td>2.C</td>
<td>Male</td>
<td>Air-Air Source (ducted)</td>
<td>Tenant</td>
<td>Over 65</td>
</tr>
<tr>
<td>2.D</td>
<td>Female</td>
<td>Air-Air Source (ducted)</td>
<td>Tenant</td>
<td>Over 65</td>
</tr>
<tr>
<td>3.E</td>
<td>Female</td>
<td>Ground Source</td>
<td>Tenant</td>
<td>Under 65</td>
</tr>
<tr>
<td>4.F</td>
<td>Female</td>
<td>Ground Source</td>
<td>Tenant</td>
<td>Over 65</td>
</tr>
<tr>
<td>5.G</td>
<td>Female</td>
<td>Air-Air Source (fan)</td>
<td>Tenant</td>
<td>Under 65</td>
</tr>
<tr>
<td>5.H</td>
<td>Male</td>
<td>Air-Air Source (fan)</td>
<td>Partner of tenant 5.G</td>
<td>Under 65</td>
</tr>
</tbody>
</table>

Some tenants responded to the focus group recruitment, by contacting the social housing organisation representative, to say that they could not attend the focus group but wanted to partake in the research. The tenants were unable to travel to
the focus group location. Therefore, it was decided that contextual interviews would be a suitable supplementary method of data collection, to obtain the viewpoints of these participants. It was better to extend the investigation through an alternative method than to omit the contribution of others because of their inability to attend the focus group. The researcher would instead visit the tenants in their home after the focus group had been carried out. A modified structure of questioning to suit the setting was developed, aiming to elicit information comparable with the focus group data collection and to validate and develop further the findings from the focus group. Table 6 outlines the participants who were involved through contextual interviews. Again, these participants were contacted by the social housing organisation first with information about the interview process and to arrange an appointment.

Table 6: Service recipients interview participants

<table>
<thead>
<tr>
<th>Code</th>
<th>Gender</th>
<th>Heat Pump System</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>CI1</td>
<td>Male</td>
<td>Air-Air Source (fan)</td>
<td>Over 65</td>
</tr>
<tr>
<td>CI2</td>
<td>Male</td>
<td>Air-Water Source</td>
<td>Over 65</td>
</tr>
<tr>
<td>CI3</td>
<td>Female</td>
<td>Air-Air Source (fan)</td>
<td>Over 65</td>
</tr>
<tr>
<td>CI4</td>
<td>Female</td>
<td>Air-Air Source (fan)</td>
<td>Over 65</td>
</tr>
<tr>
<td>CI5a</td>
<td>Male</td>
<td>Air-Air Source (ducted)</td>
<td>Over 65</td>
</tr>
<tr>
<td>CI5b</td>
<td>Female</td>
<td>Air-Air Source (ducted)</td>
<td>Over 65</td>
</tr>
</tbody>
</table>

The service providers appropriate to inform this phase of research were employees of the social housing organisation who are involved in the installation process for heat pumps and who interact with tenants regarding their heat pump and the contracted installers of the systems. As was the case with the tenant recruitment, participants representing the service provider perspective needed to have experience of the processes involved in installing renewable technology. A sound understanding of the processes involved, their knowledge of activities and experience of tenants’ reactions, enabled them to proffer their views of the positive
and negative aspects of the service. Recruitment of participants with these criteria was requested with the representative contact at the social housing organisation.

The project contact at the social housing organisation recruited the participants, both internally and the external contracted installers, and communicated the purpose of the study to all, with a study information sheet supplied by the researcher. Again, it was determined that this would produce a better response rate, particularly from the external installers. Table 7 gives details of the participants in the focus group with service providers. For these participants, age details were not obtained as they were not necessary for the research. Their job role was the key piece of participant information, to understand their position in the service and the type and level of interaction they have with tenants in relation to heat pump installations.

Table 7: Service Providers Focus Group Participants

<table>
<thead>
<tr>
<th>Code</th>
<th>Gender</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Male</td>
<td>Council employee – Contract Officer</td>
</tr>
<tr>
<td>B</td>
<td>Male</td>
<td>Council employee – Energy Officer</td>
</tr>
<tr>
<td>C</td>
<td>Female</td>
<td>Council employee – Energy Officer</td>
</tr>
<tr>
<td>D</td>
<td>Male</td>
<td>Council employee – Energy Officer</td>
</tr>
<tr>
<td>E</td>
<td>Female</td>
<td>Council employee - Business Support (Energy)</td>
</tr>
<tr>
<td>F</td>
<td>Male</td>
<td>Installer</td>
</tr>
<tr>
<td>G</td>
<td>Male</td>
<td>Installer</td>
</tr>
<tr>
<td>H</td>
<td>Male</td>
<td>Installer</td>
</tr>
</tbody>
</table>
5.2.2 Method
The second study to refine requirements and develop solutions was divided into three parts as previously outlined. Two user-centred research methods were used, as described above; a focus group method was used for eliciting further information from service users and service providers and contextual interviews were used as a supplementary research method to obtain further information from service users. The diagram below in Figure 19 depicts how this study formed. How these methods were applied and carried out in each part of the study is explained in the following sections.

![Refinement and Development Study Diagram](image)

Figure 23: Refinement and Development Study Diagram

5.2.2.1 Pilot study for refinement and development study
Robson (2011) outlines that case-based research can make piloting more difficult to set up. It may be that particular factors of the case being considered mean that a sensible equivalent is unable to be obtained to act as a pilot. As demonstrated through the thesis thus far, the parameters of this research create a niche target population. With such a specific nature of questioning and sample required for this phase, practicalities of assembling a representative group of people to trial the method was implausible: recruitment for the main study alone was feasible. Therefore, although the importance and benefits of piloting a study are highlighted in this thesis and were considered, a thorough pilot study was not a viable option for this phase of the research.
The researcher had, however, established experience with conducting focus groups in previous research projects and in industry so moderating skills had been developed prior to this study. Although these focus group moderating skills had not been trialled with a group of older people, substantial experience of conducting social research with older people was obtained through the first study. A recognised limitation was the inability to test the structure and questioning in this study with a representative group of people for each of the participant groups. However, the focus group plan and questioning developed by the researcher was reviewed by the energy agency co-facilitating the focus groups for clarity and whether they felt anything had been omitted.

5.2.2.2 Service Recipients: Focus Group

The focus group structure and questions were designed by the researcher and the session was carried out by the researcher along with the representative from the energy agency involved in the project. The aim of the session was to find out what the tenants felt would improve the service they received and how to achieve these improvements. The focus group guide of questions produced can be found in Appendix E. The guide was semi-structured, with questions that were open and broad to stimulate discussion in the group. The structure was used as a guide to give the session direction and ensure the time allowed for the focus group was both kept to and utilised effectively. The focus group lasted approximately two hours in total, with a ten-minute break in the middle for refreshments. The break was to keep participants engaged and focused during the two parts of the session and to ensure it was not too onerous on the participants, maintaining a relaxed, pleasant atmosphere.

The participants had received an Information Sheet and a Consent Form prior to attending the focus group but spare forms were available from the researcher at the session, to ensure all participants were sufficiently informed and could consent to participant prior to the session. Tenants were offered refreshments on arrival and had some time for socialising whilst waiting for all to arrive. The focus group was in two sections, separated by a break, and had two primary objectives, structured to systematically elicit the desired information from participants. The two objectives
were, firstly, more exploration of user experiences and opinions, to further inform and validate the first phase of this research and, secondly, idea generation from the user’s perspective of what they felt would have improved the service for them from installation stages through to current on-going support.

At the beginning of the first section, the participants’ experiences with the heat pumps were discussed; this was to encourage participants to talk openly and focus on the topic. Following this, the participants were asked to make suggestions about how they thought their experience or service could have been improved overall. Responses were recorded on post-it notes and flipchart paper in the middle of the table in front of the whole group, enabling all to see and to stimulate conversation around these points. A break of approximately ten minutes was included where participants could have more refreshments. It was expected that conversations would continue during the break concerning the heat pump installations and experiences, therefore the recording equipment was left running throughout the duration of the entire focus group session. After the break, the discussion resumed with a focus on the control that participants had over their heat pump. The participants were asked about their experience of controlling the heat pump and the control devices themselves and what they felt could be done to improve this element of the system. Lastly, the participants discussed what they would like in terms of information provision. Ideas and design considerations presented by the participants were written on post-it notes and arranged on flipchart paper in logical groupings.

5.2.2.3 Service Recipients: Contextual Interviews

As outlined in section 5.2.1.1, some tenants responded to the focus group recruitment to notify that they could not attend the focus group session but would like to participate in the research. It was determined that carrying out contextual interviews in this event would be suitable, to provide a deeper level of detail at this stage and validate or refute results of the focus group. The social housing organisation was the point of contact and arranged the interviews with the tenants, to be conducted at their homes. The interviews were semi-structured and the researcher designed a protocol of questions (the guide produced is available in
Appendix F); the researcher also led the interviews. For some of these interviews the energy agency representative accompanied the researcher; for others a representative of the Council attended with the researcher.

The interviews lasted approximately one hour and were conducted in the tenants’ home, thus providing the contextual understanding through the interview process. Questions obtained background information about the tenant’s experience of their heat pump installation for greater contextual detail and obtained opinions and ideas regarding what would improve the service for them. The outcomes of the focus group were phrased in questions and discussed to obtain the opinions of the interviewee about the proposed suggestions.

### 5.2.2.4 Service Providers: Focus Group

A focus group lasting approximately two hours was held with the service providers of heat pump installations in this case study. Relevant members of the social housing organisation, relativity as described in section 5.2.1.1, and representatives of two contracted installation companies attended, as outlined in table 7. Following a brief introduction about the purpose of the focus group with participants, a semi-structured plan of questions was used to direct the discussion (see Appendix G). Throughout the focus group, data were obtained from all participants’ perspectives what lessons had been learned already and what they thought could be done differently and better in the future.

For the first hour, both employees of the social housing organisation and installers were present, to discuss issues that concerned both parties. After a short 5-10 minute break, the focus group continued with the social housing employees only in order to discuss issues relating to the social housing organisation and not place too much demand on the installers’ time.

### 5.2.3 Analysis

By being both researcher and moderator, an advantage is gained in the analysis process through the greater level of insight and in-context knowledge the
researcher has of the information obtained from participants and the research overall (Litosseliti, 2003). The deeper level of understanding of both the data gathered and the overall research means that the researcher can establish the important links between the information obtained and the research questions. This also means that analysis can to some extent be considered as the data is gathered (Litosseliti, 2003), identifying emerging themes and key outtakes by being both researcher and analyst.

Robson (2011) outlines that focus group analysis should follow the general principles and processes for qualitative data analysis but indicates that attention should be paid to the specific issues arising from focus group dynamics. Caution should be taken over the interpretation of data; for example, an absence of disagreement should not be taken as consensus as, whilst it may indicate agreement, it may be due to an unwillingness to express dissent.

The sample size in this phase of the research was small for each of the parts which made up the study. However, the intention of the study was to have a representative view from the service providers’ and service recipients’ side to inform the development of service recommendations and, in particular, written information. The method adopted enabled a range of opinions to be obtained alongside a further contextual understanding through the incorporation of interviews in tenants’ homes as well as the focus groups.

The mixed methods required the researcher to immerse in the data and draw insights, which would inform this phase of the research to refine requirements for the service improvement measures to be taken forward and, in particular, for the written information materials. As with the previous study, a thematic analysis was most appropriate at this stage to identify key insights and themes which edify what was necessary to address. Due to the small sample sizes in each part, however, more specific insights were required to be drawn upon rather than broader themes from the sample, to inform the development process.
5.3 Findings: Refined user requirements

As outlined in section 5.2, the methods combining to inform this phase of research comprised of three parts. Each of the parts served to provide perspectives from the end users (tenants) and at the organisational level (landlord and installers) and the mixed methods approach was adopted in order to maximise the data capture possible. The parts each also served to validate the previous by obtaining additional perspectives on the outcomes of the previous data collection, as well as provide a further level of insights into user requirements. This following section presents the findings from each stage in turn, to identify the development of requirements and, ultimately, solutions.

5.3.1 Findings from service recipients focus group

As outlined earlier in the description of the method, the service recipient in this part of data collection refers to a tenant or a stakeholder on the end user side of the service. As shown in the participant sampling information in Table 5, the service users involved in this focus group consisted of mostly tenants living in a property with a heat pump but also family members or partners who interact with the heat pump and experience the home environment. The participants in total represented five households.

5.3.1.1 Contextual issues

Of the five households involved in the study that participants represented, four households were having a negative experience with their heating system post-installation, in the usage phase. The main issues arising from all of these participants were a lack of information about the system, a lack of control over the system and insufficient heat in the home. The household (couple: participants 2.C and 2.D) that was happy with their heating system, although not registering complaints as such, however concurred that the information they were provided with could be improved and that they wanted clearer, understandable information on their heating controls. The findings are presented first as the key themes emerging from the data collection. Under a separate heading are explicit suggestions participants made that
they felt could be implemented that would improve the service they received and still receive.

**Written information materials**
Validating the key finding of the exploration phase, all tenants reported that they received insufficient or inadequate information on how to use the systems. The two participants of the one household who were happy with their heating system had some understanding of how their system works and felt they were given helpful verbal information when it was installed, but that they required more detailed, specific information to refer to during usage. They require some written information, which is easy to understand, to explain the controls and symbols on their control device.

**Setting expectations pre-installation**
There was a mixture of opinion within the group over whether they had been prepared enough prior to installation for what would happen during the installation. Tenants stated they were told about the heat pump system and how it worked. However, the tenants with ground source heat pumps reported that they were not prepared beforehand for the size and placement of the internal heat pump unit; they did not expect to lose the substantial storage space, such as airing cupboards, that they did when the units were installed inside the home.

**Service from contractors**
The majority of the participants were happy with the service they received at the installation stage, when the practical work was carried out, and were satisfied with the standard of service carried out by the contracted workmen. This was not the case in all households, with reports of some impolite and disrespectful behaviour from workmen in terms of handling their personal belongings in the home. However, participants who reported this followed with comments that the housing organisation was alerted to this fact and dealt with the problem effectively. This reflected positively on the customer service provided by the housing organisation.
Experience of heating in use
Inadequate heating was a frequently and extensively reported problem across the group, by 6 out of the 8 participants. In some cases, particularly those with ground source heat pumps, the tenants believed that the systems were incorrectly sized and they displayed a lack of trust in the installations.

5.3.1.2 User generated ideas for service improvements
The second part of the focus group was to discuss any ideas that would make the service better for them and identify what they would require in written information materials to help ensure they were useful for them.

Communication
Some of the participants reported that someone from the landlord or an engineer had visited their property to carry out checks or work on the system externally but they would not interact with the tenant at this point and explain to them what was happening. All 8 of the participants felt that a follow up visit post-installation from the Council or installers would have been beneficial to them, to check how they were getting on with the system, whether they were running it suitably and to answer any questions. They felt this would be especially helpful a few weeks subsequent to having it installed, to allow a period of adjustment becoming accustomed to using the new system. There was a strong opinion amongst the participants that this should be a personal visit and that a telephone call would not suffice if they had questions or needed a better understanding of something, particularly controls. The participants suggested that the engineers carrying out services or checks could see the tenant at the same time as checking the system to make it an easier task.

The participants stated that they felt staff at the Council should have better training with regards to heat pump systems so that when the tenants contact frontline staff they can be confident the person they are talking to has knowledge of their system.
**Written information requirements**

In terms of preferences for the information they require, all participants reached a consensus over the criteria they would want from communications, written or verbal. The participants wanted to be supplied with information on:

- What to expect practically during installation
- What to expect practically during usage
- Expected running costs
- Explanations of functions and symbols on their heating controls
- Contact information for help.
- Guidance on what electricity tariff is the most suitable and cost effective.

The participants highlighted the criteria they felt was important to consider when producing written materials for information about the heat pumps. They wanted to be supplied with written information that was simple and clear, in ‘plain English’ language so it is easy to understand. Participants also emphasised that text size and font should be considered for older people with poorer eyesight.

**5.3.2 Findings from service recipients contextual interviews**

These findings generate insights from the same population from which the focus group sample was recruited, the service recipients, but through employing a different method of data collection. Carried out subsequently, they provided validation of the previous findings and the method enabled contextual understanding, to further refine requirements. Analysis of the contextual interviews identified issues and design considerations in common with the focus group and between interviews but some factors also emerged on an individual basis that gave useful insights in the refinement of design criteria and ideas.

**Information provision**

Tenants CI1 and CI3 showed the researcher the manual they were provided as written information. Participant CI3 said they did not understand the manual and CI1 said they found it too much and confusing. Participant CI1 also commented that the manual content was poorly organised in terms of structure, causing the reader to constantly change sections and pages when reading an instruction. Participant CI1
stated that they wanted shorter written material giving details outlining how to turn the heating on and off, what to do in an emergency and how to change the temperature. He wanted simple instructions in an understandable format to give more immediate information.

Other participants confirmed these same preferences but in addition wanted information such as how to set programme timers and electricity tariff advice.

Tenant CI2 stated that both verbal and written information would be useful rather than one in preference to the other and this was reiterated by participant CI3. Participants CI5a and CI5b agreed, stating that a demonstration of how to use their control panel helped but they also wanted some helpful, simple written instructions.

The general consensus across all participants was that written information should be a short leaflet with pictures and labels to help them understand functions and symbols. In addition to this, information on the best ways to 'live' with a heat pump were requested; most tenants commented on manipulating the heating by closing doors or leaving them open and none were certain that they were doing the correct thing.

Tenant CI4 showed the researchers the Tenant Handbook that she received when she moved in, that is given to all Council tenants. This handbook contains all useful information and contact numbers. It was discussed that it would be suitable to create information material for the heat pump that could be located in the handbook.

**Lack of control**

Tenants reported not being able to operate the controls for their heat pump system. Participant CI2 reported that the programmed timings do not currently suit their lifestyle and it was found that they use a supplementary electric heater two to three times during the day for around one hour at a time when they feel cold as they don’t know how to change the timer using the controls.
Participant CI3 also reported that being able to use the timer would make operating
the system easier for her and to suit her electricity tariff to be cost effective, but
did not know how to change the timer. Being able to change the time was also
reported by some participants in the event of when the clocks change.

**Moving into a void property**

Some of the tenants interviewed highlighted the need for a better service when
moving into a void property that already has a heat pump installed. Two of the
participants were not given sufficient information about how to work the systems
when they moved in. A tenant who moved into a property with a heat pump
already installed reported they:

> “found a book [manual] on the side” [kitchen work surface] (Participant CI4)

They stated they were not given any other information. This participant called the
council for help and they sent a representative to visit, but the representative who
visited the tenant did not know what the system was when they got to the property.
Another tenant (participant CI1) stated they were given no verbal information
about the system: a representative from the Council Tenant Services showed CI1
around the property when they moved in and pointed out where the heating
system was but gave no more verbal information than that.

**Communication**

Participant CI2 said they would have benefited from a follow up check from the
landlord, but this would be done better in person rather than over the telephone.
This participant reported that they trust their landlord and so would be happy for
them to visit and give advice. Participants CI5a and CI5b added to this stating that
service information on when the landlord will check the systems would be useful.

Participant CI3 reported that when she needed help with the system she was
unsure whether to contact the landlord or the installers, but decided it was ‘best’
to call the landlord. The participant pointed this out as something that should be
clear as part of the information they receive. Participants CI5a and CI5b also
highlighted an uncertainty over contacts and who attends their property. They would contact the landlord in the first instance but they want to trust they are getting a heat pump engineer to visit.

5.3.3 Findings from service providers focus group
The findings derived from participants grouped as the service providers incorporated representative employees of the social housing organisation who have involvement in heat pump installations and contracted installers. It emerged in the focus group that although there is no active renewables programme currently, if or when this came in, the process would need streamlining. Lessons have already been learned from the original installations to the present service: it was not initially standard practice to do physical checks of the property prior to installations, whereas now this is the case.

The installers play a key role in the service provision and tenant experience. At first it is the social housing organisation’s responsibility to approach tenants and communicate with them about the heat pump installation; following this the installers visit to do a site inspection of the property. According to the installers, during this visit they give tenants information on what to expect during the installation and use, including advice on home behaviours regarding the heating. The installers’ perspective was that in order to complete a successful installation, the site inspection is crucial. The installers reported that the tenants are given information materials but that they do not use it and prefer to call straight away.

The installers give their contact number to tenants for any problems during the installation process. There is regular contact between the social housing organisation and the installers; they have a good relationship which is a positive for the process according to participants from both sides. For maintenance issues, the participants stated that tenants are expected to call the social housing organisation in the first instance and they then contact the installers. It was suggested by the participants through discussing their processes that clarifying the contacts for tenants to use at different stages would help to ensure a smooth process.
It was outlined in the focus group by the participants that tenants’ perceptions of how the system should be run need addressing and behavioural advice needs to be given, to try and aid their understanding of how to operate the system effectively. All of the participants agreed that the major problem with heat pump installations is the tenant’s control of them, both in terms of their understanding and the design of the controls themselves. The focus group discussion continued between the participants, without further question or prompting from the researcher, in a direction that changing control equipment would improve heat pump installations. All participants thought that heat pump controllers are too complicated for users and more complex than necessary. They felt that the control functions could be prioritised and only the necessary functions should be on the control device; for example, it was suggested that the air-conditioning function could be removed. They suggested it would help to change controllers to give tenants a degree of familiarity using them and liken them to gas boiler controls. The social housing organisation and installers recognised that tenants who previously had coal-fired systems find the heat pumps most difficult to understand as they have no previous knowledge of this kind of control at all.

Other than changing the manufacture of controllers, the social housing organisation and installers discussed the benefits of standardising the control devices across installations, to make the information provision and internal management easier for frontline staff. It was identified this would streamline the process as one of the major problems currently is the diversity of systems and control devices and knowing what is installed in which property. As a result of this focus group discussion, the social housing organisation and installers were subsequently going to meet to discuss the potential of taking this forward and request manufacturers to supply this.

Currently the social housing organisation has some initiatives for tenant groups, to make things easier for tenants and to give them an opportunity to discuss matters. These include tenant leaders to support the community, scheme managers for programmes put in place and a scheme entitled ‘village voice’.
The social housing organisation is restricted on what advice they can give regarding electricity tariffs; it is the responsibility of the individual tenant to choose and set up their own tariffs. The social housing organisation can make a suggestion that a tenant should look at their bills and advise with general tariff information but cannot tell them what they should do in terms of opting for a specific electricity tariff. Any changes to tariffs are the tenant’s responsibility and at their discretion. The social housing organisation would however advise in general that tenants should not be on an Economy 7 tariff with a heat pump.

When discussing with tenants about having a heat pump and what savings are possible by having one installed, the social housing organisation suggested that stating it in terms of kWh would be more suitable than in terms of cost. They have encountered problems when setting expectations in terms of monetary savings when these are not realised following the installation. The participants stated that caution must to be applied when setting expectations of savings, to minimise dissatisfaction if what they have been told is not realised.

The social housing staff proposed that better training for housing officers and them doing follow up visits with tenants would be beneficial. The housing officers already visit tenants in other capacities, in other services provided, so it would not be a significant strain on resources for them to carry out follow up checks on heat pump installations, with suitable training. ‘Void officers’ deal with empty properties that tenants move into. Some of these properties have heat pumps installed so the social housing staff participants advised it would be beneficial for them to have training also, for when they show a new tenant around the property.

One of the energy officers pointed out that having more readily available resources within the organisation’s internal systems would help improve the service they provide, by enabling better staff knowledge. A representative energy officer participant said that frontline staff do receive training but forget things over time, so having reference materials would be useful. For example, databases on the relevant estimated costs of running different heating systems giving clear comparisons would be useful to educate both staff and tenants.
5.4 Discussion of findings to refine requirements

The data collection findings as a whole are reviewed to refine requirements and make recommendations for the service, based on the further understanding of user requirements on the service recipients’ side and of service understanding from the service providers’ perspective.

Three core issues surfaced from the large majority of the participants in the investigation with social housing tenants: that the information they received was not adequate enough, that they have a lack of control over their systems and that the heating is inadequate. This validates findings from the first exploration phase outlined in chapter 4. Arguably, these are related issues, one being a cause of the other. It could be deduced that the lack of information results in a lack of control through not having the knowledge of how to use the controls and that a lack of information and control is resulting in the inadequate heating through inefficient or incorrect usage, due to insufficient understanding.

The installers reported that the tenants are given information materials and showed the researcher a copy of what they produced but stated that the tenants do not use the information materials preferring to call straight away instead. The tenants however said they want written materials to provide them with usage information and stated that they had either received nothing or that what they had received was inadequate. Therefore, arguably, the materials the installers provided did not satisfy what the tenants needed.

The tenants outlined that they wanted better information about expected costs of running the systems. In both the first exploration study and this second study, this was a common theme across tenants. It was one of the most significant causes of dissatisfaction with heat pump systems when the cost of running did not match with the costs and savings they had been led to expect from initial information provided to them. However, landlords also outlined this area as problematic where tenants had been given cost information that had not been realised and were now much more wary of delivering such information; the running cost information is difficult to predict with changing energy prices The landlord in this study suggested that giving
information about savings by having a heat pump in terms of kWh would be more appropriate; however, it is likely that this would be less understandable by tenants than if delivered in monetary terms.

The landlord proposed that better databases were needed within the organisation to help with operations. Internal resources that are more readily available for staff would enable them to be better informed and able to help tenants quicker and with greater accuracy. This supported information from a tenant in this case study, involved in the first exploration stage, which reported that a chimney sweep was sent to his home to clean the chimney after he had a heat pump installed. This is evidence of the social housing landlord not being fully aware of which systems were in which properties and an impact this has on time and resource costs. On reflection, it would have been useful to have housing officers present at the focus group for their additional perspective. They could have reported first-hand on their experiences of interacting with tenants at effectively a ‘customer service’ level, working with tenants in-situ in the home. In particular, void officers could have provided interesting insight into their role; what they experience and what they feel is expected of them. In the recruitment process it was requested for participants who interact with tenants during the heat pump installation process, but roles were not specified. It is a recognised limitation that the role of housing officer was discussed but from the perspective of others in the organisation and not themselves.

5.4.1 Refined requirements
The focus group and contextual interviews identified a set of more specific user requirements for what tenants need or want from written information materials. These informed the development of the prototype heat pump information materials.

Design of the materials
- Shorter length
- Simple, understandable language
- Pictures and labels to help understand functions and symbols
- Sized to fit in the Tenant Handbook
Content of information

- How to turn the heat pump on and off
- How to change the temperature
- How to set programme timers
- What to do in an emergency
- Clear contact information
- Energy tariff advice
- Best ways to ‘live with’ a heat pump

5.5 Development of service improvements

In the final part of this chapter, the recommendations for potential improvements to communication aspects of the service are presented. Firstly, identified measures to enhance the communication in the service of installing renewable technology into socially rented houses are outlined. These cover suggestions that are both shorter term and longer term in application. Furthermore, they cover recommendations that could be implemented by the core service providers, the social housing organisation and the contracted installers as the key stakeholders that interact with tenants, and some that have implications for the wider industry. Following this, the development of the written information materials is explained, being the key requirement identified in the research insights and taken through a user-centred design process with end users.

5.5.1 Recommendations for the design of the service

As outlined in Chapter 4, the service for heat pump installations was found to be formed of three main phases: introduction to the technology, installation of the system and usage of the system. The recommendations for improving communications spanned across these three phases and there were differences between requirements at each of these phases. Therefore, the recommendations are presented in this way, to show the process of the service and where each recommendation applies.
Introduction to the heat pump technology

• Home visits

Home visits are a priority when first introducing tenants to the heat pump technology. A preceding letter being sent appears to be standard practice across social housing to inform tenants of impending works or visits to be undertaken. Therefore, an introductory letter should be sent to the tenants informing them of the potential change to their heating system and that a home visit would be made to discuss the matter in more detail. This letter is an opportunity to first surface benefits of the technology and give some indication of what it is, in order to encourage uptake as early as possible. However, a home visit is required to explain the installation process, the system and to answer any of the tenants’ questions.

Furthermore, a home visit allows the landlord to obtain contextual understanding of that tenant’s property, to assess the user and environment better in order to deliver relevant information. The member of staff attending the tenant’s home would be able to tell the tenant in context where the heat pump would be situated and indicate what impact would be had on the property during and after installation. For example, they could show the tenant the amount of space they would lose to the installation of the heat pump unit internally.

This first home visit is imperative to the successful uptake and usage of the system and to the tenant’s satisfaction with the system, as this is where expectations are first created. Problems with previous installations, this research has found, occurred when the information provided at this stage did not match with experiences; the gap between expectation and reality was inconsistent creating dissatisfaction. The member of staff carrying out the home visits to introduce the technology to the tenants should be well trained and well informed about how the system works and what the installation process entails.

• Community information event

A community information event is a beneficial approach to introducing tenants to the heat pump systems. Carrying out an event where the target community are
invited to attend together has benefits over home visits. It allows the landlord to speak to more tenants at one time and a greater platform to demonstrate any equipment, to help inform the tenants about the systems. It enables tenants to discuss with each other what they think about the systems. This research identified that communities talk amongst themselves about having the systems and how to use them, with this sometimes resulting in greater uptake. It is recognised that community-wide events are not always possible, depending on the landlord’s capacity and also the tenant’s ability to attend a venue. Community events should not be done in place of home visits; the home visit is a crucial part of the process to encourage tenants to have the systems and understand the context into which it is being installed.

- **Information delivered to existing tenants**

When introducing heat pump technology to tenants to retrofit it into the property they are currently living in, information provided should be improved. As referred to above, the information provided at this point sets the expectations for tenants over what will be done, how it will impact them and what they will receive. They should be fully informed over the physical installation, what space will be taken up by the heat pump system, what changes will be made to their home and any redecoration that may be required. The tenants should be well informed over the impact to their gardens as this is identified as a key concern for tenants and a barrier to uptake.

Cost implication is a primary aspect to discuss; tenants want to know how much the system will cost them to run. Landlords are much more wary of the information that they give concerning this through experience of previous installations. It is a significant area for causing dissatisfaction through incorrect expectations being set. This issue is outlined separately below under ‘energy costs’.

Tenants may not make a decision about having the heat pump installed at the first introduction or may refuse. This research found that some tenants would seek other sources subsequently as reference information, such as the Internet, when making a decision or wanting to find out more about the systems. Tenants
described a lack of written information provided at the introductory stage. This research recommends that written material should be provided at the first home visit to leave tenants with a reference for more information or to remind them what the landlord had told them about. This is part of the suite of information leaflets produced and presented in section 5.6.2.

- **Energy costs**

  Giving information about cost savings should be presented in a way that does not set too high expectations incorrectly. Discussing this aspect verbally with tenants at a home visit enables a better discussion, to help tenants understand better and allow them to ask questions. Cost savings are achievable by having a heat pump installed and should be experienced but information can only be predictions based on averages; this is highly dependent on other factors such as efficiency of use and energy supply tariff. This caveat needs to be explained in order to set expectations in a clear way. It outlines that cost savings are a benefit of heat pump technology but without presenting it as a definitive outcome. Furthermore, it emphasises the need of the tenant to understand and use the heat pump effectively.

  The identified fact that cost savings are dependent on energy supply tariff also highlights the need for the tenant to discuss their own tariff with their energy provider. The research identified that the social housing landlord cannot tell the tenant what energy tariff they should be on or make changes for them, but advice can be given to encourage the tenant to take action. This advice can be delivered at this point and contact details provided for independent groups who can give the tenants advice. It would be beneficial at this stage to ensure the tenant is on the optimal energy tariff from the beginning with a new heat pump installation.

- **Information delivered to tenants moving into a void property**

  This relates to tenants who move into a property where a heat pump is already installed; the property was a void property so the tenant’s introduction to the system differs to those having it retrofitted into their home. These tenants would not be contacted about having a heat pump and having a choice of whether it is
installed or not. These tenants would have been assigned to a property irrespective of the heating system.

Void housing officers need training so that they are well informed to explain to the tenant what the heat pump is and how to use it, when introducing them and showing them around their new home. The energy cost advice described above should be given to the tenant moving into the property at this point also. A tenant moving into a property with a heat pump already installed would not receive the introductory written information material but rather the written information material to be given when tenants have a heat pump installed, outlined in the next section (Installation of the heat pump system) and detailed in section 5.6.2.

**Installation of the heat pump system**

- **Setting the system**

  When installing the system, the installer sets the programmer (if applicable) and heating temperature level. Rather than setting this as a default, tenants should be consulted to identify their lifestyle patterns and preferences in order to set timers and temperatures in ways that suit the tenant best and allow the heat pump to operate effectively.

- **Information delivered to tenants having an installation done**

  It is clear that information about the heat pump system and how to use it is delivered to the tenant at this stage by both social landlord contacts and the installers. The tenants are highly likely to ask questions during this part of the process and should be able to expect assistance and answers. It is highly important here that the messages delivered by whoever is informing the tenant are consistent with each other.

  This is clearly another important point at which to supply tenants with written information materials for their reference on how to use the systems. Written information thus far has been reported to be lacking or unsuitable through being non-existent or overly complicated. Provision of simpler, understandable
Information was a clear requirement across this research and the key touchpoint focused upon through a user-centred design process; this is described in more detail in section 5.5.2. This material is for tenants when the heat pump is installed or for tenants who have moved into a property with a heat pump.

Providing tenants with information on how to control the heating systems is important. Ensuring tenants can control the basic functions of the heat pump, such as turning it on and off, altering the temperature and programme timer reduces feelings of vulnerability through needing to rely on others to operate it for them. It also enables the tenants to operate the heating system to fit with their lifestyle patterns. The heat pumps can be set for the tenants by installers at installation which could reduce the tenant’s need to change settings, but the option for them to do so is important. This goes hand in hand with the need to educate tenants on operating the systems efficiently, so that their ability to control the heat pump does not impact it operating effectively. This also reduces the demand on the landlord in time and resource costs that would be incurred by needing to visit tenants each time to change temperature settings etc.

- **Installation workforce**

There must be a good level of relationship and communication between the social housing landlord and the contracted workmen carrying out the installation. The tenants recognise the social housing landlord as their primary contact and in charge of the installation. So although the tenants recognise that the workmen are often external to the social housing organisation, the workmen represent the social housing organisation and tenants experience the service as one whole. Tenants highlighted communication as an issue between people involved in the installations they experienced and the landlord in this case study recognised that a particular workforce did not meet their expected standards. Through this experience, the landlord stated they would retain greater control in future operations. Ensuring the workforce understands the expected level of standard from both the tenants’ perspective and the landlords’ perspective is important.
There was a clear difference in tenants’ satisfaction levels dependent on the service experienced from the workmen carrying out the installation in their home. Social housing organisation LE had clearly satisfied tenants who recurrently reported the workmen providing a good service, being helpful and clean, covering their carpets and belongings to protect them as far as possible. Some tenants had reported workmen being less careful and respectful of their home and belongings, causing some damage; clearly this impacts the tenants’ experience greatly. Social housing landlord LG, the case study followed in this research, highlighted that using contractors they have worked with previously and local to the area was beneficial, as they were used to working in their properties and interacting with the tenants so standards could be trusted.

Usage & maintenance of the heating system

- Tenant representative(s)
A lead tenant or tenant group should be established, where possible, to help in the communities where heat pumps are installed. Tenant representatives or groups are already a mechanism adopted in many social housing organisations. Where heat pumps have been installed, there is already evidence of the community discussing the installations with each other, perceptions and how to use them. In some cases, neighbours often help each other with operating them, particularly where one tenant is savvier with using it than others. Tapping into this community aspect and utilising it to improve perception and operation of heat pumps would have a positive impact on tenants and would reduce time and resource costs for the social housing staff.

- Help service
Tenants should be supplied with one contact for any help and support: the social housing landlord. This ensures no confusion over whom to speak to about queries or problems and enables the social housing landlord better awareness of issues through easier monitoring of communications.
• **Maintenance contractors**

As far as possible, use local workforces for maintenance teams. By having a local workforce, it minimises exacerbating problems through maintenance teams being slow to react because of the distance to reach the property. Maintenance contractors have a direct relationship with tenants and have been found to communicate with tenants, giving them information or advice about the heat pumps. It should be ensured that messages and information delivered is consistent between the landlord and the contractors to not cause tenants confusion on concern.

• **Home visits**

Housing officers and staff who carry out visits to tenants' properties should be trained to be knowledgeable enough about heat pumps to communicate with tenants about them on visits. A follow up visit should be scheduled as far as possible in the month following an installation, to ensure the tenant is confident in using the system.

• **Internal staff resources**

Resources should be readily available for staff within teams that deal with heat pump systems. There should be easily accessible resources of information such as costs of heating systems to be able to give tenants up to date average information.

There should be a clear database of what type of heating systems are in which properties, to know which tenants have heat pump systems in their homes. It should show clearly which properties have a heat pump and what type of heat pump. Databases need to be kept up to date and easily accessible for frontline staff. Tenants need confidence when they ring the landlord that the person they are speaking to knows what their system is if they have a problem. This resource also saves time and resource costs for the landlord, ensuring the right services and support is delivered to the right people.
• **Staff training**

Frontline staff who interact with tenants on the telephone need enough knowledge of the heat pump systems to be able to talk to a tenant who rings with a system query or problem and deliver the tenant confidence that they know what they have installed. This ensures the frontline staff can do their job effectively and direct the tenant to the correct people with their problem or query.

Housing officers require training to assist and help inform tenants about the heat pump systems in their homes. Void officers, as outlined, need training to show tenants how to use a system in a property they are moving into. The training for housing officers should be refreshed periodically to ensure they remain well informed and to deal with staff turnover.

5.5.2 **Heat pump information leaflet prototypes**

This second phase of the research focused on the tenant requirements for the production of heat pump information leaflets. Design considerations and content requirements were outlined by the tenants in the focus group and interviews of this phase of the research. Some data from the first phase of the research also provided supporting information to feed into the development of the materials.

As indicated above, it was determined that written information should be provided at two stages of the service: when the tenant was introduced to the heat pump technology and when the installation was done. The research indicated a need for tailored information to the tenants’ specific system. The tenants required information material that was relevant to them both in terms of heating system type (i.e. ground source or air source heat pump) and in terms of the operating controls they have. This led to a suite of information leaflets being prototyped that would cater for both stage of the service and the type of systems installed.

Two sets of leaflets were produced: one set of system-specific leaflets to be given when the tenant is approached about having a heat pump installed (leaflet A) and a set of system-specific leaflets for tenants to be given when the heat pump is installed (Leaflet B). The second leaflet type – leaflet B – is also to be given to tenants who
move into a void property with a heat pump. Leaflet A is one sheet with the information on either side. An example of this leaflet for tenants with a ground source heat pump is shown below.

Figure 24: Leaflet A: Introduction - front page

Figure 25: Leaflet A: Introduction - page 2
Leaflet B is a two-page folded leaflet with the information on four sides. Pages 1, 3 and 4 are pages of information common to all installations. Leaflet B given at installation also has an inserted page covering the specific control information for the tenant’s particular heat pump system. The systems installed do not have standard controllers across the board as they are from different manufacturers. Control specific information is required in order that the tenants are able to operate the heating system, programmers or temperature settings. However, this information needs to be delivered in a user-friendly format that is easy to digest, to assist tenants in understanding and using their heat pump. The second page is where the relevant control information would be inserted. The examples below show the pages of this leaflet.

Figure 26: Leaflet B: Installation - page 1
Your heating controls...

Fan Unit Functions:
Press the button under FAN SPEED to scroll through the options and select the speed at which you want the air to blow out.

Setting the timer:
ON - press Timer ON (A) button and TEMP arrow buttons to scroll through and select the desired time for heating to come on. Press Timer ON (A).
OFF - press Timer OFF (B) button and TEMP arrow buttons to scroll through and select the desired time for heating to go off. Press Timer OFF (B).

Turning ON/OFF:
Press the ON/OFF button in the middle under the display screen to turn the unit on or off. The unit being ON does not mean the heating is actually running at all times.

The MODE button changes the way your unit operates. For your home heating, the sun symbol (indicated) should be selected.

Press the blue button above AIR FLOW to alter the angle of the air flow up or down.
Press the blue button below AIR FLOW to alter the angle of the air flow left or right.

For both options, keep pressing to go through different angle settings until you find what suits your needs.

If you are having any problems with your controller or need some assistance with functions, feel free to contact us:

Telephone number

Email address

Changing the temperature:
You can alter the temperature to be:
- Warmer by pressing or cooler by pressing ideally, this should be 22°C.

Living with a heat pump

How to use the system cost effectively...
The amount a heat pump will cost to run is dependent on how efficiently it is used. It is important therefore that the engineer who sets the initial heating programmes discusses with you the times of day and days of the week that you typically require your heating and hot water.

Heat pumps use a small amount of electricity to transfer heat from a lower temperature source, in this case the ground, to a higher temperature to heat your home and water. Therefore, the higher that you set your heating thermostat, the more electricity you will use as the heat pump has to work a little harder. So, to keep your home at a constant warm temperature in an efficient way, the heating should be run for longer periods of time at a slightly lower temperature.

The cost of your heating will also depend on your electricity tariff. We advise you to contact your energy supplier to check you are on the best tariff for you. Be sure to let them know you have a 'ground source heat pump' when contacting them. For more help with this, you can contact the 'Warm and Well Energy Advice Line' on freephone 0800 500 3076.

Top tips - There are things that can affect the efficiency of your heating system. The following recommendations would help your heating run better.

- Try not to dry laundry on your radiators - this blocks the heat from moving into the room.
- Set your room thermostat to between 18 and 21 degrees. If you are warm enough, try turning it down by a degree and see if you notice the difference!
- Try not to place furniture in front of radiators. A clear, open space around your radiators will ensure that you get the best distribution of heat.

Still have any queries? See overleaf for contact details and we'll be happy to help with any problems.

Figure 27: Leaflet B: Example control insert - page 2

Figure 28: Leaflet B: Installation - page 3
5.5.3.1 Development of the leaflets

Information content
The tenants specified that they wanted written information which included how the heat pump works, what to expect during an installation, cost expectations and how to use the system.

Leaflet A, the introduction information, covered how the heat pump system works, key benefits of the system and contacts for further information. This was to act as a point of reference for the tenants between introduction and installation, during the decision-making stage or post-decision, pre-installation. Leaflet B included information also on how the heat pump works and key contact information. It provided more detailed information about how to use the system and the controls.

The content about how the heat pump works and any other related information was written in collaboration with the energy agency involved in the research, in
order that the information was correct and validated by a professional body. The experience of the energy agency in developing materials about energy-related matters for the general public helped to ensure that the materials were written in a user-friendly manner.

Cost expectations was not included as part of the written information. Through the research done with tenants and landlords it was evident that this is a primary aspect to discuss but is better done verbally to ensure tenants understand the implications regarding cost of how they use the system. Factors concerning cost are mentioned in the leaflet in terms of how their operation of it affects its performance, but no definitive cost data is given.

The type of system that the tenant had, whether it is a ground source heat pump, air to air heat pump or air to water heat pump is clearly displayed on the leaflet. This is to ensure the tenant knows what to communicate to frontline staff at the landlord or to their energy provider about what their system is. It was clear in this research that tenants were unsure how to refer to their heating system exactly.

Tenants also wanted pictures to visualise the heat pump system they would be getting, to understand what they would be having put in their home.

**Size & length**

The size and shape of the leaflet was determined by findings from the data collection of both explorative studies. The first study identified the negative aspect of information materials that had been given of being too lengthy and difficult to understand; largely this was the manufacturer’s manual being given to tenants. Tenants wanted a clearer, more succinct document that provided the information that they required. Through the contextual interviews in this second study, which focused more on the information materials provided to tenants, it was ascertained that tenants receive a handbook when moving into a property. This contained information on various landlord services and advice materials. It was determined that this would be a suitable place to keep the heat pump information leaflet for
tenant’s reference. Therefore, the leaflet was designed in the appropriate shape and size for the handbook.

The length of the leaflet and amount of content was also developed taking into account considerations of cognitive load and the impact of this on older people. The literature reviewed as the first objective of this thesis provided evidence of impaired cognitive function and limitations concerning the older population that were considered when developing the leaflets.

Text format
Tenants involved in the research who were older outlined the need to consider weaker eyesight when providing written materials to them. Morrell & Echt (1996) suggest that older adults may benefit from text font sizes of 12-14 point for printed text, after reviewing studies of text preferences of older readers (Hawthorn, 2000). This suggestion is validated by the Royal National Institute for the Blind (RNIB) who propose a minimum typed text font size of 12 point for normal use (RNIB, 1993) and that large print, at least size 14 point, should be used or available for people with major reading difficulties (Raynor & Yerassimou, 1997). Morrell & Echt (1996) furthermore suggest that older readers benefit from short line lengths and left justified text. These guidelines were used to determine how the text was presented on the leaflets.

5.6 Summary of Refinement & Development
This study chapter presented the progression of the research from initial contextual understanding and definition of user requirements. The intention of this phase was to refine user requirements for a more specific need for service improvement and develop solutions based on those identified requirements. In order to continue the user-centred design process, the developed solutions should be evaluated with end users to determine the suitability of the proposed measures. This leads into the third phase of this research, presented in chapter 6.
6 Evaluation phase

To validate the developments of this research and adhere to a user-centred design framework, an evaluation phase was carried out. Evaluation of the developed designs, of any design project, with relevant users ensures focus is maintained on the end user throughout the design process. The evaluation phase is not the last phase in the user-centred design cycle; it is the opportunity to determine whether further exploration and design development is needed or whether it satisfies user requirements, provides a suitable solution and may be implemented.

As shown in the methodology chapter and Figure below, the evaluation phase is the last phase in this doctoral research. Although time and resource constraints played a factor in the scope of this work, substantive research had been conducted after the three research phases which enabled conclusions to be drawn on the application of a user-centred design process in this context. Furthermore, extended research opportunities could be identified from this point.

The evaluation study assessed the usability and end users’ opinions of the heat pump information materials produced, as the key recommended touchpoint which this research focused upon in the design phase. The study served to ascertain whether the outcome catered for the user requirements identified in the previous two research phases, as far as possible, by testing it with users. This chapter outlines the methods adopted to evaluate the information materials and presents the data collection findings.

![Figure 30: Evaluation phase of the UCD approach](image.png)
6.1 Evaluation Research Methods

As this evaluation study forms the final phase of the case-based research, the social housing provider involved was the same as in the previous two phases, Landlord LG, and therefore the same population of tenants were recruited from. Evaluating the heat pump information leaflets was not as essentially dependent on participants being social housing tenants with heat pumps as the previous phases of research were. It was considered that the evaluation could be done by people without a heat pump with some accompanying guidance to clarify contextual issues, to test their understanding of the content and obtain their opinions overall. However, social housing tenants with heat pumps were the ideal participants because of the contextual, practical understanding that they have and the consistency this would provide in the investigation. It was therefore decided that, for greater rigour in this research, the participants should be heat pump users for this study also.

Consequently, the population to recruit a sample from was the same niche, smaller sub-set of tenants as in the previous phases of research and, as such, there was a high potential for tenants who had already participated in either of those phases, or both, to be recruited again for this study. For this reason, it was deemed important to select and design a research method that would not be perceived as too onerous, in order to maximise response rates.

Indubitably, research methods should not be selected on a purely practical basis in terms of recruitment and participant needs; however, it is a factor to consider in planning a successful empirical study. The research method or methods must be identified, above all, based on what would satisfy the research study aim and objectives. This study aimed to test the usability of the heat pump information materials and whether they met user requirements by obtaining users’ opinions on the design and content of the information materials.

Qualitative user research methods such as interviews and focus groups, as discussed in previous study chapters, are beneficial for obtaining a rich level of detail and understanding of a given topic. Furthermore, they provide the opportunity for clarification on questions and responses. However, as such, they are time-
consuming, more demanding methods of data collection. Interviews were used in a similar study in 2001 which investigated effective leaflet design. This study applied consumer testing, an interchangeable term with user testing or usability testing, to determine both an effective design for information leaflets and demonstrate the benefits of consumer testing in this area (Dickinson et al, 2001). Usability testing is a well-established method across academia and industry of assessing the functionality of a product and how easy it is for people to use. It is a user-centred research method employed during development stages to minimise risk when a new product or service is launched and reduce the need for costly changes after implementation.

In the study reported, the investigation was to ensure information leaflets for medicines were patient-orientated. However, the benefits of applying this methodology can be transferred to the context of this research, substituting the user as patient to tenant: ensuring the information leaflets are tenant-orientated. Lessons could be learned from this study (Dickinson et al, 2001) in terms of study design. To evaluate the design of one medical leaflet, 20 participants took part in a structured interview to assess their understanding of key points of the leaflet. Part of the interview involved rigid questioning: the participants were asked to locate different pieces of information and subsequently explain what they thought it meant in their own words. The aim was for 16 out of the 20 participants to be able to complete this with ease, in order to deem the leaflets as ‘usable’. Some open questions were also asked in the interviews, to obtain feedback on the leaflets.

Interviews were therefore considered as a proven suitable method for this type of study, based on the evidence from Dickinson et al (2001). However, as outlined, interviews are a more onerous method of data collection. This is a limitation for both the researcher and the participants; it can be perceived by participants as significant effort on their part. The practicalities discussed earlier of participant recruitment and the demand already placed on the potential participants became an important factor in choosing research methods. The study required a research method that was both suitable and would have a higher likelihood of positive response rates. Therefore, an interview was determined unsuitable for this research study.
The type of structured questioning in the study by Dickinson et al could be carried out in a structured questionnaire format, for ease of completion by the tenants. Questionnaires are a relatively inexpensive way to collect information (Edwards et al, 2002) are less demanding and are a relatively unobtrusive method of data collection. A postal questionnaire is appropriate when the aim is to collect information from a wide population of people, particularly when geographically divided (Edwards, et al, 2002). The social housing provider in this case, although a local authority, manages properties covering a widespread, rural area of the UK. Therefore, a qualitative method other than a postal questionnaire survey would be significantly more time-consuming and costly to carry out.

An exception to this would be an online survey, which Conversely reduces time and cost, through eliminating the need for printing and mailing and the immediate return of data in an electronic format (Kaplowitz et al, 2004). However, this method was not suitable in this context with a substantial amount of the target population not having access to or using the internet; this was observed during the contextual interviews in the exploration phase of this research. Furthermore, a comparison study by Kaplowitz et al (2004) reported that response rates for email and online surveys were significantly different dependent on age, with a much higher response rate of participants 24 years old or younger than people over 24 years. It could be inferred that response rates to a survey over the internet would be significantly lower amongst an elderly population, given the review of literature of older people and technology (in section 2.2.3) and generational differences seen in internet access and usage (Nie & Erbring, 2000).

A questionnaire survey does have limitations as a research method, in that the level of detail that can be acquired is shallower than other methods of qualitative data collection. Clarification and probing of responses and researcher’s questions cannot be practised through questionnaire data collection. However, the questionnaire can be designed effectively so that the value of the data is not diminished and important information is captured. A deeper level of detail and contextual richness in the data was determined unnecessary for this phase of research. Therefore, a well-designed
questionnaire could elicit the information required to evaluate the information materials and achieve the research study aim.

A postal questionnaire survey was selected as an appropriate method for this study design. Questionnaires offer a less arduous option as the researcher can design it to be an optimal length, which is relatively easy to complete but captures key information through the content and style of questioning. The benefit of a postal questionnaire is that it allows for completion at the participants’ convenience, within a given timeframe. This reduces demand on both the researcher and the participants in carrying out the study. Although completion at the participants’ leisure is beneficial, setting a timeframe within to do so is important. A specified end date helps to encourage participants to complete the survey and gives the researcher a point at which to accept the number of responses and sufficient time for analysis. This timeframe should, however, be generous enough for participants to complete the survey and allow time for postage. As the target population includes such a significant proportion of elderly people, the practicalities of posting the survey should be considered and time allowed for this; for example a visiting family member may need to post it for an elderly tenant with disabilities.

A disadvantage of postal questionnaires is that recruitment is on an opt-in basis. Participants must choose to complete the survey and post it back to the researcher to create a sample population for the study. Non-response to the survey reduces the effectiveness of the sample size and can introduce bias (Edwards et al, 2002). However, some measures have been identified that can help to increase the likelihood of participants responding, which were considered for this phase of research and adopted where possible. For example, providing stamped, addressed envelopes is a relatively easy measure to implement that ensures return of the completed questionnaires is as easy as possible and at no cost to the participant. This was particularly important as a key proportion of the target population of the survey was older people, with potential ailments; therefore, it was important to make completion of the survey as convenient as possible. This provision removes any physical demand on the participant’s part to obtain these items.
Edwards et al. (2002) reported that questionnaires should be made personal and kept short. While the length could be managed by the researcher and the questionnaire can be made as user-friendly and engaging as possible, a personal address was not possible in this case as the tenant details were not available to the researcher. Edwards et al. (2002) also include in their review that prior contact with the participants and follow up reminders, including another copy of the questionnaire and incentives are methods to increase response rates to questionnaires. However, contact directly between the researcher and the tenants was not possible. The social housing provider distributed the survey to the relevant properties; therefore, demand on their time to arrange the study needed to be minimised. The representative of the social housing organisation arranging the distribution of the survey did, however, offer to remind any tenants to complete their survey when routinely visiting them at their homes. This encouraged tenants to respond and added emphasis that their opinion was valued. Incentives were not viable for this study due to practicalities of outlay.

In an effort to maximise the data gathered from the questionnaires, whereby clarification or probing of details was not possible, they were structured to include open-ended questions throughout. This was to allow participants the freedom to comment and respond without being prompted or guided, to capture a greater level of detail and their own opinions. Furthermore, the questionnaire survey was designed to incorporate a usability test. The use of this practice was based on the benefits identified in the study by Dickinson et al. (2001), as discussed above, and designed using learning extracted from this study of how to apply the method. Due to the unpredictable response rate to the opt-in postal questionnaire, a usability threshold, as adopted in the study by Dickinson et al. (2001), could not be determined; a general overview of tenant feedback would be analysed to generate user insights.
6.2 Evaluation study method
The following section delineates the recruitment of participants, process of data collection and means of data analysis.

6.2.1 Sampling
A representative of the social housing organisation involved in the progress of this research distributed the postal survey and was the point of contact for tenants. The researcher’s contact details were available to the tenants on the enclosed information sheet, for them to be able to contact the researcher directly and ask questions, but the researcher had no access to the tenants’ contact details. Participation in the survey was, therefore, on an opt-in basis. 120 surveys were distributed to households that had heat pumps installed, with the household receiving the leaflet relevant to their particular system. Those who wished to take part completed the survey and returned it with the consent form and leaflet prototype in the provided stamped, addressed envelope directly to the researcher.

6.2.2 Pilot study of evaluation
As outlined at the beginning of section 6.1 (research methods), evaluating the heat pump information leaflets was not as dependent on participants being social housing tenants with heat pumps, although the criteria were preferable. This concession could be made in the pilot study though, as the primary purpose of the pilot is to test the evaluation study method rather than to collate evaluation data. The objective of the pilot study was to verify that the questionnaire could be understood and that the method worked as intended.

A pilot of the evaluation study was carried out with six people, recruited through friends and family of the researcher – information shown in Table 8. The sample included a range of ages, including an elderly participant, which assessed the ease of understanding and completion of the questionnaire, and each individual question, across this demographic. The feedback from the elderly participant was particularly valuable in ascertaining whether the questionnaire was designed appropriately for the key target population this study aimed to investigate.
Table 8: Evaluation study pilot participants

<table>
<thead>
<tr>
<th>Participant code</th>
<th>Gender</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE1</td>
<td>Female</td>
<td>56</td>
</tr>
<tr>
<td>PE2</td>
<td>Female</td>
<td>28</td>
</tr>
<tr>
<td>PE3</td>
<td>Female</td>
<td>22</td>
</tr>
<tr>
<td>PE4</td>
<td>Male</td>
<td>56</td>
</tr>
<tr>
<td>PE5</td>
<td>Female</td>
<td>51</td>
</tr>
<tr>
<td>PE6</td>
<td>Male</td>
<td>93</td>
</tr>
</tbody>
</table>

The pilot study participants were given an Information Sheet, Consent Form, prototype of a leaflet and the associated questionnaire, as would all be sent out in the evaluation study postal survey. The pilot study was not carried out as a postal survey; it was conducted in person with four of the participants and over email with the remaining two. This meant it was less time consuming in execution and enabled participants to give direct feedback on the questionnaire itself. It was sent via email where face-to-face was impractical and the feedback was written in the return email that the completed questionnaire was attached to. A participant completing the questionnaire in the presence of the researcher was beneficial, particularly in the case of participant PE6, for the researcher to observe reactions and to give participants the opportunity to ask the researcher any questions, which highlighted where anything was unclear.

The pilot study participants were asked to complete the questionnaire as best as possible and give their responses, after the circumstances in which this product applied – i.e. social housing – was explained. After completing the questionnaire, or during completion when clarification was required, they were asked to provide feedback on how easy they found the questionnaire to fill in and whether they understood all the questions. The pilot study demonstrated that the questionnaire was easily understood and completed. One of the participants was a teacher who is required to judge the level of difficulty of text as part of her job, to ensure it is
accessible to different levels of literacy and understanding. The participant’s comments were that the questionnaire used appropriate language and would not lose readers’ interest. The elderly participant, however, commented it was difficult for him to read in visual terms; he requested that the font should be larger and quoted size 14. It was noted that this participant had significant visual health impairments and did manage to read the questionnaire and leaflet, albeit it with some effort and hesitancy. Therefore, the questionnaire text was enlarged from Trebuchet font size 12 to Trebuchet font size 14, as this research focused on the impact for elderly tenants and this was a target population.

When completing a questionnaire about the ‘introduction’ leaflet, participant PE5 queried the purpose of the leaflet in consideration of what they should expect to get from it. Explanation was required from the researcher that this leaflet was to be used after tenants had been approached about having a heat pump and was a source of reference during, or post, the decision-making phase before installation. There were some clear key pieces of information about how to actually use the heat pump not included at this stage, intentionally. This may have caused confusion to participants who did not know that there was other information material containing this content, to be obtained at a later stage of the installation process. This potential confusion, highlighted by PE5, could have resulted in some predictable negative responses and not given an accurate picture of the usefulness of this leaflet in its intended purpose. Therefore, an alteration was made to the main evaluation study to include a guidance note indicating that this was the case.

All of the responses were also useful in terms of evaluation data about the leaflets as well as evaluating the survey itself. The responses to the questions provided some interesting feedback on the designs which also indicated that evaluation of the leaflets was a valuable procedure. The pilot study demonstrated that the method was appropriate and needed very little modification which did not affect the question content. The results from the pilot study could therefore be used as additional supporting data to inform the evaluation study findings. The evaluation carried out by pilot study participants produced some interesting and varied findings that provided beneficial insights in the evaluation phase. But, they are reported
separately to the findings from the main postal survey, due to the different sample profiles of the participants, with different socio-economic circumstances to the social housing tenants involved in the main study.

6.2.3 Method
The postal survey consisted of a questionnaire and a prototype of the leaflet to be appraised. Tenants who have had a heat pump installed received these documents along with an information sheet about the study, a consent form and a stamped, addressed envelope. All types of leaflet should have been tested as far as possible, for both stages when leaflets would be obtained and for the different systems tenants have. As previously described, two types of leaflet were designed: one to be given to tenants when they were approached about having a heat pump and one to be given to tenants when the heat pump was installed. For the purposes of this study, the first ‘introduction’ leaflet is referred to as leaflet A and the ‘installation’ leaflet is referred to as leaflet B. Two questionnaires were designed in order to pose suitable questions about each of the types of leaflet. Samples of the questionnaires are located in Appendices H and I.

The surveys were distributed containing an information leaflet relevant for the type of heat pump system of each household. An even distribution of leaflets A and B were sent to tenants with the questionnaire related to the type of leaflet. For example, one household with a ground source heat pump may have received leaflet A to review with the associated questionnaire designed for this leaflet, whereas another household with a ground source heat pump would receive leaflet B with the associated questionnaire to accompany that type of leaflet. Which households received which type of leaflet and questionnaire was a random selection, but the delivery endeavoured to have an even distribution of each type of leaflet across each type of system.

The questionnaire included broad questions to obtain opinions from the tenants about what had been produced in terms of both content and aesthetic presentation. There was a mixture of closed multiple choice questions and open questions allowing free responses, in an attempt to maximise data collection and insights. The
tenants were also instructed on the Information Sheet that they could write or draw on the prototypes if they felt it would help them to make comments or clarify any responses.

The questionnaires included some user testing questions to assess the usability of the leaflets. For instance, tenants were asked to consider a scenario and determine whether they thought they could carry out the task using the leaflet for information. For ethical and practical reasons, tenants were directed not to carry out any task on their control panel, as it was an unmonitored testing method and there should be no risk of causing disruption to the tenants’ heating systems. They were simply asked to consider whether they thought they could complete a task, to indicate a level of understanding from the information. This may reduce the validity of the results but, from an ethical standpoint, the potential for causing undue concern or problems with the running of an elderly person’s heating system took precedence.

The tenants were allocated up to three weeks to complete the survey and respond. They were given an end date by which to complete the survey and an end date by which to post the survey. This was to help ensure responses were returned within a suitable timeframe and to give the researcher an end date by which to accept responses in order to create the sample population.

6.2.4 Analysis of evaluation study
Situational analysis is where the nature of the analysis is not determined before the researcher has had exposure to the data, to ascertain what is appropriate (Krueger, 1998). This approach was applicable to the evaluation study, as the survey was distributed to a large number of tenants but the response rate could not be predicted. Therefore, the method of analysis was not decided upon prior to the receipt of responses.

The size of the sample that was returned was too small to achieve any statistical significance or to be generalised to a wider population. As such, the data captured was explored to generate insights which inform any requirements for further iterations before implementation. The positive aspects and any drawbacks of the
leaflets produced were ascertained, where amendments or further development may be appropriate.

### 6.3 Evaluation study findings

Out of 120 questionnaires distributed in the postal survey, 15 responses were received completed from the social housing tenants, giving a response rate of 12.5%. In this data set was an even amount of responses to the two types of leaflet: eight assessed leaflet A and seven assessed leaflet B. Although a small sample, this increased the representativeness of opinions of both types of leaflet in the sample. The questionnaires were completed by ten females, four males and one couple responded together. The couple was treated as one household and, therefore, one participant in analysis of the data as there was no differentiation between individual opinions in the responses to questions.

Table 9: Evaluation study participants

<table>
<thead>
<tr>
<th>Code</th>
<th>Age</th>
<th>Gender</th>
<th>Status</th>
<th>Leaflet type</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>25-34</td>
<td>Female</td>
<td>Unemployed</td>
<td>Introduction</td>
</tr>
<tr>
<td>E2</td>
<td>80+</td>
<td>Female</td>
<td>Retired</td>
<td>Introduction</td>
</tr>
<tr>
<td>E3</td>
<td>45-54</td>
<td>Female</td>
<td>Part-time employed</td>
<td>Introduction</td>
</tr>
<tr>
<td>E4</td>
<td>45-54</td>
<td>Female</td>
<td>Unemployed</td>
<td>Introduction</td>
</tr>
<tr>
<td>E5</td>
<td>45-54</td>
<td>Female</td>
<td>Self-employed</td>
<td>Introduction</td>
</tr>
<tr>
<td>E6</td>
<td>25-34</td>
<td>Male</td>
<td>No response</td>
<td>Introduction</td>
</tr>
<tr>
<td>E7</td>
<td>35-44</td>
<td>Female</td>
<td>Unemployed</td>
<td>Introduction</td>
</tr>
<tr>
<td>E8</td>
<td>25-34</td>
<td>Female</td>
<td>Unemployed</td>
<td>Introduction</td>
</tr>
<tr>
<td>E9</td>
<td>25-34</td>
<td>Male</td>
<td>Full-time employed</td>
<td>Installed</td>
</tr>
<tr>
<td>E10</td>
<td>65-74</td>
<td>Couple</td>
<td>Retired</td>
<td>Installed</td>
</tr>
<tr>
<td>E11</td>
<td>55-64</td>
<td>Female</td>
<td>Retired</td>
<td>Installed</td>
</tr>
<tr>
<td>E12</td>
<td>45-54</td>
<td>Female</td>
<td>Unemployed</td>
<td>Installed</td>
</tr>
<tr>
<td>E13</td>
<td>65-74</td>
<td>Male</td>
<td>Retired</td>
<td>Installed</td>
</tr>
<tr>
<td>E14</td>
<td>65+ (no detail given)</td>
<td>Male</td>
<td>Retired</td>
<td>Installed</td>
</tr>
<tr>
<td>E15</td>
<td>80+</td>
<td>Female</td>
<td>Retired</td>
<td>Installed</td>
</tr>
</tbody>
</table>
The questionnaires were received back from a range of ages, with five participants being over 65 years old. Therefore, one-third of the participants provided evaluation data from the core population under investigation, of older people. The remaining two-thirds provided useful feedback for a broader perspective of understanding and opinions of the leaflets designed and enabled any differences between age demographics to be identified, if any emerged.

All participants answered the question about their first impressions of the leaflet they were reviewing and across the range of participants responses were similar. Options were given to select from to answer what their first impressions were. By supplying a range of options, it created a consistent response structure to provide comparable results across the data set. The options chosen to supply as answers to the question aimed to offer a wide range of criteria and to obtain a span of opinions, both positive and negative, across functional and aesthetic aspects. The range of aspects and balance of positive and negative options were in order to achieve a number of responses in total does not reflect the number of participants, but the amount of times that term was chosen by participants. For example, one participant selected ‘attractive’, ‘clear’ and ‘easy to read’ whereas another participant only chose ‘clear’ and so the total percentage adds up to more than 100%.

Table 10: First impressions of leaflet design

<table>
<thead>
<tr>
<th>Attractive</th>
<th>Boring</th>
<th>Clear</th>
<th>Cluttered</th>
<th>Easy to read</th>
<th>Difficult to read</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of respondents (n=15)</td>
<td>20% (n=3)</td>
<td>7% (n=1)</td>
<td>40% (n=6)</td>
<td>7% (n=1)</td>
<td>53% (n=8)</td>
</tr>
</tbody>
</table>
A total of 53% of the participants said that the leaflet was easy to read. It was noted that both the participants aged over 80 years old responded that it was easy to read. However, where additional comments were optional, E2 stated that it was easy to read but with a magnifying glass. Participant E8 selected ‘attractive’ and ‘clear’ but also commented it was difficult to understand without being an engineer. The participant who chose ‘difficult to read’ clarified against this point that they did not understand how to set the timer because their system model did not match the manual, inferring that it was difficult for them to understand rather than physically read. Participant E12 decided not to choose any of the given options but recorded their own response stating it was ‘informative’.

The participants were asked to write any comments relating to what they liked or disliked about the leaflet. It was commented twice that the colours and colourful layout were positive and also that it was neat. Participant E14 commented that it had very clear information and pictures, but that it was “a tad boring”. Some comments from participants were contradictory: one participant responded positively that it was short and to the point, whereas another responded negatively that it was very brief; one participant commented that it was simple language with no jargon making it clear and easy to understand, whereas two separate comments responded it was confusing and that it did not flow logically to them.

Participants with both leaflets A and B were all asked what they thought about the size of the leaflet. Only participant E12 did not answer this question.

Table 11: Opinion on leaflet size

<table>
<thead>
<tr>
<th>Percentage of respondents</th>
<th>Too big 0%</th>
<th>Just right 57% (n=8)</th>
<th>Too small 14% (n=2)</th>
<th>I don’t mind 29% (n=4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The majority of respondents inferred that the size of the leaflet was acceptable by stating it was ‘just right’ (8) or that they did not mind (4), with the exception of two participants who said it was too small. Both of the participants who responded that the leaflet was too small were in the 25-34 age range; therefore, this was not an issue relating to older people and accessibility.

Participants were also questioned on what they thought about the size of the writing on the leaflet. The font size of the text was clearly appropriate as all participants’ responses were positive or indifferent, with the large majority being positive.

Table 12: Opinion on text size

<table>
<thead>
<tr>
<th>Percentage of respondents</th>
<th>Too big</th>
<th>Just right</th>
<th>Too small</th>
<th>I don’t mind</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0%</td>
<td>79% (n=11)</td>
<td>0%</td>
<td>21% (n=3)</td>
</tr>
</tbody>
</table>

Participant E12 did respond to this question but chose not to tick any of the given answer options but wrote their own comment stating it was ‘helpful’. The participant aged over 80 who said they read with a magnifying glass selected ‘just right’ in giving their opinion of the text size. Responding that the text size was just right and the leaflet was easy to read suggests that using a magnifying glass may be a practice the participant is used to with reading activities because of acute eyesight issues and it does not mean that there is a legibility problem with the leaflet.

Only the participants who were given leaflet B were asked where they would keep the leaflet, as a whole, and where they would keep just the control instructions insert part of the leaflet. This was to determine whether tenants have a preference to keep them together or separate, for the control insert leaflet to be more readily available or to be by the control panel, to identify the need for the control page to be a removable section. Because these questions were only asked of those who received a leaflet for the ‘installation’ stage, the maximum response rate was seven participants. All responded, and all responded with the same answer for both where
they would keep the leaflet and where they would keep the control section of the leaflet, surmising they would be kept together. The responses were not the same as each other, however. One tenant would keep it on a table, one tenant would put it on a noticeboard, three participants would keep it in a drawer and three tenants recognised the use of the tenant handbook for keeping it in. One respondent selected both the tenant handbook and drawer indicating they would keep all tenant information together in a drawer.

Both types of leaflet included information about what a heat pump is and how a heat pump works. Therefore, all participants were asked whether, after reading the leaflet, they felt they understood how a heat pump works.

Figure 31: Graph to show the level of understanding of the system from content
All participants were also asked whether they felt well informed about what to expect from a heat pump installation. Of the 15 participant data set, 14 participants responded to this question.

![Graph showing understanding of expectations from content](image)

**Figure 32:** Graph to show understanding of expectations from content

Participants were given the opportunity to write comments about any other things they felt the leaflet did not provide enough information on. This option was used by six participants and of those who answered this question, the majority did not answer it in terms of the information the leaflet did or did not provide, but to voice problems they have with their system or their understanding of the system’s functionality. Participants E5, E7 and E10 all used this comment box to report problems with the functionality of their system, as shown in the responses below.

“*Why does my bungalow never feel warm? Heater absolutely useless.*”  
(Participant E5)

“*Why can they not independently heat water to a temperature that would be guideline safe against legionnaires? Not economic having to keep immersion on as well!*” (Participant E7)
“I have got one installed, but it cuts out when the temperature reaches -3 and I have no heating at all when most needed.” (Participant E10)

Three participants commented under this question about use of or understanding of controls, which also may have no impact on the leaflet evaluation:

“Handset used to operate heat pump system too fiddly not clear enough. i.e. no word ‘heat’ on handset. i.e. heat = high temp, low temp.” (Participant E12)

“E8: I did not see or understand the heating controls. I’ve never touched the heating controls except the thermostat in the hall, where I turned it off when going away and back on when I came back.” (Participant E8)

“I’m not sure how to set it so it comes on in the morning so can only use it manually.” (Participant E6)

The latter of these is more reflective of the leaflet in that this is information the participant clearly wants but cannot get from the leaflet. However, participant E6 had leaflet A so this control information was not included intentionally. It may be that the participant could have obtained this information from having leaflet B, but this was not tested.

Two participants did make comments that were reflective of the information design which would be considered in a further iteration to improve the leaflet from this evaluation. Participant E8 pointed out an error on the leaflet where some text had been omitted. Participant E10 stated:

“I think it would be a good idea to show people what the pipework in their airing cupboard is going to look like.”
Participant E10 also commented later in the questionnaire:

“I think it would be helpful to know that you can’t have heating and hot water on at the same time.”

Participant E10 had leaflet A to evaluate, indicating that setting expectations for these practical details would be useful from the earliest stage.

The participants who received leaflet A were asked whether they felt that it would have been useful to receive this at the time when they were approached about having a heat pump. Seven out of the eight participants who reviewed leaflet A said it would. This question was not asked of those who received the leaflet B as the previous empirical research with tenants in these social housing properties found that some tenants did receive some written information at this stage of the installation process, but it was reported to be insufficient or inappropriate. Furthermore, those who had not received any at this stage had presented a need for it at this stage. This question relating to leaflet A was intended to ascertain whether supplementary information prior to the actual installation has an added value in the tenants’ opinion.

There were questions specific only to leaflet B owing to the further information this intended to provide on usage of the system. Participants were given scenarios to make a judgement on whether they felt they could complete the given task. Out of the seven participants who received leaflet B to review, six answered the questions.

Firstly, they were asked whether they would be able the change the temperature that the heating is set to.
Secondly, participants were asked whether they felt they could set the timer on their system.

Table 14: Subjective view of ability to use the timer

<table>
<thead>
<tr>
<th>Participant</th>
<th>Yes</th>
<th>Yes, but I do not feel confident using the controls</th>
<th>No, I do not understand</th>
<th>No, there is no information</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of respondents</td>
<td>33% (n=2)</td>
<td>33% (n=2)</td>
<td>17% (n=1)</td>
<td>0%</td>
<td>17% (n=1)</td>
</tr>
</tbody>
</table>

All participants were given the scenario that they had a query about their heating system and asked whether they knew what to do in this event. They were subsequently asked whether the leaflet helped them know what to do. Of the 15 participants, 13 answered the question about whether they knew who to contact.
with a query. Only 11 participants then answered the question about whether the leaflet helped them to find this information. Participants with both types of leaflet were asked this question as having a query would be an appropriate scenario both before and during installation.

Table 15: Tenant understanding of how to handle queries

<table>
<thead>
<tr>
<th>Participant</th>
<th>Would you know what to do if you had a query about your system?</th>
<th>Does the leaflet help you find this information?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Percentage of respondents</td>
<td>67% (n=8)</td>
<td>33% (n=4)</td>
</tr>
</tbody>
</table>

One of the participants who responded that the leaflet helped them in knowing what to do when they had a query answered “no” to whether they knew what to do when they had a query which was contradictory. Questionably, the participant’s answer could mean that they did not know what to do originally and that the leaflet then provided the information after they looked at it, but this is too ambiguous to be deemed reliable. Therefore, that particular piece of data is disregarded for evaluation. This resulted in samples of 12 participants answering about the understanding in the event of a query and 10 participants answering about the helpfulness of the leaflet in this event.

Participants who were reviewing leaflet B were also asked to write down what they would do, in order to assess what their action would be and whether it was derived from the leaflet. This question was only asked of participants reviewing leaflet B in order to better understand communication and interaction during and post-installation. Those reviewing leaflet A would only have had one point of contact at the Council at this stage when the heating system was first introduced to them. At or after installation, where leaflet B was applicable, tenants would have had interaction with actors in the service delivery other than the council, such as installers or maintenance and through a variety of methods. Only four of the seven
participants who had leaflet B answered what their action would be, but all stated they would phone the council. Details for doing this were provided on the leaflet.

Participants reviewing leaflet B only were also given the scenario that there heating system appeared not to be working properly. They were asked if they would know what to do and what they would do in this event. Six out of the seven possible respondents answered this question; four said they would know what to do and two said they would not. The four participants responded with what action they would take, with all saying they would phone the council. Two of them stated they would also refer to the leaflet. This unprompted reference to the leaflet suggests the information material was acknowledged as a resource to be used.

Participants with leaflet B were asked to state what type of heating system they have in their home; seven participants wrote what they thought their heating system was. All participants who responded gave an answer in line with the type of heating system that they do have, if not the exact phrasing. Two of these responses were just ‘heat pump’; they did not specify which type of heat pump. In most cases, the responses were vague but relevant and one was very specific to the manufacture of the heat pump; none reported the wording indicated on the leaflet except one, indicating the leaflet was not used to answer this question.

At the end of the questionnaire, participants were all invited to make any other comments. Some of these comments have been reported on earlier in the findings where they were relevant to the information provision. However, two participants used this space to express their dissatisfaction with the system rather than comment to evaluate the leaflets.

Participant E5 commented:

“It is a totally unusable system for the shape of our bungalow, not happy with it! Council did not consider layout before getting it installed.”
Participant E7 commented:

“Crap system. Have had to have 3 rads [radiators] in the sitting room, hardly room for furniture. Never hot enough. Have coal fire to back up on cold days. How economic is that!”

These comments are noted as they have relevance for the service provision and consideration installation design.

6.3.1 Pilot study findings

Participant data from the pilot study was useful and informative in terms of feedback on the leaflets rather than the study design, to supplement the main evaluation study findings. It is outlined separately because the participants’ socio-economic backgrounds are different to those in the core sample, as they do not live in the social housing sector, and they do not currently have heat pumps installed in their homes. The latter makes these findings particularly interesting regarding leaflet A for approaching new people to introduce the technology to. In the main study, tenants of the social housing organisation who already had heat pumps were retrospectively assessing the benefit of this leaflet and its provision at the introduction stage. The pilot participants were reviewing the leaflet from a potentially more novice perspective, as would be more likely in the real context.

All of the pilot study participants are living in private housing, with the exception of the elderly male who is living independently in a self-contained flat within a nursing home. Nevertheless, they provided useful additional information which, in some responses, was in line with the core sample findings. As explained in the pilot study method, this research was conducted in person with the majority of participants. Therefore, some of the leaflet evaluation feedback was obtained verbally rather than on the questionnaire and recorded in note form by the researcher.

Two of the pilot participants, PE4 and PE5, provided comments that indicated there is too much text on the leaflets. This was judged as applicable to both types of leaflet as each of the participants had a different type of leaflet to assess. One stated it was ‘too wordy’ when asked to comment on anything they disliked about the
leaflet. The other wrote a constructive comment that they would have found a diagram helpful to show how a heat pump works. Positive comments were consistent amongst the participants in terms of the use of colour and clear content, i.e. headings and contact details. The response that contact details were clear was verified by the majority of answers to what they would do in terms of a query, with participants stating they would use one of the options of contact details that they found on the leaflet.

Participant PE2 received leaflet A to assess. They thought that information was clearly presented and liked the ‘key question’ format to signpost to users and to show that questions the users will want answers to have been proactively considered. They thought that the key pieces of information to obtain from the leaflet were benefits and practicalities of the installation process; benefits were well displayed, in their view, but they felt that the practical issues could have been more prominent. This was in line with the comment from participant E10 in the main evaluation study about displaying pictures of the pipework installed in the ‘introduction’ leaflet. This participant also commented they would like more information on cost in comparison to other heating systems, rather than just being told it is a cost-efficient system.

PE1 commented that they thought one of the instructions was mistyped because they thought the information did not seem as if it was correct. The information concerned was that the heat pump would start between 5 and 60 minutes before the programmed time, dependent on the room temperature. Participant PE1 questioned whether this should have read 50 rather than 5, as between 5 and 60 felt like a large difference. This indicated that there was not enough understanding obtained to explain why it may require a very short period or a longer period for the heat pump to be on prior to the time the heat would actually be required, to achieve the set desired temperature at that time.
6.4 Discussion of evaluation study

A drawback of the study design was highlighted by one of the collected responses to the survey. By receiving one questionnaire that was completed as a response from a couple, it highlighted that each household only received one survey where there may have been multiple occupants and, therefore, multiple opinions. Across all the heat pump properties, this means that a substantial amount of potential data capture was untapped. However, this was a result of the researcher having no access to or full information of the households and occupants prior to the survey distribution, for ethical reasons of data protection; surveys could only be produced for the number of households with heat pump systems. To provide occupant information for each household without tenant consent would have ethical implications and to do so with consent would be a laborious task for the social housing provider that they did not have the time or resource to enable.

The response rate to the survey was low, at 12.5%, creating a small sample size, although this response rate is typical for this type of research. The design of the study created this potential risk but it was unavoidable in these circumstances. Measures were taken, where possible, to increase response rates. For instance, by minimising the length of the questionnaire and providing all necessary items to return it, such as a stamped addressed envelope which reduced both effort and cost to post it, it more convenient to complete and return. The social housing provider distributing the survey removed the ability to carry out other measures to improve response rates, such as approaching participants prior to them receiving it. However, it was anticipated that the contact and receipt of the study from the social housing organisation may increase the credibility of the research for tenants, due to the relationship between the housing provider and themselves. Unfortunately, unknown prior to commencing the research, due to the extent of installations done by this social housing organisation and the organisation’s proactiveness in evaluating them it has attracted research from several avenues and parties. Therefore, tenants had already been involved, or requested to be involved, in interview and questionnaire studies preceding this study. Consequently, their willingness to participate may be reduced irrelevant of this study design but because of repeated targeting.
Because of such a small sample size, the data cannot be used to generalise to a wider population. This is furthermore a disadvantage of case-based research: the findings cannot be generalised to a wider population as the research has been conducted to such a level of detail in one specific set of circumstances. Findings and insights can be extrapolated however, that contribute to knowledge, as is the case with this evaluation work. The questionnaires that were completed and sent back were answered comprehensively with participants making use of the opportunities to provide extra comments. It was noted that on consecutive questions with similar structure, such as when tenants were asked whether they could change the temperature or set the timer, participants did not respond with the same answers for each, indicating they thought about each individual question and did not complete it as quickly as possible with little consideration. Thus, this increases the dependability of the data that was collected.

The qualitative responses to open-ended questions by tenants which highlight concerns with the system functionality, such as not having enough heat in the home [participants E5 and E7 comments, page 222 ], indicate there are issues with heat pump installations that the information leaflets may not have the ability to address. The problems may be a result of the installation design and system issues, as has been outlined in other research of heat pump installations in the UK. In this case, these comments inform the wider parameters of the service provision that should be considered for improvement, as presented in Chapter 5. However, issues of not feeling warm enough in the home, such as that reported by participant E5, may be attributed to tenant usage of the system. Potentially, the leaflets may have the ability to improve these circumstances if the tenant understands more thoroughly from the leaflet information how the system works and is controlled. However, this could not be tested without leaving the information leaflet with the tenant for a period of time, as an intervention, to observe any real improvement in user behaviour and experience. The scope and timescale for this doctoral research did not allow for a further longitudinal study to investigate this, as will be discussed in the overall research discussion in Chapter 7.
A limitation of the postal survey design that was identified after responses had been returned was that not all tenants returned the prototype leaflet with the questionnaire. This made it difficult to determine what system they had when reviewing the prototype and in assessing their knowledge of what their system is. The representative from the social housing organisation, however, was able to provide the information when requested, to enable a fuller picture of the evaluation feedback and overcome this issue.

The results presented indicate positive responses to the design of the leaflet on the whole and greater positive responses to the information provided than negative responses. The responses suggest that the prototype leaflets are a helpful tool. Yet, some uncertainty clearly remained among participants over aspects of the information the leaflet intended to inform them about. This indicates that the current design of the leaflets may not fully satisfy user requirements to an optimal level. Further iterations of earlier stages in the design process would be required and beneficial to make improvements before implementation. The impact of this is discussed in Chapter 7, through discussing the application of the methodology.
7 Discussion

Over the following chapter a discussion of the research conducted for this thesis is presented. The research is reviewed over two main sections; firstly, the implications of the research outcomes are considered and, secondly, the user-centred design approach taken and research methodology applied are reflected upon. Across these sections of the chapter, the author assesses and discusses how the research addressed each of the research questions outlined in Chapter 1 and poses answers to each of these questions. As a reminder, the research questions this work set out to investigate are repeated below:

1. What lessons can be learnt from previous experiences when retrofitting heat pumps technologies into social housing?

2. What measures would help augment the successful introduction and adoption of heat pumps in future?

3. Can user-centred design add value when applied to the service of installing heat pumps into social housing properties?

The first section of this chapter addresses research questions 1 and 2 by discussing the overall research outcomes and their implications. The final research question is answered through the discussion of the research methodology and approach taken, in the second section of this chapter.
7.1 Discussion of research outcomes

In this section of the discussion chapter, the findings and developments as a result of the empirical research carried out are considered, with reference to the literature reviewed to place this understanding within the wider context of the research parameters.

7.1.1 Understanding of contextual issues

The understanding of contextual issues was developed through the exploratory research carried out over the first two phases and is presented in this part of the discussion chapter. This contextual understanding that was obtained through the research identifies the lessons that have been learned through past experiences of installing heat pumps; thus, addressing the first research question: What lessons can be learnt from previous experiences when retrofitting heat pumps into social housing?

7.1.1.1 Delivering heat for warmth preferences of older people

Maximising efficiency of use of the heat pump is the critical factor to ensure the benefits of the renewable technology are realised whilst enabling the occupant to achieve thermal comfort. Being able to provide affordable warmth is one of the drivers for installing renewable heating technology into homes, particularly in place of fossil fuels such as coal and oil. The heat pump systems need to be used efficiently to enable tenants to receive the desired level of warmth. If the heat pump system is not used effectively then it will cost the tenants more in energy bills trying to achieve their desired level of thermal comfort, as the heat pump has to work harder to reach desired temperature levels and uses more electricity. Cost of fuel bills emerged as a concern across the population sample in this research and is reflected in the press with recent energy price rises across the sector (BBC, 2013). Some tenants reported that the heat pump cost more to run at first until they learnt how to use it. This shows the high dependence of end-usage on the cost of running the system and the need to communicate to tenants this relationship and how best to use the system.
Some tenants reported dissatisfaction with the heat pumps because they do not produce enough heat. This was in cases where the heat pump may have been underperforming or the heat distribution was felt to be imbalanced or where the performance of the heat pump was not fully understood and the tenants expected instant, hotter heat. Whilst underperformance or imbalanced heat distribution may be a result of the practical installation, misuse because of a lack of understanding is an important factor for tenant education. In one example, the tenant was not using the heat pump at all because it was not producing instant heat of a high enough temperature. As a result of not being used properly, the tenant did not grasp how the heat pump worked and so was not achieving the expected warmth in the property. This clearly relates to the need for good communication to all tenants who will be living in a property with a heat pump, so that tenants understand how to use the system efficiently and to achieve satisfactory thermal comfort.

The literature reviewed suggests that there is not a significant difference in the thermal comfort requirements of older people and younger people based on age alone. It has been outlined that a preference for higher temperatures in the home environment may be attributable to the lower metabolic rate and more sedentary lifestyle of older people rather than age itself (Parsons, 2003). This research found that a preference for higher temperatures amongst older people is not an assumption that can be made due to the range of temperature settings reported by some tenants across the sample. Tenants who reported their temperature settings in the research were those who were more satisfied with their heating provision and aware of what the heat pump had been set to by installers or through their own use of thermostats. Individual differences are apparent across the segment of the population categorised as older people, across the range of ages within this segment and through a variety of reasons such as health complications, activity level and subjective preference.

For example, tenants interviewed who had blood circulation problems and were taking Warfarin, the main anticoagulant medication prescribed in the UK (NHS, 2012) reported being more susceptible to feeling cold and requiring a higher room temperature to achieve thermal comfort; incidences of this were found multiple
times across the data set in this research. This corresponds to the literature found from Collins (1986) relating to older people with health problems being more susceptible to feeling cold at temperatures deemed acceptable for thermal comfort in general standards from the World Health Organisation. Some tenants, on the other hand, reported their homes being too hot and having to stand by the open back door to cool down, having to use window dressings to regulate room temperatures because the position of the sun in combination with the heating, or altering their clothing levels significantly when doing housework activities.

The WHO outlines best practise temperature guidance of 21°C for a living room and 18°C for other occupied rooms, such as bedrooms, for thermal comfort and health (Ranson, 1988). As stated above, temperature preferences varied across dwellings, due to individual differences, such as health issues, activity level in the home and preferences playing a factor; however, a trend was found for tenants preferring a cooler bedroom. It was found that tenant participants tended to leave the bedroom window(s) open frequently. The reasons for this were often reported to be for ‘airing out the room’, the phrase used to describe circulating fresh air into the room, or reducing the bedroom temperature. Leaving windows open in rooms when the heating is operating is wasteful behaviour. This demonstrates the importance of tenants understanding the use of TRVs on the radiators to regulate the level of heating across different rooms and maximise efficiency.

The issue of varying temperature preferences or requirements is one of the key drivers for the need for tenants to have control over their systems, or rather understand the controls of their systems, to be able to alter the temperature to suit their individual needs. This also, however, indicates a need for consultation with occupants regarding their thermal comfort and behaviours when setting heat pump temperatures rather than installing with a standard default across all dwellings. Some of the social housing landlords reported that heat pumps are installed at a default temperature at first and then they work with tenants to adjust the systems to their preferences. Whilst this is a positive step towards ensuring individual needs are catered for, some information could be obtained upfront that would help in
determining what temperature would be preferable, for example by finding out about any relevant health issues.

The effect of individual differences also relates to the setting of programme timers. A consultation with tenants at the installation stage over their routines and behaviours would help to ensure that the timer settings for the heat pump are reflective of their lifestyle and when they want and need the heating. This was evident in the data; for instance, the tenant who was found to be using an additional heating device regularly for set periods of time during the day because the programmed times for his heating system to operate did not correlate with his daily routine. The tenant felt they did not understand enough or was too wary of using the controls to change the timer themselves. This also indicates the impact that a lack of knowledge how to use controls has on energy use and carbon emissions, by increasing appliance use as a workaround for the problem.

An interesting point to note here is that this tenant was happy with the heating system and had not contacted the landlord about the heating times being a problem; they had implemented a workaround to compensate and this was only ascertained through visiting the tenant for this research. This highlights that if the landlord is not contacted about a problem, they would not be aware of this issue without proactively visiting the tenant. If they were aware and could rectify the problem, or had consulted upfront to avoid the issue, it would impact the efficiency of energy use for heating, the cost for the tenant as well as improve their thermal comfort.

Whilst some extent of temperature regulation appears to be required for different needs across time, activity levels and other individual preferences, in general the exploration research carried out for this thesis identified that for those tenants who were satisfied with the heat pump system, having a constant, warm temperature within the home was recurrently reported by tenants as a positive aspect of the heat pump heating system. The way that a heat pump functions, if operating correctly, means that the fabric of a home is heated to provide continuous warmth. Where tenants were experiencing an imbalance of heat distribution in their home,
this was resulting in dissatisfaction; this may be attributed to practical installation issues however.

7.1.1.2 Facilitating ageing in place
Section 2.2.1 of the literature review outlined the importance being placed on facilitating ageing in place in the UK. This refers to the emphasis being put on the benefits of older people being able to remain in their own homes into later life, personally and economically, and intervening measures to help enable this, such as assistive technologies. Assistive technologies aim to help people with forms of disability, of varying degrees and conditions, to perform tasks they would otherwise struggle with and to function better within their daily environment, achieving a higher quality of life (Lancioni et al, 2013; Royal Commission on Long Term Care, 1999). Assistive technology is a key area of focus in relation to ageing in place, aiming to provide measures to help people with age-related disabilities, physical or cognitive, to remain living independently in their homes.

Heat pump heating systems are not a technology that would normally be categorised as an assistive technology. However, a heat pump is a new technology which assists older people to remain independently living in their home. As discussed, heating is of critical importance to older people; they need to have a functioning system that provides a satisfactory level of heat for thermal comfort and health. It was found in the research that heat pumps were chosen by landlords as an alternative heating system, in particular, to coal-fired systems because of the easier management and use of a heat pump system for the tenants in comparison. Older people or people with disabilities would be found to struggle with using and maintaining a coal-fired heating system because of the practicality of transferring coal from a store at the home to the fireplace within the home and the laborious tasks of laying, lighting and cleaning the fireplace.

The exploration data showed that in some cases the installation of a heat pump was pro-active on the landlord’s part, suggesting to tenants that the heat pump system would be better for them; in other cases it was reactive to a tenant contacting the landlord to say that they were having difficulties with their existing system through
cost or practically being able to manage it. This research has found that often the priority for heat pump installations was in properties where older people lived in rural areas with coal or oil-fired systems. This ensures a system that is easier to manage and which provides a more reliable source of home heating at reduced cost to the tenant in terms of energy bills. Each of these factors is linked to an older person being able to remain in their own home living independently, lessening the risk of being unable to manage or afford to heat their home.

7.1.1.3 Introducing heat pump technology to older people
Through the literature reviewed, it was indicated that there are issues concerning older people and their use of technology, particularly focused on their physical ability to use the technology or confidence in using new technology. These are important issues to consider and address and were validated through the research findings. Willis et al (2011) proposed that older households were less inclined to adopt renewable technologies. This was not necessarily the case found in this research. There were reports from tenants that they were wary of the new technology, it being something that they knew nothing about, and this resulted in them being cautious about adopting the technology but it did not prevent them having a heat pump installed. Their wariness was abated by the landlord discussing the installation and system with them and the possibility of the system changing if it was unsuitable post-installation.

The findings of this research particularly identified a lack of confidence with using the heat pump system controls. Tenants often reported that they did not want to touch the heat pump controls as they felt they could not operate them. It was evident that tenants felt confident in using a thermostat control device but there was a lack of confidence in using the digital control panels, which was shown to be a result of, or exacerbated by, a lack of information on how to operate them. In many cases, tenants were remaining dependent on the landlord to operate controls for them.
This lack of confidence and initial wariness of having and using a heat pump should not be viewed as an aversion to new technology altogether amongst older people. In one regard, older people are not one homogenous segment of people and will have different approaches towards the use of technology, as was evident in the findings of the exploration study in this research. The variety of technology use indicated that older people and a lack of use of technology is not a strict correlation.

A spectrum of technology use was found across the research sample. With regards the heat pump controls, some people were able to use the controls, some people understood some elements of the controls but not others and some people demonstrated more of a lack of confidence to try using the controls, rather than a lack of ability. There are two key points to be made here: firstly, to consider the difference in the heat pump systems and understanding of the controls across different organisations and, secondly, to consider the implication of introducing this particular new technology.

In many properties, the tenants had a thermostatic heat control device, the same control as on conventional gas central heating systems. It is noted that the tenants currently receiving heat pumps are in rural areas off the gas network and previously had coal, oil or storage heater systems. Therefore, thermostats may not be the familiar mechanism to control their heating temperature. However, they may be aware of them from other environments, such as a workplace, as they are a standard heating control feature in many places. Furthermore, they are a simple control mechanism to use physically once shown; there is only one action to be learned of turning the dial up and down. Other properties in the research sample had control devices which were wall-mounted digital display units or hand-held controllers that the tenants used to control the programme or temperature settings. In one of the social housing organisation’s involved in the research, the heat pump controls were an interface on the heat pump unit itself. These controls posed greater problems for tenants, as they are felt to be more complex to learn and understand.
The importance of providing warmth in the home has been outlined, with the implications of inadequate heat in the home on thermal comfort and health being discussed through the literature review and previously in this chapter. The heat pump system, therefore, is a critical technology which provides this heat to deliver the warmth required by the occupant. Given the importance of a heating system in a tenant’s daily life, it is a significant problem if tenants are wary of the new heating system or lack confidence in using the controls. Some tenants interviewed in this research stated they did feel wary about having the heat pump system installed because it was something they knew little about and both tenants and landlords recognised this ‘fear of the unknown’ as a barrier to adoption.

A related difficulty was tenants grasping how the heat pump system worked to heat the home compared to other heating systems. Radiators not feeling hot and no sense of instant heat were issues presented by the tenants as problems. But, it is the different form and delivery of home heating which needed to be understood in order to know the system was working correctly and to use it appropriately. This increases the need to provide plentiful information when introducing the technology to the tenants, to ensure they understand what the system is and how it works, to increase their likelihood of accepting the technology.

A final important aspect to be surfaced in relation to the introduction of heat pump technology to tenants is the difference that exists between a tenant receiving a heat pump retrofitted into their home and a tenant moving into a void property that already has a heat pump installed. Tenants moving into void properties have far less prior engagement and preparation about the heat pump system; they have no contact with installers and therefore receive no information from them as tenants having a heat pump installed in their home would likely do. This places a different emphasis on the service requirements for tenants moving into a void property, to introduce the technology to them when they move in and educate them in how to use it.
7.1.1.4 The installation process

During the research carried out with both tenants and landlords, participants did refer to the installation of heat pumps as a service provided from the council or housing association to the tenants. Aside from the service provider to service recipient relationship existing in this situation, the authority of the landlord places a particular dynamic on this service, differing, for example to a consumer service where there is a more equal dynamic. Although the tenants were referred to as ‘customers’ and the element of tenant choice was surfaced in the data, tenants indicated that they did not always feel as though they had a choice about having the new system. This was largely in cases where the current system was broken and the landlord would not be replacing it or where it was suggested that if the installation was not carried out at that time it would be done so at a later date, leading the tenant to feel as though the installation was inevitable.

It is clear from the evidence that the timing of installations is currently heavily driven by funding availability. Thus far, installations have been possible through grants and financial schemes; social housing organisations do not have disposable funds to enable retrofit programmes of energy saving measures without subsidisation from external bodies. Consequently, the timing of carrying out heat pump installations is not wholly within the landlord’s control. However, it is an important observation that practicalities of the installation process make the timing impactful upon the tenant experience. In this research, it was identified that some installations were carried out during winter months. When a heat pump system is installed, the dwelling would unavoidably be without full internal heating during the period of removing the previous system, installing the heat pump components and time for the heat pump to warm the home to the set temperature in the first instance. If this is done during winter months, the property is without central heating when the external temperature is coldest. In all cases observed, the tenant remained living in the home during this time. Landlords providing alternative heating sources such as oil heaters assist but any unexpected problems during installation would extend this period and so negatively affect the experience. The ideal situation would be to carry out installations during warmer months but, as highlighted, it is recognised this is impacted by funding availability.
Besides funding availability dictating the timing of installations, landlords have endeavoured to carry out installations alongside other major works, particularly with those required to meet the Decent Homes Standard in recent years. Carrying out major works in the same timeframe minimises disruption for the tenant; while there may be more work happening in the property at one time it means less repeated disruption in their home whilst living in the property. It was identified this may also be sought after by the tenants; for example, a landlord interviewed reported that their tenants wanted installations to be done at one time within the same street, to minimise the disruption across the community. The optimal solution is to carry out major works and heat pump installations in void properties, while no tenants are living in the property, but the frequency of tenancy changeover and the benefit of addressing multiple properties in a community at once to take advantage of the economies of scale makes this impractical. Furthermore, it should be noted that the tenants involved in the research reported that they did not find it a difficulty living at home during the installations; the way disruptions and problems were dealt with abated any poor experience.

The installation of heat pumps into social housing properties involves multiple actors providing the service. The tenants are aware that multiple external organisations are involved in the process of the installation but they experience the installation and maintenance as one service process. The tenants view the landlord as their primary service provider and they are the contact point for any problems. Some tenants of housing provider LG involved in the first two phases of this research reported problems with the workmen working in their properties. They highlighted that they informed their landlord and the matter was dealt with by them, to the tenants’ satisfaction. Landlord participant LG interviewed also highlighted that there was instance of external contractors not working to their expected standards. This demonstrates the importance of a good relationship between the social housing landlord and the external workforce(s) they employ to carry out installation work. Contracting external organisations who meet the landlord’s standards and who they trust to work with tenants in their homes was clearly an important factor for landlords interviewed.
This relationship is also important in delivering a consistent service, in order to deliver a consistent message from the various service providers the tenants come into contact with. Tenants involved in the research reported that they received information on how to use the heat pump systems, including what to do around the home regarding opening windows and doors, from the installers. They also receive information from their landlord and, in some cases, other actors such as maintenance workmen and neighbours. All social housing landlords involved in this research reported the education of tenants in understanding and using the systems as the biggest and most critical issue they encountered when doing installations. Aside from written materials, verbal communication played an important part in educating tenants; therefore, it is important that this message is consistent.

Some tenants outlined experiencing an imbalance of heat in their homes across the rooms. This was mostly found to be the case in properties with air-air source heat pump units where there was one unit installed in a living room or hallway and the heat was not felt to reach other rooms. Some tenants reported the heating being inadequate in producing enough heat for the home and, in the second study, tenants with ground source heat pumps suggested that their heat pumps were undersized for their property based on research they had done. Whilst the technical installation is a significant part of the service, this anecdotal evidence cannot be assessed further in this thesis and requires practical technical investigation to determine whether this is the case existing in homes; this falls outside the scope of this research. What it does surface in this thesis is the significant importance of the practical, technical surveys carried out prior to the heat pump installation and implications for practical work.

7.1.2 Service recommendations development
The second research question of this thesis was: What measures would help augment the successful introduction and adoption of renewable technology in future? The empirical studies carried out to inform this thesis produced insights which highlighted a variety of elements that could be addressed. A set of recommendations was compiled as a result of the research with both service
providers and recipients: outlined in chapter 5, section 5.5. It is proposed that the implementation of these recommendations could improve the holistic service of heat pump installations.

A key area of concern which emerged through the exploration research across all social housing organisations involved was information provision about the heat pump systems and how to use them. From the landlords’ point of view, tenant education was a critical factor in the process of installing heat pumps because tenants were finding the technology difficult to understand and then be able to use it effectively. From the tenants’ perspective, they were finding the system and/or controls difficult to understand because of a lack of, or inadequate information for their needs. The social housing organisation forming the main case study in this research had already endorsed the need for information materials at the time of this research being conducted, therefore supporting the continuation of this research with such a focus. The nationwide heat pump field trial in the UK conducted by the Energy Saving Trust (2010) reported in the review of literature also established this as an area requiring work, further verifying the research direction from a wider context.

Therefore, the research for this thesis continued from the exploration study outcomes by addressing aspects relating to communication within the service and a more specific focus on written information provision. As evident in the empirical studies, the written information delivered to tenants was a key touchpoint that was viewed as an issue from both the landlords’ and tenants’ perspectives and so was the core focus for the refinement of requirements and development in chapter 5 and evaluation in chapter 6. The exploratory research conducted in the first two studies produced insights about what the tenants thought of the information they had been provided with. The second study conducted to refine requirements for this particular touchpoint delivered useful information from the tenants which helped in the development of the information leaflets.

Prototypes of the leaflets were created, as displayed in chapter 5, section 5.5.2, in order that they could be evaluated with tenants to assess their suitability and
whether they could be an improvement to the service in the tenants’ opinion. Chapter 6 presents the detail of this evaluation; however, overall, it can be reported that they were well-received by tenants and informative feedback was extracted through the tenants reviewing the prototypes and responding to a questionnaire. The results of this survey did indicate that further work would be required to improve the leaflets to be more beneficial in the tenants’ opinion before being ready for wide-scale implementation and distribution to all heat pump users. This, therefore, demonstrates the value of prototyping and evaluating with end-users, to determine whether the product, system or service is appropriate and beneficial for them. This would identify whether the outcome is ready for implementation or whether further iterations of development would improve it further; thus potentially saving the organisation time and cost resources of needing to redevelop and improve something after implementation.

The other recommended measures for an improved service, outlined in Chapter 5 section 5.5.1, emerged as a result of the first two empirical studies. The first study of exploratory research and the exploration part of the second study served to provide insights from both the tenants and the landlords of opportunities, limitations and contextual information. The other part to the second study was to move into the development of solutions to service problems and user requirements with the involvement of landlords and tenants, to extract user generated ideas to formulate suggestions for service improvements. At this point in the research, the other recommended measures are indeed just that: recommendations; they have not been trialled in full application for their real benefit to be determined. These aspects could not be taken further into development as a part of this research because of the scope of this research thesis; this is explained in greater detail in section 7.1.2.1. Extended time and resources would be required to fully address each recommendation applying the user-centred design process advocated in this research, developing each touchpoint with the involvement of users and evaluating the outcome of the developments.

Whilst this is a recognised limitation of the research outcome, the emergence of them through user research and user generated ideas implies that there is viability
and value in the suggested measures. Particularly with recommendations surfaced from the service providers, such as databases and training, it can be assumed therefore that the service providers suggested these as feasible and valuable measures. End-user, i.e. service recipient, generated ideas are at risk of not accounting for organisational requirements, whereas the social housing landlord discussed ideas with the researcher with awareness of the organisation’s limitations.

7.1.2.1 Implications for industry

The clear focus of this research was on the context of installing heat pumps into social housing properties, with an aim to address the service of this from the social housing landlord to the tenants. The methodology this research applied obtained a rich level of insight across the holistic process from both the end service users’ perspective and the process facilitators’ perspective. By this, the author refers to the social housing landlord as the process facilitator; they provide the service surrounding the installation from introduction of the technology to the on-going maintenance, facilitating the installation being carried out and the technology being used. From the in-depth insight of practical and contextual issues gathered through this research, information relevant to the industry of heat pump installations could be extracted. This surfaces aspects where changes within the industry would augment a better service for installations, in a general wider application and specifically for social housing.

In terms of benefit for the manufacturers, a user-friendly system would potentially become a market differentiator – validated by the focus group with service providers in the second study reported in chapter 5. If the system controls were easier to understand and use, this would make the service provision from landlords to tenants easier as tenants would have less problems or wariness in using the controls, there would be less dependence on the landlord to control the systems for tenants and information provision would be clearer. In particular, the issue of a wide variety of controls makes the service provision more difficult as more understanding is needed within the social housing organisation to assist tenants and so information provision needs to be tailored and in multiple forms. Standardisation of control panels across the types of heat pump systems emerged as a potential
avenue for improvement of heat pump systems and the case study in this thesis highlighted that landlords would be inclined to choose a supplier who could offer such products; therefore, this would become a market differentiator for the heat pump manufacturer.

Heat pump manufacturers could consider developing simulated control panels to distribute to social housing landlords or other stakeholders who work with educating tenants how to use heat pumps. The ‘fear’ tenants have over doing something wrong by using the controls would be removed by using a training module and enable tenants to learn and understand how the controls work and what they need to do to operate the heat pump system.

The research also surfaced insights and recommendations relevant to stakeholders in the service of heat pump heating systems. Energy suppliers, for example, should ensure that heat pumps are included in training for frontline staff that deals with tenants. Tenants reported corresponding with their energy suppliers on the telephone and the customer service operator not knowing what heating system they were talking about. It is important that energy suppliers’ staff have knowledge of heat pumps, particularly those who manage the energy tariffs for tenants, to ensure they are on a suitable tariff for the system. Tenants often get a heat pump system after storage heaters; this means they were likely on an economy 7 tariff which is unsuitable for the way a heat pump systems works and costly for the tenant. Being able to provide appropriate advice is a responsibility of the energy supplier; landlords are not able to advise tenants what energy tariff they should be on but only encourage them to speak to their energy supplier to ensure they are on the most suitable plan.

The research conducted and the research outcomes have implications for stakeholders other than those within the social housing sector; they are an indication for wider the energy industry that user-centred design is a valuable approach for the development of products and services. For example, a user-centred approach could have beneficial implications for the design of heat pump controls, heat pump information or maintenance staff procedures. Findings
presented in this research could inform such design through the insights and issues highlighted in this thesis; there are design considerations for various parts of the installation service that could be directly extracted from this research to inform development at the manufacturer level, the installer or supplier level or at the social housing organisation level. This thesis presents the case for applying a user-centred design approach to this service context of renewable technology installations but the approach could be valuable in other areas of the social housing system, as a multi-service provider. The applicability of user-centred design to services in general is discussed in further detail in section 7.2.1.

7.1.2.2 Wider application of recommendations
The differences between social housing and private housing relevant to the context of this research have been outlined previously in the review of literature. This was to identify the reasons why this research took a focus on social housing alone to investigate heat pump installations. The service surrounding the heat pump installations is different between private and social housing and there are important differences between private housing occupants and social housing occupants in their role as end user, in terms of decision-making, ownership and relationship with the service providers.

The chosen focus of this research is not to detract from the significant importance of addressing the energy efficiency of private housing and application of renewable technology in this area of the domestic sector, as the largest proportion of the UK housing stock. This area and context, however, produces its own challenges to be addressed. To be noted is that the private housing sector includes private rental properties and private home ownership. These, in turn, each have different contextual considerations that create different issues around the installation of renewable technology and cannot, or should not, be addressed in the same way.

In the private rental sector, responsibility and decisions lie with the landlord of the property. The upfront cost of a heating system installation is not the occupant’s responsibility; the landlord invests this capital cost. The occupant’s role is to adopt and use the system efficiently and they would have little or no choice over the
heating system provided in their property. In these respects, the private rental sector is more closely comparable to the social housing sector, with the landlord’s role as decision-maker and provider and the tenant occupant receiving the system to live with. Further research would be required to understand the type and level of service between private landlords and their tenants to identify what, if any, outcomes of this research could be applied to that aspect. For example, in the case study for this research, tenants were found to receive a handbook and a more involved service from the landlord and it is not known whether private landlords provide the same level of service.

There are different concerns around heat pump installations with regards to private homeowners. The private homeowner has to make the pro-active individual decision to install renewable technology in their home and invest the upfront capital as well as understand and use the technology effectively to maximise energy efficiency and the payback benefits in terms of cost. These issues make this a potentially more difficult and complex area to address. Arguably, this is significantly contributing to the slow integration of heat pumps into the UK energy infrastructure.

Some of the issues found in this research, however, are directly transferable to private sector housing. Furthermore, as indicated above, they impact the energy industry. The verbal communication at the time of selling the technology and, particularly, at the time of implementing the technology are critical stages affecting the final uptake of heat pumps, understanding of heat pumps and usage of heat pumps. The usage stage of heat pump technology does not differ between social housing tenants and private home renters or owners in terms of the controls to use and understanding how to use it efficiently; therefore, some information provision at this point discussed in this thesis is applicable in all sectors. The need for user-friendly written information at all is, arguably, a requirement that could be extrapolated to the private sector. The maintenance stage would be different between the private sector and social sector because of the dynamic of the service which exists in social housing, as covered in this research, although it may be that
there are some relevant findings for the private rental sector where a landlord service exists.

7.2 Discussion of Methodological Approach
In this section of the discussion chapter, the adoption of a user-centred design approach and the research methodology applied is reflected upon. The suitability, success and limitations of taking a user-centred design approach in a service context are appraised, addressing the final research question of this thesis. The research methodology designed to fulfil a user-centred design approach is reviewed to highlight the benefits and limitations of its process.

7.2.1 Applying a user-centred design approach to a service
The final research question of this thesis is: Can user-centred design add value when applied to the service of installing heat pumps into social housing? The overall answer to this question is essentially yes. Through the evidence in this thesis of the studies conducted, insights gathered, greater understanding obtained and resulting recommendations, it can be seen that a user-centred approach can be applied to the service of installing heat pumps into social housing and deliver valuable information with a view to improving the service provided.

The principal ideals of user-centred design are to create the best possible outcome for the end user by understanding their requirements and designing what attends to those needs. Obtaining this knowledge of the users and developing designs with a user focus is achieved by involving the user in the design process. User-centred design advocates the involvement of users from the earliest stage, to understand them and the context and maintain a focus on them to deliver suitable and beneficial end products or systems.

Applying user-centred design to a service is different, however, to applying it to a product or interactive system, as is its traditional application. Services are much more complex systems involving a multitude of interactions of various people and objects over time. The user-centred design process and involvement of users can
be applied to a service context to achieve the intended better outcome but this level of complexity impacts the approach.

Instead of just referring to the user, which identifies the end user of a product or system, this thesis denotes the end user as the service recipient and involves both the service recipient and the service provider. The involvement of both at the earliest stage of the process to understand the context and requirements of both sides of the service is both achievable and valuable. This stage allows for a view of the holistic service and where the positive and negative aspects lie in its delivery. An in-depth, comprehensive understanding of the service can be obtained by carrying out the first stage of the user-centred design process.

It is at this point where the user-centred design process is impacted by the complexity of a service. The overall service delivery may be hindered by multiple aspects, or touchpoints, which make up the service and the interaction between them. Alternatively, or additionally, the holistic review of a service may present opportunities for multiple new aspects to improve the service. The scope of all these factors is too wide to deal with all at once in one user-centred design process cycle. As indicated in this thesis, the user-centred design process is suitable for a review of a service to develop a better understanding of the situation and requirements but, at this point, there needs to be a focus drawn on a particular area. The areas or touchpoints requiring a design solution need to be addressed through a user-centred design process to produce the best possible solutions. Therefore, the user-centred design process when applied to a service involves a greater level of iteration to approach the overall service delivery and the touchpoints which form the service.

It is key to note here, however, the value that there is in applying user-centred design to the holistic service and not just to the individual touchpoints. Firstly, an in-depth review with service recipients and service providers of the holistic service may identify touchpoints that need addressing, improving or creating, that would not have been realised prior to the involvement of users. Secondly, it enables touchpoints to be designed within the service context. Other aspects of the service
may interact with or impact on a touchpoint and should be considered in its development. Touchpoints that are only created in isolation may, even if created through a user-centred process, not work well together when experienced in the service as a whole.

The close link between user-centred design and service design was presented in 3.4.1.4 and a reason for applying the user-centred design process to a service was outlined. As this presented, the user-centred design process and service design process are not entirely different. They are based on the same philosophy of putting a focus on the end users, being iterative in their approach, understanding both the end users’ and organisations’ requirements and involving users in the process. Where the approaches differ is the level of user involvement at the design stage.

The core principle of the user-centred design process is to design for users, creating and maintaining a focus on the end user throughout the design process. However, caution is considered here, as even when designing with end users in mind, through elicited user requirements, there is potential for designer’s assumptions, perspectives and creative opinion play a part in development. The emerging field of service design is not just the application of a user-centred approach applied to services but is, in this author’s opinion, an evolution of the traditional user-centred design process by employing co-creative methods at the design stage.

The principle of co-creation involved in the service design process is to design and develop solutions with users rather than for users based on the information retrieved from them. The ideal of this increased involvement in design is the emergence of user innovation for enhanced outcomes. User innovation or design by users reduces the imposition of researcher or designer bias. However, whilst service design is deemed by the author to be an appropriate and valuable approach to the development of optimal services, it is recognised that achieving true co-creation is not always possible in real-world research. Barriers to co-creative methods exist and without this element the process is effectively a more traditional
user-centred design process applied to a service. This thesis is demonstrating the applicability and value of a user-centred design approach to a service context.

7.2.2 Applied research methodology

This section reflects on the research methodology designed and carried out for this doctoral research. Firstly, there is a brief consideration of the use of case-based research. Darke et al (1998) assert that it is important to differentiate between case-based research and a consultative project. It seems appropriate to make this distinction for this research as there is reference to both during the empirical research phases and confusion may arise. As seen in the research study chapters, part of this research was carried out in collaboration with an independent agency that was contracted by the social housing organisation to help improve the information delivery for heat pump installations within their housing stock. The intention was to produce written information materials as a deliverable of this consultative contract. This research did contribute to the consultative project as a result of the collaboration but this was neither the intention at the outset of the research, nor did it impact the direction that the research took. The execution of the research was not influenced by the external organisation, only the participants involved in the research and the research findings, and it covered a broader scope than the remit of the agency.

The research carried out was case-based research as described in the methodology chapter. The decision to focus on aspects relating to communication and physical information materials emerged from the first phase of exploration research for this thesis; the findings from investigation with several social housing agencies resulted in the focus of this research going forward. The opportunity to collaborate with the independent agency arose subsequent to this. Furthermore, the aim and outcomes of this thesis encompasses more than the deliverables expected by the agency and social housing organisation. To form this thesis, the research looked at the broader context of the service to contribute a wider perspective to research and industry.

The research methodology was formed in order to enable a user-centred design process to be carried out. The intention of the first exploration phase was to
understand and specify the context of use, to define requirements. This was achieved through the use of a contextual interview method. Contextual interviewing was an appropriate method of empirical study for this phase of the research as it enabled in-depth, rich insights to be obtained. Of particular importance, tenant participants were able to discuss their opinions and experiences in a comfortable, relaxed environment in their own home. The observation possible through the interviews with tenants being conducted in their homes contextualised their responses to questions and information they provided. This provided an even greater level of detail to form a better understanding of the heat pump installations, what that entailed and how tenants were using the heating systems and their home environment.

However, recruiting participants for the tenant sample of the exploration research proved a difficult task for this research. The field of research in this thesis is a relatively new area and the topic is of contemporary relevance. As such, it was found that tenants were being targeted for research purposes from a variety of places. It is felt by the researcher that the recruitment of tenants was hindered by a high demand on them participating in other research studies and also the reasonably recent disruption they had undergone with the installation works in their home. The recruitment of tenants was carried out by the social housing landlord because of data protection obligations but it was hoped this potentially could have been perceived as an endorsement of the research by the landlord and the tenant may see value in participating.

The second study conducted in this doctoral research was, in part, to further explore user experiences with heat pump installations and requirements. This was with a more specific focus on aspects of communication across the service and, in particular, information materials. The ensuing intention of this study was to refine requirements for these service elements and generate ideas for improvement. Focus groups were an effective method of finding out information from multiple participants in a shorter period of time and which was less demanding on researcher resource. Several perspectives were obtained through holding a focus
group and, even more valuably, these perspectives could be discussed and debated by others with experience of the same context.

The environment of a focus group and open discussion it allowed enabled ideas to emerge and be considered by multiple participants with individual viewpoints. The sessions were a relaxed, semi-structured format which helped to guide the discussion and keep timing, but the flexibility and informality allowed for freer discussion and issues to be covered that were not pre-empted by the researcher. The difficulty encountered with conducting focus groups was the demand it placed on participants, particularly the tenants, requiring people to give their time and also to get to the venue. This can create barriers to taking part, particularly in the case of older people where mobility issues and inability to drive may impact whether they could get to the venue. This was combated as far as possible, by holding the focus group in the local village hall so that it would be a nearby venue easier to access, but did result in a small sample size. The researcher also ensured the focus group was not too long with refreshments provided and a break taken so it did not feel too onerous on the participants’ time; the semi-structured schedule helped to ensure the specified timeframe was kept to.

The decision to carry out contextual interviews where tenants were unable to attend the focus group but wanted to participate in the research proved to be valuable. It allowed further exploration and extended viewpoints on the service experience. Furthermore, by being carried out subsequent to the focus group, the interviewees could give an opinion on the perspectives and ideas produced in the focus group. Additionally, the observation possible within the tenants’ homes contextualised the ideas and suggestions, enhancing the insight gained.

The final phase of this research was to reflect the evaluation stage of the user-centred design process through an evaluation study. Evaluation is an important part of the process, to validate what has been developed and to ascertain, as far as possible, whether implementation will be successful. The postal survey method employed provided the opportunity to target a large population sample and is less demanding on participants than interviews or, furthermore, focus groups. However,
when using postal surveys, particularly on an opt-in basis as in this research, low response rates may be anticipated. In case-based research, in a user-centred design process, a low response rate may be expected because the participants have already been requested to be involved, and in instances in this research have been involved, in research studies previously. A third research study with the same target population increases the perceived demand on people and poses a barrier to taking part.

The social housing landlord distributed the survey to tenants in order to adhere to data protection practice. However it was also considered that this would place more perceived value on the research for the tenants by the social housing landlord being aware of the research and accepting it as worth sending to tenants; thus, reducing the barrier to participation. The privacy and anonymity a postal survey allows, it could be argued, also promotes users to be more honest in their answers than in a face-to-face situation.

The postal survey distributed to carry out the evaluation study provided a level of understanding of how well the heat pump information leaflets were received by tenants through the questions posed in the survey. Opinions on the content of the information leaflets and how useful the tenants felt they could be were obtained through the mixture of closed and open questions in the questionnaire. However, it is a limitation of the evaluation study conducted that it cannot assess the value of them in real use within the scope of this doctoral research. A longitudinal study would be required in order to trial the information materials with new tenants receiving heat pumps and using the systems for a period of time, in order to determine their ‘real-world’ benefit, but this was outside the timeframe of this doctoral research.

The benefit of the information materials in helping people to understand how to use the control panels could have been assessed through adopting a different method of evaluation. In face-to-face interviews, tenants could have given verbal feedback on the information leaflets and a simulated control panel could have been used to enable tenants to test the use of the controls with the information leaflets. This may
have provided more accurate feedback on the assistance the information materials
gave for operating the control panels. However, creating a simulated control panel
would both require more resources and extended the study for this doctoral
research. The major barrier to this form of evaluation was considered upfront and
is outlined in section 6.1 reviewing the research methods; the difficulty of recruiting
participants for a more in-depth study at the evaluation stage outweighed the
opportunity a postal survey presented of giving tenants the option of participating in
a study where the means of doing so was immediately in their reach.

A further limitation of the evaluation was that no control data were recorded to
help in assessing the leaflets as an intervention. Without prior assessment of the
households, there were no data to determine the level of understanding and ability
to use the heat pump controls before being asked to assess the leaflets. Therefore,
responses to the benefit of the leaflet against actions such as changing the timer or
temperature were limited in their accuracy. A barrier to being able to achieve this,
however, was the more intensive study required and the demand this would place
on participants, for the same reasons as presented above and in the methods
review.
8 Conclusion

The final chapter contributing to this doctoral thesis is a conclusive overview of the scope of research carried out by the author. Here, the core outcomes of this research are outlined and the novel contributions of this doctoral thesis are highlighted. Potential opportunities and avenues for further work identified as a result of this research process are presented as a closure to this scope of work but an indication of how the learning may be expanded upon or further applied.

8.1 Meeting the aim and objectives

This doctoral research adopted a user-centred design approach, to explore and define the requirements and preferences of specific stakeholders in the social housing system when installing heat pump systems. This was with the intention of identifying any means of creating a better service when providing these technologies, with a view to improving the levels of uptake and efficiency of use of these technologies. This overall aim was achieved, as evident through the empirical research conducted, presented in Chapters 4, 5 and 6, and the subsequent discussion of this process and its outcomes in Chapter 7.

The first objective of this research, to review literature concerning the parameters which set out the scope of the area for investigation, contributed to the achievement of the research aim. Reviewing existing literature enabled the author to develop an understanding of the research context and recognise gaps in research to date where issues that warranted further inquiry emerged. This helped to clarify the research focus and validated the avenue taken for empirical research studies, as set out over the subsequent objectives. Existing literature also consolidated the researcher’s understanding of the proposed methodological philosophy underpinning the research and the formation of an appropriate research procedure to follow, outlined in the methodology chapter.

A user-centred design approach was applied, as presented in Chapter 3. The research methodology was designed to allow the fulfilment of a user-centred design process, which enabled the aim to be achieved. The application of the methodology is identifiable across the research studies in chapters 4, 5 and 6. Users were
involved in all phases of the research, from exploration through to evaluation, as is the underlying fundamental principle of user-centred design. In this research, the user involvement included both the service recipient, who is the end user of the system, and the service provider. The use of this methodology enabled in-depth exploration to investigate the process involved in heat pump installations. Through this, processes across different social housing organisations could be reviewed and people’s experiences could be investigated to establish a substantial, contextual understanding.

This deep and rich exploration, with both the service recipients and service providers, enabled requirements and any problems of the service recipients to be identified, defined and then balanced against the opportunities and restrictions of the service delivery highlighted by the service providers. This understanding of both sides of the service process enabled the researcher to identify areas of the service which could be addressed to improve the process. Further exploration, in a second empirical study, involving relevant stakeholders on the recipient side of the service and the service provision side enabled the refinement of identified requirements and opportunities.

This refinement and the user-generated ideas which emerged through the study focus groups were then translated into ways in which these aspects of the service could be changed to improve the service delivery and experience. The service recommendations and ideas developed with evaluation of their benefit, where possible, were presented in this thesis, thus fulfilling the research objectives and overall aim. The final objective of this thesis was to deliver conclusions drawn as a result of the research conducted, to highlight the key outcomes and novel contribution of this research. This objective is achieved over the following two sections.
8.2 Conclusions drawn

To increase successful integration of renewable technology into the UK domestic sector, people need to accept and adopt the technology and use it to best effect. This places significant importance on the end users occupying dwellings and how to achieve this adoption and comprehension of new renewable technology. It is, therefore, important to have greater contextual knowledge of the relationship between occupants and the new technology and, furthermore, the surrounding ecosystem that affects this relationship. How best to approach the occupants, in order for them to take the perspective that the new heating system is a benefit and the right choice for them, needs to be considered to augment successful uptake and usage of new heat pump systems. Beyond this, the end user needs a substantial enough comprehension of how the technology works and how it is best used to maximise the efficiency and benefit of it.

User-centred design is an appropriate philosophy to apply to obtain a deeper understanding of people, their opinions and experiences. Involving people in research, who have been involved in heat pump installations, either as the provider or recipient, provides valuable information about the current processes and experiences, to identify problems and opportunities, in order to learn how to improve for future applications. Through the research carried out, this thesis has made the case that user-centred design is a suitable approach to apply to the design of services, albeit complexities arise with the nature of a service. The traditional user-centred design approach requires substantial iteration to review the holistic service and when focusing on the design of particular touchpoints. Whilst the user-centred design approach is an iterative process, compared to the design of a product or interactive system, services are more complex with a multitude of products, systems and interactions making up their existence. The holistic design of service delivery can be addressed from a user-centred approach, as can the products and systems within it, through greater iteration of the user-centred design process.

This research investigated the service of installing heat pump systems with a particular focus on the implications for older people. Through both the review of
literature and the empirical studies carried out, this research has found that there are implications for older people regarding domestic heating and its impact on health and thermal comfort. Heat pumps evidently provide benefits for older people living at home, particularly those with physical ailments. This research clearly highlighted that a heat pump system is a better alternative to solid fuel for older people in terms of it being less laborious to use and to maintain in terms of cleanliness. It was also highlighted that there could be difficulties in dependency on coal or oil if a delivery was missed for any reason. A tenant would go without their heating because of a lack of fuel; a heat pump would provide more reliable heating.

The benefits of a heat pump system for increasing thermal comfort is important for older people because of the imperativeness of a substantial heat level in the home for their health, particularly with a higher likelihood of illnesses and physical ailments amongst the older population. The research indicated that some tenants felt they experienced preferred levels of warmth and in these cases the tenants were very satisfied and promoted the installation of heat pumps. Some households reported that thermal comfort was not improved and in some cases it appeared to have worsened in their opinion, compared to their previous system. The research identified that this appeared to be a result of either heat pumps underperforming in the dwelling they were installed in or the tenants not understanding and using the heat pumps effectively.

The literature and investigations with social housing landlords have shown that the intention of implementing heat pump systems was to reduce fuel bills for social housing tenants. This is a benefit to all social housing tenants, who live in this sector due to lower levels of income, but particularly to older, retired tenants who have a fixed income pension. These cost savings are dependent on the appropriate usage of the system and it was evident through the research with tenants that cost-savings were not realised in all cases; in some cases tenants found the heat pumps expensive to run.

The increased thermal comfort and cost-savings associated with heat pumps are only realised if the systems function efficiently, which is affected by both practical
installation factors and end-usage by tenants. This issue was outlined as the reason behind the development of this research, from the review of literature, and was validated by the research findings. The importance of the various stages of the service to install heat pumps – the introduction, the installation and usage and maintenance of the system – was identified through the research studies. Aspects relating to communication in these stages came into focus, to address how to manage these aspects effectively, in order that potential benefits through improved information and better understanding may be experienced by tenants. This research found that there was little difference between implications of the communication at the various stages for the older people and younger people involved in the studies. On the whole, older people were not delivered the service differently to younger people. Tenants involved in the research indicated the same requirements of the service across ages. Consistent requirements were for information to be delivered both verbally and in written format, at the point of introducing the technology and when the system was installed, to fully inform the tenant what to expect from the system and how to use it. Reference materials for how to use the system controls need to be provided and user-friendly so that tenants are able to operate their own systems. This reduces feelings of frustration and vulnerability through reducing the dependency on others to operate the systems.

To draw a conclusion to this research against the research aim set out, the empirical studies and discussion in this thesis outline the requirements and preferences of the specific stakeholders in the social housing system, through the extensive exploration that was undertaken. The importance of setting accurate expectations, communicating effectively and delivering a satisfactory customer service was evident. Means of improving the service were addressed as a result of the contextual understanding developed and by involving users in generating ideas. The research process undertaken enabled recommendations to be made to improve the service. The final part of the aim was to achieve this with a view to improving levels of uptake and efficiency of use of the systems; however, this cannot be concluded without further longitudinal study being conducted and this is an area where further work is recommended.
8.3 Novel contribution

The multifaceted nature of this research, with distinct parameters, results in various novel contributions to knowledge from different perspectives. This thesis investigated the interesting focus created by combining the issues of renewable technology, social housing and older people. The researcher applied user-centred design to the service process of integrating heat pumps into social housing with a view on the impact of this on older people.

Applying user-centred design to the service delivery of installing heat pump systems into social housing is a new way of approaching the design of this service process. In a relatively immature area of industry, installations to date have been heavily focused on the technical aspects of the system. There is an increasing recognition of the importance of the end user, their experiences and behaviours, but employing user-centred design to enhance this user understanding and inform the service process design for installing heat pumps into social housing has not been done before. The service of installing heat pumps into social housing is a specific application within this research context but from this emerges a question of whether the same principle can be applied to other services within the social housing sector. Social housing providers are service providers to tenants relating to all aspects of the property and maintenance issues; therefore, insights gained from this research may be applied to other housing services, such as the integration of other technology systems.

A novel contribution of this research, through the process taken, is an in-depth understanding of the heat pump installation service in UK social housing, the approaches taken of various organisations and their successes and difficulties. A substantial understanding of tenants' perceptions, comprehension and usage of the systems has been established through the qualitative, explorative nature of the research. Furthermore, this research has led to better knowledge of what is required for user-friendly information materials for heat pump users in social housing properties. The key touchpoint of information leaflets developed in this research highlighted the benefit of involving users to better define how products and services for them should be created and evaluate whether the proposed designs
fulfil their needs. The development of these materials also provides a novel contribution to the area.

8.4 Further work
This section of further work is an overview of opportunities for extended research, as an outcome of the research presented here in this thesis. The author has selected some areas of potential further work that emerged as both interesting and important to contribute to new knowledge, subsequent to the conclusions of this thesis.

8.4.1 Evaluation and implementation
The final two stages of the user-centred design process are to evaluate the design solutions developed and implement the changes. This thesis incorporated an evaluation phase to assess the key touchpoint developed and demonstrate the viability and value of doing so in this context. Time and resources limited the evaluation that could be carried out. An extension of this research would be to conduct further longitudinal study in order to trial the recommended changes to the service and evaluate the impact they had over time. It would warrant an extended period of time to trial any recommendations in order to assess whether they had any effect on the uptake of heat pumps and efficiency of use of the systems. In order to assess the efficiency of use, this research would need to be in combination with technical monitoring of heat pumps. A significant amount of heat pump installations are being monitored in the UK for their performance, so collaboration between this technical research and social research would be practicable.

The discussion outlined the extent to which the other service recommendations were developed within the scope of this thesis. They were not assessed through an evaluation stage because of the high-level view of them ascertained thus far. Whilst they emerged as valuable measures by the research participants, the development of them and therefore evaluation was restricted by the capacity of this research. As has been carried out with the refinement and development of the information
leaflets, the products, systems or sub-services involved in the recommended improvement measures require creating or designing. Each of these could be addressed through a user-centred design approach to ensure they work as best as possible and fit within the service context and other interacting or impacting touchpoints. Therefore, a further level of detail would be required for the refinement of requirements and development of the other service recommendations prior to trial and evaluation.

8.4.2 Heat pump controls

There is a clear issue over people’s understanding of using heat pumps and wariness of operating the controls. Suppliers are aware of users’ issues with them and their complexity. For example, installers involved in the second study of this research suggested the cooling operation controls should be removed from heat pumps as they are currently never used and just cause confusion. Personal communication with a heat pump supplier informed the researcher that they were placing effort on altering heat pump controls from current digital panels on the heat pump alone to integrate a conventional thermostat control as the primary control mechanism for users. This indicates that it is recognised in the industry that heat pump control panels are not user-friendly.

In dwellings where occupants have a thermostat control mechanism, tenants seemed happier and understand how to use these controls. In some cases, during the exploration interviews, tenants with only a heat pump control panel on the unit stated they would prefer a thermostat control device to make control simpler for them. The interviews and focus groups conducted for this research also highlighted that the variance in controls makes the service provision more cumbersome. This issue was encountered in the development of information materials in this thesis, as more materials had to be produced on the basis of such variance in systems across one housing provider’s stock. This has two implications, one of which arose in this research.

Firstly, it makes a case for improvements and standardisation of heat pump control interfaces. The social housing landlord, and installers contracted by them, who were
involved in the focus group for this research suggested the benefits of having standardised control mechanisms across the types of heat pumps they installed. They proposed that they would be inclined to select a supplier on the basis of them providing this. Hawthorn (2000) identified that there is very little research existing on usable interface design for older people. Whilst this research was reported around a decade ago, it referred to interfaces in general; therefore, arguably, the interface design for new heat pump technology has also not received this consideration. The design of heat pump controls was out of the scope of this thesis but research findings provided insights that would inform such an area of research. The research conducted for this thesis highlighted the control designs as an important area to consider. There is the potential for better heat pump control design to impact on other service components positively.

Secondly, it emphasises a responsibility of the heat pump manufacturers to provide user-friendly information materials for the end-user with the systems they supply rather than an over-complicated technical manual. This thesis highlighted some issues of retrospectively creating information materials to explain complex technology that the end user can understand. This again, indicates the importance of the manufacturer being best placed to produce user-friendly information materials which can be distributed with the technology when it is introduced or installed. It furthermore highlights that if the technology and controls were designed to be more user-friendly then the task of creating corresponding information materials would become easier.

This research looked at the service of installation, tenant satisfaction and experiences of using heat pumps. It did not address this with reflection on the actual performance of the heat pumps through technical monitoring. Therefore, the research cannot comment on the impact of particular user behaviour on the efficiency of performance of the system. Another aspect interesting to research relating to the control mechanism is the suitability of programmers and thermostats for heat pump technology and the effect these have on the efficiency of the system. With increased control and the ability to turn the heating up and down or on and
off regularly, does this conflict with the way the heat pump performs and decrease efficiency? This presents another socio-technical aspect worthy of investigation.

Another area of research which this author has considered as a potential avenue for further investigation is the development of a training module for heat pump controls. One of the core reasons that was found why tenants were cautious over using the controls was the fear of doing something wrong and causing a problem with the heating system. Equipping social housing staff, installers or other stakeholders who may deal with teaching people to how use the control panels with a ‘dummy’ control panel would enable the user to learn practically how to use the functions without the concern of breaking anything.

### 8.4.3 Wider application of the research

The differences between the social housing sector and private housing sector have been outlined in this thesis and the case was presented in the literature review why social housing was a focus in this research. Addressing the private sector has also been outlined as an important area for research concerning heat pump installations, as discussed in chapter 7. The private homeowner market has significant differences to the social housing sector which create new dynamics and factors to consider. The private rental sector is closer to the social housing sector in terms of a landlord-tenant relationship and the dynamics of control over the property. As outlined in section 7.1.2.2, further research would be required to understand the type and level of service between private landlords and their tenants to identify what, if any, outcomes of this research could be applied in that sector.

### 8.4.4 Enabling service design

A key difference between a user-centred design approach and a service design approach highlighted in this thesis is the co-creative aspect of the design stage. In this thesis, it was decided that co-creative methods might not be received well or conducted effectively with the target participant sample. The researcher did not directly recruit the participants and had no contact with them prior to the commencement of the empirical study; therefore, a judgement of how open they...
may be to highly-participative methods was difficult to make but based on the age of the target population and the lack of contact it was felt that true co-creation may be difficult.

The interesting point to consider here is what would reduce barriers to co-creation and people being willing to participate in design activities? A second question arises over whether co-creation is always required to enhance the design process. There is a positive case for adopting co-creative methods but rather than just being used to make sessions more interesting or engaging, they should be adopted when they really add value to what is trying to be achieved. Arguably, they can be assistive with analysis subsequent to workshops and they can surface more innovative ideas by giving users a platform to contribute to the design process in a greater sense. However, methods adopted should be valuable to the process and not hinder the session in any way by making the session disjointed or participants less comfortable to freely converse and discuss. What methods work well with particular situations or particular types of participants would be an informative aspect of research to investigate.

8.4.5 Psychology of introducing new systems
The difficulty of tenant education and getting tenants to understand how the heat pump performs that was highlighted in this research produces an interesting aspect to investigate. Mental models are the conceptual ideas people develop to understand how something works, through regular use of it. How people establish these mental models about systems and, more importantly, how difficult it is to alter people’s mental models poses an interesting research focus. An understanding of how mental models are formed or how to effectively undo a mental model, to shift to a new understanding, has potential to inform the way in which to communicate to people in situations like that presented in this research.
List of References


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http://www.communities.gov.uk


DCLG. (2013). *Improving the energy efficiency of buildings and using planning to protect the environment.* Retrieved August 11th, 2013, from GOV.UK:


http://www.guardian.co.uk/environment/2010/feb/25/low-carbon-housing-technologies-uk-trial?


Appendix A: CCC tenant interview guide

A copy of the interview guide for the CCC project is displayed on the following pages 284-291.
PROJECT INFORMATION:
Who we are
(a) My name is <name> and this is <name> from <University>.

Project details
(b) We are working on a project, called CCC (Carbon, Comfort, and Control) with a group of universities looking at comfort and heating in the home. We are visiting a lot of local properties to find out what people think and do. You should have already received information about this study.

- Are you happy to take part?
  Any questions?
  Sign consent forms if they have not already done so
  We should be finished within an hour, is that ok?

GENERAL INFORMATION/NOTES:
TOPICS
1. Background

First of all we’d like to find out a bit more about you, if that’s ok.

(a) Could you tell us a little bit about yourself?

(b) How long have you lived here?
    Where did you live before?

(c) Who else lives here?
    - Do you have any children?
      How old are they? School? University?
    - Do you look after anybody
      Other children, elderly relatives, others requiring care
    - Do you have any pets?

(d) What do you do during the day?
    What do you do in the evenings?
    What do you do at the weekends?
    - [if working] What kind of work do you do?
      Where do you work?
    - [if retired] What kind of work did you do?

(e) What kinds of things do you do when you’re at home?
    Do you invite people over?
    What do you do together?

(f) What kinds of things do you do for fun?
2. Comfort

We’d like to find out what makes you feel comfortable.

(a) When you’re at home, what kinds of things do you do to feel comfortable?

(b) Do you use any particular objects to help you feel comfortable when you’re at home?

(c) What do you do when you feel too warm?

(d) What do you do when you feel too cold?

NON TEMP: - SECURITY (GOING OUT, NIGHT)
- NOISE
- LIGHT
- FOOD
- COLOUR
TOPICS
3. Building

(a) We’d like to ask a few questions about your home, now. Has anything changed with your home since you moved in?

(b) Can you tell us a bit about your heat pump?
   - How long have you had it installed?
   - Do you have any extra heaters
     When do you use them?

(c) How does this system compare to your previous heating system?

(d) How do you control your heating?
   - At the heat pump itself?
     How easy do you find the controls to use?
     Do you know what temperature it is set to?
     Who tends to do control the heating?
   - Do you leave the heat pump on all the time?

   - Do you have controls on your radiators?
     Do you use them?
     Do you set them differently in different rooms?
     Who tends to do this?

(e) Do you do anything else to make your home more comfortable?
   Do different people in your home have different ideas about how to make it comfortable?

(f) How do you pay for your energy bills?
   Are you happy with how much it costs?
   Do you keep an eye on your meters?
   Do you do anything to try and use less energy? [If yes] Why do you do this?
**TOPICS**

4. Variability

We'd like to find out a bit more about how the things you do in your home to feel comfortable might change at different times and in different situations.

(a) [Refer to info on who is at home and when]
   - When X is at home, do you do anything differently?

(b) When you have guests, do you do anything differently?

(c) We've had quite a cold winter.
   - Are winters here normally this cold?
   - Does your house get quite cold in this weather?
   - What kinds of things have you been doing to keep warm?
   - Could you run me through what you do when you get home on a cold day?

(d) Thinking about the warmer months,
   - Does your house get warm in the warmer weather?
   - Does what you do in the warmer weather differ much from what you do in the colder weather?
   - What kinds of things do you do to keep cool in the warmer weather?

(e) Thinking about how you keep comfortable at night,
   - Do you have the heating on at night?
   - Do you leave windows open at night?
   - Do you leave any lights on at night? Why?
   - Is there anything else about how you keep comfortable at night that's different to what you do during the day?
   - Could you briefly run me through what you do when you wake up?
TOPICS
(f) Thinking about times when you don’t feel well
   - What kinds of things do you do to feel comfortable at home?
   - Do you find that the weather affects your health?
   - When you feel unwell, how do you keep warm, or cool down at home?
<table>
<thead>
<tr>
<th>TOPICS</th>
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<tbody>
<tr>
<td>5. Environment</td>
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<tr>
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<tr>
<td>We'd like to find out whether you do</td>
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<tr>
<td>anything to try and help the environment,</td>
</tr>
<tr>
<td>Recycle?</td>
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<tr>
<td>Grow own food?</td>
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<tr>
<td>Try to use less energy? Etc.</td>
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</tbody>
</table>

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<tr>
<th>RESPONSES</th>
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<tr>
<th>6. Other</th>
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<tbody>
<tr>
<td>Is there anything else that you think we should know about how you keep comfortable at home?</td>
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</table>
PROJECT INFORMATION:
Closing Statements

(a) That’s it; we are finished for the day, thank you for your time and <the cup of tea>.

(b) This second visit involves an audio tour of your home, and would again last approximately one hour. This would involve you taking the researchers around your home and answering questions on what areas are more comfortable than others and how you make areas more comfortable. You do not have to take the researchers to any part of your home you do not wish to. With your permission, the researchers will record the tour using a digital audio recorder and a digital camera, in addition to taking notes. You can select areas where we may take photographs, or you can refuse the use of audio and photographic equipment in your home.

(c) We would like to come back in a few days for the next visit; it should take around the same amount of time, when would that be convenient?

GENERAL INFORMATION/NOTES:
Appointments

<table>
<thead>
<tr>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
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Loughborough University_interview guide_V0.1c
Appendix B: Tenant interview guide

How were you first approached about having a Ground Source Heat Pump installed in your home?

What information were you given when you were first approached?

What were your first impressions of what was being offered?

Why did you choose to have the heat pump installed?

How did you find living at home during when the heat pump was installed?

Did anything happen during the installation that you did not expect?

What do you think of the system since you’ve had it installed?
  - What do you like about the system?
  - Is there anything you’ve found you don’t like?

Do you use the controls on the heat pump?
  - How easy do you find them to understand?
  - How easy do you find them to operate?

Has changing your heating system had any effect on the way you do things in the home? Such as, washing, opening windows etc.

Is there anything you know now about having a heat pump that you wish you had known beforehand?
Appendix C: Landlord interview guide

What types of renewable heating technology have been installed in residential properties?

How and why were these specific renewable technologies chosen?

How is the supplier for the technology chosen?

How is it determined which tenants/properties to introduce renewable heating technology to?
*ie Is offering a renewable technology driven by who occupies the house or the property itself?

How is it determined which specific renewable technology to allocate to a property/tenant?

Is there a particular time when the renewable technology is introduced to tenants?
*ie alongside other major works.

How are the renewable technologies introduced to tenants?
- Method (letter, newsletter, visit, phone call etc.)
- By whom
- Content: What information are they given at the outset?
- Do they have a choice over whether they have the technology?

What information are tenants given when the renewable technology is installed?

How is the system operated?
- Do tenants have control over the system?
- How do tenants control the system?

Are tenants communicated with after the installation?
Is this instigated by tenants or by the landlord? Is there a developed programme?

How is the technology maintained after installation?
*ie How is it technically maintained and who supplies this service
Appendix D: Piloted stickers for interviews
Appendix E: Service recipients focus group

Refreshments on entry

Welcome & Introduction – 10 minutes

Good morning to everyone and thank you for coming. [INTRODUCE OURSELVES AND WHAT WE DO]
As you know, we’ve invited you along because you all have a heat pump in your home and we want to know how you’ve got on with them. It’s just going to be a relaxed discussion and there are no wrong answers to anything, so please speak freely and we’d like everyone to contribute.

To start off we’d just like to go round the group and everyone tell us who you are, what type of heat pump you have and how long you’ve had it.

Main session pt 1 – 45 minutes

So firstly, what were the main reasons you decided to have it installed?

What did you think of how it was presented to you as a replacement heating system option?

Now you’ve got a heat pump, what would you tell others like you who might be considering whether to have one installed?

How do you think the council should introduce the idea of having a heat pump to other tenants, based on your experience?

Now for a bit more detail, can anyone tell us anything about how a heat pump works? Even if it’s just a bit of it you think you know, tell us.

If people don’t answer with much knowledge –
Do you want to know more about how the heat pump works?
How can we make it make sense for you?
Ie pictures, text, video…?

*If people do answer* -
How do you know that information?
Was it easy to understand?
Would you like anything changed about the information you had?

**Break – 10 minutes, refreshments**

**Main session pt 2 – 20 minutes**

We know some of you may have different heat pumps in your homes, but we’d like to talk about the control of them.

Can you tell us about how you control your heating?
Do you have any difficulties controlling it?

Can you think of any other things around the home or anything you do at home that might affect your heating, not necessarily to do with the system itself? For example your windows.

Were you given advice on changing / checking on your electricity tariff when you had the heat pump installed?

How would you like to be given this advice?

**Main session pt 3 – 30 minutes**

Information material design discussion
Appendix F: Contextual Interview Guide

1. So firstly, what were the main reasons the heat pump was installed in your home?

2. What did you think of how it was presented to you as a replacement heating system option?

3. Based on your experience, how do you think the council should introduce the idea of having a heat pump to other tenants?

4. Can you tell us anything you know about how a heat pump works? How do you know that information? Was it easy to understand? Would you like anything changed about the information you had? Do you want to know more about how the heat pump works?

5. Can you tell us about how you control your heating? Do you have any difficulties controlling it? Have you needed to ask for further advice about the heating system or its controls since having it installed?

6. We’d like now to see what you think about some ideas, whether you agree with them or whether you feel differently based on your own experience.
   - Did you have or would you have benefitted from contact from the council in the weeks following your installation?
   - How would this work best do you think?
   - Do you think it’s a good idea to have some written information before the installation AND when it is installed?
   - Would it be better to have information both written and verbally?
7. Of the following, which do you agree are important for written information
given about heat pump installations or which are better given in an alternative
way:
   - Cost of running
   - Energy savings
   - How a heat pump works
   - Control instructions
   - Contact information
   - Electricity tariff advice
   - What to expect during installation
   - How to live with a heat pump – what other things affect your heating
   - Can you tell us any things around your home that might affect your
     heating?

8. What would you suggest about the presentation of written information, to
make it easier to understand? Such as the text, language, amount of pictures,
type of pictures.
Appendix G: Service providers focus group guide

2:00-2:10 Welcome & Introduction
Tea & Coffee
Group introductions – who they are and what they describe their role as in relation to the heat pump installation.

2:10-3pm: Council & Installers
Pre-installation (Once a property has been chosen and tenant agreed – between decision and starting installation)

- When a decision has been made to install the heat pump, what kind interaction takes place with tenant on the change? (ie are tenants contacted? what are tenants told, are tenants informed what disruption they are likely to expect?)
- Who does this? - SDC? Installers? Both
- What form does this interaction take? Visits? Letters? Literature etc
- Does the tenant have someone to contact if they have any concerns / queries etc? (if they have questions between making a decision to have it installed and the installation being started)
- What improvements do you think could be made to this particular stage of the process?

During installation

- Who determines where to site external & internal units?
- Do you assess/who assesses to find out about occupancy of the property to best assess the chosen system settings?
- Any communication with the resident at this stage over how the heat pump works/how to operate it? Whose responsibility is it at this stage? (while the work’s being done)
- Does the tenant know who to contact if there are problems / queries etc? (during installation)
- Who gives training and information to the tenant on how to operate the heat pump when it’s all fitted?
- How is the decision made on what operation materials are provided? What is provided?
- Who would provide suggested behavioural advice to the resident? – e.g. not blocking rads with sofas, curtains etc.
- What do you think could be done better by any party during the actual installation work?

Post Installation

- Is there a clear line of communication for the tenant to resolve any mechanical technical issues with the heat pump? Who do they go to? (Installer or council?)
- Who do tenants go to for problems / advice if required for adjusting the system?
• Does this current process work well or do you have ideas how it could be streamlined?

Other points –
Are there any other things from your point of view as installers/maintenance contractors that you think are worth mentioning?

3:30-10 Tea break (Installers leave)

3:10-4pm
Pre-installation
• What staff are involved in deciding whether to install a heat pump in a property?
• What instigates this potential decision to install a heat pump? Does a tenant approach the council? Or is it from a survey / review of stock by SDC?
• How is it decided whether to install a heat pump and what type?
  o Is there a physical survey of the property?
  o Is there an assessment of the occupants and an appropriate system for them?

Post-installation
• Is an independent post installation check of the system carried out (i.e. by anyone other than the installer)
• Are council staff trained on, or at least aware of, the potential issues tenants may face with their heat pump? Or would they know who to pass specific enquires regarding the system on to?
• Do you think it would be worth visiting the tenant after installation (2 weeks?) to follow up how they are finding the system, and to obtain feedback on the installation process / installer service and would this be possible within the council’s capacity?
• Is there another time you think a follow up visit could be possible?
• Is tariff advice given? How is this done?
• What kind of handover information (literature / visit etc) on the heating system is provided when a property is re-tenanted?

General –
• What areas or processes do you think could be improved from your perspective/your role?
• What feedback have you had from tenants that indicate where improvements could be made?
• From your experience, what do you think are the most important considerations for written information materials? Content & Physical appearance.
Appendix H: Leaflet A questionnaire

Heat Pump Information Leaflets Survey

Thank you for agreeing to take part in this survey. The following questions are to find out your opinions of the design of the leaflets and how useful you find them. Please answer all the questions on this sheet of paper and be honest in your responses. Also feel free to write or draw anything on the prototype of the leaflet where you feel your comments would be helpful or it would help you explain your answers. All responses are appreciated.

About you:

Gender:  □ Male  □ Female
Age:  □ 16-24  □ 25-34  □ 35-44  □ 45-54  □ 55-64
            □ 65-74  □ 75-80  □ 80+
Occupation:  □ Full-time employed  □ Part-time employed
            □ Unemployed  □ Self-employed
            □ Student  □ Retired

1. What are your first impressions of the leaflet design? Please tick all that apply.

□ Attractive  □ Cluttered  □ Boring
□ Clear  □ Difficult to read  □ Easy to read

308
☐ Other - Please write any other comments
_______________________________________________________
_______________________________________________________
____________________
_______________________________________________________

2. What, if anything, do you like about the leaflet?

3. What, if anything, do you dislike about the leaflet?

4. What do you think about the size of the leaflet?

☐ Too big  ☐ Just right  ☐ Too small  ☐ I don’t mind

5. What do you think about the size of the writing on the leaflet?
6. After reading the first page, do you think you understand how a heat pump works?

☐ Yes  ☐ No  ☐ Somewhat

7. After reading this leaflet, do you feel well-informed what to expect from a heat pump installation?

☐ Yes  ☐ No  ☐ Somewhat

If you have questions about the heat pump the leaflet cannot answer, please comment on these here.

8. After reading this leaflet, do you think this would have been useful when you were first approached about having a heat pump?

☐ Yes  ☐ No

9a. If you had a query, would you know what to do?

☐ Yes  ☐ No

9b. Does the leaflet help you find this information? (refer to 9a)
☐ Yes  ☐ No

10. Any other comments?

Thank you for taking part in this survey. Please post this completed questionnaire with the test leaflet in the stamped addressed envelope provided, by Monday 16th July 2012.
Appendix I: Leaflet B questionnaire

Heat Pump Information Leaflets Survey

Thank you for agreeing to take part in this survey. The following questions are to find out your opinions of the design of the leaflets and how useful you find them. Please answer all the questions on this sheet of paper and be honest in your responses. Also feel free to write or draw anything on the prototype of the leaflet where you feel your comments would be helpful or it would help you explain your answers. All responses are appreciated.

About you:

Gender: ☐ Male ☐ Female

Age: ☐ 16-24 ☐ 25-34 ☐ 35-44 ☐ 45-54 ☐ 55-64
☐ 65-74 ☐ 75-80 ☐ 80+

Occupation: ☐ Full-time employed ☐ Part-time employed
☐ Unemployed ☐ Self-employed
☐ Student ☐ Retired

1. What are your first impressions of the leaflet design?
Please tick all that apply.

☐ Attractive ☐ Cluttered ☐ Boring
2. What, if anything, do you like about the leaflet?

3. What, if anything, do you dislike about the leaflet?

4. What do you think about the size of the leaflet?

- [ ] Too big
- [ ] Just right
- [ ] Too small
- [ ] I don’t mind
5. What do you think about the size of the writing on the leaflet?

☐ Too big  ☐ Just right  ☐ Too small  ☐ I don’t mind

6a. Where would you keep the whole leaflet? Tick all that apply.

☐ In a drawer  ☐ In the tenant handbook  ☐ Noticeboard
☐ Stuck (blutak/pin) somewhere visible  ☐ On a table
☐ By the heat pump controls

6b. Where would you keep the control specific page of the leaflet?
Tick all that apply.

☐ In a drawer  ☐ Noticeboard  ☐ On a table
☐ With the rest of the leaflet  ☐ Separated from the other parts
☐ By the control panel  ☐ In the tenant handbook
☐ Stuck (blutak/pin) somewhere visible

7. After reading the first page, do you think you understand how a heat pump works?

☐ Yes  ☐ No  ☐ Somewhat
8. After reading this leaflet, do you feel well-informed what to expect from a heat pump installation?

☐ Yes    ☐ No    ☐ Somewhat

If you have questions about the heat pump the leaflet cannot answer, please comment on these here.

For the following questions, please consider the task and whether you think you could carry this out using the information leaflet. Please do not attempt to carry out the task on your own control panel, just consider the task alone.

9. You want to change the temperature, can you do this?

☐ Yes    ☐ No, there is no information
☐ No, I do not understand
☐ Yes, but I do not feel confident using the controls    ☐ Unsure

10. You want to set the timer, can you do this?

☐ Yes    ☐ No, there is no information
☐ No, I do not understand
☐ Yes, but I do not feel confident using the controls  ☐

Unsure

<table>
<thead>
<tr>
<th>11a. You have a query about your system, would you know what to do?</th>
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<tbody>
<tr>
<td>☐ Yes  ☐ No</td>
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If yes, what would you do?

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<tr>
<th>11b. Does the leaflet help you find this information? (refer to question 11a)</th>
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<tbody>
<tr>
<td>☐ Yes  ☐ No</td>
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<thead>
<tr>
<th>12a. Your system does not appear to be working correctly, would you know what to do?</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Yes (answer Q12b.)  ☐ No</td>
</tr>
</tbody>
</table>

12b. If yes, what would you do?

<table>
<thead>
<tr>
<th>13. What heating system do you have?</th>
</tr>
</thead>
</table>


14. Any other comments?

Thank you for taking part in this survey. Please post this questionnaire with the test leaflet in the stamped addressed envelope provided, by Monday 16<sup>th</sup> July 2012.